CoRWM Document 2500

OUTLINE OF CORWM INTERIM STORAGE REPORT

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CONTENTS

EXECUTIVE SUMMARY

Scope of report

- this report is about CoRWM's work during 2008/09 on:
    - the conditioning, packaging, interim storage and transport of higher activity radioactive wastes
    - the management of nuclear materials that may be declared to be wastes in the future, that is spent nuclear fuels, plutonium and uranium
    - research and development (R&D) on the above topics
    - public and stakeholder engagement (PSE) on the above topics.
- for R&D only our main findings are included in this report. There is a supporting report with more details.

How we worked

- we worked by gathering information from the waste producers and holders of spent fuels, plutonium and uranium, from all the regulators, and from other organisations. We held meetings with all the major organisations, the notes of which are available on our website, and we attended stakeholder workshops held by the Nuclear Decommissioning Authority (NDA). We also sought the views of stakeholders and the public via our website and at a CoRWM PSE event in October 2008.

Proposed conclusions and recommendations – for comment

- this report sets out the information we gathered on each topic, referencing other CoRWM documents for more details, and gives our proposed conclusions and recommendations on each topic.
- our proposed overall conclusions and recommendations are as follows.

Strategic Co-ordination

- in all the areas considered in this report (waste conditioning and packaging, waste storage, waste transport, the management of spent fuels, plutonium and uranium) there is a need for better strategic co-ordination across all the UK nuclear industry organisations, civil and defence.
- the NDA has made a good start for its sites, with its "strategy management system", and its increasing co-ordination with the Ministry of Defence is welcomed. However, the NDA is necessarily focused on its own strategies.
- *CoRWM recommends to Government that UK-wide strategies be developed for:*
    - *the management of higher activity wastes (including, their conditioning, packaging, storage and transport)*
    - *the management of all spent fuels*
    - *the management of plutonium*
    - *the management of uranium*
    - *R&D on all the above topics.*
- *we also recommend to Government that priorities be established for strategy development and implementation, so that UK resources can be targeted where they will do most to improve safety. security and the protection of the environment, in the short term and the long term.*

Public and Stakeholder Engagement

- CoRWM has found from its own PSE activities that the issues covered in this report are not well-understood outside the technical community that deals with them on a day-to-day basis. Both lay people and technical people who are not expert in these areas have difficulties in finding information in accessible forms, and thus are not well-equipped to become involved in consultations and decision-making.

- there have also been instances where the past PSE activities of other organisations have been unsatisfactory, and there are gaps in future plans.
- *CoRWM recommends to Government that more information be made publicly available on the management of higher activity wastes, spent fuels, plutonium and uranium, and on R&D, and that a co-ordinated PSE approach be developed to ensure that there is sufficient stakeholder participation in decisions on these topics, at national, regional and local levels.*
- *There is a particular need to make information available to the public about how the security of stores for radioactive wastes, spent fuels, plutonium and uranium is assured.*

1 INTRODUCTION AND BACKGROUND

1.1 Scope of Report

Report covers the following areas from CoRWM's 2008/09 work programme [CoRWM doc. 2266]:

- interim storage of higher activity radioactive wastes, including waste conditioning, packaging, storage and transport (task 2.1)
- management of spent fuels (task 2.2)
- management of plutonium and uranium (task 2.3)
- research and development (R&D) on waste conditioning, packaging and storage, and management of spent fuels, plutonium and uranium (task 4.1)
- Letter of Compliance (LoC) process and waste package specifications (task 1.2)
- scrutiny of others' public and stakeholder engagement (PSE) related to the above (task 8.2).

Does not cover new build wastes and spent fuels – a task being planned for 2009/10 [CoRWM doc. 2515].

Report only covers main aspects of our findings on R&D; a further report has more details [CoRWM doc. 2389].

1.2 Definitions

(See also Glossary in Section 8.)

- radioactive waste – as defined in the Radioactive Substances Act 1993: in essence any substance for which there is no further use and in which artificial radionuclides are present at any level and/or natural radionuclides are present above the levels given in Schedule 1 of the Act. Note that spent fuels, plutonium and uranium are not radioactive wastes unless it has been decided that there is no further use for them and they are declared to be wastes.
- higher activity radioactive waste – waste with activity above the thresholds for low level waste (LLW), ie above 4 GBq/t alpha or above 12 GBq/t beta gamma [Defra et al, 2007]; usually also taken to include LLW unsuitable for near-surface disposal.
- storage – placing wastes or other materials in a facility with the intention of retrieving them at a later date. (As distinct from disposal, which means emplacing wastes in a facility with no intention of retrieving them. Note that the time when a geological disposal facility is open does not constitute storage because there is no intention to retrieve the waste. If some wastes or other materials were placed in such a facility with the intention of retrieving them, the facility would no longer be simply a disposal facility but a combined storage and disposal facility, and would need to be constructed and regulated as such.)
- conditioning – any process used to prepare waste for long-term storage and/or disposal by converting it into a stable solid form eg vitrification, encapsulation in cement.
- packaging – loading of waste into a container for long-term storage and/or disposal. In some cases this includes conditioning but in others waste is simply placed in containers, with or without being compacted to reduce its volume.
- waste package – the container and all its contents (waste, any encapsulating material, any capping grout).

1.3 Context

- CoRWM 2006 recommendation 2: robust interim storage must play a part in the long-term management strategy for higher activity wastes; due regard should be paid to reviewing and ensuring the security of stores, store longevity, prompt immobilisation of

wastes, minimising the need to repackage wastes, implications for waste transport [CoRWM, 2006].

- Government response: accepted recommendation 2, required the Nuclear Decommissioning Authority (NDA) to take the recommendation into account in the review of interim storage of wastes it was conducting to fulfil a commitment in its Strategy [Defra et al, 2006; NDA Strategy, 2006].
- NDA National Radioactive Waste Storage Review: scope, relationship to this report, conclusions as to immediate actions required [NDA, 2008a; NDA, 2009].
- Context for spent fuels, plutonium and uranium: NDA strategy development work and December 2008 paper to Government on plutonium management options [NDA, 2008b-h].
- Geological disposal: CoRWM understands the Government's preference for a single geological disposal facility (GDF) for all legacy and committed wastes, including any spent fuels, plutonium and uranium that are declared to be waste. However, until potentially suitable sites have been identified, we think that it is too soon to determine whether a single GDF is the safest and most cost-effective solution, and that the NDA should be flexible in its approach. When we refer to a single GDF in this report it is only for simplicity of wording.

1.4 Our Approach to the Work

- We view interim storage of higher activity radioactive wastes as having two roles in their management:
    - as an essential precursor to geological disposal (or such other long-term management method as may be decided on for wastes in Scotland)
    - as a fallback in the event of a delay in implementing geological disposal, or even a failure to implement it.
- Our primary concern is that future UK waste storage arrangements should be robust, in the sense that they will keep waste safe and secure for long enough. Our remit is for storage arrangements in general. Ensuring the safety and security of specific storage facilities is the responsibility of nuclear site licensees, overseen by the regulators.
- For spent fuels, plutonium and uranium storage cannot be considered in isolation from other activities in their long-term management.
- We worked by gathering information from the waste producers and holders of spent fuels, uranium and plutonium (NDA, some of its site licence companies (SLCs), British Energy, Ministry of Defence (MoD), GE Healthcare, Urenco), and from their regulators (the Health and Safety Executive's (HSE's) Nuclear Installations Inspectorate (NII) and Office of Civil Nuclear Security (OCNS), the Environment Agency (EA), the Scottish Environment Protection Agency (SEPA), the Department for Transport (DfT). We held meetings with most of these organisations. The information we gathered, and on which this report is largely based, is recorded in the notes of our meetings, which are available on our website. It is also intended to produce a summary to accompany the full draft of this report.
- For R&D, we also held meetings with a number of other organisations [see CoRWM doc. 2389].
- We attended a number of meetings organised by others eg the NDA Storage Workshop, the NDA Plutonium Workshop [NDA, 2008a & 2008d].
- We gathered information and views from CoRWM's stakeholders and the public via our website and through the October 2008 CoRWM PSE event [CoRWM docs 2457 & 2488].
- We involved some members of HSE's Nuclear Safety Advisory Committee (NuSAC) in some of our meetings. NuSAC ceased to exist at the end of October 2008. We are continuing to involve some former members by asking them to review this outline report and, in due course, the full draft of this report.

1.5 Layout of Report

- Section 2 is about the conditioning and packaging of higher activity wastes.
- Section 3 is about the storage and transport of higher activity wastes.
- Section 4 is about the management of spent fuels: the fuels from Magnox reactors and AGRs, that from the Sizewell B PWR, and the so-called "exotic" fuels from the various research reactors that have operated in the UK and from nuclear-powered submarines.
- Section 5 is about the management of plutonium and uranium, and also the small amounts of thorium that are held on some nuclear sites.
- Section 6 contains our overall conclusion and recommendations, drawn together from Sections 2-5.

2 CONDITIONING AND PACKAGING OF HIGHER ACTIVITY WASTES

2.1 Waste Quantities and Characteristics

- high level waste (HLW) – what it is, arisings to date (1,730m^3 to 1 April 2007, of which 648m^3 is vitrified, in 4,319 packages), future arisings (about 300m^3 liquid HLW), total expected quantity of vitrified waste (1,090m^3 in 7260 packages), all will have arisen by 2030 [2007 UK Inventory].
- intermediate level waste (ILW) – what it is, arisings to date (92,500m^3 to 1 April 2007), total expected conditioned volume (275,000m^3 in 200,000 packages), volume by site (table to be added) [2007 UK Inventory]
- timing of future ILW arisings – about 30% before 2020, 15% between 2020 and 2040, 22.5% between 2040 and 2100, and 32.5% after 2100 [2007 UK Inventory].
- note that later arisings are decommissioning wastes and the timing of their arising can be controlled by adjusting the time at which decommissioning is completed, thus avoiding the need to build storage facilities for them. This is particularly true of reactor decommissioning wastes, where the care and maintenance ("safestore") period could be tailored to the availability of a geological disposal facility and to the schedule for emplacing wastes in it.

2.2 Progress in Conditioning and Packaging ILW

- quantity of ILW conditioned to date (approx. 21,000m^3 in 40,000 packages) [2007 UK Inventory].
- at present, about 85% by volume of the UK's conditioned ILW is at Sellafield [2007 UK Inventory]. Types of waste that have been conditioned include Magnox and AGR fuel cladding, floc from the Enhanced Actinide Removal Plant (EARP) and plutonium contaminated materials (PCM). All of the conditioned ILW at Sellafield is in cement-based matrices.
- other sites at which ILW has been conditioned are Dounreay, Harwell, Windscale (now part of Sellafield), Winfrith and Trawsfynydd. The ILW conditioned includes various liquors and sludges, ion exchange resins and miscellaneous activated components. It is all in cement matrices apart from the Trawsfynydd ion exchange resins, which are in an organic polymer [2007 UK Inventory].
- most of the conditioned ILW is in 500 litre stainless steel drums.
- other packages used include boxes of various sizes [NDA, 2008i].

2.3 Future Conditioning and Packaging

- our understanding from waste producers is that not all the "raw" (ie unconditioned) wastes in store now will require conditioning; subject to obtaining a Letter of Compliance (see Section 2.5), some could be placed in drums or boxes, with or without

compaction, in order to make a stable, solid waste form for storage and subsequent disposal.

- there is an advantage in storing some ILW in raw form: it allows radioactive decay so that waste can be dealt with as LLW. This advantage needs to be balanced against the disadvantages of additional waste handling, and the best option chosen for each type of ILW.
- much of the ILW arising in future, especially from reactor decommissioning, is inert and stable and could probably be packaged without conditioning.
- for mobile or potentially mobile wastes there should be prompt immobilisation, ie conditioning should take place as soon as reasonably practicable after waste arises [CoRWM, 2006]. There is also a need to condition reactive wastes promptly, to put them in more chemically inert form.
- there are a few legacy wastes for which it is not possible to carry out immobilisation as soon as they have been retrieved from their current locations. This is because it is urgent to retrieve the wastes but further R&D is needed before a suitable conditioning method can be identified. In such cases there is no option but to place the wastes in raw form in a buffer store, pending conditioning for longer term storage and disposal [CoRWM docs 2436, 2459].
- for all legacy wastes the approach adopted is to condition and package them in ways that are “fit or purpose”, rather than delaying their retrieval and treatment indefinitely while the best possible method is sought [CoRWM doc 2436].
- cement-based matrices have been used for so much of the ILW conditioned to date because of their advantages (ease of use, compatibility with potential backfilling materials for a geological disposal facility, porosity to gas, cost etc) [CoRWM doc 2459].
- other conditioning materials and methods are being considered for the future for some wastes, eg vitrification for sludges and other “wet” ILW; hot pressing of ion exchange resins, dewatering ion exchange resins and packaging them without further conditioning [CoRWM docs 2459, 2419].
- role of the NDA Higher Activity Wastes Strategy Working Group in co-ordinating future work on conditioning and packaging issues across NDA and other nuclear sites (and mention previous co-ordination mechanisms).

2.4 The Regulatory Framework for Waste Conditioning and Packaging

- HSE, the EA and SEPA have produced guidance for nuclear site licensees on the management of higher activity wastes [HSE, EA & SEPA, 2007].
- waste producers need to prepare “radioactive waste management cases” (RWMCs) to demonstrate the safety of proposed conditioning and packaging methods and the safety of waste packages during storage, transport, emplacement in a geological disposal facility and the post-disposal period; the RWMCs for major waste streams have to be submitted to regulators [HSE, EA & SEPA, 2007].
- some technical guidance has been issued and further technical guidance is planned [HSE, EA & SEPA, 2007, 2008].

2.5 The NDA Letter of Compliance Process

- role of NDA waste package specifications and LoC process as a risk management method and precursor to the setting of waste acceptance criteria for geological disposal [CoRWM docs 2459 & 2464; NDA, 2008k].
- how the LoC process works [NDA, 2008i, j & k; Nirex, 2007].
- how specifications have changed with time [CoRWM docs 2397, 2386; NDA, 2007a].
- questions have been raised about the target container life of 500 years in the current waste package specifications. This is based on the assumption that a geological disposal facility may need to be kept open for a longer period (up to 300 years), in such

a way that waste packages could be easily retrieved. We plan to examine the whole topic of "retrievability" in 2009/10 [CoRWM doc. 2515].
- progress in issuing LoCs: 14% ILW has final LoC, 29% is within the LoC process and 57% has yet to be addressed (conditioned waste volumes form 2007 UK Inventory) [CoRWM doc 2459; NDA, 2008j & l].
- NDA reviews of LoCs issued to date [CoRWM doc 2459; NDA, 2008j].

2.6 Dealing with Failed and Out of Specification Packages

- however good the quality management system, there will be a few packages that for some reason do not meet specifications.
- it is also possible that the condition of some packages will deteriorate during storage, or be damaged during handling, transport or emplacement in a disposal facility. For example, there is one type of stored waste where some deterioration has been found (see Section 3.4).
- NDA is developing package failure criteria, which will meet the concerns expressed in the recent NWAT report) [EA, 2008a; CoRWM doc 2459; NDA, 2008j].
- types of remedial measures for failed or out of spec. packages: repair, overpack, stabilise waste form, complete reworking/repackaging (empty and recondition into new containers) [EA, 2005].
- ways to choose between the measures [EA, 2005].

2.7 Waste Conditioning and Packaging R&D

- to be added.

2.8 Proposed Conclusions and Recommendations on Waste Conditioning and Packaging

- we welcome the moves to improve co-ordination of waste conditioning and packaging and related R&D throughout the UK (for example via the NDA Higher Activity Wastes Strategy Working Group and the Nuclear Waste Research Forum (NWRF)).
- however, these moves are relatively recent and current approaches are still fragmented. There is a need for greater coordination at a strategic level, involving not only the NDA but also the other major waste producers (British Energy and MoD), and all the relevant regulators. Although current NDA led groups involve other organisations, their focus is NDA strategy. What is needed is a strategic approach for all UK waste conditioning and packaging, so that each organisation makes the best use of its resources.
- the joint regulatory guidance is valuable, and will become more so as more technical guidance is added.
- the LoC process is a good one but improvements are needed in a number of areas, most of which the NDA has in hand.
- conclusions and recommendations on R&D to be added.

3 STORAGE AND TRANSPORT OF HIGHER ACTIVITY WASTES

3.1 Current Storage Arrangements

3.1.1 Legacy Facilities

- some were built as waste stores but not intended for long-tem use (eg Sellafield Magnox Fuel Cladding Silo and Pile Fuel Cladding Silo, Dounreay silo, Berkeley ILW vaults, Hunterston solid active waste building, Harwell mortuary holes, Trawsfynydd reactor vault).

- some were used to hold materials prior to processing (eg Sellafield First Magnox Pond and Pile Fuel Storage Pond).
- for all the legacy facilities it is necessary to retrieve wastes, condition and package them, and place them in modern purpose-built stores, then decommission the facilities.
- in some cases this work is urgent because of the hazard posed by the facilities in their current state [BNG, 2007; HSE, 2008].

3.1.2 Short-Term Stores

- these include stores built when it was expected that a geological disposal facility would be available early this century (eg at Aldermaston), and various buildings in which sea dump drums or other types of ILW are held (eg at Harwell, at GE Healthcare Amersham and Cardiff).
- in most cases the waste in the stores requires conditioning and packaging, or some form of remedial action, before it will be in a suitable form for longer-term storage.
- unless the stores can be extensively refurbished, the waste will need to be moved to modern purpose-built facilities.

3.1.3 Longer-Term Stores

- refer to NDA national waste storage review for full information, summary is as follows.
- Sellafield – 9 modern purpose-built stores, 8 for ILW and one for vitrified HLW.
- Magnox sites – ILW stores recently built at Trawsfynydd and Hunterston.
- Dounreay – one modern-purpose-built ILW store.
- Harwell – one modern purpose-built ILW store.
- Winfrith – one modern purpose-built store.
- Sizewell B – one modern purpose-built ILW store.
- Aldermaston – one modern purpose-built ILW store.
- GE Healthcare – one modern ILW store at Amersham and one at Cardiff.

3.2 Plans for Future Storage Arrangements

- refer to NDA national waste storage review for full information, summary is as follows.
- Sellafield – have plans for 5 new stores, one of which is a replacement for the Vitrified Product Store, and two of which are, or soon will be under construction. In general, Sellafield adopts a 50+50 approach for new stores (ie the structure has a 100 year design life and the equipment a 50 year life, extendable for another 50 years with refurbishment or replacement). Some of the existing stores would require refurbishment or replacement to achieve a life of 100 years from the time at which they began operating.
- Magnox sites – baseline plan is for ILW stores similar to those at Trawsfynydd and Hunterston to be built at each Magnox site (except Wylfa where the small number of ILW packages can be stored in the reactor building). Such stores are included in the sites current Lifetime Plans (LTPs). An alternative being considered is to use large self-shielded packages (“yellow boxes”) of unconditioned dry waste and dewatered wet waste. This is known as the “mini-store” concept, because each package is, in effect, a store. The packages would be kept in a simple building. There is further work to be done to assess this concept before it could be adopted.
- Dounreay – there are plans for two new ILW stores, each with a 100 year design life.
- Harwell – there is a plan for one new ILW store, with a design life of 50 years.
- Winfrith – there is a plan for one new ILW store.
- AGR sites – baseline plan is to construct one new ILW store at each AGR site, at the time when decommissioning begins (between 2015 and 2025, if there are no life extensions for the AGRs). Other options being considered are to store ILW at adjacent Magnox sites, and to use “mini-stores”.

- Sizewell B – conditioned ion exchange resins will be stored in self-shielded casks in the existing ILW store or in other areas near it. No new store will be needed [CoRWM docs 2419 & 2489].
- Devonport and Rosyth – MoD is investigating options for storing operational ILW (conditioned ion exchange resins and metals), and ILW from decommissioning submarines. One of these options is to move these wastes to NDA sites for storage.
- there is limited scope for consolidation (optimisation) of storage arrangements, and no plans for large central or regional stores.

3.3 Evaluation of Robustness of Future Storage Arrangements

3.3.1 Storage System Approach

- recent developments have highlighted the need for a "storage system" (or "whole store") approach, in which the contributions of various components and operations to the robustness, safety and security of storage arrangements are considered.
- the waste form, its container, the building structure, the ventilation system, the handling equipment, the monitoring and inspection regime and the maintenance and refurbishment regime all have roles to play and "safety functions" to fulfil.
- different storage concepts place different degrees of reliance on the various components. For example, most existing modern stores in the UK have massive concrete structures, but the newer "mini-store" concepts rely on massive containers and these are used in some other EU countries.
- not every component need last for the whole design life of a storage system. It is acceptable to plan to replace or refurbish various components (eg cranes, the outer cladding on buildings or even whole buildings).

3.3.2 Strategic Approach

- to date, the approach to planning future storage arrangements has been somewhat piecemeal. There have been differences in the design lives assumed to be needed, and hence in the designs of new stores and the plans to refurbish or replace existing stores.
- we think there is a need for a more strategic approach, similar to that being adopted by the NDA throughout its work, but for the UK as a whole, within each organisation and at each of the larger sites, especially Sellafield.
- in such an approach there would be a reference strategy ("plan A") and contingent strategies ("plan B", "plan C" etc).
- the reference storage strategy would be based on the assumption that geological disposal is implemented but take account of uncertainties about when a GDF is available for the category of waste and about the schedule for emplacing the waste in it. The strategy would involve a design life of 100 years for new storage systems to be built before 2040 (the planning date for a GDF for ILW to be available). Plans for new storage systems to be built after 2040 could assume design lives of less than 100 years. Refurbishment of existing stores would be planned on the basis of achieving the maximum lifetime possible, with replacement by a new store planned if that lifetime was reached before, say, 2100. The reference strategy would be regularly reviewed to see if any assumptions needed to be changed, or if a contingent strategy needed to be adopted.
- contingent strategies would be for the situations in which the implementation of geological disposal was substantially delayed, began earlier than anticipated or never occurred. These strategies would also be regularly reviewed to ensure that they were still appropriate.
- such a strategic approach would be consistent with the CoRWM 2006 recommendation to plan for storage for at least 100 years, but with the flexibility to adjust plans according to the progress made in implementing geological disposal.

- initially the same reference and contingent strategies would apply in Scotland, but with the assumption that a long-term management method other than geological disposal would be implemented. If necessitated by policy developments, strategies specific to Scotland could be established in due course.

3.4 Safety of Storage Facilities

- safety is the responsibility of the nuclear site licensee.
- the regulator is HSE, via the Nuclear Installations Inspectorate (NII), which is part of HSE's Nuclear Directorate.
- safety standards are given in HSE's Safety Assessment Principles for Nuclear Facilities, known as the SAPs [HSE, 2006].
- the SAPs cover both new and existing storage facilities, throughout their construction, operation and decommissioning.
- the SAPs have been benchmarked against international standards developed by the International Atomic Energy Agency (IAEA) and the Western European Regulators Association (WENRA) [see www-ns.iaea.org/standards/documents and www.wenra.org].
- the HSE's procedures for regulating waste storage have been subject to international peer review via WENRA. In this exercise HSE submitted documents about its assessment of three UK stores to regulators from other countries [CoRWM doc. 2436].
- EA and SEPA also regulate storage facilities, largely from the point of view of ensuring that wastes are disposable at the end of the storage period. EA applies its Radioactive Substances Regulation Environmental Principles (REPs) [EA, 2008b].
- joint regulatory procedures for storage are covered in the guidance on the management of higher activity wastes [HSE, EA & SEPA, 2007].
- an example of how these procedures work in practice is the case of the drums of waste from the Magnox Encapsulation Plant (MEP) that have been removed from the Sellafield Encapsulated Product Stores (EPS1 and EPS2) for detailed examination. Localised swelling can be seen on 4 of the 24 drums examined to date. The EA and HSE have required Sellafield Ltd to investigate the causes of the swelling and to improve MEP operating procedures to avoid it happening to future drums [CoRWM docs 2464 & 2389]. (More to be added during drafting of report.)
- the regulators recognise that more attention needs to be paid to controlling the atmosphere in some stores (especially humidity and concentration of chloride ions), so as to minimise the corrosion of waste drums [CoRWM doc. 2464]. There are also issues to be resolved about monitoring and inspection procedures [CoRWM docs 2436 and 2464].
- HSE, EA and SEPA will issue technical guidance on storage in 2009 (see www.hse.gov.uk/nuclear/wastemanage.htm).

3.5 Security of Storage Facilities

- concern about security led CoRWM to include in its 2006 Recommendations the point that due regard should be paid to "reviewing and ensuring security, particularly against terrorist attacks" [CoRWM, 2006].
- the perceived need for review arose from a specialist workshop which agreed the following statement [CoRWM doc. 1502, p44]:

  "The security specialists appointed to the CoRWM Specialist Security Workshop recognise that CoRWM is not responsible for the priority that is being given to the conditioning and mode of storage of nuclear waste forms prior to their transportation to the selected storage/disposal facility that may not occur for some decades into the future. However, it is our unanimous opinion that greater

attention should be given to the current management of radioactive waste held in the UK, in the context of its vulnerability to potential terrorist attacks.

We are not aware of any UK Government programme that is addressing this issue with adequate detail or priority, and consider it unacceptable for some vulnerable waste forms, such as spent fuel, to remain in their current condition and mode of storage. We urge the Government to take the required action and to instruct the NDA, in co-operation with the regulators, to produce an implementation plan for categorising and reducing the vulnerability of the UK's inventory of radioactive waste to potential acts of terrorism, through conditioning and placement in storage options with an engineered capability specifically designed to resist a major terrorist attack."

- we discussed security in general and this statement in particular with the Office of Civil Nuclear Security (OCNS), which since the CoRWM 2006 Recommendations has become part of HSE's Nuclear Directorate [CoRWM doc. 2414].
- OCNS told us that reviewing security of storage facilities is part of their normal work and that all nuclear facilities are categorised according to their inventory of nuclear materials, including radioactive wastes. Where OCNS consider it to be necessary, additional security measures to reduce the probability of terrorist attack or mitigate the consequences of attacks are introduced for both new and existing buildings. It is not the NDA's responsibility to review or ensure security: these are matters for nuclear site licensees and OCNS [CoRWM doc. 2414].
- our conclusion from our discussion was that the major problem is not that the security of UK nuclear facilities is inadequate or below the standards applied in other countries but that there is so little publicly available information about how security is ensured. We noted that this issue has been recognised in the US, where the US Nuclear Regulatory Commission (USNRC) has been consulting the public about the security information they would like to have access to. There is also IAEA work to produce and publish guidance on nuclear security [CoRWM doc. 2414].

3.6 Transport of Higher Activity Wastes

- at present there is almost no transport of higher activity wastes in the UK. Unused fuel is transported from Springfields to the power stations and spent fuel is transported from the power stations to Sellafield. There is also transport of LLW from various sites to the LLW Repository.
- implementation of geological disposal would entail the transport of over 200,000 packages of higher activity waste from existing nuclear sites to wherever the GDF or GDFs are located. NDA estimates that the number of annual movements involved could be ten times the number of movements of spent fuel to Sellafield. It has work in hand on potential transport modes and scheduling, in preparation for discussions with communities that express an interest in hosting a GDF [CoRWM doc. 2397]. We will be looking at this work as part of our 2009/10 work programme.
- the transport regulator is the Department for Transport (DfT), but OCNS regulates the security of transport nuclear materials. Our discussions with DfT showed that there are issues to be resolved about the appropriateness of current transport regulations for bulk waste transport, the need to maintain and improve transport infrastructure, and the choice of modes of transport [CoRWM 2406]. We will be examining these in our 2009/10 work programme.
- DfT and their counterparts in other countries have recognised that the current international and national regulatory frameworks for the transport of radioactive materials are based on assessment of proposed transport packages and arrangements a short time before transport will occur. In the case of radioactive wastes destined for geological disposal, transport will take place decades after the wastes have been

conditioned and packaged. There can be no guarantee that a waste package designed for transport now will be suitable after decades in store. Not only could the package deteriorate but also regulations may change. These are also issues we will examine in our 2009/10 work programme.

3.7 Waste Storage R&D

- to be added.

3.8 Public and Stakeholder Engagement on Waste Storage and Transport

- PSE on waste storage and transport is currently carried out via the same means as PSE on other nuclear issues. Local PSE is largely via the Site Stakeholder Groups (SSGs) at NDA sites and their equivalents at other sites. Means of national PSE include the NDA's National Stakeholder Group (NSG).
- these existing means may need to be supplemented as geological disposal is implemented and if there are any proposals to move wastes from the sites on which they arise to other sites, for processing or storage. It will be important to engage with communities along transport routes, as well as those around the sites that will receive wastes and from which wastes are moved.

3.9 Proposed Conclusions and Recommendations on Storage and Transport

3.9.1 Current Plans

- at present, retrieval of wastes from high hazard legacy facilities is the first priority. Resources will continue to be focused on these facilities until substantial hazard reductions have been achieved.
- several nuclear sites have short-term stores which will need to be replaced.
- there are modern purpose-built stores at Sellafield (9 stores), Hunterston, Trawsfynydd, Dounreay, Harwell, Winfrith, Sizewell B and Aldermaston.
- current baseline plans are to build 5 new stores at Sellafield, 2 at Dounreay, and one each at the Magnox sites (other than Wylfa), Harwell and Winfrith. These plans are for concrete buildings that provide considerable protection. Other options, involving large self-shielded packages in simple buildings, are being considered.
- there are no plans to establish large central or regional stores.

3.9.2 Strategic Approach to Waste Storage

- there is a need for a more strategic approach to waste storage in the UK as a whole, in each organisation (eg NDA, its SLCs, BE), and at each nuclear site.
- in each case, there should be a reference storage strategy ("plan A"), which assumes that geological disposal (or in Scotland some other long-term management method) will be implemented but takes into account some uncertainties about timing.
- there should also be contingent storage strategies (plans B, C etc), which outline what would be done in other situations, for example if there were very long (many decades) delays in implementing geological disposal or if it were never implemented.
- there should be regular reviews of reference and contingent strategies and clear criteria and methods for determining when and how they need to be changed

3.9.3 Whole System Approach to Waste Storage

- there is a need to consider all the components of storage systems together when planning for the future (eg waste form, container, store building, its atmosphere, its equipment, the monitoring and inspection regime, the maintenance regime, the refurbishment plans).
- it should be recognised that each component contributes to the robustness of a storage system.

- replacement of some components during the system's lifetime is acceptable, provided it is planned for at the design stage and there are clear criteria and procedures for determining in advance when replacement will be necessary.

3.9.4 Public Access to Security Information

- more information should be made available to the public about the security of waste stores and of transport of radioactive materials.
- this should include information about how security regulators work, the sorts of requirements they impose for new stores and the issues considered in reviewing the security of existing stores and deciding whether improvement is needed.
- in deciding what information to provide, account should be taken of existing and proposed practice in other countries, especially the US and those EU countries that have a strong freedom of information culture.

3.9.5 Public and Stakeholder Engagement

- there should be further engagement of stakeholders and the public in the development of plans for on-site storage of wastes. Use should be made of existing engagement mechanisms (eg SSGs and their equivalents at non-NDA sites, the NDA NSG), but it may also be necessary to develop new mechanisms.
- in particular, if further consideration is to be given to consolidation of storage facilities, appropriate mechanisms will need to be developed to involve stakeholders and the public in decisions about movement of wastes between sites
- appropriate mechanisms should be developed to involve stakeholders and the public in decisions about movement of wastes between stores and geological disposal facilities

4 MANAGEMENT OF SPENT FUELS

4.1 Magnox Fuel

- the long-term management of Magnox fuel is the responsibility of the NDA. It is addressing it via a "topic strategy" in its strategy management system [CoRWM doc 2418].
- the current reference strategy is to reprocess all Magnox fuel. Details are given in the current, eighth, edition of the Magnox Operating Plan (MOP8) [NDA, 2007b]. This involves storing some Magnox fuel in some shutdown reactors for several years, and completing reprocessing of Magnox fuel by early 2017. About 5,000 tonnes (heavy metal) of Magnox fuel will be reprocessed in the future.
- all of the Sellafield plant used for Magnox reprocessing is old. Considerable effort is expended on maintaining this plant and keeping it running for as long as is practicable.
- NDA is reviewing alternative management strategies for Magnox fuel, with the aim of producing one or more viable contingent strategies for use should MOP8 fail for any reason [CoRWM doc 2418].
- three management methods have been identified as potential contingencies for the failure of MOP8 [CoRWM docs 2520 & 2533]:
    - encapsulation of the fuel in a suitable matrix (eg a polymer or a type of cement), then geological disposal
    - reprocessing through THORP, with geological disposal of the ILW and HLW, and management of plutonium and uranium products
    - drying the fuel, placing it in steel canisters for storage, then overpacking and geological disposal.
- the first option would require substantial R&D to find a suitable waste form for disposal. The second option would require a new dissolver to be installed in THORP, would be costly and would disrupt the THORP programme. For all these reasons there is no

further work on it at present. Drying of metal fuel has been shown to be viable at Hanford in the US and to work well, even for highly corroded fuel. R&D would be needed before a safety case could be made for the use of the Hanford process in the UK, and to show that dried Magnox fuel is a suitable waste form for disposal [CoRWM docs 2520 & 2389]. NDA is funding some of the required R&D now and will decide over the next year or so how much further investment to make in developing this option. This decision may depend, in part, on the rate of progress with MOP8 [CoRWM doc 2533].

- the Magnox fuel that is not reprocessable (eg that in legacy ponds) will be dealt with as waste and is taken into account in the NDA's higher activity waste strategy [CoRWM doc 2533].

4.2 AGR Fuel

- there are two tranches of AGR fuel, one which was loaded into reactors prior to the restructuring of British Energy (ie prior to midnight on 14 January 2005) and one afterwards. These are known as the "historic AGR fuel" and the "new AGR fuel" [CoRWM doc. 2419].
- about 75% of the historic AGR is contracted to be reprocessed at Sellafield, either as part of the THORP baseload or subsequently. The remainder is contracted to the NDA to store or reprocess, at their discretion.
- all the historic AGR fuel and the wastes and products of reprocessing it (HLW, ILW, plutonium and uranium) are owned by British Energy and are its liability. British Energy has contracts with the NDA to store the wastes and products but has no contracts covering their disposal. These remaining "uncontracted liabilities" are to be paid for out of British Energy's Nuclear Liabilities Fund [CoRWM doc. 2419]. These arrangements are unaffected by the takeover of British Energy by EDF [CoRWM doc. 2489].
- British Energy has a contract with the NDA to manage all the new AGR fuel, including that arising from any extensions to the lifetime of AGRs. The new AGR fuel becomes the property of the NDA when it arrives at Sellafield and there is no residual liability for British Energy after this time. It is at the NDA's discretion whether to reprocess the new AGR fuel [CoRWM doc 2419]. However, any use of THORP beyond its baseload would require the agreement of the Government, who are committed to a public consultation on the issue.
- the limited lives of THORP and related plant mean that it will not be possible to reprocess all AGR fuel. The NDA is developing an oxide fuels reference strategy, which will set out how much is to be reprocessed and what is to be done with the rest. There will also be one or more contingent strategies.
- dry storage of AGR fuel at Sellafield is being considered as part of the reference strategy and as a contingency. R&D is required on drying of AGR fuel, and on its geological disposal [CoRWM doc 2389, 2520 & 2533]. For dry storage there are a number of options that could be used, all of which are used in other countries for oxide fuel [CoRWM doc 2418].
- there may be stakeholder concerns about storage of large quantities (several thousand tonnes) of AGR fuel at Sellafield for long periods.
- there are short-term issues for management of AGR fuel that may affect what can be done in the long term. In particular, additional pond storage capacity needs to be provided at Sellafield, with pond water chemistry to minimise corrosion of AGR fuel awaiting reprocessing or drying. This entails changes in the operating regime in the THORP Receipt and Storage Pond [CoRWM doc 2520.

4.3 Sizewell B PWR Fuel

- spent fuel from the Sizewell B PWR is British Energy's responsibility. It is currently stored in the pond but the plan is for dry storage on site to begin by 2015. There are

no plans to reprocess this fuel but neither will it be declared to be waste in the near future [CoRWM doc 2419].

- British Energy has a major project in hand to assess dry storage options. The front runner is cask storage in a simple building, with passive ventilation. If it were decided to declare the fuel waste and to dispose of it, the casks would be used to transport the fuel to a geological disposal facility, where the fuel would be removed and placed in canisters (eg of copper) for emplacement, without any special conditioning. The option of exploring dry storage of Sizewell B fuel at Sellafield has not been ruled out but there are likely to be difficulties with capacity and timing [CoRWM doc 2419].
- there is considerable international experience of dry storage of PWR fuel to draw on, particularly in the US, and there has been R&D in a number of countries on geological disposal of PWR fuel.
- there are stakeholder concerns about the security of storage of spent fuel at Sizewell B.

4.4 Exotic Fuels

- some of the so-called exotic fuels have already been declared to be waste and are included in the 2007 UK Radioactive Waste Inventory [ref]. These are spent fuels from the Windscale Piles, the Graphite Low Energy Experimental Pile (GLEEP) reactor, and the Dragon and Zenith reactors, plus small quantities of prototype commercial fuels [Defra & NDA, 2008]. Most of these are stored at Sellafield and Harwell.
- most of the other exotic fuels, made up of about 20,000 items, are at Sellafield. They include fuel from the Steam Generating Heavy Waste Reactor (SGHWR). At Dounreay there are both irradiated and unirradiated fuels, mainly from the Dounreay Fast Reactor (DFR) and the Prototype Fast Reactor (PFR). There are small amounts of fuels at other sites; in particular there are Zero Energy Breeder Reactor Assembly (ZEBRA) fuels on loan to Cadarache and due to be returned to the UK [Defra & NDA, 2008].
- NDA is carrying out a strategic review of processing options for non-standard fuels. This is a high priority task because of the potential interactions with the Magnox and AGR strategies, including planning the future use of the Magnox reprocessing plant and THORP, and the need to identify soon the existing plants and other infrastructure that will have to be maintained to deal with exotic fuels.
- DFR fuel was considered first because decisions are needed about its management in the near future and it will be a good precedent for the consideration of other fuels. The reference strategy for DFR fuel has been established to be processing in the Sellafield Magnox reprocessing plant. NDA has directed Dounreay and Sellafield to submit proposed changes to their Lifetime Plans to implement this strategy [CoRWM doc 2533].
- various other routes are being considered for other fuels at Dounreay. For example, recycling opportunities are to be considered for PFR fuel but it may also have to be treated as waste [NDA, 2008h]. At Sellafield, it is planned to reprocess WAGR and SGHWR fuels if possible. It is recognised that further R&D will be needed before the plans for management of many exotic fuels can be implemented [CoRWM 2520 & 2533].
- submarine fuel is also an “exotic fuel”. MoD view it as an asset, not a waste (hence their use of the term “used fuel”, rather than “spent fuel”). It is currently stored in ponds at Sellafield, where there is sufficient capacity for the current class of submarines and their replacements. The fuel in the ponds shows no signs of deterioration, even after 20 years. Submarine fuel might be difficult to reprocess because of its high uranium enrichment and its physical form. As far as CoRWM is aware, there have been no substantial studies of options for the long-term management of UK submarine fuel.
- MoD is to join the Strategy Development and Delivery Group (SDDG) that oversees all the NDA strategy work. NDA has also invited MoD to join the Spent Fuels and Nuclear

Materials Forum that discusses technical issues and advises the SDDG. DECC, Scottish Government and regulators are represented on the SDDG and the Forum.

4.5 Proposed Conclusions and Recommendations on Management of Spent Fuels

- there is no one "solution" for all spent fuels.
- the reference strategy for Magnox fuel is to reprocess it. Contingent strategies are being developed; the current emphasis is on drying Magnox fuel, dry storage and geological disposal.
- the reference strategy for AGR fuel is still being developed; the issue is how much is to be reprocessed and how to manage the rest. Contingent strategies also need to be developed. R&D is required on drying AGR fuel and on its geological disposal. There are various dry storage methods that could be used and there is experience of them in other countries for other oxide fuels.
- the reference strategy for Sizewell B fuel is dry storage at Sizewell, which could be followed by geological disposal if the fuel is declared to be waste. As yet there is no contingent strategy.
- NDA is developing strategies for the management of exotic fuels. DFR fuel was considered first as an example of the process that will be followed.
- there has been very little work on the long-term management of submarine fuel. MoD is now more closely involved with NDA fuel strategy work.
- there would be merit in developing an overall strategy for managing all UK spent fuels. Such an approach would help to make the best use of the UK's resources and help to optimise protection of people and the environment.
- the recommendations about public access to information on security of waste storage (see Section 3.9.4) also apply to storage of spent fuels, especially in older facilities.

5 MANAGEMENT OF PLUTONIUM, URANIUM AND THORIUM

5.1 Plutonium

- when all the fuel in the current UK power programme has been reprocessed there will be about 100 tonnes of separated civil plutonium that requires long-term management. Most of the existing separated plutonium is in store at Sellafield, where a new Sellafield Product and Residue Store has recently been built, to which plutonium will be moved from existing stores. There is a small amount of plutonium at Dounreay. Continued storage is not a viable option in the long term for various reasons, including that it is expensive and entails considerable worker doses [NDA, 2008b].
- it is the NDA's responsibility to develop a management strategy for this plutonium and submit it to Government for approval. At a stakeholder workshop in October 2008, it was suggested that NDA focus its work on three strategic management options [NDA, 2008d; CoRWM doc 2481]:
    - immobilise and dispose
    - sell for re-use
    - a combination of these two.
- the various immobilisation options (eg make the plutonium into a ceramic waste form, encapsulate it in cement, vitrify it) and sale options (direct sale or make into MOX) could then be considered as tactical variations.
- the NDA will submit a paper to Government on plutonium management options in December 2008 [NDA, 2008e]. The paper will set out some of the features of the options, summarise stakeholder views and outline the work required over about the next two years to provide the information needed to make a decision between them [NDA, 2008d; CoRWM doc 2481].

- NDA is taking on board the criticisms made at the workshop about its PSE approach for plutonium management [NDA, 2008d, CoRWM doc 2481]. It has yet to agree with stakeholders a PSE approach for the next two years or so.
- NDA has various R&D projects in progress related to plutonium management [CoRWM doc. 2389].

5.2 Uranium

- total UK civil holdings of uranium were 96,400 tonnes at the end of 2007. Almost all of this is depleted, natural and low enriched uranium. Less than 1.5 tonnes is highly enriched uranium (ie with 20% or more uranium-235). Uranium is held at various NDA sites, including Sellafield, Dounreay, Capenhurst and Springfields. Future arisings are estimated to be about 90,000 tonnes of depleted, natural and low enriched uranium [Defra & NDA, 2008].
- the NDA is exploring a range of strategies for managing the various forms of uranium. This follows a "macroeconomic study" published in 2007 [NDA, 2007c]. One strategy involves selling as much uranic material as possible for potential re-use, and minimising the quantity of uranium that is declared to be waste and has to be conditioned and placed in a geological disposal facility. The price of uranium is a major factor in strategy development for uranic materials and there is a close link with NDA's work on the future of its Springfields and Capenhurst sites. NDA currently regards any uranium above 0.3% enrichment as a potential asset [CoRWM doc 2418].
- once uranium has been declared to be waste it is for the sites where it is held to investigate conditioning options for it, co-ordinating with other sites as appropriate through NDA arrangements (see Section 2) [CoRWM doc 2418].
- there are significant non-NDA holdings of uranium at Urenco Capenhurst Ltd (UCL). This is in the form of "Hex tails", ie uranium hexafluoride, which is a solid at room temperature and pressure but sublimes to a gas at relatively low temperatures and gives off hydrogen fluoride in contact with water or water vapour. UCL plan to "deconvert" the Hex tails back to uranium oxide (U_3O_8), which is a stable solid, and store it pending a decision on its long-term management. The oxide could be reconverted to Hex if it became attractive to re-enrich it and sell it. UCL are also supporting international work which is investigating the possibility of sending the uranium oxide back to the original producers of the ore, for disposal in exhausted uranium mines.
- UCL aim to build a Tails Management Facility (TMF) at Capenhurst, consisting of a deconversion plant and a uranium oxide store. The planning application has been submitted and they hope the TMF will start operations in 2014. This approach differs from that of the NDA because there is not enough demand or capacity to re-enrich the UCL Hex tails and there is a regulatory limit on the quantities that can be stored on the UCL site. This limit is based on an aircraft crash scenario and the chemical toxicity of the tails. The Hex tails are currently stored in drums outside.
- one option for NDA's Hex tails is to have them deconverted in the Urenco TMF. This would have implications for Capenhurst effluent discharges and may not be the most cost-effective option for the NDA [CoRWM doc 2418].
- there are MoD holdings of uranic materials on various sites, including some NDA sites. MoD will co-ordinate its work on a management strategy for its materials with the NDA through the SDDG and the Spent Fuel and Nuclear Materials Forum (see Section 4.4).
- British Energy also owns uranium, from reprocessing of its AGR fuel (see Section 4.2). This is stored at Sellafield.

5.3 Thorium

- there are small amounts of thorium at various NDA sites (eg Dounreay, Winfrith). There is no market for thorium and the current strategy is to treat it as waste for

geological disposal. This strategy is straightforward if the thorium is in oxide form (because the oxide is stable and insoluble). However some forms of thorium can be pyrophoric and may require conversion to the stable oxide for their long-term management. It is for the NDA sites to carry out R&D on the conditioning and packaging of their thorium holdings [CoRWM doc 2418].

5.4 Proposed Conclusions and Recommendations on Management of Plutonium, Uranium and Thorium

- NDA work on a strategy for the management of plutonium is progressing. A paper will be put to Government late in 2008. Further work over the next two years or so is expected to lead to a UK strategy for the management of its civil plutonium. There have been concerns over NDA's PSE approach for plutonium issues over the past year. A revised approach is required for the work leading to a UK plutonium strategy.
- NDA is investigating a range of strategies for managing the various forms of uranium that it owns. The price of uranium is a major factor in the assessment of potential strategies. A high price favours strategies that maximise the amount of uranium sold for re-use and minimise the amount declared waste and disposed of.
- UCL is implementing a strategy for the management of its uranium Hex tails that involves conversion back to oxide form.
- MoD has yet to develop a management strategy for its uranic materials, some of which are on NDA sites. It is now working more closely with NDA on this topic.
- British Energy also owns substantial quantities of uranium, which are stored at Sellafield.
- there would be merit in developing a UK management strategy for uranium, which covers all uranic materials at all the nuclear sites.
- thorium is regarded as a waste and R&D is in progress to develop suitable treatment and conditioning methods to allow its geological disposal.

6 PROPOSED OVERALL CONCLUSIONS AND RECOMMENDATIONS

6.1 Strategic Co-ordination

- in all the areas considered in this report (waste conditioning and packaging, waste storage, waste transport, the management of spent fuels, plutonium and uranium) there is a need for better strategic co-ordination across all the UK nuclear industry organisations, civil and defence.
- the NDA has made a good start for its sites, with its "strategy management system" and its increasing co-ordination with MoD is welcomed. However, the NDA is necessarily focused on its own strategies.
- *CoRWM recommends to Government that UK-wide strategies be developed for:*
    - *the management of higher activity wastes (including, their conditioning, packaging, storage and transport)*
    - *the management of all spent fuels*
    - *the management of plutonium*
    - *the management of uranium*
    - *R&D on all the above topics.*
- *we also recommend to Government that priorities be established for strategy development and implementation, so that UK resources can be targeted where they will do most to improve safety. security and the protection of the environment, in the short term and the long term.*

6.2 Public and Stakeholder Engagement

- CoRWM has found from its own PSE activities that the issues covered in this report are not well-understood outside the technical community that deals with them on a day-to-day basis. Both lay people and technical people who are not expert in these areas have difficulties in finding information in accessible forms, and thus are not well-equipped to become involved in consultations and decision-making.
- there have also been instances where the past PSE activities of other organisations have been unsatisfactory, and there are gaps in future plans.
- *CoRWM recommends to Government that more information be made publicly available on the management of higher activity wastes, spent fuels, plutonium and uranium, and on R&D, and that a co-ordinated PSE approach be developed to ensure that there is sufficient stakeholder participation in decisions on these topics, at national, regional and local levels.*
- *There is a particular need to make information available to the public about how the security of stores for radioactive wastes, spent fuels, plutonium and uranium is assured.*

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8 GLOSSARY AND ACRONYMS

- to be added.

9 ACKNOWLEDGEMENTS

- to be added.