Nuclear Decommissioning Authority

NDA Technical Note no. 12877243

Geological Disposal

Inventory presentation to West Cumbria Managing Radioactive Waste Safely Partnership: Issue 2

November 2010

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Bibliography

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Abstract

This note has been prepared for the West Cumbria Managing Radioactive Waste Safely Partnership meeting on the 5th August 2010.

It briefly describes the estimated inventory potentially requiring geological disposal in the UK, how uncertainty in this inventory is managed and the impact of a potentially larger inventory on the design and operation of a geological disposal facility.

The note also briefly explains how changes to the inventory for geological disposal will occur and refers to relevant statements made in the Managing Radioactive Waste Safely White Paper for how these changes will need to be managed.

Following the meeting on the 5th August 2010 this note was revised through the addition of Section 3 and re-issued as Issue 2. Section 3 was added, at the request of the Partnership, in order to provide a clear response to the issues raised in a paper also presented at the meeting by an independent Environmental Consultant (Pete Roche).

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1 Introduction

1.1 Background

The Managing Radioactive Waste Safely (MRWS) White Paper [Ref 1] confirmed that the Nuclear Decommissioning Authority (NDA) is responsible for planning and implementing geological disposal in the UK. To implement geological disposal the NDA has set up the Radioactive Waste Management Directorate (RWMD). RWMD will eventually be developed into a Site Licence Company responsible for the construction and operation of a geological disposal facility.

This note has been prepared for the West Cumbria Managing Radioactive Waste Safely Partnership meeting on the 5th August 2010 to support discussions on inventory issues. It briefly describes the estimated inventory potentially requiring geological disposal in the UK, how uncertainty in this inventory is managed and the impact of a potentially larger inventory on the design and operation of a geological disposal facility.

The note also briefly explains how changes to the inventory for geological disposal will occur and refers to relevant statements made in the Managing Radioactive Waste Safely White Paper regarding such changes to the waste inventory.

Section 2 of this note includes the slides from the presentation by representatives from RWMD and the Department of Energy and Climate Change to the MRWS Partnership.

Following the meeting on the 5th August 2010 this note was revised through the addition of Section 3 and re-issued as Issue 2. Section 3 was added, at the request of the Partnership, in order to provide a clear response to the issues raised in a paper also presented at the meeting by an independent Environmental Consultant (Pete Roche).

1.2 UK Radioactive Waste Inventory

The UK Radioactive Waste Inventory (UKRWI) is the public compilation of data on existing and expected radioactive wastes from historical and ongoing nuclear operations and is updated periodically (currently every 3 years). This inventory was first produced in 1984.

The 2007 UK Radioactive Waste Inventory (the 2007 UKRWI [Ref 2]) is the latest public record of information on the sources, quantities and properties of low level waste (LLW), intermediate level waste (ILW) and high level waste (HLW) in the UK. It comprises of a number of reports and additional detailed information on the quantities and properties of radioactive wastes in the UK that existed at 1 April 2007 and those that were projected to arise after that date. The 2007 Inventory contains details of over one thousand individual wastes that have been reported by organisations responsible for their management.

The 2007 UKRWI [Ref 2], for the first time, contains radioactive materials not currently classified as waste. This change in the scope of the UKRWI will allow it to be used to track the latest estimates in waste and materials that will potentially need to be treated as waste at some future point [Ref 1].

Work is ongoing on the production of the 2010 UK Radioactive Waste Inventory which will include updated information, based on wastes which existed at 1 April 2010 and those projected to arise thereafter.

1.3 Baseline Inventory

The MRWS White Paper [Ref 1] provides an estimate - the 'Baseline Inventory' - of the higher activity radioactive waste and other materials that could, possibly, come to be regarded as wastes that might need to be managed in the future through geological disposal. The Baseline Inventory[1] is based on the 2007 UK Radioactive Waste Inventory (RWI) [Ref 2] and is presented in Slide 5 in Section 2 of this note.

1.4 Upper Inventory

We need to recognise that there is uncertainty associated with the information in the UK RWI, e.g. in relation to the activity concentration in individual waste streams, in relation to the estimates of wastes and materials that have not yet arisen, and in relation to future operation of existing facilities e.g. how long reactors will operate. Also there may be wastes and materials not recognised in the UKRWI because they either exist but are not considered as wastes or because they will arise from future activities. This latter category includes wastes and spent fuel that could arise from a new build programme.

RWMD has therefore compiled an Upper Inventory to allow the implications of these uncertainties to be explored (as summarised in Slide 7) although this is not intended to be a maximum inventory and does not set out the largest inventory which could be disposed of in a geological disposal facility.

1.5 New Build Inventory

The amount of radioactive waste and spent fuel that would arise as a result of a new nuclear build programme would depend on such issues as the number and type of reactors. The upper inventory is based on the assumption that a new build fleet is comprised of four APR1000 reactors (Advanced Pressurised Water Reactor) and four EPR reactors (European Pressurised Water Reactor) operating for 60 years generating 10GW(e) The estimated packaged volume of waste and spent fuel from a new build programme, included in the Upper Inventory, is summarised in Slide 8. This includes estimates of intermediate level waste (ILW) from reactor operations and decommissioning, spent fuel and depleted uranium from fuel production. No ILW is anticipated from fuel fabrication or uranium enrichment plants in manufacturing nuclear fuel, and no low level waste (LLW) has been identified that might be unsuitable for near-surface disposal.

RWMD has completed assessments for the wastes from two designs of reactors proposed to inform the consideration of these designs through the regulators Generic Design Assessment process [Ref 3,4]. These studies concluded that compared with legacy waste and existing spent fuel, no new issues arise that challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of both designs of reactor. Fuel from new reactor designs will be subject to higher “burn-up” than in existing UK reactors. This refers to the extraction of more energy from the same amount of fuel, with the result that the spent fuel is hotter and more radioactive. The disposability assessments showed that spent fuel with such characteristics can be accommodated without adverse effects on the safety of a suitably designed geological disposal facility [Ref 5].

1.6 Derived Inventory for NDA Planning Purposes

The MRWS White Paper sets out the Baseline Inventory in terms of volume and activity according to waste category and recognises the figures are only indicative. For design and assessment purposes, RWMD need more detailed information related to waste packages.

Therefore RWMD has developed a more detailed inventory based upon the Baseline Inventory and using the information from the UK RWI.

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[1] It should be noted that at present the Baseline Inventory is based on UK RWI figures, and as such, currently contains waste expected to be managed under the Scottish Government’s policy for higher activity waste as announced on April 2010.

The term 'Derived Inventory' is used to explain this, but in practice this should be seen as a more detailed description of the Baseline Inventory rather than a separate distinct inventory. Information at the 'waste package level' (rather than 'waste stream level' as is supplied in the UK RWI) is also an important input to the development of Generic Specifications, which define the required standards and performance specifications for waste packages.

A Derived Inventory, based on the 2007 UK RWI, was developed in 2009 and provides the current basis for disposal system designs and safety and environmental assessments. It is, however, recognised that a 2010 UK RWI will be published shortly, and therefore a report will be published to identify the differences between the Derived Inventory produced in 2009 and the information in the 2010 UK RWI.

1.7 Illustrative Generic Designs for a Geological Disposal Facility

A number of generic designs have been developed for geological disposal in the UK based upon specific assumptions derived from the typical characteristics of the geological environments that occur in the UK (Figures shown in slides 11 -13). These designs have been developed by drawing on work done both in the UK and in international programmes in a number of different geological environments [Ref 5]. The illustrative designs provide a basis for a typical disposal facility and operations at sites and in rock formations that are yet to be determined. Developing these designs helps to enhance RWMD's understanding of how waste disposal could be carried out in different geological environments; how safety and environmental impacts can be addressed in all phases of development; how long it might take to develop and what it is likely to cost. These illustrative designs and layouts have been based on assumed parameters and typical host rock properties - the actual design would obviously depend on the chosen site. As the geological environment for which a design will need to be developed is not yet known, no decision has yet been made on the geological disposal concept design to be adopted.

The illustrative designs are based on the assumption of a single geological disposal facility to accommodate all the wastes and materials in the Baseline Inventory. In such a "co-located" disposal facility it is currently assumed that there would be two distinct disposal areas, excavated on a single level and separated by an appropriate distance, one for ILW/LLW and the other for high-level waste (HLW).

Currently RWMD assume that if required the disposal concepts for ILW/LLW would be more appropriate[2] for the geological disposal of uranium residues in the Baseline Inventory and that the disposal concepts for HLW and spent fuel would be more appropriate[2] for the geological disposal of the separated plutonium and highly enriched uranium in the Baseline Inventory. While these materials are considered in the Baseline Inventory they are included as radioactive materials that are not currently classified as waste but that may, if it were decided at some point that they had no further use, need to be managed through geological disposal.

The disposal operations would share surface facilities, access tunnels, construction support and security provision. It is also currently assumed that no packaging of wastes would be undertaken at the facility - wastes would be transported to the facility by road, rail or sea in a manner wholly compliant with International Atomic Energy Agency regulations.

1.8 Implications of Upper Inventory Volume

For the Upper Inventory volume (shown in Slide 7) the footprint for the illustrative designs would increase to approximately 9.8km^2 in the higher strength rock, 19.5km^2 in the lower strength sedimentary rock and 18.4km^2 in the evaporite rock.

[2] Note: this approach is not optimised and would be subject to optioneering.

Although no new technical challenges would be posed by the requirement for a larger facility, there would be an inherent increase in the construction and backfill materials used and increased ventilation requirements for the facility. The larger throughput of waste would also lead to the extended operation and maintenance of the site infrastructure and a higher utilisation of the waste handling equipment.

1.9 Future Changes

The MRWS White Paper also recognises that estimates of future waste inventory depend on a number of detailed assumptions and can only be taken as indicative. Future changes to the inventory may be as a result of changes in assumptions or because waste amounts will change over time, for example, due to changes in planned operations and ability to reduce the amounts of waste for disposal through application of the waste hierarchy. In practice, there may also be some types of waste where alternative management options could alter the inventory of waste destined for geological disposal.

The MRWS White Paper therefore also refers to some of the issues that will need to be addressed in managing these changes. For example,

Paragraph 3.17: Changes in the UKRWI, and hence the Baseline Inventory, will occur. The estimated quantity and the types of waste to be consigned to a disposal facility needs to be visible and regular UKRWI updates will ensure transparency and indicate the nature of these changes. Any final agreement with a community on a preferred site for the geological disposal facility will need to address possible changes to the Inventory in future years.

Paragraph 3.22: Through agreed mechanisms for updating the Baseline Inventory, inclusion of new waste will be taken forward in discussion with host communities as the programme proceeds. Geological disposal facility design activities will consider the necessary features to safely accommodate particular waste types if that proves necessary.

To provide a clear definition of the requirements on the disposal system RWMD has developed a Disposal System Specification [Ref 6,7].

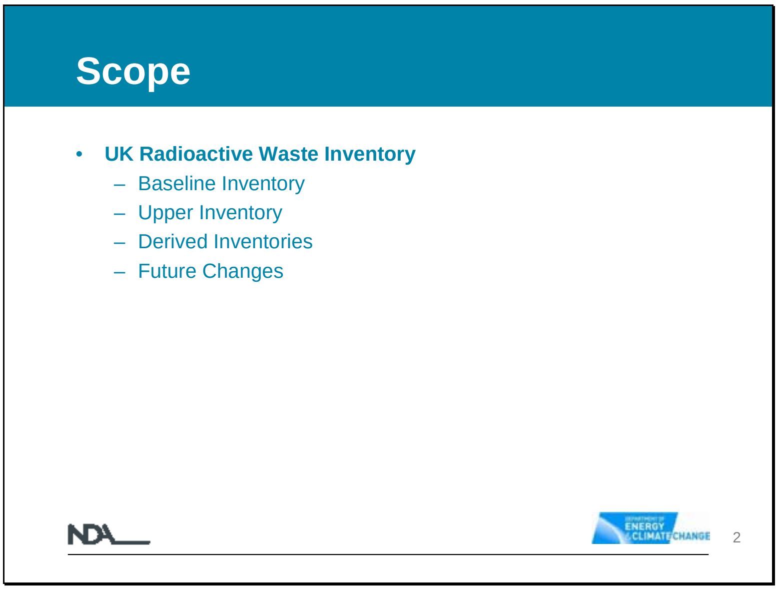
As part of the iterative approach to disposal system development, a disposal system design is produced to meet the specification. At present the site and geology of the eventual facility are not yet known and therefore RWMD has developed a number of illustrative generic designs as discussed above. These designs are then subject to assessments of its safety and environmental impacts.

Any changes to the specification (including those caused by changes in the inventory), designs or safety or environmental assessments are subject to change control. RWMD operates a change control procedure to ensure that all proposed changes are assessed at the appropriate level, according to their safety significance, prior to implementation and that all approved changes are correctly implemented and reviewed, and the changes formally logged.

2 Presentation

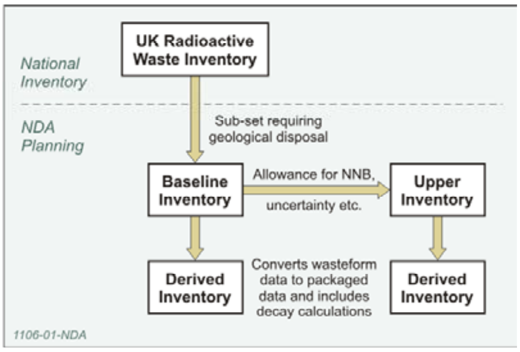
Slide 1

Slide 2



Slide 3

NDA – Use of Inventory



NDA 3

Slide 4

UK Radioactive Waste Inventory

- **Compiled every 3 years - 2007 most recent**
  - 2010 in preparation
- **Includes stocks and future arisings (from existing facilities)**
- **Radioactive Waste**
  - High Level Waste
  - Intermediate Level Waste
  - Low Level Waste
- **Materials Inventory (since 2007)**
  - spent nuclear fuel from existing reactors
  - separated plutonium
  - separated uranium
  - based on actual measurements and estimates – hence subject to change

NDA 4

Slide 5

Baseline Inventory

Materials	Packaged volume		Radioactivity (At 1 April 2040)	
	Cubic Metres	%	Terabequerels	%
HLW	1,400	0.3%	36,000,000	41.3%
ILW	364,000	76.3%	2,200,000	2.5%
LLW (not for LLWR)	17,000	3.6%	<100	0.0%
Spent nuclear fuel	11,200	2.3%	45,000,000	51.6%
Plutonium	3,300	0.7%	4,000,000	4.6%
Uranium	80,000	16.8%	3,000	0.0%
Total	476,900	100	87,200,000	100

0643-02-DECC

Table 1 from Defra, BERR and devolved administrations for Wales and Northern Ireland,
Managing Radioactive Waste Safely
– A Framework for Implementing Geological Disposal, June 2008.

NDA ENERGY & CLIMATE CHANGE 5

Slide 6

Upper Inventory

- Developed for NDA planning - design and safety assessments
- Not an upper `limit'
- Uncertainty in estimates in Baseline Inventory
- Alternative scenarios for future operation of nuclear plants
- Additional materials owned by Ministry of Defence
- Wastes from potential new nuclear power stations

NDA ENERGY & CLIMATE CHANGE 6

Slide 7

Upper Inventory

Materials	Packaged Volume (Cubic metres)
HLW	23,000
ILW	584,000
LLW (not for LLWR)	156,000
Spent fuel	22,300
Plutonium	10,400
Uranium	175,000
Total	970,700

Figures rounded to 3 significant figures

NDA

ENERGY & CLIMATE CHANGE

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Slide 8

Nuclear New Build only

Materials	Packaged Volume (Cubic metres)
ILW	25,000
Spent fuel	20,300
Uranium	56,400
Total	101,700

Figures rounded to 3 significant figures

- **Based upon 10GW from 4 x AP1000 and 4 x EPR operating for 60 years**
- **Recognise that current estimates from developers are for 16GW**

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ENERGY & CLIMATE CHANGE

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Slide 9

Derived Inventory

- **Derived Inventory converts inventory data into the form required for design and safety assessments**
  - Provides data for waste packages (rather than waste streams)
  - Removes inconsistencies in data
  - Decays radionuclide inventory to required dates
- **Recognised 2010 UK RWI to be published shortly**

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Slide 10

Key design assumptions

- **Transport to GDF by road, rail or sea**
- **All transport packages will be compliant with IAEA Regulations**
- **Stand alone facility on a single surface site**
- **Designed to accept Baseline Inventory**
- **Implications of Upper Inventory considered**
- **Excavated on a single level or "horizon"**
- **500m separation distance between ILW/LLW and HLW/SF disposal zones**
- **No packaging of wastes undertaken at GDF**

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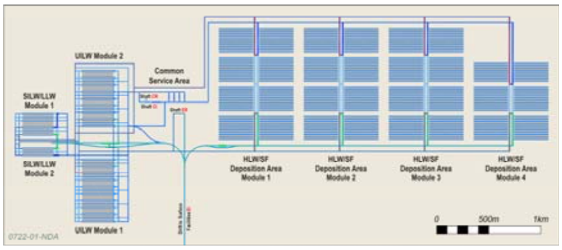
Slide 11

Underground layout in a Higher Strength rock to accept the Baseline Inventory



Footprint – 5.6 sq km

NDA

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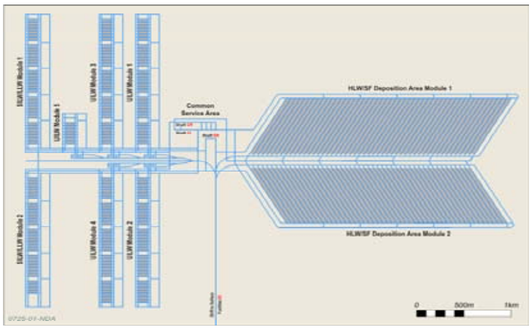
Slide 12

Underground layout in a Lower Strength Sedimentary rock to accept the Baseline Inventory



Footprint – 10.3 sq km

NDA

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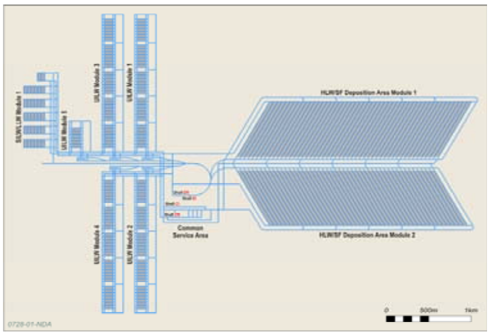
Slide 13

Underground layout in an Evaporite rock to accept the Baseline Inventory



Footprint – 8.8 sq km

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DEPARTMENT OF ENERGY & CLIMATE CHANGE

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Slide 14

Implications of upper inventory volume

- Underground footprint approximately doubles in size
- Extended operation and maintenance of site infrastructure
- Higher utilization of waste handling equipment
- Ventilation requirements increased
- Increased construction and backfill material required
- No new technical challenges

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Slide 15

Future Changes

- **Different types of change**
  - Data quality improvements in the inventory itself
  - Operational changes and new technology
    - e.g. reactor life extensions, new waste conditioning techniques
  - Policy changes and development
    - e.g. decisions on the management of nuclear materials
- **Disposal Inventory in Disposal System Specification**
- **Implications of potential changes in the Disposal Inventory are assessed in terms of design, safety and environmental performance**

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Slide 16

MRWS White Paper

- **Changes in the UK Radioactive Waste Inventory will occur**
- **Regular updates of the UK Radioactive Waste Inventory will ensure transparency and indicate the nature of these changes**
- **Any final agreement with a community on a preferred site for the geological disposal facility will need to address the Inventory at that time and implications of possible changes to the Inventory in future years**
- **Geological disposal facility design activities will consider the necessary features to safely accommodate particular waste types if that proves necessary**

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3 Response to Key Points Raised in Paper by Pete Roche

This Section responds to key points raised in the paper by Pete Roche for the West Cumbria Managing Radioactive Waste Safely Partnership [Ref 8].

Section 3.1 provides a general response the points raised in the paper. Section 3.2 provides a response to the specific questions raised for NDA in the paper. Section 3.3 provides a response on the summary and conclusions in the paper.

3.1 General Response

We agree with the key point made in the paper by Pete Roche [Ref 8] that more waste will be generated if the amount of energy to be provided increases. We also agree that for a given site, there will be a maximum inventory that can be disposed of. However, it is important to note that it is not possible to derive a "maximum acceptable inventory" for a single geological disposal facility until a site for such a facility has been identified and characterised and its capacity established.

3.2 Response to Questions

1. Can the NDA confirm the numbers given in Tables 2 & 3 for a "Maximum Inventory" or provide an alternative set of figures and an explanation about why these are incorrect.

The estimated packaged volumes and footprints for the Baseline Inventory and an Upper Inventory[3] were presented in Sections 1 and 2 of this RWMD Technical Note.

The Upper Inventory takes into account a range of uncertainties in the Baseline Inventory. In addition to wastes and spent fuel that could arise from a new build programme the Upper Inventory also takes into account other sources of uncertainty, such as reprocessing of legacy wastes, inclusion of Ministry of Defence material and the quantity of LLW requiring geological disposal.

The Upper Inventory (as described in Section 1.4 of this note) assumes a new build programme, operating for 60 years, that generates approximately 10GW(e). This is not intended as a maximum since the eventual installed capacity of a new build programme is not known; for instance energy companies have recently committed to build up to 16GW(e) of new nuclear power stations[4], although the proposed reactor types have not yet been determined.

The estimated amount of waste and spent fuel from a new build programme will depend on many factors, including the assumptions made regarding electricity generation and types of reactor.

In Tables 2 and 3 of the paper by Pete Roche [Ref 8] estimated packaged volumes and footprints for a modified Upper Inventory based on a 16 GW(e) new build programme (a so called "maximum inventory") are presented. In the paper [Ref 8] a simple scaling of the estimated new build inventory for ILW, spent fuel (SF) and uranium (25,000 m^3, 20,300 m^3 and 56,400m^3, respectively) was applied to estimate the packaged volume for this modified Upper Inventory (i.e. scaling by a factor of 1.6). These values seem reasonable as

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[3] The NDA RWMD Upper Inventory is not intended to be a maximum inventory and does not set out the largest inventory which could be disposed of in a geological disposal facility.

[4] Department of Energy and Climate Change http://www.decc.gov.uk/en/content/cms/what_we_do/uk_supply/energy_mix/nuclear/office/office.aspx

indicative figures at the present time, given the uncertainty over the reactor types that will be used.

The estimated packaged volumes for the Baseline Inventory, Upper Inventory and a modified Upper Inventory are shown in Table 1.

Table 1 NDA RWMD estimated packaged volume for a range of Inventory scenarios

Materials	**Baseline Inventory [1] (cubic metres)**	**Upper Inventory (based on 10GW(e) programme) (cubic metres)**	**Modified Upper Inventory (based on 16GW(e) programme) (cubic metres)**
HLW	1,400	23,000	23,000
ILW	364,000	584,000	599,000
LLW	17,000	156,000	156,000
Spent fuel	11,200	22,300	34,480
Plutonium	3,300	10,400	10,400
Uranium	80,000	175,000	208,840
Total	476,900	970,700	1,031,720

An increase in the packaged waste volume will have an impact on the required footprint of a geological disposal facility. The implication of the Upper Inventory is to approximately double the footprint that would accommodate the Baseline Inventory. For a modified Upper Inventory (based on a 16GW(e) new build programme) the footprint would potentially increase (over the Baseline Inventory) by a factor of approximately 2.5. These estimated footprints have been calculated on a consistent basis from footprint layouts (similar to those shown in slides 11 to 13). Hence, these estimates are slightly lower than the scaled footprints estimates presented in the paper by Pete Roche. The estimated footprints for the Baseline Inventory, Upper Inventory and a modified Upper Inventory are shown in Table 2.

Table 2 NDA RWMD estimated footprints for a range of inventory scenarios

Illustrative Concept Example	Geological Disposal Facility Underground Footprint		
	Baseline Inventory	Upper Inventory (based on 10GW(e) programme)	Upper Inventory (based on 16GW(e) programme)
Higher Strength rock	5.6 km^2	9.8 km^2	11 km^2
Lower Strength Sedimentary rock	10.3 km^2	19.5 km^2	23.3 km^2
Evaporite	8.8 km^2	18.4 km^2	21.9 km^2

It is worth noting that these estimated footprints are illustrative and would depend on a range of factors, in particular the characteristics of a site and hence the design and layout of the geological disposal concept selected for that site.

The illustrative designs that have been used to estimate footprints assume that there would be two distinct disposal areas (one for ILW/LLW and one for HLW/SF), excavated on a single level and separated by an appropriate distance. Once site characteristics are known, it may be possible to design a geological disposal facility that is on multiple levels, hence reducing the overall footprint.

2. Why does the HLW jump from 1,400m^3 to 23,000m^3 from the Baseline Inventory to the Upper Inventory; and why does spent fuel from existing reactors fall from 11,200m^3 in the baseline inventory to 2,000 m^3 in the Upper Inventory? Does this mean the Upper Inventory is assuming the reprocessing of un-contracted spent fuel?

The reasons for the increase in the packaged volume of HLW from Baseline Inventory relative to the Upper Inventory are summarised below.

- The Upper Inventory includes the disposal canister in the calculation of the packaged volume[5], where as the Baseline Inventory does not.
- The Upper Inventory is based on the assumption that all spent fuel in the Baseline Inventory and spent fuel arising as a result of extended operations of existing reactors (but not from any new reactors) is reprocessed (this includes contracted and uncontracted spent fuel). The Upper Inventory therefore includes the HLW from the reprocessing of this spent fuel.
- The Upper Inventory takes into account the uncertainty in the volume of HLW reported by Sellafield in the UK RWI.

For the Upper Inventory it is also assumed that some non-commercial fuels from existing reactors will come forward for disposal to a geological disposal facility. The quantities of

[5] This therefore represents an estimated packaged volume for disposal.

non-commercial spent fuel reported in the 2007 UK RWI, as well as a nominal estimate for MoD submarine fuel assumed for the Upper Inventory are listed below:

- 350tU of miscellaneous SF at Sellafield[6];
- 13tU of spent PFR fuel;
- 100tU of spent submarine fuel.

The estimated packaged volume for these quantities and types of spent fuel is 2,100m^3. All packaging assumptions for these fuels are illustrative only.

However, the process for preparing the Derived Inventory considers a range of scenarios, therefore an alternative scenario for the Upper Inventory that assumes the non-reprocessing of un-contracted spent fuel is available and included in the Derived Inventory reports to be published in early 2011 (as part of the suite of generic Disposal System Safety Case reports).

3. It is not clear why the plutonium in Baseline Inventory jumps from 3,300m^3 to 10,400m^3 in the Upper Inventory.

The reasons for the increase in the packaged volume of plutonium from Baseline Inventory relative to the Upper Inventory are summarised below.

- The Upper Inventory includes the plutonium disposal canister in the calculation of the packaged volume, where as Baseline Inventory does not.
- The Upper Inventory is based on the assumption that all spent fuel in the Baseline Inventory and spent fuel arising as a result of extended operations of existing reactors is reprocessed. The Upper Inventory therefore includes the plutonium from the reprocessing of this spent fuel.
- The Upper Inventory includes plutonium from defence programmes (approximately 7.6 tonnes).

4. What assumptions have been made about AGR lifetimes and the lifetime of Sizewell B to calculate the inventory of spent fuel in the Baseline Inventory?

The Baseline Inventory is based on the assumptions in the 2007 UK RWI[7] regarding future arisings. Predicted waste arisings from AGR stations assume an operational lifetime of 30 or 35 years, dependent on the station. The PWR station is assumed to operate for 40 years. The assumptions regarding operating lifetimes are:

- AGR power stations assumed operating timescales:
    - Hinkley Pt B 1976 – 2011
    - Hunterston B 1976 – 2011
    - Dungeness B 1983 – 2018
    - Heysham 1 1983 – 2014

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[6] The 350tU of miscellaneous SF at Sellafield is considered to effectively bound all other SF (e.g. SF from research reactors such as Imperial College) that does not have separate streams in the Derived Inventory.

[7] Since 2007 UKRWI data was compiled, British Energy has announced operational life extensions for Hinkley Point B and Hunterston B of 5 years to 2016. Further studies will be conducted by 2013 regarding the potential for additional life extension beyond 2016. The potential for life extensions at the company's other nuclear power stations will be considered in due course.

    - Hartlepool 1983 – 2014
    - Heysham 2 1988 – 2023
    - Torness 1988 – 2023
- Sizewell B PWR station: assumed operating lifetimes 1995 – 2035.

5. Can the NDA say what the implications are for the spent fuel inventory of a likely scenario of AGR and PWR life extensions?

The Upper Inventory assumes that the lifetimes of existing AGR power stations are extended from 30 or 35 years (depending on the station) to 40 years and the existing PWR power station is extended from 40 years to 60 years. On the basis of the assumptions the estimated increase in SF would be 2,300tU [8]. This is equivalent to 3,500m^3 of packaged volume of SF.

3.3 Response to Summary and Conclusions

1. Any community considering participating in the GDF implementation process should do so only on the basis of an agreed waste inventory.

The MRWS White paper sets out the Baseline Inventory as an estimate of the higher activity radioactive waste and other materials that could, possibly, come to be regarded as wastes that might need to be managed in the future through geological disposal. Changes to the Baseline Inventory will occur. The implementation of a geological disposal facility is a long-term project, hence there is a need for a flexible approach that includes the ability to address changes in the inventory over time.

It is noted in the MRWS White Paper that any final agreement with a community on a preferred site for the geological disposal facility will need to address possible changes to the inventory in future years. It was acknowledged at the West Cumbria MRWS Partnership Meeting on 5th August 2010 that the key question for the Partnership *at this stage* is what is realistic to be in place before it can make a judgement on its recommendations about a decision about participation. The suggestion made at the meeting that *at this stage* it would be appropriate to identify a set of principles for a process for changing the Baseline Inventory is supported by NDA.

2. CoRWM's recommendations did not apply to new build waste. The ethics of planning to generate more nuclear waste when we only have a "least-worst" option for dealing with waste we have already created is highly questionable.

It is correct that CoRWM's 2006 recommendations [Ref 9], were made in relation to the existing and committed inventory of higher activity wastes and CoRWM recommended that a separate process was needed in relation to new build. This was carried out through the 2007 Consultation on the Future of Nuclear Power [Ref 10], the associated public stakeholder and deliberative events and the subsequent Nuclear White Paper [Ref 11] in January 2008, all of which considered the ethical and technical issues around the creation of new nuclear waste.

The conclusion reached following the 2007 consultation is that "*Having reviewed the arguments and evidence put forward, the Government believes that it is technically possible to dispose of new higher-activity radioactive waste in a geological disposal facility and that this would be a viable solution and the right approach for managing waste from any new nuclear power stations. The Government considers that it would be technically*

[8] Note: The Upper Inventory assumed that this additional spent fuel is reprocessed (as described in the response to Question 2), resulting in 4,900m^3 of ILW and 2,300m^3 of HLW.

possible and desirable to dispose of both new and legacy waste in the same geological disposal facilities and that this should be explored through the Managing Radioactive Waste Safely programme. The Government considers that waste can and should be stored in safe and secure interim storage facilities until a geological facility becomes available".

The disposability assessments that have subsequently been conducted by the NDA [Ref 3, 4] to inform the Generic Design Assessment (GDA) process support this view, and have concluded that compared with legacy wastes and existing spent fuel, no new issues arise that challenge the fundamental disposability of the wastes and spent fuel expected to arise from operation of the EPR and AP1000 reactors.

CoRWM's current position on new build wastes was published in March 2010 [Ref 12]. It believes that a range of issues, including social, political and ethical issues, arising from a deliberate decision to create additional wastes should be considered as an integral part of the new build public assessment process. The Committee recognises that there are several strands to this process and that some of these are complete, some are currently underway and some are yet to start.

3. The community should demand a veto on any substantive changes to the inventory for disposal, and it should insist that the Government makes clear that its vague threat to "explore other approaches" would preclude using any sort of compulsion on volunteer communities.

As noted earlier, the implementation of a geological disposal facility is a long-term project, hence there is a need for a flexible approach that includes the ability to address changes in the inventory.

It is noted in the MRWS White Paper [Ref 1] that any final agreement with a community on a preferred site for the geological disposal facility will need to address possible changes to the inventory in future years. At this early stage of the MRWS Site Selection Process, regarding Community consideration of a decision to participate, it should be possible to develop and agree generic principles for any future inventory change process, in order to support near-term decisions regarding further participation, with detailed agreements to follow if the process moves towards final decisions on facility siting in the future.

The statement in the MRWS White Paper [Ref 1] about the possibility of having to explore other approaches in the event that the current process fails has been discussed many times. It is not a "vague threat" but a simple statement of fact recognising that, if the current siting process fails, we will still have to manage the waste that exists so will need to explore other approaches. Government representatives have stated publicly on several occasions that, in the event of failure of the current process, there is currently no "Plan B" other than trying to make the voluntarism and partnership approach work better.

4. The NDA should be asked to establish a 'maximum' inventory and state where the cut off point would be for the quantity of waste which could be emplaced in a single repository.

At this generic stage it is not possible to state a 'maximum' inventory. The maximum capacity of a geological disposal facility can not be determined until details of a specific site has been identified, when the characteristics of the geological environment (i.e. the natural barrier) have been investigated and when these, in combination with the engineered barrier, have been evaluated though application of the safety case.

5. A new build programme of the scale currently being considered could almost triple the repository footprint.

Table 2 of this note shows the estimated footprints for the Baseline Inventory and an Upper Inventory that includes waste and spent fuel from both a 10GW(e) and a 16GW(e) new build programmes. The implication of the Upper Inventory is to approximately double the footprint that would accommodate the Baseline Inventory[9]. For a modified Upper Inventory (based on a 16GW(e) new build programme currently proposed by energy companies) the footprint would potentially increase by a factor of approximately 2.5.

However, the Upper Inventory takes into account a range of uncertainties in the Baseline Inventory. In addition to wastes and spent fuel that could arise from a new build programme, the Upper Inventory also takes into account other sources of uncertainty, such as reprocessing of legacy wastes, inclusion of MoD material and the quantity of LLW requiring geological disposal.

The footprint for a geological disposal facility will depend on a range of factors, these include the strength of the host rock (i.e. the size of excavations), the thermal conductivity (i.e. the spacing between disposal canisters), size and depth of suitable host rock (i.e. layout of disposal areas on multiple levels) and the size of disposal canisters (i.e. efficiency of packaging and volume utilisation).

6. Just 6 new EPR rectors could 'use up' more than half of the Environment Agency's risk target.

In the studies conducted in support of the GDA process, we considered the impact of SF arising from a 10GW(e) power programme. The assessment reports [Ref 4,13] reported that the estimated peak post-closure risk[10] from these materials ranged from 0.01% and 50% of the risk guidance level[11] defined in the Environment Agencies' guidance [Ref 14] depending on assumptions made.

The method for performing a post-closure performance assessment necessarily needs to take account of the many uncertainties inherent in modelling the future evolution of a disposal system. At the current generic stage of the geological disposal implementation programme, we do this by making assumptions regarding the performance of the engineered barrier system (including when canisters will "fail"), and the characteristics of the geological environment, including groundwater movement through the facility and the travel time for water to reach the biosphere.

In the particular example of the EPR report [Ref 13] we chose to present a pessimistic case where the disposal canister was assumed to be manufactured from carbon steel and was assumed to fail 39,000 years after emplacement. We noted that other disposal programmes (Canadian, Finnish, Swedish) assume use of copper for the canister material with a reported lifetime in excess of 1 million years.

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[9] It should be noted that the estimated footprints will probably change when a site is available and a design has been selected and optimised. At present, a single level facility is assumed, but it is possible that multiple levels could be used.

[10] Estimated peak risks ranged from 5.3 $x10^{-7}$ per year and 9.9 $x10^{-11}$ per year depending on assumptions made (e.g. the former assumes that all canisters fail simultaneously).

[11] In February 2009 the Environment Agencies published revised Guidance [Ref 14] to regulate the disposal of radioactive waste. One requirement is the Risk Guidance Level ($1x10^{-6}$ per year) which concerns the period beyond closure of the site and provides the primary long-term assessment standard for environmental safety. Whilst use of this guidance is not legally enforceable it does set out those requirements that the Environment Agencies would expect to be met in order for it to grant an Environmental Permit to an operator. NDA RWMD is currently using this Guidance in developing the generic Disposal System Safety Case.

As we generate more information about the characteristics of a particular site we will in parallel develop the required engineered barrier system and tailor the facility design and safety case to provide the necessary degree of safety.

7. New build could also require the GDF to remain in operation up to around 2200.

The timescales for operation of a geological disposal facility are currently based on a range of assumptions and at this stage of the programme the operational regime has not been optimised. In the studies undertaken in support of the GDA process [Ref 3, 4] it was estimated that spent fuel would require cooling for the order of 100 years prior to emplacement in order for the fuel to be sufficiently cooled to meet the temperature limits specified for the engineered barrier system. The disposal concept against which this evaluation was undertaken had been developed from our understanding of the characteristics of legacy spent fuel and we recognised that further work would be required to optimise the disposal system for higher burn-up fuels from a new build programme.

We are currently working with the Nuclear Industry Association (NIA) to investigate the options that could be adopted within the packaging regime and a geological disposal facility engineered barrier system, to reduce the need for extended storage before emplacement. The study (which is due for publication this autumn) is indicating that power station operators could themselves make a significant reduction in the required cooling period by the judicious mixing of long- and short-cooled fuel within the same disposal canister. The study has also identified other options which would appear to be feasible and offer the potential for earlier underground emplacement.

8. More work needs to be done on the impact of achieving risk targets of the disposal of plutonium and uranium.

We agree that more work is required in this area and it is already in the RWMD work programme. We will be publishing our generic Disposal System Safety Case (DSSC) in the new year. This document suite includes a preliminary assessment of the safety and environmental impacts associated with the geological disposal of the plutonium and uranium in the Baseline and Upper Inventory. For the purposes of the generic DSSC we have assumed that the illustrative geological disposal concept for ILW/LLW would be appropriate for depleted, natural and low-enriched uranium and that the illustrative concept for HLW and spent fuel would be appropriate for plutonium and highly-enriched uranium. These assessments will provide us with a quantified platform enabling us to see where we should focus efforts for future research and assessment studies.

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