Committee on Radioactive Waste Management

CoRWM REPORT TO GOVERNMENT

INTERIM STORAGE OF HIGHER ACTIVITY WASTES AND THE MANAGEMENT OF SPENT FUELS, PLUTONIUM AND URANIUM

MARCH 2009

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INTRODUCTION BY THE CHAIR

This is one of three CoRWM reports to Government in 2009. The reports are about:

- interim storage of higher activity wastes (including waste conditioning, packaging and transport, and the management of materials that may be declared to be wastes) (this report)
- the implementation of geological disposal of higher activity wastes
- research and development for interim storage and geological disposal.

The reports cover the three strands of the Government's *Managing Radioactive Waste Safely* programme. They contain the results of CoRWM's scrutiny, during 2008 and the first part of 2009, of the work of the Government, the Nuclear Decommissioning Authority, other nuclear industry organisations, the regulators, local authorities and various organisations that carry out research. The recommendations in the reports are to Government but also affect others.

Robert Pickard
31 March 2009

EXECUTIVE SUMMARY

1. CoRWM's remit is to provide independent scrutiny and advice to Government on the long-term management, including storage and disposal, of radioactive wastes and materials that may be declared to be wastes. This is the first of three reports to be produced in 2009 that describes the results of the Committee's scrutiny work in 2008 and the first part of 2009 and provides advice to Government.

Scope of Report

2. 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
   - public and stakeholder engagement (PSE) on the above topics.

3. For each topic we summarise the current position and provide advice for use in making plans for the work to be carried out over the next few years. We intend to monitor whether and how this advice has been acted on by Government and others.

How We Worked

4. 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 CoRWM stakeholder events in October 2008 and February 2009. An outline and then a full draft of this report were sent to key stakeholders for comment and placed on the CoRWM website for public comment. Responses to all the requests for comments were taken into account in preparing the final version of the report.

Overall Conclusions and Recommendations

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

Strategic Co-ordination

6. 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. Recent NDA work on its "strategy management system" goes some way towards achieving this but the NDA can only develop strategies that cover the sites for which it has responsibility.

7. At all nuclear sites the current plans for storage of higher activity wastes are adequate to meet the CoRWM 2006 recommendation, and Government commitment, that there should be arrangements for safe and secure storage for at least 100 years. However, the present UK approach to storage lacks robustness: it is fragmented and too few sites have contingency plans. A more strategic approach is required.

8. Through various discussion fora, the NDA involves other waste producers and holders of nuclear materials in the development of its strategies for the management of higher activity wastes, spent fuels and uranium. However, none of these fora has a remit to provide the required degree of strategic co-ordination between the NDA and other

organisations. An additional co-ordination mechanism is needed, initially for strategy development and in due course for strategy implementation.

9. The NDA strategy for plutonium management is UK-wide in the sense that it is for all separated civil plutonium and all this is held on NDA sites. However, some of this plutonium is owned by British Energy, which may choose its own strategy. There is also other plutonium owned by the Ministry of Defence. Thus co-ordination is also required on strategies for managing UK plutonium.

10. The type of overall co-ordination mechanism needed for all the wastes and materials that may be declared to be wastes is one that has strong regulatory involvement. It is the regulators who enforce most of the legislation that implements Government policy and who require nuclear site licensees to have strategies in place for the management of radioactive wastes and nuclear materials. Ideally, the degree of co-ordination would be such that it would be possible to describe overall UK strategies for the management of higher activity wastes, spent fuels, plutonium and uranium, made up of the strategies of the various waste producers and holders of nuclear materials.

11. The co-ordination should include priorities for managing the various types of higher activity wastes and nuclear materials. Priorities should be agreed between the various nuclear industry organisations, the regulators and, where policy matters are involved, the Government. The priorities need not necessarily be the same for all waste producers and holders of nuclear materials but the reasons for differences should be made clear.

Recommendation 1

CoRWM recommends to Government that there should be greater UK-wide strategic co-ordination of:

- *the conditioning, packaging and storage of higher activity wastes*
- *the management of all spent fuels*
- *the management of plutonium*
- *the management of uranic materials*
- *future transport arrangements for radioactive wastes and nuclear materials.*

The co-ordination should include agreement on priorities.

Public and Stakeholder Engagement

12. CoRWM has found 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 forms that are useful to them. As a result, they are not well-equipped to become involved in consultations and decision-making processes, and they lack confidence in the organisations that are managing radioactive wastes and nuclear materials.

13. Through the compilation of the UK Radioactive Waste Inventory, a great deal of information is available about the quantities and characteristics of radioactive wastes, and this is published in formats suitable for experts and non-experts. There is a need for complementary information about how wastes, and materials that may be declared to be wastes in future, are managed now and the management options under consideration for the future. There is also a need for more information to be made available to the public about how the security of storage facilities and transport arrangements is assured.

14. CoRWM will be reporting at a later date on the outcome of its overall scrutiny of PSE approaches for the management of higher activity wastes but it would like to emphasise two points here. One is the continuing importance of public and stakeholder engagement. The other is the need for more co-ordination between the NDA and the other waste producers on PSE, so as to address our recommendations on strategic co-ordination (see above) and to avoid "stakeholder fatigue". Increased co-ordination on PSE is required at national, regional and local levels. Some of this might be achieved by changes to existing mechanisms (for example, Site Stakeholder Groups and their equivalents at non-NDA sites). In other cases, particularly waste transport, new mechanisms will almost certainly be needed.

Recommendation 2
CoRWM recommends to Government that appropriate information be made publicly available on the management of higher activity wastes, spent fuels, plutonium and uranium. There is a need to summarise, for a variety of readerships, the progress to date, the management options under consideration for the future, and the issues involved in choosing between alternative options. The information should complement that on waste quantities and characteristics given in the various documents about the UK Radioactive Waste Inventory.

Recommendation 3
CoRWM recommends to Government that more information be made available to the public about how the security of the storage and transport of radioactive wastes, spent fuels, plutonium and uranium is assured. The objective should be to give the public more insights into security issues, without compromising security in any way. In deciding what information should be made available, account should be taken of existing and proposed practices in countries with similar security needs to the UK and a strong freedom of information culture (for example, the USA).

Recommendation 4
CoRWM recommends to Government that there be more co-ordination of PSE between the NDA and other UK nuclear industry organisations, at national, regional and local levels. The objective should be to ensure that there is sufficient stakeholder participation in decision-making processes for the conditioning, packaging, storage and transport of higher activity wastes, and the management of spent fuels, plutonium and uranium, without incurring "stakeholder fatigue".

1 INTRODUCTION AND BACKGROUND

1.1 CoRWM's remit is to provide independent scrutiny and advice to Government on the long-term management, including storage and disposal, of radioactive wastes and materials that may be declared to be wastes (CoRWM docs. 2235, 2266). This report is the first of three to be produced in 2009 that describes the results of the Committee's scrutiny work in 2008 and the first part of 2009, and provides advice to Government.

Scope of Report

1.2 In March 2008, the reconstituted CoRWM submitted its first year's work programme to Government for approval (CoRWM doc. 2266). The work programme was developed from the CoRWM Recommendations to Government in 2006, the Government's response to those recommendations, and views expressed by stakeholders. The 2006 Report recommended robust interim storage as part of a long-term management strategy for higher activity wastes and the Government accepted this recommendation (CoRWM doc. 700; Defra *et al.*, 2006).

1.3 The work programme identified the following storage-related areas for scrutiny (CoRWM doc. 2266):

- interim storage of higher activity radioactive wastes, including waste conditioning, packaging, storage and transport
- management of spent fuels
- management of plutonium and uranium
- the Letter of Compliance (LoC) process and waste package specifications
- waste producers', regulators' and other relevant organisations' public and stakeholder engagement (PSE) related to the above.

1.4 This report covers these areas. The report does not cover the issue of wastes and spent fuels from future nuclear power stations. This issue will be included in a future CoRWM work programme.

1.5 Although research and development (R&D) is mentioned in the report it is not covered in detail. R&D for storage-related areas is dealt with in a CoRWM position paper and is included in CoRWM's 2009 R&D report (CoRWM docs. 2389, 2543).

Key Definitions

1.6 The following key definitions are used in the text and are presented here for clarity. A fuller glossary and a list of acronyms are given in Section 8.

1.7 *Radioactive waste* – as defined in the Radioactive Substances Act 1993. In essence it is 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.

1.8 *Higher activity radioactive waste* – waste with activity above the thresholds for low level waste (LLW), *i.e.* above 4 GBq/tonne alpha activity or above 12 GBq/tonne beta/gamma activity (Defra *et al.*, 2007). It is usually also taken to include LLW unsuitable for near-surface disposal.

1.9 *Storage* – placing wastes or other materials in a facility with the intention of retrieving them at a later date. (As distinct from disposal, which entails the emplacement of wastes in a facility without the intention of retrieving them. Note that the time when a geological disposal facility is open does not constitute storage in this sense 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.)

1.10 *Conditioning* – any process used to prepare waste for long-term storage and/or disposal by converting it into a suitable solid form *e.g.* vitrification, encapsulation in cement.

1.11 *Packaging* – loading of waste into a container for long-term storage and/or disposal. In most cases this includes conditioning but in some cases waste is simply placed in containers, with or without being compacted to reduce its volume.

1.12 *Waste package* – the container and all its contents (waste, any encapsulating material, any capping grout).

1.13 *Reference and contingent strategies* – a reference strategy (*e.g.* for waste storage) is one based on realistic assumptions about the future and represents the course of action that is to be followed unless circumstances change (colloquially "plan A"). A contingent strategy is one that can be used if it becomes clear that the reference strategy is no longer appropriate ("plan B"). In most of the areas covered in this report, several contingent strategies are required in order to address various possible future scenarios.

Context

1.14 In 2003, CoRWM was appointed and commissioned to review options for the long-term management of the UK's higher activity radioactive waste. CoRWM was asked to recommend the option, or combination of options, that could provide a long-term solution and provide protection for people and the environment. The objective was to provide recommendations which inspired public confidence and were practicable in securing the long-term safety of those wastes.

1.15 In 2006, CoRWM submitted its recommendations to Government (CoRWM doc.700). The 2006 CoRWM report made 15 recommendations. The first recommendation was that the Government should aim to progress geological disposal of higher activity wastes as soon as was practicable, consistent with developing and maintaining stakeholder confidence. This recommendation was accepted and the Nuclear Decommissioning Authority (NDA) was given the responsibility for implementing geological disposal. The second recommendation stated that robust interim storage must play an integral part in the long-term management strategy for higher activity wastes. It also stated that 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, and the implications for waste transport (CoRWM doc.700). In accepting this second recommendation, the Government required the NDA to take it into account in the review of the interim storage of wastes it was conducting to fulfil a commitment in its Strategy (Defra *et al.*, 2006; NDA Strategy, 2006). The Scottish Government subsequently decided against geological disposal but continues to support long-term interim storage and an on-going programme of R&D (Defra *et al.*, 2008).

1.16 The NDA held a stakeholder workshop to discuss its review of UK radioactive waste storage in October 2008 (NDA, 2008a). It was agreed at the workshop that the NDA's report on its review would focus on current storage arrangements at sites and future baseline plans for new or replacement stores. The report would also cover NDA work on the potential for consolidation of storage by only building stores on some sites and moving wastes between sites. The NDA published a draft of its report in January 2009 and held a second workshop in February 2009, which CoRWM attended. The information in the NDA review has been used in Section 3 of this report (NDA, 2009a).

1.17 Storage of spent fuels, plutonium and uranium cannot be considered in isolation from other stages in their long-term management. Decisions have yet to be made on the majority of these materials as to whether they are to be declared to be waste and dealt with as such, or considered as an asset and re-used in some way. The NDA is developing strategies for the management of the spent fuels, uranium and plutonium that are its responsibility (NDA, 2008b-g; NDA, 2009b-f). CoRWM has scrutinised this work and that of the other organisations that have spent fuels, plutonium or uranium to manage: British Energy, Urenco and the Ministry of Defence (MoD).

1.18 In June 2008, the Government published a White Paper on the framework for implementing geological disposal and an invitation to communities to participate in discussions to host a geological disposal facility (Defra *et al.*, 2008). The White Paper states that, in principle, the UK Government sees no case for more than one geological disposal facility for all legacy and committed wastes, including those spent fuels, plutonium and uranium declared to be waste, if one facility can be developed. CoRWM considers that, until potentially suitable sites have been identified, it is premature to determine whether a single site is the safest and most cost-effective solution. The NDA should therefore be flexible in its approach. References in this report to a single geological disposal facility (GDF) are for ease of wording only.

Our Approach to the Work

1.19 CoRWM views the interim storage of higher activity radioactive waste as having two roles in its 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.

1.20 Our primary concern is that future UK waste storage arrangements should be robust to ensure that they will keep the waste safe and secure for long enough. Our remit is to advise on and scrutinise the overall national storage arrangements. It is the responsibility of nuclear site licensees, overseen by the regulators, to ensure the safety and security of specific storage facilities.

1.21 The report does not deal in any detail with storage of raw waste in legacy facilities. This is because CoRWM's focus is the long-term management of radioactive wastes. All raw waste that is being held in legacy facilities will be retrieved, characterised, conditioned and packaged, prior to storage in new facilities and eventual disposal.

1.22 For spent fuels, plutonium and uranium our concern is with the development of long-term management strategies, including interim storage as necessary. Our role is to scrutinise the development work, not to advise on the particular strategies to be adopted, unless asked to do so by Government.

1.23 We worked by gathering information from the waste producers and the holders of spent fuels, plutonium and uranium (NDA, some of its site licence companies (SLCs), British Energy, 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), and the Department for Transport (DfT)). We held meetings with most of these organisations. The information we gathered is recorded in the notes of these meetings, which are available on our website.

1.24 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). An outline of this report was placed on the website in December for comment and the comments received were taken into account in preparing a full draft (CoRWM doc. 2540). This full draft was placed on the website for comment in February 2009. We held a stakeholder event in February 2009 to discuss the draft (CoRWM doc. 2563). All the comments received on the draft were considered in preparing the final version of the report (CoRWM doc. 2562).

1.25 We involved some members of the HSE's Nuclear Safety Advisory Committee (NuSAC) in some of our meetings. NuSAC ceased to exist at the end of October 2008. We continued to involve some former members by asking them to review the outline of this report and the full draft. They also attended our February 2009 stakeholder event.

Layout of this Report

1.26 Section 2 of this report deals with the conditioning and packaging of higher activity wastes, while Section 3 covers the storage and transport of higher activity wastes. Section 4 is about the management of spent fuels. This includes the fuels from Magnox reactors and Advanced Gas Cooled Reactors (AGRs), fuel from the Sizewell B Pressurised Water Reactor (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 conclusions and recommendations.

2 CONDITIONING AND PACKAGING OF HIGHER ACTIVITY WASTES

Waste Quantities and Characteristics

High Level Waste

2.1 High level waste (HLW) is defined to be waste in which the temperature may rise significantly as a result of its radioactive content, so that this factor has to be taken into account in the design of waste storage or disposal facilities (Defra & NDA, 2008a). In practice, the term is only used in the UK for the nitric acid solutions arising from reprocessing spent fuels and for the vitrified form of the solutes in these solutions. HLW only arises at Sellafield.

2.2 The 2007 UK Radioactive Waste Inventory states that 1,730m^3 of HLW had been produced by 1 April 2007, of which 648m^3 had been vitrified and was being stored as 4,319 packages (Defra & NDA, 2008a). Future arisings of HLW are estimated to be about 300m^3 liquid HLW). The total quantity of vitrified waste expected to arise in the UK from currently planned reprocessing operations is 1,090m^3 (7,260 packages). All of this will have arisen by 2030, when the reprocessing and associated plants at Sellafield are scheduled to have been decontaminated prior to full decommissioning. Details of the assumptions leading to these estimates are given in the main inventory report (Defra & NDA, 2008a).

Intermediate Level Waste

2.3 Intermediate level waste (ILW) is defined as waste exceeding the upper activity boundaries for LLW[1], but for which its heat output need not be taken into account in the design of storage or disposal facilities. There are many different types of waste in the ILW category, including ion exchange resins used in the treatment of liquid effluents, sludges that have accumulated in fuel storage ponds, fuel element cladding that has been removed prior to reprocessing, activated and contaminated steels, graphite from reactor cores, activated and contaminated concrete, and some contaminated soils.

2.4 The 2007 UK Radioactive Waste Inventory states that 92,500m^3 of ILW had arisen by 1 April 2007. The total conditioned volume of ILW arising in the UK is estimated to be 275,000m^3, as about 200,000 packages. Table 1 shows the estimated volumes of ILW arising at each nuclear site (Defra & NDA, 2008a). These estimates do not include any ILW from new nuclear reactors. The estimates of total conditioned volumes and numbers of packages are very dependent on the assumed conditioning and packaging methods, as well as on assumptions about methods of sorting, segregation and decontamination. We understand from waste producers that they tend to err on the side of caution when providing information for the UK Radioactive Waste Inventory, and that future arisings of ILW are likely to be smaller than implied in Table 1.

Table 1 Estimated Volumes of Intermediate Level Waste Arising at Each Site

Site	*ILW volume at 1 April 2007, m^3*	*Total volume conditioned ILW, m^3 (existing and committed)*	*Total number of ILW packages (existing and committed)*
All UK sites	**92,500**	**275,000**	**200,000**
NDA sites			
Reprocessing and research sites			
Sellafield	63,900	139,000	148,000
Dounreay	4,580	12,500	20,500
Harwell	2,020	4,110	4,200
Magnox sites			
Berkeley	1,600	6,120	1,050
Bradwell	1,080	5,990	759
Calder Hall	2.9	3,250	297
Chapelcross	113	6,010	566
Dungeness A	327	5,490	549
Hinkley Point A	1,790	6,790	958
Hunterston A	2,940	6,800	1,410

[1] These boundaries are 4 GBq/tonne alpha activity and 12 GBq/tonne beta/gamma activity (Defra *et al.*, 2007).

Site	*ILW volume at 1 April 2007, m^3*	*Total volume conditioned ILW, m^3 (existing and committed)*	*Total number of ILW packages (existing and committed)*
Oldbury	586	4,800	616
Sizewell A	791	5,850	670
Trawsfynydd	2,060	10,000	865
Wylfa	759	7,760	444
Other NDA sites			
Culham	35	397	118
LLWR	358	309	616
Windscale	759	7,540	1,190
Winfrith	437	1,070	1,410
NDA total	**84,100**	**234,000**	**185,000**
British Energy			
AGR sites			
Dungeness B	394	4,110	534
Hartlepool	275	4,260	396
Heysham 1	292	4,370	633
Heysham 2	269	4,470	506
Hinkley Point B	578	4,310	440
Hunterston B	819	4,890	666
Torness	186	4,200	402
Sizewell B PWR	82.7	2,360	1,100
British Energy total	**2,900**	**33,000**	**4,670**
GE Healthcare			
Amersham	115	279	525
Cardiff	278	328	705
Harwell	0.1	0.1	1
GE total	**393**	**608**	**1,230**

Site	*ILW volume at 1 April 2007, m³*	*Total volume conditioned ILW, m³ (existing and committed)*	*Total number of ILW packages (existing and committed)*
MoD			
AWE	4,280	4,380	8,810
Devonport	28.6	263	17
Portsmouth	0.1	0.2	1
Rosyth	23.9	110	8
submarines	640	2,340	184
MoD total	**4,980**	**7,210**	**9,030**
Urenco	0.7	2.5	6
Minor waste producers	97.5	40	100

2.5 The “raw” (*i.e.* unconditioned) volume of future UK arisings of ILW is estimated to be 143,000m³. Of this, about 30% is predicted to arise before 2020, about 15% between 2020 and 2040, about 22.5% between 2040 and 2100, and about 32.5% after 2100 (Defra & NDA, 2008a). The later arisings are decommissioning wastes and it may be possible to control the timing of their arising to some extent by adjusting the time at which decommissioning is completed, thus avoiding the need to build storage facilities for them. A particular example is reactor decommissioning waste. In this case, provided safety and other considerations allow it, the care and maintenance (“safestore”) periods for the reactors could be tailored to the availability of a geological disposal facility and to the schedule for emplacing wastes in it. This would require development of a safety case for the safestore strategy and regulatory acceptance of that case.

Progress in Conditioning and Packaging ILW

2.6 Less than 10% (in terms of volume) of the total predicted UK arisings of ILW have been conditioned to date (CoRWM doc. 2459; NDA, 2008i). The volume of conditioned ILW in store is about 21,000m³; this is in about 40,000 packages. The volume of raw ILW in store is about 71,500m³ (Defra & NDA, 2008a).

2.7 At present, about 85% by volume of the UK’s conditioned ILW is at Sellafield. The 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 (Defra & NDA, 2008a).

2.8 Other sites at which ILW has been conditioned are Dounreay, Harwell, Windscale (now part of Sellafield), Winfrith and Trawsfynydd. The conditioned ILW 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 (Defra & NDA, 2008a).

2.9 At all the sites, most of the conditioned ILW is in 500 litre stainless steel drums, which are 0.8m in diameter, 1.2m high and weigh up to 2 tonnes (2,000 kg). These drums are usually placed in four drum "stillages", and will probably also be transported in this way. Other containers used include stainless steel boxes of various sizes, for example three-cubic-metre ($3m^3$) boxes (width and depth 1.72m, height 1.245m, weight up to 12 tonnes), and $3m^3$ drums. The use of "four-metre boxes" (width 2.438m, depth 4.013m, height 2.2m, weight up to 65 tonnes) is also being considered (NDA, 2008h).

Future Conditioning and Packaging

2.10 Much of the "raw" (*i.e.* unconditioned) waste in store now will require conditioning, as will much of the decommissioning ILW arising at sites such as Sellafield and Dounreay. However, some of the decommissioning ILW arising in future, especially from reactors, is relatively inert and stable and may be able to be packaged without conditioning. Subject to obtaining a Letter of Compliance (para. 2.22 *et seq.*), it could probably be placed in drums or boxes, with or without compaction, in order to make a solid wasteform suitable for both storage and disposal (CoRWM doc. 2386; NDA, 2008i).

2.11 The time at which conditioning and packaging will be carried out will vary from one waste type to another. For wastes that are in an unstable form and that contain substantial quantities of long-lived radionuclides, prompt immobilisation is the preferred option. For more stable wastes containing mostly short-lived radionuclides there is an advantage in storage in raw form. This is that, after radioactive decay has occurred, the waste can be sorted and some of it 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.

2.12 Prompt immobilisation tends to be more easily achievable when the wastes involved arise from new processes. In such cases, regulators require that conditioning methods are considered before any waste is generated and that the necessary plant is designed and built on a timescale to minimise storage of wastes in raw form (para. 2.17 *et seq.*). The situation is more complex for legacy wastes. Ideally, conditioning of such wastes should occur immediately after they have been retrieved, so as to achieve the greatest hazard reduction in the short term. On the other hand, it is desirable to find the conditioning and packaging methods that will maximise the safety of interim storage, transport and disposal, including safety in the long period after a disposal facility has been closed.

2.13 The NDA and the regulators recognise the tensions between short-term hazard reduction and optimising long-term safety. For most legacy wastes, pragmatic solutions are being found that meet the need for passive safety as soon as practicable and the need for long-term safety after disposal (NDA, 2008i; CoRWM doc. 2436). This is the situation for most of the Sellafield Legacy Ponds and Silos wastes (NDA, 2008i). An exception is the wastes in the Original Dry Silo, for which the current plan is to retrieve the wastes and place them in a buffer store. They will then be characterised and sorted prior to conditioning for longer-term storage and disposal (CoRWM docs. 2436, 2459).

2.14 Cement-based matrices have been used for much of the ILW conditioned to date. These matrices have the advantages of ease of use, compatibility with potential backfilling materials for a geological disposal facility, porosity to gas and relatively low cost (CoRWM doc. 2459). Cementation is well-understood and the technology is readily available. Waste producers may also be of the view that it will be easier to obtain a Letter of Compliance (para. 2.22 *et seq.*) for a cement-based wasteform (NDA, 2008i). It is thus likely that cement-based matrices will continue to be proposed for many wastes.

2.15 However, other conditioning materials and methods are being considered for the future for some wastes. For example, polymers are being investigated for reactive metals and thermal treatment (such as vitrification) is being considered for sludges and other "wet" ILW. Options being considered for ion exchange resins include hot pressing, and dewatering and packaging them without further conditioning (CoRWM docs. 2419, 2459; NDA, 2008i).

2.16 The NDA Higher Activity Wastes Strategy Group is addressing strategic conditioning and packaging issues across NDA sites. It involves representatives from other waste producers and from the regulatory organisations. There is also a Waste Packagers' Liaison Group and, for R&D, the Nuclear Waste Research Forum (NWRF) and its sub-groups (NDA, 2008i).

The Regulatory Framework for Waste Conditioning and Packaging

2.17 The conditioning and packaging of radioactive wastes on nuclear-licensed sites is regulated jointly by HSE and the relevant environment agency (EA for sites in England and Wales, SEPA for sites in Scotland). HSE's primary concern is the safety of the conditioning and packaging processes and whether the resulting waste packages can be stored safely. The environment agencies are concerned with discharges during conditioning, whether the waste packages will be able to be disposed of after storage, and with disposal of any secondary wastes produced during conditioning and packaging.

2.18 HSE, EA and SEPA have produced joint guidance for nuclear site licensees on the management of higher activity wastes. The guidance describes the regulatory process for conditioning and packaging (HSE, EA & SEPA, 2007). It specifies that 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.

2.19 The regulators request waste producers to submit selected RWMCs to them for scrutiny. The submissions are assessed from a safety perspective by HSE and from an environmental protection perspective by the relevant environment agency. HSE then decides whether the RWMC needs to be reviewed or revised, or whether the proposed conditioning and packaging method can be implemented. There are further regulatory hold points during implementation, and a requirement for waste producers to carry out periodic reviews of RWMCs (HSE, EA & SEPA, 2007). This selective regulatory scrutiny of RWMCs is in addition to the arrangements that waste producers must have in place to comply with nuclear site licence conditions and conditions of their authorisations under the Radioactive Substances Act 1993.

2.20 Five modules of technical guidance are being produced to explain what the regulators expect to see in waste conditioning and packaging proposals. The modules cover:

- the Radioactive Waste Management Case
- conditioning and disposability
- waste minimisation, characterisation and segregation
- managing information relating to radioactive waste in the UK
- storage.

2.21 The modules on the RWMC, on waste minimisation, characterisation and segregation, and on managing information were issued in 2008 for trial use and comment; they will be finalised during 2009 (HSE, EA & SEPA, 2008). The other two modules are to be issued for comment and trial use, and finalised in 2009.

The NDA Letter of Compliance Process

2.22 The Letter of Compliance (LoC) process began in the 1980s and was operated by Nirex until that organisation was subsumed into the NDA. It was originally called the Letter of Comfort process. Its main purpose is to give confidence to waste producers and others that their waste conditioning and packaging processes will lead to packages that are "disposable", in the sense that they can be safely emplaced in a geological facility and will contribute to its long-term safety in the required way (NDA, 2008i, j).

2.23 The regulators require waste producers to show that waste packages are disposable as part of their preparation of their safety case for waste conditioning and packaging (para. 2.17 *et seq.*). Their guidance states that they recognise NDA's Radioactive Waste Management Directorate (RWMD) as the appropriate body to provide advice on this issue and that this advice will be provided through the LoC process (HSE, EA & SEPA, 2007). The guidance also states that advice provided through the LoC process will be compatible with a range of long-term management options, including long-term storage.

2.24 The LoC process can be thought of as a risk management method. This is because gaining an LoC does not guarantee that a type of waste package will be accepted for disposal. Such a guarantee could only be obtained when formal waste acceptance criteria have been set for a geological disposal facility. The LoC process goes as far as is possible at this stage in the implementation of geological disposal (CoRWM docs. 2459, 2464; NDA, 2008i).

2.25 The LoC process takes place in stages, each based on a submission to RWMD from the waste producer. In the first stage, RWMD assesses the proposed waste conditioning and packaging method in outline; this leads to a "conceptual LoC". The waste producer then provides a more detailed submission containing supporting R&D evidence, which leads to an "interim LoC". The last stage is intended to be based on proof that conditioning plant operates as intended and leads to a "final LoC" (NDA, 2008j). The RWMD assessment is carried out against its generic waste package specification (Nirex, 2007; NDA, 2008h). This specification is supported by a suite of documents that give further information. LoCs are accompanied by RWMD assessment reports that explain the basis on which the LoC is issued and any caveats that apply.

2.26 The specification defines a number of standards for wasteforms and containers, some of which are related mainly to short-term safety and others mainly to long-term, post-disposal safety (Nirex, 2007). It specifies a target container life of 500 years, based on the assumptions that waste packages may have to be stored for 150 years, emplacement operations in a GDF may take 50 years, and a GDF may have to be kept open with packages easily retrievable for a few hundred years (NDA, 2008i). This target was adopted by Nirex in 2005 and replaced one of 100 years. There are concerns that it is difficult to achieve a 500-year container life and difficult to demonstrate that any container will last for 500 years (CoRWM docs. 2386, 2397; EA, 2008a). There is also the question of whether or not older containers will need to be overpacked to meet the new target.

2.27 The generic waste package specification includes a target for wasteform integrity of 200 years (Nirex, 2007). This is based on the 150-year storage period and the 50-year emplacement period used for the waste container, with the assumption that if the container is intact it will be possible to retrieve waste packages, even if the wasteform has degraded. This is not to say that wasteform behaviour beyond 200 years is not considered in the LoC process, only that there is no integrity target for longer periods (NDA, 2008i).

2.28 At present, the links between the waste package specification and the post-closure safety of a GDF are not sufficiently clear (NDA, 2008i). It is implicit in the specification that the waste container is not required to make a contribution to post-closure safety. The principal contribution of the wasteform is not its physical integrity but its chemical properties; in particular, its ability to enhance, or at least not disrupt, the alkaline environment provided by the cementitious backfill. In these senses, the waste package specification is linked to a particular geological disposal concept (NDA, 2008i).

2.29 There is a link between the sizes of waste container that are accepted by RWMD under the LoC system and the requirements for geological disposal. Allowing waste producers to use too many different sizes of container would make it difficult to design and operate a GDF, which is why RWMD encourages the use of a small number of standard types of container (NDA, 2008h). Proposals to use the larger containers, such as 4m boxes, have been assessed by RWMD from the point of view of whether they could be safely transported to and handled within a GDF, as well as on their performance during storage and disposal.

2.30 RWMD issues annual reports on progress with waste conditioning and packaging. The latest report states that, of all the ILW in the 2007 NDA Inventory, about 14% of ILW has a final LoC, about 29% is within the LoC process and about 57% has yet to be addressed (NDA, 2008k). Of the ILW that has a final LoC, only just over half has been conditioned and packaged (*i.e.* about 8% of the NDA's ILW). RWMD has told CoRWM that the industry has focused on the most difficult types of ILW first, hence the apparently slow rate of progress. It did not believe that the LoC process, itself, was delaying the immobilisation of wastes (CoRWM doc. 2459).

2.31 There is a system for reviewing LoCs issued to date (CoRWM doc. 2459; NDA, 2008i). The reviews take into account changes in package specifications, advances in knowledge, and evidence from inspection of stored packages. As yet, very few LoCs have been subject to review. RWMD's intention in future is to carry out reviews on a ten-year cycle (CoRWM doc. 2459).

Dealing with Failed and Out-of-Specification Packages

2.32 However good the quality management system at any nuclear site, there will be a few packages that for some reason do not meet the specifications used when designing the process to manufacture them. 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 (para. 3.42). It is important to have pre-defined criteria that are used to judge whether such packages require remedial action (EA, 2008a). Such package failure criteria need to cover failure during storage, transport, emplacement in a GDF, and the period when a GDF is open with wastes retrievable. The NDA is developing package failure criteria to meet these needs (CoRWM doc. 2459; NDA, 2008i).

2.33 There are four basic types of remedial action that could be taken to deal with failed or out-of-specification packages (EA, 2005):

- repair (*e.g.* re-sealing or replacing a container lid, sealing a small hole in a container)
- overpacking (*i.e.* placing the whole waste package in a new container)
- stabilising the wasteform (*e.g.* by injecting a substance to fill voids)
- complete reworking/repackaging (*i.e.* emptying the container, re-conditioning the waste and placing it in new containers).

2.34 The EA has carried out research on ways to choose between these types of remedial action, using approaches based on minimising environmental impact (EA, 2005). The NDA has investigated overpacking (CoRWM doc. 2459; NDA, 2008i).

Conclusions on Waste Conditioning and Packaging

2.35 CoRWM welcomes the moves to improve co-ordination of waste conditioning and packaging work throughout the UK (for example *via* the NDA Higher Activity Wastes Strategy Group and the NWRF). However, these moves are relatively recent and current approaches are still fragmented. Although current NDA-led groups involve other organisations, their focus is NDA strategy (NDA, 2008l, n). In CoRWM's view these groups will not, in their present form, lead to each waste-producing organisation, and thus the UK as a whole, making the best use of its resources.

2.36 There is a need for greater co-ordination 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. CoRWM would wish to see agreement between all the organisations on issues such as which types of waste can be conditioned and packaged using commercially available ("off-the-shelf") techniques and which require substantial R&D to develop suitable wasteforms. Such agreements could be followed up by joint procurement of techniques and joint commissioning of R&D (CoRWM doc. 2389). We believe this would lead to both cost savings and faster progress in conditioning and packaging ILW.

2.37 The joint regulatory guidance on the management of higher activity wastes is valuable, and will become more so as the remaining technical guidance is added. The relationship between the regulatory process and the NDA's LoC process is clearly stated in the guidance. The LoC process is essentially a good one but improvements are needed in a number of areas. One of these is to make the link between the waste package specifications and the post-closure safety of a geological disposal facility much clearer. Another, which the NDA has in hand, is to develop package failure criteria.

2.38 CoRWM welcomes RWMD's intention to review existing LoCs on a regular basis but in its view the reviews are proceeding too slowly and a ten-year review cycle will not be appropriate for all types of ILW. It is desirable to review all the older LoCs within the next few years, then to implement a programme of subsequent reviews. This programme should involve more frequent reviews for waste packages for which the uncertainties about their future performance are greatest. There should be clear procedures for waste producers to follow in the event that an LoC is found to be questionable or no longer valid. It may be that RWMD will require further resources in order to both carry out these reviews and speed up the LoC process for the 57% of ILW that has not yet been considered.

2.39 In our discussions with stakeholders and the public, it has become apparent that much of the information about waste conditioning and packaging is not widely available nor in a form that is useful to non-experts (CoRWM docs. 2488, 2519). This is in contrast to the situation for waste quantities and characteristics, where information is made available at various levels of detail and in various formats as part of the work on the UK Radioactive Waste Inventory. There is a need for information that summarises, in fairly non-technical language, the main types of higher activity wastes, the conditioning and packaging options in use or under consideration for them, and the issues involved in choosing between the options. Provision of such information will promote confidence in waste management and enable those who wish to do so to play a full role in consultations about future waste conditioning and packaging decisions.

3 STORAGE AND TRANSPORT OF HIGHER ACTIVITY WASTES

Current Storage Arrangements

Legacy Facilities

3.1 In the early years of the UK's nuclear weapons and power programmes, the associated radioactive waste management aspects were treated with less importance than the R&D priorities. There were no regulatory requirements for the sort of radioactive waste management strategies and plans that are needed today. The approach was mainly to put the waste into some type of holding facility, in the full knowledge that a final solution for it had not been developed and that retrieval from these interim arrangements would be needed in the future. Conditioning and packaging for long-term storage or disposal were not at the time immediate areas of interest.

3.2 Although some legacy waste holding facilities were built purposely as waste stores, most were not originally intended for long-term use. Examples of legacy waste facilities are the Magnox Fuel Cladding Silo and the Pile Fuel Cladding Silo at Sellafield, the Dounreay ILW Wet Silo, the Hunterston solid active waste building, the Harwell mortuary holes, and the Trawsfynydd reactor vault. Some of these facilities are nearly 50 years old.

3.3 Other legacy waste facilities were constructed for operational holding of materials prior to reprocessing. Examples of these legacy waste facilities are the First Magnox Pond and the Pile Fuel Storage Pond at Sellafield and the Dounreay Fast Reactor (DFR) and Prototype Fast Reactor (PFR) fuel ponds at Dounreay.

3.4 The wastes in legacy facilities are not in a form or condition suitable for long-term storage or ultimate disposal. It is necessary to retrieve the legacy wastes, condition and package them and place them in new purpose-built stores. Retrieval of most of these legacy wastes will be difficult and the problems for both the implementers and the regulators should not be underestimated. Before any work can proceed, a robust safety case is necessary and the uncertainties in the legacy wastes' properties and inventories make achieving this difficult. It may be difficult actually to move and manipulate the wastes.

3.5 The waste producers and the regulators have identified the facilities that require the earliest attention. For these, retrieval of the wastes is necessary in the near future to reduce the risks presented to the local people and environment by the facilities and their contents (BNG, 2007; HSE, 2008). The NDA uses a structured process to assess the safety and environmental detriment (SED) of its facilities in order to prioritise funding and action. This process has confirmed that the Sellafield Legacy Ponds and Silos are the highest priority (NDA, 2008l).

3.6 The clean up and decommissioning of the legacy facilities will be considerable challenges, themselves, even after the wastes have been removed. They will produce many thousands of cubic metres of ILW and LLW during their decommissioning and demolition. In some cases, these wastes could be programmed to arise after suitable disposal facilities have come into operation, and thus it may not be necessary to build additional stores to hold them. In other cases, the legacy facilities may need to be decommissioned as soon as is practicable, for safety reasons.

Short-Term Stores

3.7 A number of short-term stores were built at various nuclear establishments when it was expected that a geological disposal facility would be available in the first two decades of the 21st century. Examples of these are at Aldermaston, Harwell, Dounreay and GE

Healthcare (Amersham and Cardiff). The end of sea dumping of ILW in 1983 necessitated the storing of those drums previously destined for that disposal route. These sea dump drums were initially placed in short-term stores, on the assumption that sea dumping might be resumed, and some are still in such stores over 25 years later.

3.8 In most cases, the wastes in short-term stores will require further conditioning and re-packaging, or at a minimum some remedial work, before they will be suitable for longer-term storage and disposal. Detailed surveys will also need to be undertaken to establish whether these stores can be refurbished and upgraded for long-term use. If they are unable to be so then the reworked wastes will have to be placed in other existing longer-term stores satisfying current standards, or into new purpose-built facilities. This is recognised in the current baseline plans for most of the sites in question, which include requirements for improving storage arrangements (NDA, 2009a).

Longer-Term Stores

3.9 The NDA has undertaken a UK-wide review of waste storage. The report on its review contains information on the stores for higher activity wastes that have been built and brought into operation within the last 20 years (NDA, 2009a). These stores generally accord with present day requirements but will require refurbishment at specific future times to provide safe, secure and operable storage until geological disposal has been implemented. The stores have different design lifetimes, different refurbishment programmes and different time periods for emptying them. There are a few stores that may have to be replaced because refurbishment is not feasible. Table 2 lists the UK's current purpose-built stores for solid higher activity radioactive wastes.

Table 2 Existing Stores for Solid Higher Activity Wastes

Owner	Location	Number of ILW Stores	Number of HLW Stores
NDA	Sellafield	9	1
NDA	Dounreay	1	
NDA	Harwell	1	
NDA	Winfrith	1	
NDA	Trawsfynydd	1	
NDA	Hunterston	1	
British Energy	Sizewell B	1	
MoD	Aldermaston	2	
GE Healthcare	Amersham	1	
GE Healthcare	Cardiff	1	

3.10 The review indicates that, if refurbishment and/or replacement is carried out, all these stores can be made fit for purpose assuming a geological disposal facility for ILW is available around 2040. This conclusion is based on information provided to the NDA by site licensees (NDA, 2009a). As is recognised in the review, licensees will need to produce safety cases to establish that stores can achieve their original design lives and to obtain regulatory agreement to life extensions.

Plans for Future Storage Arrangements

Overview

3.11 The NDA's report on its UK-wide waste storage review contains information on the UK nuclear industry's plans for future new stores for higher activity wastes (NDA, 2009a). The overall situation is that the industry expects that these new stores, along with the existing stores, will have sufficient capacity to hold safely and securely all the UK's ILW and HLW until the wastes can be moved to a geological disposal facility. This expectation is dependent on four key assumptions:

- an ILW geological disposal facility is available to begin receiving wastes around 2040
- the Magnox and AGR reactor buildings will not be demolished until the geological disposal facilities are available
- the subsequent demolition of the stores themselves will produce small quantities of higher activity waste
- a number of regional new near-surface disposal facilities are brought into operation for managing LLW.

3.12 The first assumption is important because some of the existing stores approach the end of their operational lifetimes around 2040 and it would be preferable not to have to build new stores to replace them. The second assumption is consistent with British Energy's plans for long-term minimum care and maintenance of their reactor buildings (the "Safestore" concept) and with proposed arrangements for decommissioning Magnox reactors (CoRWM doc. 2419; NDA, 2008l). However, none of these plans for delayed completion of reactor decommissioning yet has regulatory approval.

3.13 Modern storage systems have robust containment provisions so little radioactive contamination is likely to be encountered in the store structure itself. Only a small amount of waste from their decommissioning is likely to be unsuitable for near-surface disposal and to need to go to geological disposal. However, there are large quantities of LLW being generated through normal day-to-day activities in the nuclear industry, and further large quantities when major decommissioning is underway. The management of these wastes, including the possible provision of new near-surface disposal facilities, is being addressed in developing the UK strategy for the management of nuclear industry LLW (NDA, 2008n). The plans for new stores are summarised below.

Sellafield

3.14 Sellafield plans to construct five new ILW stores for storing wastes from retrieval and repackaging operations, decommissioning and commercial operations. These will come into operation from 2011 for the first, to 2026 for the last. Sellafield also expects to have to construct a new HLW store to replace the existing Vitrified Product Store (VPS). The operating lifetime of the VPS is assessed to end around 2045 and there may be limited scope to extend its lifetime. Current NDA planning assumes that geological disposal of HLW will not begin before 2075.

3.15 In general, Sellafield has adopted a so-called 50+50 approach in designing new stores. With this approach the building has a 50 year design life but is constructed using civil design codes that are believed to lead to a lifetime of at least 100 years. The store's operational equipment also has a design life of 50 years but this can be extended for another 50 years by refurbishment and replacement.

Dounreay

3.16 Dounreay plans to construct a new ILW store in association with a new cementation plant for reprocessing liquors. This store will also hold the retrieved and conditioned wastes from the ILW Shaft. It is being designed at present with a 100-year design life. Dounreay also plans to convert an existing LLW steel-framed and clad store into a store for shielded ILW packages (4m boxes). This would be done when the LLW at present in the store is disposed of in proposed new LLW disposal facilities at Dounreay. If this strategy is not approved by regulators, then a new 100-year design life store would be built to hold the 4m boxes of ILW from PFR and DFR decommissioning.

Harwell and Winfrith

3.17 Harwell and Winfrith each plan to build one new ILW store. Decisions on the design lives of these stores will be taken when the projects are initiated.

Magnox Sites

3.18 New ILW stores are included in seven of the Magnox sites' current Lifetime Plans (LTPs). These would be constructed at Chapelcross, Oldbury, Berkeley, Bradwell, Dungeness A, Hinkley Point A, and Sizewell A. The plan is for these ILW stores to be similar to those that have already been built at the Trawsfynydd and Hunterston Magnox sites. It is not planned to build a new store at Wylfa because the SLC believes the small number of ILW packages can be stored in the reactor building.

3.19 An alternative being considered by the Magnox SLCs is to use self-shielded packages (known in the industry as "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 steel-framed and clad building. There is considerable further work to be done to assess this concept before it could be formally proposed and adopted. A key issue is whether the packages would also be suitable for transport and disposal, or whether some wastes would need to be removed, conditioned and re-packaged. Any new treatment facilities required would have to be identified in the sites' LTPs.

AGR Sites

3.20 British Energy's baseline plan is to construct one new ILW store at each of the seven of the AGR sites, *i.e.* Dungeness B, Hartlepool, Heysham 1, Heysham 2, Hinkley Point B, Hunterston B and Torness. These stores would be constructed in time for the onset of decommissioning at the stations (between 2017 and 2026, if there are no life extensions for the AGRs). British Energy is assuming that an ILW geological disposal facility will be available in 2040 so the current design life of the stores is 50 years, but this could be changed to 100 years if circumstances demand that at the time of starting design. Other options being considered are to store ILW at adjacent Magnox sites, and to use "mini-stores" (para. 3.19).

Sizewell B

3.21 At Sizewell B, British Energy plans to store conditioned ion exchange resins from the PWR reactor system in self-shielded casks in the existing ILW store or in other areas near it. British Energy believes that no new ILW store will be needed on this site (CoRWM docs. 2419, 2489).

MoD Sites

3.22 MoD is investigating options for storing operational ILW (conditioned ion exchange resins and metals) arising at Devonport and Rosyth, and ILW from the future decommissioning of nuclear submarines. One of the options under consideration is to transfer these wastes to appropriate NDA sites for storage. This is under discussion with the NDA and the relevant SLCs but no agreements have been made. At present there are no plans to build any new ILW stores at Aldermaston. A major volume reduction programme is currently in progress at this site and AWE estimates that no new ILW store will be needed until 2030.

Consolidation of Storage Arrangements at Fewer Sites

3.23 The NDA has undertaken some work on the subject of whether, instead of each nuclear site having its own storage facilities, some ILW should be stored in larger facilities on a few sites (NDA, 2009a). This work only covered the NDA estate and there could be some additional work undertaken to assess the inclusion of MoD and British Energy sites. From the NDA work to date there appears to be limited scope for consolidation (or optimisation as it is often called) of storage arrangements. The timing of waste arisings, the complexity of transport arrangements, communities' concerns at accepting waste from non-local sites and lack of flexibility are factors leading to this preliminary conclusion. At present, there are no plans in the UK for any large central or regional stores (NDA, 2009a).

Evaluation of Robustness of Future Storage Arrangements

Storage System Approach

3.24 During the work on storage that has followed from the CoRWM 2006 report to Government, there has been more appreciation of the need to consider the whole storage system rather than concentrating on just the store building itself (NDA, 2008a; CoRWM doc. 2519). A number of interacting components and operations combine and contribute to create the necessary robust, safe and secure storage arrangements. These factors must be considered in an integrated manner, as is recognised in regulatory guidance (HSE, 2006).

3.25 The waste form or product, its container, the building structure, the atmospheric control system, the handling equipment, the monitoring and inspection regime and the maintenance and refurbishment regime all have roles to play in ensuring safety and security. Different storage concepts and designs require different performances from these various components and operations and therefore place different degrees of reliance on them. Quite different combinations of them can provide equally safe and secure storage. For example, most existing modern stores in the UK have massive concrete structures holding unshielded containers, but alternative concepts rely on heavily shielded containers within lightly built stores. This latter concept is used in some other EU countries (CoRWM docs. 2397, 2436, 2464, 2519).

3.26 In a storage system not every component need last for the whole design life. It is possible at the design stage to plan to replace or refurbish various components and build in at the outset specific features to enable this. More straightforward items to consider include building fabrics, external ventilation systems and power supplies. The more complex refurbishments or replacements to consider include cranes, active area surveillance equipment, control systems, software and major building structures (CoRWM docs. 2397, 2436, 2464, 2519).

3.27 In the past, there has been a tendency to consider components of storage systems in isolation from each other, and to give inadequate consideration to refurbishment and replacement in storage system design. The result is that improvements are required in a number of existing stores and that some stores will need to be replaced because it is not practicable to refurbish them. There are also concerns that insufficient attention is being paid to provisions for monitoring and inspection of waste packages (para. 3.35 *et seq*.).

Strategic Approach

3.28 During the last twenty years, the approach to planning future storage arrangements has been that each nuclear organisation has made its own plans and has focussed on its particular needs. There has been little co-ordination between the organisations to derive standard objectives or common strategies. Also, from 1997 to 2007 there were no clear plans in the UK for geological disposal. This has had the effect of different organisations and nuclear sites making different assumptions on the design lives needed for their new stores. The result has been that differences in the designs for new stores, and differences in the plans for refurbishment or replacement of existing stores, have occurred within the UK nuclear industry (NDA, 2009a).

3.29 NDA is now adopting a strategic approach across its estate and throughout its work. This includes the development of an Interim Storage Strategy for Higher Activity Wastes (NDA, 2008m). CoRWM thinks there is also a need for a more co-ordinated strategic approach for radioactive waste storage throughout the UK. This would increase the robustness of storage arrangements and could make better use of resources. It would require more co-ordination between all the waste producers, and the regulators, at a strategic level, in addition to the co-ordination at a technical level that is already occurring.

3.30 The organisations and sites would have a reference strategy ("plan A") for their waste storage, and contingent strategies ("plans B, C, *etc.* ") for use if it became evident that the reference strategy was no longer appropriate. The reference storage strategy should be based on the assumption that geological disposal will be implemented successfully but it should take some account of the uncertainty about when a geological disposal facility will become available. This could be different for different categories of waste. Also, the reference strategy should address the timing and timescale for emplacing the wastes in a geological disposal facility, and the uncertainties in this.

3.31 The NDA's current planning date for a geological disposal facility for higher activity wastes to begin operation is 2040. This date should be used as the baseline for the reference storage strategies at each site in England and Wales and within each organisation (*e.g.* British Energy, MoD). The implications for planning storage are different for new storage systems to be built before 2040, new systems to be built after 2040 and existing stores. In CoRWM's view these implications are as follows.

- For new storage systems to be built before 2040 it would be prudent to use a design life of 100 years, to allow for uncertainties about the time that a disposal facility will be available and about the schedule for placing wastes in it.

- Present day planning of new storage systems to be built after 2040 could assume design lives of less than 100 years and be linked to their operating lifetimes. Such lifetimes could include the time to empty the stores to the geological disposal facility. These planned design lives would be reviewed regularly, as part of the review of the reference strategy (see below).

- Refurbishment of existing stores should be planned on the basis of trying to achieve an extended lifetime to about 2100. If the maximum extended lifetime possible falls short of 2100 a replacement new store should be planned for. The design life for such replacements would depend on when they were to come into operation relative to 2040 and the timescales for emptying them.

3.32 The reference storage strategies should be regularly reviewed to see if any assumptions need to be changed, or if a contingent strategy needs to be adopted.

Contingent strategies should be developed for situations in which the implementation of geological disposal began earlier than anticipated, was substantially delayed, or never occurred (in particular, because no site could be found where the local community was willing to host a GDF and the geology was suitable). There should also be contingent strategies to address other eventualities, for example the need for earlier than planned decommissioning of some nuclear facilities. All these contingent strategies should also be reviewed regularly to ensure that they are still appropriate.

3.33 Adopting such a strategic approach would be consistent with the CoRWM recommendation to plan for storage for at least 100 years (CoRWM doc. 700). It would also provide the flexibility to adjust plans according to the progress made in implementing geological disposal.

3.34 The reference and contingent storage strategies for sites in Scotland should be developed after Scottish Government policy has been set out in more detail. If an assumption is required in the meantime, it could be that the same reference and contingent strategies would apply in Scotland, but that the endpoint for interim storage is a long-term management method other than geological disposal.

Improvements to Storage Arrangements

3.35 Our discussions of storage arrangements with regulators and others have highlighted a number of areas where improvements are required (CoRWM docs. 2436, 2464, 2519, 2562). Some of these mainly concern existing storage systems and practices. Others are more relevant to the design of new storage systems.

3.36 In some existing stores, particularly those in coastal locations, atmospheric conditions are not well-enough controlled. As a result, waste containers are corroding at a somewhat faster rate than envisaged when the LoC was issued. While not an immediate safety issue, this makes it more likely that remedial action (for example, overpacking) will eventually be needed prior to waste transport and disposal. There is a need to assess options for improving ventilation systems and for monitoring atmospheric conditions in those existing stores where accelerated container corrosion is occurring or could occur in future. It is also essential that new storage systems are designed with appropriate ventilation and atmospheric monitoring provisions.

3.37 Some existing stores do not have good arrangements for monitoring and inspecting waste packages. For example, there are a few stores where the only access is through another store, so there are limited opportunities to remove waste packages for examination. These deficiencies may be too difficult to rectify in existing stores but they can and should be avoided by better design of new storage systems.

3.38 Further work is required to demonstrate that existing stores will achieve the design lives claimed for them and to assess whether these lives can be extended, and if so by how much. Both engineering assessments and R&D will be needed (CoRWM doc. 2389). Safety cases to justify design lives and extensions will need to be prepared well before decisions are required on store refurbishment or replacement.

Safety of Storage Facilities

3.39 The safety of radioactive waste storage facilities 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. The safety standards and good practice that HSE expects operators to use 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.

3.40 The SAPs have been benchmarked against international standards developed by the International Atomic Energy Agency (IAEA) and the Western European Nuclear Regulators Association (WENRA) (see *www-ns.iaea.org/standards/documents* and *www.wenra.org*). The UK regulatory system for the storage of radioactive waste has also been benchmarked against the WENRA Safety Reference Levels (SRLs) and the results have been subject to international peer review by regulators from other WENRA countries. In addition, the degree of compliance with the SRLs has been benchmarked for three UK radioactive waste stores and the results peer-reviewed (CoRWM doc. 2436).

3.41 EA and SEPA contribute to the HSE's regulation of storage facilities in the way shown in the joint guidance on the management of higher activity wastes (HSE, EA & SEPA, 2007). As indicated in para. 2.21, joint HSE-EA-SEPA technical guidance on storage will be issued during 2009 (HSE, EA & SEPA, 2008). EA and SEPA regulate discharges from storage facilities, and disposals of solid radioactive wastes from the operation and decommissioning of these facilities, in the same way as they regulate other discharges and disposals from facilities on nuclear licensed sites. EA applies its Radioactive Substances Regulation Environmental Principles (REPs) to storage facilities as it does in all its regulatory activities for radioactive substances. The REPs are currently being finalised following public consultation (EA, 2008b).

3.42 An example of how the joint regulatory 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. 2389, 2464).

Security of Storage Facilities

3.43 In its 2006 report, CoRWM noted that security specialists who attended a workshop to advise on the scoring criteria in the multi-criteria decision analysis process had unanimously agreed a statement that (CoRWM docs. 700, 1502):

"…..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."

3.44 In the light of these comments, CoRWM concluded that: "in reviewing existing stores special attention should be given to their ability to withstand a terrorist attack and the need to reassure the public on this matter". CoRWM recommended that in considering robust interim storage due regard should be paid to "reviewing and ensuring security, particularly against terrorist attack" (CoRWM doc. 700).

3.45 The security of civil nuclear sites was reviewed after 11 September 2001. This review led to new regulations, the Nuclear Installations Security Regulations 2003, which came into force in March 2003. Under these regulations, responsibility for security rests with the operators of nuclear licensed sites (not the NDA). The operators are regulated by the Office of Civil Nuclear Security (OCNS), which is now a part of HSE. OCNS also regulates the security of the movement of civil nuclear material.

3.46 All nuclear sites must have a Site Security Plan (SSP). After the coming into force of the 2003 Regulations, all SSPs were reviewed and rewritten; this exercise was completed by December 2004. SSPs are subject to constant review, scrutiny and amendment by operators and by OCNS. The Director of Civil Nuclear Security reports annually to the Secretary of State on the state of security in the civil nuclear industry and the effectiveness of security regulation. In his most recent report, which is for 2007-2008, he states that: "(he is) confident …SSPs remain current and comprehensive, and that there are effective security regimes in place across the nuclear industry" (OCNS, 2008).

3.47 The Director's Annual Report provides an overview of the framework of responsibility for security, the general approach to ensuring security and continuous review, how this is regulated and how it reflects international obligations and best practice. In the 2007-08 report, the Director notes that in 2007 the Office for Security and Counter-Terrorism at the Home Office conducted a national review of security in hazardous industries, including civil nuclear security. This review concluded that the civil nuclear industry security regime was "strictly regulated to ensure compliance with demanding regulatory standards, that it was designed to deliver defence in depth, and that it was subject to a process of continuous improvement" (OCNS, 2008).

3.48 The Director's Annual Report for 2007-08 also notes that OCNS had recently completed a review of the planning assumptions about the malicious capabilities that can be deployed against facilities. Operators were vulnerability-testing existing security measures with regard to these new assumptions (OCNS, 2008). The system of review of SSPs and store security was described to us when CoRWM members met OCNS (CoRWM doc. 2414). CoRWM also notes that OCNS issues guidance to operators, some of which is publicly available (OCNS, 2005).

3.49 Our understanding of the approach taken to ensure security and how this is regulated, combined with our discussions with OCNS, assure us that due regard is being given to reviewing and ensuring security, particularly against terrorist attack. However, as CoRWM noted in its 2006 Report, the public need to be reassured and have confidence in security arrangements. This reassurance and confidence would be bolstered by the provision of more information about how security is ensured, how it is reviewed and how it is regulated.

3.50 We recognise the difficulty in providing information about security arrangements. We welcome the Director's Annual Reports, which provide an overview of the approach to security as well as an assurance about the effectiveness of measures. However, we note that the US Regulatory Commission (USNRC) is looking at ways of increasing public access to security information and is presently consulting the public about this. We were pleased to note that in discussion with us, the OCNS stated that they were considering how they could do more to reassure the public and provide more information (CoRWM doc. 2414). We wish to encourage this approach.

Transport of Higher Activity Wastes

3.51 At present, there is almost no transport of higher activity wastes in the UK. Most bulk transport of radioactive materials is of nuclear materials; in particular, unused fuel is transported from Springfields to the power stations and spent fuel is transported from the power stations to Sellafield. Most radioactive waste transport is of LLW from various sites to the LLW Repository and of VLLW to other disposal facilities. Implementation of geological disposal would entail the transport of over 200,000 packages of higher activity waste from existing nuclear sites to the geological disposal facility (or facilities). 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).

3.52 The transport regulator is the Department for Transport (DfT), but OCNS regulates the security of transport of 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 doc. 2406). There is time to resolve most of these issues but it is important not to underestimate the effort involved.

3.53 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. The International Atomic Energy Agency (IAEA), which sets the standards on which all international and national regulations for the transport of radioactive materials are based, has convened an initial meeting on these topics.

Public and Stakeholder Engagement on Waste Storage and Transport

3.54 As CoRWM noted in its 2006 report, it is important for ensuring public confidence that the public and stakeholders are properly involved and engaged in decision-making (CoRWM doc. 700). 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) and workshops held by the NDA and others on particular topics. We understand that the NDA will carry out further national PSE on waste storage during the development of its topic strategy for interim storage of higher activity wastes (NDA, 2008m).

3.55 CoRWM will report elsewhere on its scrutiny of approaches to PSE in relation to the overall management of higher activity wastes. We would like to emphasise here the continuing importance of public and stakeholder engagement. In particular, if further consideration is to be given to consolidation of storage facilities, appropriate mechanisms will need to be developed to involve the public and stakeholders in decisions about the movement of wastes between sites. In due course, appropriate mechanisms should also be developed to involve stakeholders and the public in decisions about movement of wastes between stores and geological disposal facilities.

3.56 Information gained during CoRWM's most recent visit to Sizewell suggests that there may be a need for more NDA involvement in PSE at a local level, and more co-ordination between British Energy, the relevant SLC and the NDA where there is one SSG for adjacent British Energy and NDA sites (CoRWM doc. 2489). As part of future local, regional and national PSE, more information should be made publicly available about current storage arrangements for higher activity wastes and the issues involved in planning for the future. There is a particular need for waste producers to provide information to, and hold discussions with, the Local Authorities that have granted, or will be asked to grant, planning permission for stores (CoRWM doc. 2563).

Conclusions on Waste Storage and Transport

Current Plans

3.57 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 (NDA, 2008l).

3.58 There are modern purpose-built stores at Sellafield (ten stores), Hunterston, Trawsfynydd, Dounreay, Harwell, Winfrith, Sizewell B and Aldermaston (two stores). Some of these will require refurbishment or replacement in order to hold wastes until a geological disposal facility is available (NDA, 2009a). In addition, several nuclear sites have short-term stores that will need to be replaced.

3.59 Current baseline plans are to build six new stores at Sellafield, two at Dounreay, and one each at the Magnox sites (other than Wylfa), at Harwell and Winfrith, and at the AGR sites. These plans are for concrete buildings that provide considerable protection. Other options, involving large self-shielded packages (mini-stores) in simple buildings, are being considered.

3.60 NDA work to date indicates that there are limited possibilities for consolidating storage on fewer nuclear sites. At present there are no plans to establish large central or regional stores anywhere in the UK (NDA, 2009a).

3.61 We conclude that current plans are adequate to meet the CoRWM 2006 recommendation, and Government commitment, that there should be arrangements for safe and secure storage for at least 100 years. However, the present UK approach to storage of higher activity wastes lacks robustness. It is fragmented and too few nuclear sites have contingency plans.

Strategic Approach to Waste Storage

3.62 Until a few years ago, waste storage arrangements in the UK were planned and implemented site by site. Storage facilities were built as and when they were needed, and their design lives varied according to the circumstances at the time. With the policy choice of geological disposal as the long-term management method for higher activity wastes in England and Wales, and the expected development of a long-term storage policy in Scotland, a more strategic approach is now required.

3.63 In CoRWM's view, each waste organisation with responsibilities for managing higher activity wastes (*i.e.* the NDA, its SLCs, British Energy, the Ministry of Defence, Urenco and GE Healthcare) should have a storage strategy. There should also be a storage strategy for each nuclear site. The complexity of the strategies will vary from organisation to organisation and from site to site. All the storage strategies should be consistent with each other and with the relevant Government policy for the sites it covers.

3.64 At the site, organisation and country level, there should be a reference strategy ("plan A"), which is based on realistic assumptions about the future, with some allowance for uncertainties. For example, the strategies for sites in England and Wales should assume that geological disposal is implemented within a particular time period but not at a particular date. At the site, organisation and country level, there should also be contingent strategies ("plans B, C, *etc.*"), for use if it proves necessary. For example, in

England and Wales the contingent strategies would need to address a long delay in implementing geological disposal, and a failure to implement it at all.

3.65 The NDA has in place the mechanisms to produce a higher activity waste storage strategy for itself, and a storage strategy for each of its sites. These mechanisms include co-ordination with other waste producers at the technical level. Further co-ordination is needed at the strategic level so that the strategies of all the waste producers are consistent with each other. There should be strong regulatory involvement in this strategic co-ordination.

Whole System Approach to Waste Storage

3.66 There is a need to consider all the components of storage systems together when planning for the future (*e.g.* wasteform, container, store building, its atmosphere, its equipment, the monitoring and inspection regime, the maintenance regime, the refurbishment plans). This is because each component contributes to the robustness of a storage system. There is agreement amongst waste producers and regulators that 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.

Public Access to Security Information

3.67 CoRWM gathered information about the UK approach to the security of civil nuclear sites and facilities, and to the security of the transport of radioactive wastes and nuclear materials, and held discussions with the regulator, OCNS. We found that due regard is being given to reviewing and ensuring security, particularly against terrorist attack. However, we think that there is a need to increase public confidence in security arrangements and that making more information publicly available would help to achieve this. It is essential not to compromise security and this places constraints on the type of information that can be made available, but it should be possible to give the public more insights into the issues involved in assuring security. In deciding what information can be provided to the public, account should be taken of existing and proposed practices in other countries that have similar security needs to the UK and a strong freedom of information culture (for example, the USA).

Public and Stakeholder Engagement

3.68 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 (*e.g.* 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.

4 MANAGEMENT OF SPENT FUELS

Magnox Fuel

4.1 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; NDA, 2008m). Within this system, a reference strategy is developed for each topic, together with a number of contingent strategies that could be used if required. There will be regular reviews of the reference and contingent strategies to determine whether any changes are required and whether the reference strategy should be replaced by one of the contingent strategies (CoRWM doc. 2418).

4.2 The current reference strategy for Magnox fuel is to reprocess it all. Details of this strategy are given in the current, eighth, edition of the Magnox Operating Plan (MOP8) (NDA, 2007a, 2009g). This involves storing some Magnox fuel in some shutdown reactors for several years, and completing reprocessing of Magnox fuel by March 2016. About 5,000 tonnes (heavy metal) of Magnox fuel will be reprocessed in the future.

4.3 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, but there can be no guarantee that it will be able to be used for all Magnox fuel. The NDA is therefore 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).

4.4 The NDA has identified three management methods as potential contingencies for the failure of MOP8 (CoRWM docs. 2520, 2523):

- encapsulation of the fuel in a suitable matrix (*e.g.* a polymer or a type of cement), followed by its geological disposal
- reprocessing through THORP (the Thermal Oxide Reprocessing Plant), with geological disposal of the ILW and HLW, and management of plutonium and uranium products
- drying the fuel, placing it in canisters for dry storage, then preparing the fuel for disposal (for example, by overpacking the canisters) and placing it in a geological disposal facility.

4.5 The first option would require substantial R&D to find a suitable wasteform for disposal. The second option would require a new dissolver to be installed in THORP; it would be costly and would disrupt the THORP programme. For all these reasons there is no further work on it at present.

4.6 The third option is also not straightforward. Drying of metal fuel has been shown to be viable at Hanford in the USA and to work well, even for highly corroded fuel, but the fuel in question did not have Magnox cladding. Considerable 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 wasteform 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. 2523).

4.7 The end of MOP8 is only seven years away and there is no guarantee that a viable contingent strategy can be developed in that time. The fallback in the event of the failure of MOP8 would be continued storage of fuel in shutdown Magnox reactors, while R&D proceeds.

4.8 There is some Magnox fuel that is not reprocessable and that is not included in MOP8 (*e.g.* the fuel in the legacy ponds at Sellafield). The intention is that this will be dealt with as waste and will be taken into account in the NDA's higher activity waste strategy (CoRWM doc. 2523). There will need to be a specific decision that the fuel is waste and significant effort may be needed to comply with EU safeguards requirements.

AGR Fuel

4.9 There are two tranches of AGR fuel, one which was loaded into reactors prior to the restructuring of British Energy (*i.e.* 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).

4.10 About 75% of the historic AGR fuel 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 its 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).

4.11 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 for the NDA to decide, in consultation with Government and the regulators, whether to reprocess the new AGR fuel (CoRWM doc. 2419). Any use of THORP beyond its baseload would require the agreement of the Government, who are committed to a public consultation on the issue.

4.12 The NDA is developing an oxide fuels reference strategy, which will set out how much AGR fuel is to be reprocessed and what is to be done with the rest. There will also be one or more contingent strategies (CoRWM docs. 2418, 2520; NDA, 2008m).

4.13 The NDA is considering dry storage of AGR fuel at Sellafield as part of the reference strategy and as a contingency. Drying AGR fuel is easier than drying Magnox fuel, particularly if the graphite sleeves are removed. Nevertheless, there are a number of issues on which R&D is required, including that of how dry the fuel needs to be to avoid corrosion of its steel cladding during storage (CoRWM docs. 2389, 2480, 2520, 2523).

4.14 For dry storage, itself, there are a number of options that could be used, all of which are employed in other countries for oxide fuel (CoRWM doc. 2418). The two basic options are vault storage and cask storage. The vaults are substantial concrete buildings in which the fuel is held in tubes or canisters. There is passive cooling and back-up forced cooling to prevent the fuel temperature rising. The casks are massive containers made of steel concrete or a composite. In some countries they are stored outdoors but in the UK they would be housed in a simple building (CoRWM docs. 2386, 2418, 2480).

4.15 R&D is also required on the geological disposal of spent AGR fuel after dry storage. Issues here include the type of canister to be used and the leaching behaviour of the fuel once it comes into contact with groundwater. There has been much R&D in other countries on geological disposal of oxide fuels from PWRs and BWRs but there are differences between these and AGR fuel (CoRWM docs. 2389, 2480, 2520, 2523). Without a demonstration that geological disposal of AGR fuel is feasible, neither the reference nor the contingent AGR fuel strategies will be complete.

4.16 At present, AGR fuel is sent to Sellafield on the understanding that it will be reprocessed. There may well be stakeholder concerns about storage of large quantities (several thousand tonnes) of AGR fuel at Sellafield for long periods. CoRWM understands that such concerns will be considered by the NDA during strategy development (CoRWM docs. 2520, 2523).

4.17 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).

Sizewell B PWR Fuel

4.18 Spent fuel from the Sizewell B PWR is British Energy's responsibility. It is currently stored in the pond at the station but the plan is for dry storage on site to begin by 2015. There are no plans to reprocess this fuel (either in the UK or in France) but neither will it be declared to be waste in the near future (CoRWM doc. 2419).

4.19 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 (*e.g.* 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). As mentioned in paras. 4.14 and 4.15, there is considerable international experience of dry storage of PWR fuel to draw on, particularly in the USA, and there has been substantial R&D in a number of countries on geological disposal of PWR fuel.

4.20 There are stakeholder concerns about the security of storage of spent fuel at Sizewell B. CoRWM was told during its visit to the station that these relate to storage of the fuel in the pond and to the consequences of terrorist attack (CoRWM doc. 2489). Such concerns were one of the reasons behind the call for a store security review during the work that led to CoRWM's 2006 recommendations (para. 3.43 *et seq.*). British Energy believes that the introduction of dry storage will allay many of these concerns. It is less clear how it will address concerns about potential sea level rise at Sizewell as a result of climate change (CoRWM doc. 2489).

Exotic Fuels

4.21 Some of the so-called exotic fuels have already been declared to be waste and are included in the 2007 UK Radioactive Waste Inventory (Defra & NDA, 2008a). 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, 2008b). Most of these are stored at Sellafield and Harwell.

4.22 Most of the other exotic fuels, made up of about 20,000 items, are at Sellafield. They include fuel from the Steam Generating Heavy Water 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, 2008b).

4.23 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 (CoRWM doc. 2523; NDA, 2008m).

4.24 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 preferred strategy for DFR fuel has been established to be to process it in the Sellafield

Magnox reprocessing plant. NDA has asked Dounreay and Sellafield to submit proposed changes to their Lifetime Plans to implement this strategy (CoRWM doc. 2523). Further work is required to confirm that the preferred strategy is fully viable before it can be designated as the reference strategy and site plans changed accordingly. One or more contingent strategies will also be developed.

4.25 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 docs. 2520, 2523).

4.26 The fuel from nuclear-powered submarines is also an exotic fuel in NDA terminology. 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 little sign 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.

4.27 MoD has joined 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 Topic Overview Group that discusses technical issues and advises the SDDG. The Department of Energy and Climate Change (DECC), Scottish Government and regulators are represented on the SDDG and the Group.

Conclusions on Management of Spent Fuels

4.28 There is no one “solution” for all spent fuels. Different management strategies are required and are being developed for the three major types of spent fuel that arise in the UK at present (Magnox, AGR and Sizewell B PWR fuel), and for the various other types of fuel that have arisen from UK civil and defence nuclear programmes (the so-called “exotic” fuels).

4.29 The reference strategy for Magnox fuel is to reprocess it. Contingent strategies are being developed for use if it is not possible for some reason to reprocess all the fuel from the Magnox reactors. The current emphasis is on drying Magnox fuel, dry storage and geological disposal. There is a difficult decision to be made in the near future about how much effort to devote to developing contingent strategies for Magnox fuel. This is because, if all goes to plan, reprocessing of Magnox fuel will cease in 2016 and there is no guarantee that any contingent strategy will be available before this date. In CoRWM’s view, this decision should be made in an open way, so that stakeholders and the public can appreciate, and express opinions on, the factors involved. We encourage the NDA to ensure this happens, through PSE on its Magnox fuel topic strategy.

4.30 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. Both the reference and the contingent strategies are likely to involve dry storage of AGR fuel at Sellafield. There are two basic dry storage methods that could be used (vaults and casks) and there is experience of both of them in other countries for other oxide fuels, but R&D is required on drying AGR fuel. More R&D is also needed on geological disposal of AGR fuel, so that it can be shown that there are complete reference and contingent strategies for its long-term management.

4.31 In CoRWM's view, it is important that viable reference and contingent strategies for AGR fuel are developed in the next few years. It is essential that the views of a wide range of stakeholders are taken into account in strategy development. There is no urgency to decide whether unreprocessed AGR fuel is an asset or a waste and there are merits in keeping options open. However, it is necessary to demonstrate that AGR fuel could be safely disposed of as a waste, and to have good estimates of the costs of disposal, in order to show that this option would be viable.

4.32 The reference strategy for Sizewell B fuel is dry storage at Sizewell. There are no plans to reprocess this fuel but neither is it likely to be declared to be waste in the near future. Dry storage would be followed by geological disposal if the fuel were declared to be waste. As yet there is no contingent strategy for Sizewell B fuel.

4.33 CoRWM would wish to see British Energy taking a longer term and more strategic view of the management of Sizewell B fuel. Ideally, there would be complete reference and contingent strategies, developed with input from stakeholders.

4.34 The NDA is developing strategies for the management of exotic fuels. The DFR fuel at Dounreay was considered first as an example of the process that will be followed. A preferred strategy for DFR fuel has been identified (reprocessing at Sellafield); its viability is being confirmed and contingent strategies are being developed. Submarine fuel is considered to be an exotic fuel. There has been very little work on the long-term management of submarine fuel but this is likely to change in the future as MoD becomes more closely involved with NDA fuel strategy work.

4.35 CoRWM agrees with the NDA that it is important to have plans for dealing with exotic fuels, so that plant, infrastructure and R&D requirements are clear. There is no need to decide in advance of developing these plans whether each type of exotic fuel is an asset or a waste. The approach should be to identify viable management options for each type of fuel, compare them on the basis of a range of factors, and choose a reference and contingent option. It will be implicit in each option whether the fuel is an asset or a waste. It is important to involve stakeholders in these option comparisons, particularly if some of the options involve transport of fuel from one site to another.

4.36 CoRWM welcomes the approaches now being used to establish long-term management methods for the UK's spent fuels but is of the view that greater co-ordination is required between the three owners of spent fuels (NDA, British Energy and MoD). This co-ordination should include agreement between these three organisations, the regulators and the Government on priorities for strategy development. There should also be increased emphasis on establishing that fuels could be safely disposed of in a geological facility of some type, should they be declared to be waste in the future. Such a co-ordinated, strategic approach would help to make the best use of the UK's resources and help to optimise protection of people and the environment.

4.37 The conclusion about public access to information on security of waste storage (para. 3.67) also applies to storage of spent fuels, especially in older facilities.

5 MANAGEMENT OF PLUTONIUM, URANIUM AND THORIUM

Plutonium

5.1 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 been built, to which plutonium will be moved from existing stores. There is a small amount of plutonium (about 2 tonnes) at Dounreay.

5.2 Continued storage of plutonium is not a viable option in the long term for various reasons, including that it is expensive and has the potential to give rise to considerable worker doses (NDA, 2008b). There are a range of views as to how urgent it is to establish an alternative to storage. Some people feel that there is no urgency, both in absolute terms and compared to, for example, the need for development of management strategies for some spent fuels (Section 4). Others are of the view that there is considerable urgency because of the financial implications of plutonium management or because it is intrinsically a hazardous material, or for both reasons.[2]

5.3 It is the NDA's responsibility to develop a management strategy for the UK's separated civil plutonium and submit the strategy to Government for approval. The NDA has been working on this topic for some time and in the summer of 2008 it published a consultation paper on options for plutonium management (NDA, 2008b). Responses to the paper have been published (NDA, 2008c). Two stakeholder workshops were held after the consultation, to discuss the way forward (NDA, 2008d).

5.4 In December 2008, the NDA submitted a paper to Government on "credible options" for plutonium management. A simplified version of this paper was published at the end of January 2009, together with a summary technical report, a full technical report, a paper describing the current position on the NDA's plutonium topic strategy, and the NDA's responses to the comments it received on the 2008 plutonium options consultation paper (NDA, 2009b-f).

5.5 The 2009 NDA documents identify four high level strategy options for managing the UK's separated plutonium:

i) continued storage until 2120, then immobilise the plutonium in a suitable waste form and dispose of the waste in a geological facility
ii) immobilise the plutonium as soon as practicable, store the resulting waste, then dispose of it in a GDF when one is available
iii) sell or lease the plutonium for recycling, then dispose of the resulting spent fuel
iv) some combination of the above.

5.6 The NDA proposes that option (i) be adopted as the reference strategy for planning purposes, while further work is carried out to develop and assess the other options (NDA, 2009b). It notes that implementing this proposal would increase the NDA's liability estimate, because plutonium disposal costs would be included. (At present the estimate only includes storage costs to 2120, with no further costs thereafter.)

5.7 To date the NDA has considered several immobilisation options for plutonium. These are: use of a cement composite, use of a glass composite, use of a ceramic composite made *via* hot isostatic pressing, and making the plutonium into low specification MOX (either in a new plant that would make MOX assemblies or by modifying the Sellafield MOX plant to produce MOX in cans). The cement option is the most expensive but also

[2] See *www.nda.gov.uk/strategy/nuclearmaterials/plutonium* for further information.

the one with the largest variations in cost, depending on how much plutonium there is in each waste package. The NDA proposes to carry out a programme of work to assess the possible wasteforms in more detail, particularly from the point of view of their suitability for geological disposal (NDA, 2009c).

5.8 So far, the NDA has not considered the option of recycling plutonium in UK reactors (either existing or new build). This is because a further "justification" exercise would be required to allow MOX fuel to be used in this country. The NDA has assumed in its analyses that recycling would occur in another country, either in an LWR or in a CANDU reactor. (Use of fast reactors is not considered "credible" at present, because of the long lead time.) The NDA proposes to undertake market engagement to gauge the level of interest in recycling plutonium. If the option seems viable, the NDA would then need to discuss with Government the type of commercial arrangement that would be acceptable (NDA, 2009b).

5.9 The NDA hopes to have a Government response to its credible options paper during the first half of 2009. It could then put the proposed work in hand. It anticipates that it will be 2012 or 2013 before the final plutonium management strategy is available.

5.10 The NDA's work to date has considered their plutonium stocks and those owned by British Energy. This could change in future if British Energy chose an alternative strategy for its material, if some MoD material were added to the civil inventory, or if foreign owners of plutonium chose not to have it returned as MOX (NDA, 2009b).

5.11 At the October 2008 stakeholder workshop, various criticisms were made about the NDA's PSE approach for plutonium management (NDA, 2008d; CoRWM doc. 2481). These included the short time allowed for responding to the plutonium options document, the holding of closed meetings with small groups of stakeholders, and lack of consultation on the document put to Government in December 2008. CoRWM understands that the NDA is taking on board these criticisms and intends to agree with stakeholders a PSE approach for the next few years' work on a plutonium management strategy. It has already indicated its intention to hold a series of seminars on plutonium in 2009, to enable stakeholders to learn more about its work and to ask questions of NDA staff, and is sending stakeholders regular email updates on its progress with its work on plutonium management.

Uranium

5.12 The 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 (*i.e.* 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). It has been estimated that, if all the UK's uranium were to be declared to be waste, when conditioned its volume would be 100,000m^3. This would require a significant amount of space in a geological disposal facility.

5.13 The NDA is exploring a range of strategies for managing the various forms of uranium that it owns. This work follows a "macroeconomic study" published in 2007 (NDA, 2007b). 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 that has to be conditioned and placed in a geological disposal facility. At the other extreme would be a strategy in which most uranium is declared to be waste. The price of uranium is a major factor in strategy development for uranic materials. There is also a close link with NDA's work on the future of its Springfields and Capenhurst sites. A decision to deal with large quantities of uranium by re-enriching it for re-use in the UK would entail construction of new plant, unless the re-enrichment was carried out in another country.

5.14 In 2008, the NDA regarded any uranium above about 0.3% enrichment as a potential asset; this figure may change with the international uranium market and user demands. The NDA encourages its SLCs to find opportunities to sell such uranium for re-use (CoRWM doc. 2418). When uranium has been declared to be waste it is included in the NDA's higher activity wastes strategy. It is for the sites where waste uranium is held to investigate conditioning options for it, co-ordinating with other sites as appropriate through NDA arrangements (para. 2.16) (CoRWM doc. 2418).

5.15 There are significant non-NDA holdings of uranium at Urenco Capenhurst Ltd (UCL). This is in the form of "Hex tails", *i.e.* uranium hexafluoride, which is a solid at room temperature and pressure but sublimes to a gas at relatively low temperatures (56.5 ^{o}C at atmospheric pressure). It also gives off hydrogen fluoride, which is hazardous, in contact with water or water vapour. UCL plans 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. Another option is to condition and package the oxide and dispose of it in a geological facility in the UK. CoRWM has been told that UCL has applied for an LoC (para. 2.22), as part of the demonstration that such an option would be practicable. UCL is also supporting international work that is investigating the possibility of sending the uranium oxide back to the original producers of the ore, for disposal in exhausted uranium mines.

5.16 UCL aims to build a Tails Management Facility (TMF) at Capenhurst, consisting of a deconversion plant for Hex tails and a uranium oxide store. The planning application has been submitted and it is hoped that 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. One option for NDA's Hex tails is to have them deconverted in the UCL TMF. This would have implications for Capenhurst effluent discharges and may not be the most cost-effective option for the NDA (CoRWM doc. 2418).

5.17 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 (para. 4.27). British Energy also owns uranium, from reprocessing of its AGR fuel. This is stored at Sellafield. Its long-term management will be funded as an uncontracted British Energy liability (para. 4.10). Some of this uranium has been exchanged with another country for enriched uranium for use in making further fuel for British Energy.

Thorium

5.18 There are small amounts of thorium at various NDA sites (*e.g.* 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).

Conclusions on Management of Plutonium, Uranium and Thorium

5.19 The NDA has made significant progress in its work on a strategy for the management of the UK's civil separated plutonium. Further work over the next few years, including R&D, is expected to lead to a Government decision on a UK reference strategy. In the meantime, the NDA proposes that the reference strategy for planning purposes should be continued storage until 2120, then immobilisation and geological disposal.

5.20 There have been concerns over NDA's PSE approach for plutonium issues over the past year. The NDA has recognised that a better approach is required for the work leading to a decision on a UK plutonium strategy and has taken action accordingly. CoRWM welcomes the NDA work on plutonium management and will monitor its future progress.

5.21 The 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. The NDA work on a uranics strategy is less well-advanced than that on plutonium, but the issues are probably simpler.

5.22 The other organisations that own uranium are UCL, MoD and British Energy. 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 owns substantial quantities of uranium, which are stored at Sellafield, and for which no long-term management method appears to have been identified.

5.23 In CoRWM's view, there is a need for greater strategic co-ordination between the NDA, UCL, MoD and British Energy on the management of all uranic materials. This should be given high priority because of the possible implications for the size and design of geological disposal facility required for higher activity wastes. Principles for the development of reference and contingent strategies should be agreed between the owners of uranic materials, the Government and the regulators, in consultation with stakeholders. In particular, there is a need to decide whether reference strategies should be based on the principle of maximising the amounts of uranium that are re-used and minimising the amounts that are declared to be waste.

5.24 Thorium is regarded as a waste and R&D is required to develop suitable treatment and conditioning methods to allow its geological disposal. This R&D is the responsibility of the NDA's SLCs. It is unclear to CoRWM whether they are giving it high priority.

6 OVERALL CONCLUSIONS AND RECOMMENDATIONS

Strategic Co-ordination

6.1 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. Recent NDA work on its "strategy management system" goes some way towards achieving this but the NDA can only develop strategies that cover the sites for which it has responsibility.

6.2 At all nuclear sites the current plans for storage of higher activity wastes are adequate to meet the CoRWM 2006 recommendation, and Government commitment, that there should be arrangements for safe and secure storage for at least 100 years. However, the present UK approach to storage lacks robustness: it is fragmented and too few sites have contingency plans. A more strategic approach is required.

6.3 Through various discussion fora, the NDA involves other waste producers and holders of nuclear materials in the development of its strategies for the management of higher activity wastes, spent fuels and uranium. However, none of these fora has a remit to provide the required degree of strategic co-ordination between the NDA and other organisations. An additional co-ordination mechanism is needed, initially for strategy development and in due course for strategy implementation.

6.4 The NDA strategy for plutonium management is UK-wide in the sense that it is for all separated civil plutonium and all this is held on NDA sites. However, some of this plutonium is owned by British Energy, which may choose its own strategy. There is also other plutonium owned by the Ministry of Defence. Thus co-ordination is also required on strategies for managing UK plutonium.

6.5 The type of overall co-ordination mechanism needed for all the wastes and materials that may be declared to be wastes is one that has strong regulatory involvement. It is the regulators who enforce most of the legislation that implements Government policy and who require nuclear site licensees to have strategies in place for the management of radioactive wastes and nuclear materials. Ideally, the degree of co-ordination would be such that it would be possible to describe overall UK strategies for the management of higher activity wastes, spent fuels, plutonium and uranium, made up of the strategies of the various waste producers and holders of nuclear materials.

6.6 The co-ordination should include priorities for managing the various types of higher activity wastes and nuclear materials. Priorities should be agreed between the various nuclear industry organisations, the regulators and, where policy matters are involved, the Government. The priorities need not necessarily be the same for all waste producers and holders of nuclear materials but the reasons for differences should be made clear.

Recommendation 1

CoRWM recommends to Government that there should be greater UK-wide strategic co-ordination of:

- *the conditioning, packaging and storage of higher activity wastes*
- *the management of all spent fuels*
- *the management of plutonium*
- *the management of uranic materials*
- *future transport arrangements for radioactive wastes and nuclear materials.*

The co-ordination should include agreement on priorities.

Public and Stakeholder Engagement

6.7 CoRWM has found 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 forms that are useful to them. As a result, they are not well-equipped to become involved in consultations and decision-making processes, and they lack confidence in the organisations that are managing radioactive wastes and nuclear materials.

6.8 Through the compilation of the UK Radioactive Waste Inventory, a great deal of information is available about the quantities and characteristics of radioactive wastes, and this is published in formats suitable for experts and non-experts. There is a need for complementary information about how wastes, and materials that may be declared to be wastes in future, are managed now and the management options under consideration for the future. There is also a need for more information to be made available to the public about how the security of storage facilities and transport arrangements is assured.

6.9 CoRWM will be reporting at a later date on the outcome of its overall scrutiny of PSE approaches for the management of higher activity wastes but it would like to emphasise two points here. One is the continuing importance of public and stakeholder engagement. The other is the need for more co-ordination between the NDA and the other waste producers on PSE, so as to address our recommendations on strategic co-ordination (see above) and to avoid “stakeholder fatigue”. Increased co-ordination on PSE is required at national, regional and local levels. Some of this might be achieved by changes to existing mechanisms (for example, Site Stakeholder Groups and their equivalents at non-NDA sites). In other cases, particularly waste transport, new mechanisms will almost certainly be needed.

Recommendation 2
CoRWM recommends to Government that appropriate information be made publicly available on the management of higher activity wastes, spent fuels, plutonium and uranium. There is a need to summarise, for a variety of readerships, the progress to date, the management options under consideration for the future, and the issues involved in choosing between alternative options. The information should complement that on waste quantities and characteristics given in the various documents about the UK Radioactive Waste Inventory.

Recommendation 3
CoRWM recommends to Government that more information be made available to the public about how the security of the storage and transport of radioactive wastes, spent fuels, plutonium and uranium is assured. The objective should be to give the public more insights into security issues, without compromising security in any way. In deciding what information should be made available, account should be taken of existing and proposed practices in countries with similar security needs to the UK and a strong freedom of information culture (for example, the USA).

Recommendation 4
CoRWM recommends to Government that there be more co-ordination of PSE between the NDA and other UK nuclear industry organisations, at national, regional and local levels. The objective should be to ensure that there is sufficient stakeholder participation in decision-making processes for the conditioning, packaging, storage and transport of higher activity wastes, and the management of spent fuels, plutonium and uranium, without incurring “stakeholder fatigue”.

7 REFERENCES

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2235	Terms of reference for the Committee on Radioactive Waste Management, 2007.
2266	CoRWM Work Programme 2008-2011, June 2008.
2386	Note of meeting with Sellafield Sites Ltd, 19 June 2008
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2397	Note of meeting with NDA on waste storage, 15 July 2008
2406	Note of meeting with Department for Transport, 18 July 2008
2414	Note of meeting with OCNS, 23 July 2008
2418	Note of meeting with NDA on spent fuels, plutonium and uranium, 8 August 2008
2419	Note of meeting with British Energy, 11 August 2008
2436	Note of meeting with HSE Nuclear Directorate on waste storage, 3 September 2008
2457	Responses to CoRWM website invitation to comment on topics in 2008-09 work programme
2459	Note of meeting with NDA on LoC process, 6 October 2008
2464	Note of meeting with EA and SEPA on waste conditioning, packaging and storage, 17 October 2008
2480	Note of Radioactive Waste Immobilisation Network (RWIN) technical meeting on radwaste storage R&D, 16 October 2008
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2489	Note of CoRWM visit to Sizewell B, 23 October 2008.
2515	Development of CoRWM's 2009-12 Work Programme
2519	Note of Institute of Physics / CoRWM Interim Storage Meeting, 26 November 2008
2520	Note of meeting with HSE and EA on spent fuels, plutonium and uranium, 9 December 2008
2523	Note of meeting with NDA on spent fuels, plutonium and uranium, 11 December 2008
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Number	*Title*
2543	National R&D for Interim Storage and Geological Disposal of Radioactive Wastes. CoRWM report to Government, to be published October 2009.
2550	Geological Disposal of Higher Activity Radioactive Wastes. CoRWM report to Government, to be published July 2009.
2562	Log of responses to consultation on full draft of Interim Storage report
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8 GLOSSARY AND ACRONYMS

Glossary of Terms

<u>Notes</u>
1. This Glossary defines terms in the way that CoRWM uses them. Differences from definitions given in publications by the Government, the regulators, the NDA and others are intentional.
2. Definitions are in normal text; additional comments and examples are in parentheses [ ] and italics.

Advanced Gas-Cooled Reactor (AGR)	A UK designed, gas-cooled reactor with a graphite moderator. [*It uses enriched uranium oxide fuel with steel cladding and graphite sleeves. The primary coolant is carbon dioxide*]
Applied research	Investigation directed primarily towards a specific practical aim or objective, which can involve using existing knowledge and understanding or acquiring new knowledge.
Basic research	See “Fundamental research”.
Becquerel (Bq)	The standard international unit of measurement of radioactivity, equivalent to one disintegration per second. [*Related units are the:* *kilobecquerel (kBq) – one thousand Becquerels* *Megabecquerel (MBq) – one million Becquerels* *Gigabecquerel (GBq) – one thousand million Becquerels* *Terabecquerel (TBq) – one million million Becquerels*]
Committed waste	Radioactive waste that will arise in future from the operation or decommissioning of existing nuclear facilities. [*As distinct from existing waste, which already exists, and new build waste, which will only arise if new facilities are built.]*
Conditioning	Any process used to prepare waste for long-term storage and/or disposal. [*Usually by converting it into a suitable solid form e.g. incorporation in glass (vitrification), encapsulation in cement*.]

Contingent strategy	A strategy that can be used if it becomes clear that the "Reference strategy" is no longer appropriate. [*Colloquially, "Plan B". In most radioactive waste management situations several contingent strategies are required, in order to address various possible future scenarios ("Plans C, D, etc.*").]
Deep borehole disposal (DBD)	Disposal of waste in boreholes more than 1000m deep. [*Also known as very deep geological disposal and very deep disposal.*]
Deep geological disposal	Disposal of waste in an underground facility at such a depth that the rock provides substantial protection from disturbances at the surface of the earth. [*Depths are usually between 200m and 1000m. The term is often used synonymously with emplacement in a "mined repository" but can also refer to emplacement in a disused man-made mine or a natural cavern.*]
Desk-based studies	Review, summary, collation or evaluation of existing knowledge, information, facts and research outcomes. *[In the context of the UK geological disposal site selection process, assessing the suitability of sites using existing knowledge about the geology, surface environment, communities etc.]*
Development	Progressive, systematic use of knowledge and understanding gained from research directed towards the production or improvement of materials, devices, systems or methods. [*Includes the design and development of processes*.]
Disposal	Emplacement of waste in an appropriate facility without the intention of retrieving it. [*Retrieval may be possible but if intended the appropriate term is "storage".*]
Disposable	A waste package is disposable if it can be safely removed from a store, transported to a disposal facility and emplaced in that facility, and if it will play its planned role in ensuring the post-closure safety of that facility.
Encapsulation	A conditioning process in which radioactive waste is physically enclosed in a non-radioactive material that prevents radionuclides from moving. [*The most commonly used encapsulants are types of cement. Others include polymers.*]
Enriched uranium	Uranium in which the mass content of the isotope uranium-235 is above the level in natural uranium ores (0.72% by mass).
Exotic fuel	Term used by the NDA for any type of nuclear fuel that is not from a commercial nuclear power reactor. [*Mainly fuels from research reactors and nuclear powered submarines*.]
Fundamental research	Original, exploratory investigation involving experimental or theoretical work undertaken primarily to acquire new knowledge and understanding of phenomena and observable facts without any immediate application or use in view.

Geological disposal	Emplacement in the Earth's crust with no intent to retrieve. [*A generic term of which there are many forms: see "near-surface disposal", "deep geological disposal", "mined repository", "deep borehole disposal". Often used as a shorthand for "deep geological disposal" or for emplacement in a "mined repository".*]
Geological disposal facility (GDF)	Any facility used for geological disposal. [*Includes mined repositories, natural caverns, disused man-made caverns or mines, and deep boreholes*.]
Geological repository	See "Mined repository".
Hex tails	Uranium hexafluoride residue from the production of enriched uranium. [*Hex tails are depleted in uranium-235 to levels well below the 0.72 wt% of natural uranium, usually about 0.2 wt%. Uranium hexafluoride is a stable solid at room temperature and pressure but sublimes to a vapour at 56.5 ^{o}C.*]
Higher activity waste (HAW)	Radioactive waste with activity above the thresholds for low level waste (LLW), *i.e.* above 4 GBq/tonne alpha activity or above 12 GBq/tonne beta/gamma activity. [*It is usually also taken to include LLW unsuitable for near-surface disposal.*]
High level waste (HLW)	Radioactive waste in which the temperature may rise significantly as a result of its radioactive content, so that this factor has to be taken into account in the design of waste storage or disposal facilities. [*In practice the term is only used in the UK for the nitric acid solutions arising from reprocessing spent fuels and for the vitrified form of the solutes in these solutions.*]
Immobilisation	A conditioning process in which radioactive waste is chemically incorporated into a non-radioactive material so that radionuclides cannot move. ["*Vitrification" and incorporation in ceramics are types of immobilisation processes.*]
Interim storage	Storage of radioactive waste prior to implementing a final management step, such as geological disposal.
Intermediate level waste (ILW)	Radioactive waste exceeding the upper activity boundaries for "low level waste" (*i.e.* over 4 GBq/tonne alpha activity or 12 GBq/tonne beta/gamma activity) but for which its heat output need not be taken into account in the design of storage or disposal facilities.
Legacy facility	A nuclear facility constructed several decades ago where waste has been generated or stored.
Legacy waste	Radioactive waste that arose several decades ago. [*A subset of existing waste; sometimes called "historic waste". The term is usually reserved for wastes kept in, or that have arisen in, legacy facilities.*]

Low level waste (LLW)	"Radioactive waste" with activity levels that do not exceed 4 GBq/tonne alpha activity or 12 GBq/tonne beta/gamma activity. [*Subsets of LLW include "very low level waste" (VLLW) and exempt waste (i.e. "radioactive waste" with activity levels below those in the various Exemption Orders made under the Radioactive Substances Act).*]
Low Level Waste Repository (LLWR)	The UK national disposal facility for low level waste. [*Located near the village of Drigg, in Cumbria.*]
Magnox reactor	A UK-designed gas-cooled reactor with a graphite moderator. [*It uses uranium metal fuel with a magnesium alloy cladding.*]
Mined repository	A facility specifically constructed for the deep geological disposal of radioactive waste. ["*Mined and engineered repository" is a more correct description. Most designs consist of excavated shafts, tunnels, caverns and vaults*.]
Near-surface disposal	Disposal at or close to the surface of the Earth. [*If underground, the depth is less than a few tens of metres. Formerly called "shallow land burial" or emplacement in a "near surface repository".*]
Overpack	An additional container for a waste package. [*Usually to make it more suitable for storage, handling, transport or disposal*.]
Package	See "Waste package".
Packaging	Placing waste into a container for long-term storage and/or disposal. [*In most cases this includes conditioning but sometimes waste is simply placed in containers, with or without compaction to reduce its volume*.]
Primary research	The obtaining of knowledge, facts and data that did not previously exist. [*All fundamental and much applied research is primary.*]
Pond	A water-filled structure in which nuclear fuel is stored. [*Usually made of concrete, the water provides cooling and shielding*.]
Pressurised water reactor (PWR)	A nuclear reactor in which water is used as the coolant and moderator. [*The fuel is enriched uranium oxide with "zircaloy" cladding. PWRs operate above atmospheric pressure to prevent the water boiling.*]
Public	People who have no particular interest in, and are not affected by, radioactive waste management. [*CoRWM distinguishes between "stakeholders" and the public.*]

Radioactive waste	Radioactive waste is defined in the Radioactive Substances Act 1993. In essence it is 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*.]
Raw waste	Waste that has not been conditioned.
Recoverability	The ability to remove wastes from a closed disposal facility by mining, drilling boreholes etc. [*Unlike "retrievability", recoverability does not entail the inclusion of any specific design features in a disposal facility.*]
Reference strategy	A strategy based on realistic assumptions about the future and represents the course of action that is to be followed unless circumstances change. [*Colloquially, "Plan A". See also "Contingent strategy".*]
Repository	A facility where waste is emplaced for disposal. [*Often used as shorthand for "mined repository", but also used in other contexts, e.g. the UK's "Low Level Waste Repository (LLWR)"*.]
Research	An investigation directed to the discovery of some fact or principle by a course of study or scientific enquiry.
Retrievability	An ability to withdraw wastes from a disposal facility that is achieved by means designed into the facility other than simply reversing waste emplacement. [*See also "reversibility" and "recoverability".*]
Reversibility	The ability to withdraw wastes from an open disposal facility by reversing the emplacement process.
Secondary research	Review, summary, collation or evaluation of existing knowledge, facts and outcomes of basic and applied research.
Scientific research	The application of the scientific method to obtaining new information to explain the nature, properties or behaviour of something in the universe around us.
Silo	A structure used for storage or disposal of radioactive waste. [*The term is applied in the UK mainly to concrete structures (buildings) used for temporary storage of wastes, but it can also apply to vertical shafts in rock used for underground storage or disposal*.]
Spent fuel	Fuel that has been used in a nuclear reactor and for which there is no further use as fuel.

Stakeholder	A person or organisation who has an interest in or is affected by radioactive waste management. [*In the context of CoRWM's work, stakeholders include waste producers, regulators, non-governmental organisations, local authorities and communities near existing nuclear sites and potential disposal sites*.]
Stakeholder fatigue	A situation in which "stakeholders" are overwhelmed by communications and consultations on a particular topic, and do not respond to requests for their views.
Stillage	A metal frame used to hold drums of radioactive waste.
Storage	Placing wastes or other materials in a facility with the intention of retrieving them at a later date.
Tonne	One thousand kilograms.
Very low level waste (VLLW)	Very low level radioactive waste (VLLW) is LLW that has radioactivity levels well below the maximum for the category. It can be disposed of with non-radioactive waste, rather than being placed in the Low Level Waste Repository or other specialised facility. [*There are two types of VLLW: low volume and high volume. Low volume VLLW is radioactive waste that can be disposed of safely to an unspecified destination with municipal, commercial or industrial waste (so-called "dustbin disposal"). It has an activity not exceeding 400 kBq in any 0.1m*^{3} *and no individual item in the waste should have an activity above 40 kBq. These levels are increased by a factor of ten for tritium or carbon-14 (i.e. 4 MBq in 0.1m*^{3} *and 400 kBq per item, where the limits apply to tritium and carbon-14 taken together). High volume VLLW is radioactive waste that can only be disposed of to a specified landfill site. Its activity level must not exceed 4 MBq/tonne or 40 MBq/tonne for tritium.*]
Vitrification	The process of converting wastes into a glass or glass-like form.
Waste package	A container and all its contents . [*Includes the waste, any encapsulating material, any capping grout, etc*.]
Zircaloy	An alloy of zirconium used for cladding nuclear fuel.

List of Acronyms

AGR	advanced gas cooled reactor (A type of reactor with a graphite core, and uranium oxide fuel in steel cladding with a graphite sleeve.)
AWE	Atomic Weapons Establishment (at Aldermaston). (AWE plc is the company that runs Aldermaston and Burghfield under contract to the Ministry of Defence.)
BNG	British Nuclear Group
BWR	boiling water reactor

CANDU	Canadian deuterium uranium reactor (a reactor with natural uranium fuel and heavy water (deuterium oxide) as the moderator and coolant)
CoRWM	Committee on Radioactive Waste Management
DECC	Department of Energy and Climate Change
Defra	Department for Environment, Food and Rural Affairs
DFR	Dounreay Fast Reactor
DfT	Department for Transport
EA	Environment Agency (for England and Wales)
EARP	Enhanced Actinide Removal Plant (at Sellafield)
EDF	Electricité de France
EPS	Encapsulated Product Store (at Sellafield, there are three stores: EPS1, EPS2 and EPS3)
EU	European Union
GBq	gigabecquerel (a unit of radioactivity)
GDF	geological disposal facility
GLEEP	Graphite Low Energy Experimental Pile (a research reactor at Harwell)
HLW	high level waste
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency (a United Nations agency)
ILW	intermediate level waste
kg	kilogramme
LLW	low level waste
LLWR	Low Level Waste Repository (near Drigg, in Cumbria)
LoC	Letter of Compliance (previously Letter of Comfort)
LTP	lifetime plan
m	metre
m^3	cubic metre
MEP	Magnox Encapsulation Plant (at Sellafield)

MoD	Ministry of Defence
MOP	Magnox Operating Plan (the current plan is the eighth, MOP8)
MOX	mixed oxide fuel (contains uranium and plutonium oxides)
NDA	Nuclear Decommissioning Authority
NII	Nuclear Installations Inspectorate (part of HSE)
NSG	National Stakeholder Group (for the NDA)
NuSAC	Nuclear Safety Advisory Committee (now disbanded, advised HSE)
NWRF	Nuclear Waste Research Forum (a group convened by the NDA)
OCNS	Office of Civil Nuclear Security (part of HSE)
PCM	Plutonium contaminated material
PFR	Prototype Fast Reactor (at Dounreay)
PSE	public and stakeholder engagement
PWR	pressurised water reactor
R&D	research and development
REPs	Radioactive Substances Regulation Environmental Principles (for Environment Agency regulators)
RWMC	radioactive waste management case (a safety case for a proposed waste conditioning and packaging process)
RWMD	Radioactive Waste Management Directorate (of the NDA)
SAPs	HSE's Safety Assessment Principles for Nuclear Facilities
SDDG	Strategy Development and Delivery Group (for the NDA, chaired by DECC)
SED	safety and environmental detriment (a scoring system used by the NDA to rank its facilities and sites in terms of hazard)
SEPA	Scottish Environment Protection Agency
SGHWR	Steam Generating Heavy Water Reactor (an experimental reactor at Winfrith)
SLC	site licence company (a company that runs an NDA site, under contract to the NDA, and holds the nuclear site licence)
SRL	Safety Reference Level (established by WENRA)
SSG	Site Stakeholder Group (at NDA sites)

SSP	Site Security Plan
THORP	Thermal Oxide Reprocessing Plant (at Sellafield)
TMF	Tails Management Facility (to be built at Urenco's Capenhurst site)
UCL	Urenco Capenhurst Ltd
USNRC	United States Nuclear Regulatory Commission
VPS	Vitrified Product Store (at Sellafield)
WAGR	Windscale AGR (an experimental reactor at Sellafield)
WENRA	Western European Nuclear Regulators Association
ZEBRA	Zero Energy Breeder Reactor Assembly (an experimental facility at Dounreay)

9 ACKNOWLEDGEMENTS

Leadership in the drafting and compilation of this report was provided by Marion Hill. CoRWM would like to thank the people and organisations who provided information and views during the work leading to this report, and those who commented on the outline and draft of the report. Particular thanks are due to (in alphabetical order): British Energy, the Department for Transport, the Environment Agency, Greenpeace, the Health and Safety Executive's Nuclear Directorate, the Nuclear Decommissioning Authority, the Nuclear Legacy Advisory Forum, former members of the HSE's Nuclear Safety Advisory Committee and the Scottish Environment Protection Agency. The report represents the views of the Committee alone.