

Generic Design Assessment – New Civil Reactor Build

**Step 4 Radioactive Waste and Decommissioning Assessment of the Westinghouse
AP1000[®] Reactor**

Assessment Report: ONR-GDA-AR-11-014
Revision 0
11 November 2011

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First published December 2011

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PREFACE

The Office for Nuclear Regulation (ONR) was created on 1st April 2011 as an Agency of the Health and Safety Executive (HSE). It was formed from HSE's Nuclear Directorate (ND) and has the same role. Any references in this document to the Nuclear Directorate (ND) or the Nuclear Installations Inspectorate (NII) should be taken as references to ONR.

The assessments supporting this report, undertaken as part of our Generic Design Assessment (GDA) process, and the submissions made by Westinghouse relating to the AP1000[®] reactor design, were established prior to the events at Fukushima, Japan. Therefore, this report makes no reference to Fukushima in any of its findings or conclusions. However, ONR has raised a GDA Issue which requires Westinghouse to demonstrate how they will be taking account of the lessons learnt from the events at Fukushima, including those lessons and recommendations that are identified in the ONR Chief Inspector's interim and final reports. The details of this GDA Issue can be found on the Joint Regulators' new build website www.hse.gov.uk/newreactors and in ONR's Step 4 Cross-cutting Topics Assessment of the AP1000[®] reactor.

EXECUTIVE SUMMARY

This report presents the findings of the Radioactive Waste and Decommissioning Assessment of the AP1000 reactor undertaken as part of Step 4 of the Health and Safety Executive's Generic Design Assessment. The assessment has been carried out on the December 2009 Pre-construction Safety Report and supporting documentation submitted by Westinghouse during Step 4.

This assessment has followed a step-wise-approach in a claims-argument-evidence hierarchy. In Step 2 the claims made by Westinghouse were examined, in Step 3 the arguments that underpin those claims were examined.

The scope of the Step 4 assessment was to review the safety aspects of the AP1000 reactor in greater detail, by examining the evidence, supporting arguments and claims made in the safety documentation, building on the assessments already carried out for Steps 2 and 3, and to make a judgement on the adequacy of the Radioactive Waste and Decommissioning information contained within the Pre-construction Safety Report and supporting documentation.

It is seldom possible, or necessary, to assess a safety case in its entirety, therefore sampling is used to limit the areas scrutinised, and to improve the overall efficiency of the assessment process. Sampling is done in a focused, targeted and structured manner with a view to revealing any topic-specific, or generic, weaknesses in the safety case. To identify the sampling for Radioactive Waste and Decommissioning an assessment plan for Step 4 was set-out in advance.

My assessment has focussed on:

- Whether the wastes that an AP1000 will produce have been identified in sufficient detail to underpin the subsequent assessments.
- The suitability of the plans put forward for short-term storage; and conditioning of the wastes for long-term storage and eventual disposal
- The suitability of the plans for long term storage of Intermediate Level Waste and spent fuel to show that this is safe and that the waste will be in a condition that would allow it to be transported for disposal.
- Whether the wastes that an AP1000 will produce are suitable for disposal.
- The plans for decommissioning an AP1000, to show that this can be achieved in a safe and environmentally acceptable way and that the wastes produced are suitable for disposal.
- The suitability of proposals for knowledge management over the lifetime of the facilities.
- The ability of Westinghouse to produce the Radioactive Waste Management Case for the AP1000, showing the safety proposals from cradle to grave.
- The Westinghouse plan for the development of waste management facilities to show that these can be developed in a timely manner.

A number of items have been agreed with Westinghouse as being outside the scope of the Generic Design Assessment process and are therefore not included in my assessment. For example, I do not require detailed designs for facilities not on the nuclear island.

For those facilities not on the nuclear island I need confidence, through the Generic Design Assessment process, that the spent fuel and waste can be safely stored and then retrieved, transported, and disposed of at the end of storage. Therefore the emphasis for these facilities is less on the specific design details and more on the evidence to show that there is a credible route.

For the waste facilities, Westinghouse has had to demonstrate that a licensee can safely handle, store and dispose of the wastes they generate. This requires sufficient levels of design to justify credibility of the storage options proposed; understanding how waste streams and their packaging evolve over the storage period; data and records management; knowledge of the constraints placed on the wastes by the disposal facilities; identification of knowledge gaps and the resulting research and development programme; and robust estimates of the required capacity.

As a result of my assessment Westinghouse has developed a credible waste management processes that could be used by a licensee to deal with the wastes produced by an AP1000. I encouraged them to work together with the Nuclear Decommissioning Authority's Radioactive Waste Management Directorate to show that these wastes could be disposed of in a Geological Disposal Facility. They have also undertaken additional work to show that there is sufficient flexibility in the design to allow the spent fuel storage facilities to address the requirements of long-term storage.

From my assessment, I have concluded that:

- Westinghouse have identified the typical wastes that an AP1000 will produce in sufficient detail to underpin the subsequent assessments.
- The size of the Waste Treatment Facilities proposed in the generic AP1000 design is too small to provide safe and environmentally acceptable short term storage options and subsequent conditioning for the wastes that an AP1000 is foreseen to produce. I have secured an undertaking from Westinghouse that new facilities, off the nuclear island, will be developed during site licensing. I consider this acceptable for Generic Design Assessment.
- The wastes can be conditioned and there is no reason to believe that the resulting products are not suitable for long-term storage and eventual disposal.
- The plans for long term storage of Intermediate Level Waste are similar to those used elsewhere in the UK nuclear industry.
- The design of the spent fuel storage facilities on the nuclear island should allow a licensee to address the needs of the long-term storage requirements so that spent fuel remains in a condition that would allow it to be transported for disposal. However, the size of the at-reactor spent fuel pool may constrict the licensee's flexibility and therefore early work will be needed to show how this could be addressed. The licensee will also need to continue to consider potential degradation mechanisms and periodically inspect the stored fuel to maintain confidence that it remains in a suitable condition.
- In the UK the Environment Agency issues the permits for the disposal of radioactive waste. I accept their advice that they foresee no reason why the wastes, likely to be produced by an AP1000, shouldn't be suitable for disposal.
- The plans for decommissioning an AP1000 are developed to a suitable level to show that this can be achieved in a safe and environmentally acceptable way and that the wastes produced are suitable for disposal. However, there remain a number of activities that will need to be undertaken prior to construction to show that the agreed plans are not inadvertently undermined.
- The licensee will need to develop a suitable system for knowledge management of the waste decommissioning information produced over the lifetime of the facilities.

- The Radioactive Waste Management Case Mapping Document for the AP1000 shows that Westinghouse proposals, from cradle to grave, are in sufficient detail to be confident that there are no foreseeable reasons why the waste cannot be managed safely.
- Westinghouse has produced the basis for a credible plan for the development of waste management facilities. The licensee will need to demonstrate that the activities can be realised in a timely manner.

In some areas there has been a lack of detailed information which has limited the extent of my assessment. As a result, the Nuclear Directorate will need additional information to underpin my conclusion and this is identified as Assessment Findings to be carried forward as normal regulatory business. The findings are listed in Annex 1. Examples include a requirement that the licensee shall identify the evidence necessary to underpin its spent fuel storage, transport and disposal strategy, the activities needed to secure this evidence and the time needed for these activities (AF-AP1000-RW-07); or the action that the licensee shall produce a Pre-construction Safety Report for the new waste management facilities (AF-AP1000-RW-06).

Overall, based on the sample undertaken in accordance with the Nuclear Directorate procedures, I am broadly satisfied that the claims, arguments and evidence laid down within the draft Pre-construction Safety Report and supporting documentation submitted as part of the Generic Design Assessment process present an adequate safety case for the generic AP1000 reactor design. The AP1000 reactor is therefore suitable for construction in the UK, subject to satisfactory progression and resolution of the additional information that becomes available as the Generic Design Assessment Design Reference is supplemented with additional details on a site-by-site basis.

I have identified no matters that need to be progressed as Generic Design Assessment issues.

LIST OF ABBREVIATIONS

ALARP	As Low As Reasonably Practicable
AGR	Advanced gas cooled Reactor
BAT	Best Available Technique
BMS	(Nuclear Directorate) Business Management System
BRIMS™	British Radwaste Information Management System
CoRWM	Committee on Radioactive Waste Management
DECC	Department of Energy and Climate Change
DfT	Department for Transport
DMD	Document Management Directory
EDMS	Electronic Document Management System
FDWMP	Funded Decommissioning and Waste Management Programme
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
HLW	High Level Waste
HSE	The Health and Safety Executive
IAEA	The International Atomic Energy Agency
ILW	Intermediate Level Waste
ISF	Interim Storage Facility
LLW	Low Level Waste
LoC	Letter of Compliance
MSL	Master Submission List
MDEP	Multinational Design Evaluation Program (OECD-NEA)
MRWS	Managing Radioactive Waste Safely
ND	The (HSE) Nuclear Directorate
NDA	The Nuclear Decommissioning Authority
NIA	Nuclear Industry Association
NII	Nuclear Installations Inspectorate
NPP	Nuclear Power Plant
NNL	National Nuclear Laboratory
NTG	Nuclear Topic Group
OECD-NEA	Organisation for Economic Co-operation and Development - Nuclear Energy Agency
ONR	The Office for Nuclear Regulation (formerly HSE Nuclear Directorate)
PCER	Pre-construction Environment Report

LIST OF ABBREVIATIONS

PCSR	Pre-construction Safety Report
PWR	Pressurised Water Reactor
RI	Regulatory Issue
RIA	Regulatory Issue Action
RO	Regulatory Observation
ROA	Regulatory Observation Action
RW&D	Radioactive Waste Management and Decommissioning
RWMC	Radioactive Waste Management Case
RWMD	The Nuclear Decommissioning Authority's Radioactive Waste Management Directorate
SAP	Safety Assessment Principles
SEPA	Scottish Environment Protection Agency
SSC	System, Structure and Component
SSM	Swedish Radiation Safety Authority
STUK	The Radiation and Nuclear Safety Authority of Finland
TAG	(Nuclear Directorate) Technical Assessment Guide
TQ	Technical Query
TSC	Technical Support Contractor
US NRC	Nuclear Regulatory Commission (United States of America)
WENRA	The Western European Nuclear Regulators' Association
WGWD	WENRA Working Group on Waste and Decommissioning

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1 INTRODUCTION

- 1 This report presents the findings of the Step 4 Radioactive Waste and Decommissioning (RW&D) Assessment of the December 2009 AP1000 Reactor Pre-construction Safety Report (PCSR) (Ref. 1) and supporting documentation provided by Westinghouse under the Health and Safety Executive's (HSE) Generic Design Assessment (GDA) process. Assessment was undertaken of the PCSR and the supporting evidentiary information derived from the Master Submission List (MSL) (Ref. 2). The approach taken was to assess the principal submission, i.e. the PCSR, and then undertake assessment of the relevant documentation sourced from the MSL on a sampling basis in accordance with the requirements of ND Business Management System (BMS) procedure AST/001 (Ref. 3). The Safety Assessment Principles (SAP) (Ref. 4) have been used as the basis for this assessment. Ultimately, the goal of assessment is to reach an independent and informed judgment on the adequacy of a nuclear safety case.
- 2 During the assessment a number of Technical Queries (TQ) and Regulatory Observations (RO) were issued and the responses made by Westinghouse assessed. Where relevant, detailed design information from specific projects for this reactor type has been assessed to build confidence and assist in forming a view as to whether the design intent proposed within the GDA process can be realised.
- 3 A number of items have been agreed with Westinghouse as being outside the scope of the GDA process and hence have not been included in this assessment, these are detailed in Section 2.4.6.

2 NUCLEAR DIRECTORATE'S ASSESSMENT STRATEGY FOR RW&D

4 The intended assessment strategy for Step 4 for the RW&D topic area was set out in an assessment plan that identified the intended scope of the assessment and the standards and criteria that would be applied (Ref. 5).

2.1 Background

5 The GDA process has been carried out against a background of continuing development of national policy in the area of Radioactive Waste and Decommissioning.

6 Low Level Waste (LLW) is routinely produced by UK industry and disposed of at the national near-surface disposal facility near Drigg in Cumbria. It is assumed that LLW from new build will be disposed of at this or a subsequent facility.

7 Intermediate Level Waste (ILW) is also produced by existing nuclear power stations during both operation and decommissioning. There is no existing disposal facility for ILW in the UK. So ILW arisings are conditioned at the reactor site into a passively safe form suitable for long-term storage.

8 Spent fuel from the Magnox and Advanced Gas-cooled Reactor (AGR) programmes have typically been reprocessed at Sellafield and the national strategy for spent fuel reflects this. But the UK Government has stated (Ref. 6) that consideration of new build should assume its ultimate disposal. Therefore throughout this report when discussing spent fuel it is assumed to be a waste, equally when discussing waste this includes spent fuel.

9 The UK Government has stated that it considers that it is technically possible and desirable to dispose of new higher activity radioactive waste in a Geological Disposal Facility (GDF) and that this would be a viable solution and the right approach for managing waste from any new nuclear power stations. The UK Government considers that waste can and should be stored in safe and secure interim storage facilities until a GDF becomes available.

10 The UK Government has committed (Ref. 7) through the Managing Radioactive Waste Safely programme (MRWS) to develop a GDF in the UK for higher activity wastes, including spent fuel. The Nuclear Decommissioning Authority (NDA), through its Radioactive Waste Management Directorate (RWMD) has been charged with leading the design implementation of the GDF and is subject to scrutiny by both Regulators as it develops the concept.

11 The timescale for the availability of a GDF for disposability of waste and spent fuel from a new build programme is inevitably an estimate which is subject to many parameters, but the RWMD has stated (Ref. 8) that it expects a GDF to be able to receive ILW and spent fuel from a new build programme by 2040 and 2075 respectively. The case for storage of ILW and spent fuel while adopting the consequential timescales as targets must also demonstrate an expectation that safety can be maintained beyond these dates should it be necessary.

12 In order to gain assurance that higher activity wastes from existing nuclear facilities can be accommodated in a GDF the Regulators and industry have developed the Letter of Compliance (LoC) protocol (Ref. 9). Assessments under the LoC process are undertaken at predetermined stages fitting in with the developer's 'stage gate' process, starting at the Concept stage, moving to an Interim stage before major contracts are placed, and then at a Final stage prior to active operations. For GDA RWMD has developed a specific approach to the disposability assessments, which apply those parts

of the LoC process that are relevant in the context of the GDA (Ref. 10). The results of RWMD's work have been submitted to the Regulators as part of the Westinghouse case.

- 13 The UK Government has also been developing a methodology to ensure that the cost of decommissioning does not fall to the taxpayer (Ref. 11). It is intended that operators will develop a decommissioning plan to allow the costs of decommissioning to be conservatively estimated, so that the UK Government can be assured that the funds for decommissioning are accrued during the operational lifetime of the plant. Decommissioning plans will be developed and refined over the lifetime of the plant taking account of operational history and the opportunity for direct measurements of some parameters rather than the conservative estimates made during the design process.
- 14 The timescale for the implementation of the decommissioning plan is likely to depend on a number of factors, including the availability of disposal routes and transportation logistics. For the purposes of GDA, Westinghouse have therefore been asked to detail the stages of decommissioning and their likely duration, recognising that there will be a need for review and revision as technology and policy develops

2.2 Assessment Plan

2.2.1 Strategy

- 15 The design and supply of a nuclear reactor normally includes the development of facilities for the short term management of spent fuel within the reactor building and space for facilities to manage other wastes. It is then the responsibility of the operator to develop the detailed plans for the processing and management of wastes. GDA placed a requirement on Westinghouse to develop these plans and show that they comply with all UK requirements. It should be noted that plans in the UK for disposal of wastes and the radiological classification system for radioactive wastes are different to other countries. Therefore all proposals need to be tailored to meet UK requirements.
- 16 At the start of the GDA process the Environment Agency published their *Process and Information Document* (Ref. 12) outlining its information requirements. This was supplemented in June 2009 by a joint position statement (Ref. 13) issued by the Environment Agency, Department for Transport (DfT) and ND outlining the level of design required on the waste plants in GDA.
- 17 At the start of the GDA the level of information presented by Westinghouse on the management of radioactive waste was limited. At the end of Step 3 the information developed by Westinghouse on the management of radioactive wastes produced by an AP1000 was at a level where meaningful assessment was possible.
- 18 So at the end of Step 3 (Ref. 14), I had completed a number of aspects of our assessment of RW&D. In the remaining areas there were two types of deliverable for assessment during Step 4, these were:
- Reports submitted towards the end of Step 3, when there was insufficient time to assess.
 - Reports and presentations that Westinghouse had committed to provide during Step 4.
- 19 I was also aware that the assessment of these deliverables could produce further TQs, ROs or RIs. I therefore developed the assessment strategy to increase the probability that these could be provided in time for my assessment in Step 4.

20 This approach has been successful. I have completed a meaningful GDA of the Westinghouse proposals for managing Radioactive Waste and Decommissioning for an AP1000. Therefore there are no outstanding issues. There are a number of findings that will be detailed within this report. These are in line with my expectations at the beginning of GDA and can be considered to be normal business that a licensee should address during construction and operation in the UK.

2.2.2 Co-ordination with Other Nuclear Directorate Assessment Areas

21 There were a number of areas where I needed to consult with other assessors as part of the RW&D Assessment process during Step 4. These areas were overseen by the Project Technical Inspectors in conjunction with Assessment Unit Heads to ensure that potential interactions were captured and that duplicate assessment work was prevented. The key interactions are discussed below.

22 Where there was overlap with other ND disciplines I initiated discussions on areas of common interests: these included the determination of As Low As Reasonably Practicable (ALARP), which involved a balance between worker doses, waste generation and disposal to the environment; and review of the reactor chemistry to balance the needs of ALARP and Best Available Techniques (BAT). I developed close working relationships with the radiological protection and reactor chemistry assessors. These relationships were reinforced with regular meetings and joint meetings with Westinghouse.

23 I gave regular updates to members of ND's Waste Management and Decommissioning Nuclear Topic Group (NTG) on progress of the RW&D Assessment. I asked for the input of the NTG on the development of a guide on good practice in PWRs to minimise radiation doses and radioactive waste, and new GDA guidance on the storage of spent fuel. Subsequently the NTG asked me to develop this later guide into a Technical Assessment Guide (TAG) for use across ND.

24 Where issues were broader than the NTG remit I consulted other ND experts. For example, I discussed spent fuel issues with ND's fuel specialist inspectors. This allowed me to ensure a consistent view was taken in GDA and to monitor the development of strategies to deal with spent fuel at operating UK sites such as Sizewell B.

2.2.3 External Dependencies

25 The principal external dependencies related to the source documentation identified and supplied by Westinghouse for the GDA process. Westinghouse also arranged a number of site visits to support the claims they were making.

26 I coordinated my assessment with the Environment Agency through a schedule of meetings and joint assessments. In 2010 the Environment Agency went out to consultation on their preliminary view of the GDA submissions. I supported this by informing the Environment Agency of the significant changes to my assessment subsequent to the publication of the Step 3 RW&D Assessment Report. Also the feedback from the Environment Agency on their consultation has informed my assessment of RW&D.

27 I continued to assess RW&D during the Environment Agency consultation. Therefore I continued to meet and work with the Environment Agency inspectors so they were aware of the results of my assessment. One specific area of joint interest was the ability to

dispose of the radioactive waste from the AP1000, I developed and implemented a joint plan for assessing this area with the Environment Agency (Ref. 5).

28 I worked with a number of international project teams on issues significant to waste management and spent fuel. This included STUK, the Radiation and Nuclear Safety Authority of Finland; the United States Nuclear Regulatory Commission (US NRC); and the independent Swedish Radiation Safety Authority (SSM).

29 GDA is an inclusive process involving the public. The public are particularly interested in Westinghouse's proposal for RW&D. A number of meetings have been held with ND and interested stakeholders present. These stakeholders have included the public; Non-Governmental Organisations; and learned bodies. The feedback from these meetings has informed my assessment of RW&D. (In particular the views expressed regarding potential difficulties of storing and disposal of high burn up fuel (Ref. 15) in response to the Environment Agency consultation).

30 The Committee on Radioactive Waste Management (CoRWM), is a group of independent experts appointed by UK Government to scrutinise plans for managing UK higher activity radioactive waste. Their remit includes wastes from new reactors. Meetings with CoRWM were held in late 2009 and early 2011. CoRWM published their views on new build wastes early in 2010 (Ref. 16); I used this publication to inform my assessment of RW&D.

2.3 Standards and Criteria

2.3.1 Safety Assessment Principles (SAPs)

31 The *Safety Assessment Principles for Nuclear Facilities* (Ref. 4) provide a framework to guide regulatory decision making in the nuclear permissioning process. It is supported by Technical Assessment Guides (TAG) which further aid the decision-making process. The principles of particular relevance to the assessment of RW&D are listed in Table 1.

2.3.2 Management of Higher Activity Radioactive Waste on Nuclear Licensed Sites

32 This is joint guidance (Ref. 17) between the Environment Agency, the Scottish Environment Protection Agency and HSE. It covers the management of higher activity radioactive waste on nuclear licensed sites. Westinghouse needs to show that they could comply with this guidance.

2.3.3 WENRA Waste and Spent Fuel Storage Safety Reference Levels

33 The objective of The Western European Nuclear Regulators Association (WENRA) is to develop a common approach to nuclear safety in Europe by comparing national approaches to the application of the International Atomic Energy Agency (IAEA) Safety Standards. The WENRA reference level report (Ref. 18) contains the results of the work of the Working Group on Waste and Decommissioning (WGWD) in the area of the safety for spent fuel and radioactive waste storage facilities.

34 Whilst the reference levels are generally reflected within our SAPs I have taken due cognisance of them within my assessment of RW&D.

2.3.4 IAEA Safety Standards

35 The IAEA Safety Standards (Requirements and Guides) were the benchmark for the revision of the SAPs in 2006 and are recognised by NII as relevant good practice. Whilst, it should be appreciated that they are safety standards rather than regulatory standards, I have used them in my assessment, where relevant

36 Of particular relevance were:

- Predisposal Management of Radioactive Waste Including Decommissioning, WS-R-2, IAEA, Vienna (2000), Ref. 65.
- Management Systems for Facilities and Activities, Safety Requirements, GS-R-3, Vienna (2006), Ref. 66.
- Storage of Spent Fuel, DS371 (in draft at the time of writing), Ref. 67.
- The process and methodology developed in the Safety Assessment Driving Radioactive Waste Management Solutions project.

2.4 Assessment Scope

37 The GDA process allows a rigorous and structured assessment of detailed safety, security and environmental aspects of the design of new build reactors. For GDA the design of the at-reactor fuel pool within the reactor building and the ILW processing facilities needs to be in sufficient detail to allow a fully detailed assessment. The joint ND and Environment Agency position statement on the RW&D assessment (Ref. 13) clarifies the minimum position for GDA so that the output is meaningful.

38 For waste management facilities on the nuclear island a typical detailed assessment would continue to be applied. For those waste management facilities not on the nuclear island I need confidence, through the GDA process, that the spent fuel and waste can be stored and retrieved, conditioned, transported, and disposed of at the end of storage. Therefore for these facilities the emphasis is less on the specific design details and more on the evidence to show that the chosen route is suitable. For the waste facilities, I need Westinghouse to demonstrate that they can safely handle, store and dispose of the wastes they generate. This will require sufficient levels of design to justify credibility of the storage options proposed; understanding how waste streams and their packaging evolve over the storage period; data and records management; knowledge of the constraints placed on the wastes by the disposal facilities; identification of knowledge gaps and the resulting R&D programme; and robust estimates of the required capacity.

39 When assessing RW&D I have chosen to consider the proposals under the following headings:

- Have Westinghouse identified all of the wastes that an AP1000 will produce?
- Does Westinghouse have suitable plans for conditioning of the wastes?
- Are there any safety issues with Westinghouse plans for short term storage?
- Are there any safety issues with Westinghouse plans for long term storage?
- Have Westinghouse shown that wastes are disposable?
- Can an AP1000 be safely decommissioned?
- Are there suitable proposals for knowledge management?

- Can a Radioactive Waste Management Case be produced for an AP1000?
- Is there a Credible Plan for the Development of Waste Management Facilities?

40 For each of these areas I considered spent fuel separately from other wastes. This is because spent fuel requires different means of managing its storage and disposal. Each of the areas is assessed separately in this report.

41 Finally it is noted that, as per reference 13, the security arrangements for waste and spent fuel in long term storage is not part of GDA and will be addressed when approving a Site Security Plan for any prospective new build site.

2.4.1 Findings from GDA Step 3

42 In undertaking my Step 3 assessment, I worked closely with the Environment Agency, the Department for Transport and the Office of Civil Nuclear Security to ensure that all significant waste arisings and discharge routes had been identified by Westinghouse, and that those wastes can be effectively managed. This was successful as I was able to share resources and co-ordinate feedback to Westinghouse.

43 At the end of Step 3 Westinghouse had:

- Identified all of the wastes that an AP1000 will typically produce.
- Confirmed there were no safety issues with their plans for the short-term storage of all wastes, except spent fuel (see below).
- Whilst arguments had been provided for spent fuel we required further clarification during Step 4.
- Provided detailed arguments for the safety of long term storage. Whilst I judge the reports showed that safe long-term storage was feasible I still required further evidence on specific aspects of the storage regime.
- Provided verbal assurance that the radioactive wastes produced by an AP1000 are suitable for disposal.

44 During the Step 3 assessment I did not identify any significant issues, or significant design or safety case changes that could impact on radioactive waste arisings or have a significant negative environmental impact.

2.4.2 Additional Areas for Step 4 RW&D Assessment

45 Using the set of questions detailed in Section 2.4, Assessment Scope, my Step 4 assessment built on the outputs of the Step 3 Report (Ref. 14). This included three specific aspects that were relevant to all six of the questions:

- the proposals for the management of records;
- the demonstration that RWMCs could be produced; and
- the production of a credible plan for the development of waste management facilities

46 The aspects that were considered for each of the six original questions are detailed below.

2.4.2.1 Have Westinghouse identified all of the wastes that an AP1000 will produce?

47 This was effectively completed as part of Step 3 when evidence was presented by Westinghouse showing they had identified all of the typical wastes that an AP1000 will produce.

2.4.2.2 Does Westinghouse have suitable plans for conditioning of the wastes?

48 The suitability of plans of Westinghouse for the conditioning of wastes was assessed during Step 4. My assessment considered whether the potential processes:

- were consistent with the requirements of the disposability assessment;
- created unnecessary waste;
- minimised the generation and accumulation of radioactive waste; and
- gave the licensee the ability to segregate and characterise ILW.

49 My assessment also considered proposals to send packaged ILW as LLW after a period of decay storage, and the management of spent fuel ancillary components.

2.4.2.3 Are there any safety issues with Westinghouse plans for short term storage?

50 In the AP1000 design the facilities for the conditioning of wastes also provide the short storage area for LLW/ILW. This had been considered during Step 3. However, I confirmed these findings during my assessment of conditioning.

51 For used fuel the AP1000 includes an at-reactor storage pool. The questions that I have specifically considered are:

- the implied storage requirements on the short term store from the long-term storage case;
- whether there is sufficient capacity in the pool to provide this storage; and
- the ability to inspect, retrieve and remediate waste and facilities.

2.4.2.4 Are there any safety issues with Westinghouse plans for long term storage?

52 During my Step 3 assessment I raised a number of questions about the long-term storage of wastes. Westinghouse provided the responses to these questions for assessment during Step 4.

2.4.2.5 Have Westinghouse shown that wastes are disposable?

53 This assessment was closely coordinated with the Environment Agency. They are responsible for disposability, which is reported in their report and not repeated here. I agreed with the Environment Agency to look at the following aspects during Step 4:

- An initial analysis to identify any significant issues and whether any information is missing.
 - A meeting with the RPs to present the findings from the initial analysis.
 - An assessment of the ability of the RPs to condition and store waste so that it is suitable for disposal.
-

54 I also provided an update on my assessment to the Environment Agency prior to their consultation.

2.4.2.6 Can an AP1000 be Decommissioned Safely?

55 I assessed Westinghouse's proposal for decommissioning during my Step 4 assessment.

2.4.3 Use of Technical Support Contractors

56 I have used a number of technical support contractors in the assessment of RW&D for the AP1000. These fall into two broad categories, those that have undertaken assessments for me, and those that have provided additional technical support.

57 I contracted React Engineering Ltd to support my assessment of decommissioning and Babcock Ltd to review the proposals for the Radioactive Waste Management Case (RWMC). The outputs of their assessments are reported in the main body of this report.

58 The provision of additional technical support has allowed my assessment to draw on a wider pool of knowledge. The contractors have considered the potential lifetime of spent fuel in long term storage; practices used in Pressurised Water Reactors (PWRs) and their affects on the wastes produced; the type of faults that have occurred when managing wastes on power stations, and a review of the published experience on decommissioning PWRs.

59 In 2009 I commissioned the National Nuclear Laboratory (NNL) to undertake a piece of work to identify those mechanisms that could lead to early failure of the fuel cladding or the fuel assembly during storage (Ref. 19). This work included:

- an identification of likely lifetimes for fuel cladding and the assembly for initial failure and chronic failure;
- identification of those factors that affect the lifetime of the cladding or assembly, supported by scoping calculations to indicate the scale of the effect;
- an initial review of the available literature and research to identify any areas of research that could identify other mechanisms that would affect the life of the cladding or assembly.

60 The conclusions of the NNL report for dry storage of fuel that had experienced a burn-up of 65GWd/tU were that:

- Clad creep should not lead to clad rupture if spent fuel assemblies are first cooled. NNL suggested that sufficient initial cooling should also allow dry storage without creep rupture, although the clad temperatures during assembly drying may be high enough to cause problems.
- Irradiation conditions will be borderline for the possible onset of radiation induced sensitisation in stainless steel, which could render the components vulnerable to attack by nitric acid (formed by radiolysis of moist air). However, the probability is that these conditions will not be met, and the likelihood of this mechanism occurring is therefore low.
- With respect to zirconium alloy components, the re-orientation into a radial geometry of zirconium hydride platelets formed during irradiation can lead to embrittlement or delayed hydride cracking, both of which can threaten component integrity. However, the probability of structural component failure by this means is considered low, and

NNL calculations indicate that cladding failure should be avoided given sufficient initial spent fuel cooling. It also acknowledged a risk during the initial cooling period that assembly drying temperatures may be high enough to cause problems.

61 The report also recognises that firmer conclusions on dry storage can generally only be drawn once dry storage and assembly drying systems are defined.

62 I had intended to involve Westinghouse in the development of the report. However, I decided that given other assessment activities associated with the design of the fuel refining these calculations further within GDA was not required (Ref. 20). Instead I have asked Westinghouse to consider the effects on the operation and decommissioning of the AP1000 of having to cool fuel in the at-reactor spent fuel pool for an assumed period of ten years.

63 The actual period that the fuel has to be cooled before it is placed into long-term storage will need to be derived on a site specific basis by the licensee. So I placed the following assessment finding:

AF-AP1000-RW-07: the licensee shall identify the evidence necessary to underpin their spent fuel storage, transport and disposal strategy, the activities needed to secure this evidence and the time needed for these activities. The provision of this evidence and associated activities will be detailed on a plan that will link the evidence needed with the construction activities for all on site facilities required to manage the spent fuel over its lifetime. The plan will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.

64 I commissioned Hyder Consulting (UK) Ltd, AMEC and Serco to review a number of standard practices used in PWRs around the world (Ref. 21). The aim of this work was not to identify best practice operations but to understand the implications of using the different practices.

65 The report they supplied examines:

- the nature of the radioactivity produced;
- the mechanisms by which it arises and is transported from its source of origin;
- how it is accumulated in plant systems, thus causing occupational dose;
- how it is treated (abated) prior to authorised discharge; and
- the resulting “solid” radioactive waste that is generated as a result of abatement processes.

66 In addition a number of technologies and procedures used to reduce dose and waste arisings were reviewed. These practices represent the worldwide nuclear industry’s technological developments and learned experience over many decades.

67 It is important to note that such technologies and procedures have been primarily developed to address worker dose issues on operating plant. However, many (but not all) of these practices provide wider benefits in reduced off-site discharges (and therefore, public dose) and in reduced volumes and activities of radioactive waste generation.

68 The technologies and procedures can be considered to fall into groupings of practices that aim to:

- minimise the radioactive source term in the first place;
- minimise the transport of the radioactive source material in the primary circuit;

- adoption of radiological protection practices to minimise worker dose uptake;
- methods of waste treatment;
- decontamination methods; and
- other technologies to replace entire large components.

69 Each of the top three groupings can add additional defence in depth with respect to minimising the radiation exposure of plant operators, while simultaneously reducing doses to the public and minimising waste volumes. For the lower two groupings, the operator radiation exposure reductions are typically traded off against potential higher discharges and increased waste arisings. Generally, it is through the use of technologies and procedures from all groupings that the greatest reductions in dose and, where applicable, waste arisings can be achieved.

70 I used this report to support my line of questioning in my assessment of RW&D for the AP1000.

71 AMEC have also produced a report correlating public concerns against specific industrial incidents (Ref. 22). In developing the report the public concerns were added to by AMEC's in-house experts. The enhanced list of issues was then compared with real data collated from the Joint IAEA/NEA International Reporting System for Operating Experience database to judge whether public concerns are borne out by the historical plant evidence, and also whether the industry has made improvements by reducing incidents over time.

72 A correlation was shown between 14 of the identified public concerns, specifically fuel handling and off-site discharges.

73 I have used this report to confirm that my assessment has addressed:

- key public concerns; and
- possible industrial incidents whilst managing radioactive waste and spent fuel.

74 I commissioned React Engineering to review publicly available information on previous reactor decommissioning projects in order to identify those aspects of decommissioning which were found to be particularly complex or challenging and conversely those that have consistently proven as straightforward or unproblematic to implement (Ref. 23).

75 Key findings from the review include:

- Spent fuel that remains in the at-reactor cooling pools will constraint dismantling and decommissioning operations.
- Segmentation of the reactor pressure vessel is a challenging aspect of reactor decommissioning.
- Remediation of contaminated land can prove to be a lengthier task than anticipated.
- Removal of components outside the reactor pressure vessel and building demolition activities have proven to be relatively straightforward to implement.

2.4.4 Interactions with other Assessment Topic Areas

76 The following interactions have been considered within this report:

2.4.4.1 The Design of the At-reactor Spent Fuel Pool

77 For irradiated fuel the AP1000 includes an at-reactor storage pool. In Section 2.4.2.3 I stated that the questions that I specifically considered in my assessment were:

- what are the implied storage requirements on the short term store from the long-term storage case;
- whether there is sufficient capacity in the pool to provide this storage; and
- the ability to inspect, retrieve and remediate waste and facilities.

78 I have assessed these aspects in conjunction with my fellow assessors, specifically the Civil Engineering and External Hazards Assessment (Ref. 24); the Fault Studies Assessment (Ref. 25); and the Radiological Protection Assessment (Ref. 26).

79 I note that each of these assessment areas has an outstanding issue (these are contained in each Annex 2 of Refs 24, 25 and 26) associated with at-reactor spent fuel pool. Therefore it is difficult, at this time, to conclude that there is sufficient capacity in the pool to provide the flexibility needed to meet the requirements of long-term storage.

80 After talking to my fellow assessors I do not believe that this aspect warrants a separate issue as the options available to address the outstanding issues all offer about ten years storage capacity. However, a licensee will need to expedite their plans for long-term storage of spent fuel, together with the research necessary to show how much the fuel has to be cooled before it placed into a long-term fuel store. I have therefore reflected this in the timings of Assessment Findings in Section 4.8.

2.4.4.2 Material Selection

81 As part of their assessment the Radiological Protection assessors have looked at the control of worker exposure to radiation due to activated corrosion product deposits within the primary circuit of the PWR (Ref. 26). This specifically considered the selection of materials which result in reductions in the use of cobalt, silver and antimony. This topic is of direct interest to RW&D as there is a correlation with the levels of activity within the waste (Ref. 21).

82 In many nuclear power plants (NPP), activated corrosion products in the primary coolant increase dose rates through activation of cobalt-59 to cobalt-60 in the Stellite™ content of hard facings, and activation of nickel-58 to cobalt-58 in inconel 690 alloys and some stainless steels; cobalt-58 and cobalt-60 typically account for over 80% of equivalent dose rates associated with the primary coolant.

83 In many NPPs, activated corrosion products in the primary coolant increase dose rates through activation of silver-109 to silver-110m in helicoflex seals, and activation of antimony-123 to antimony-124 in bearings, and these activated corrosion products contribute to worker exposure from the primary coolant.

84 The Radiological Protection Assessment (Ref. 26) expressed the opinion that the evidence to substantiate the arguments relating to radiation sources regarding information on the source term, and reductions in the source term through selection of materials associated with the primary circuit was suitable and sufficient.

85 The report also included the following finding:

- The licensee shall provide a report which demonstrates that the content of cobalt and other elements within primary circuit materials which may become activated and contribute significantly to operator radiation exposure has been reduced so far

as is reasonably practicable. The report shall take into account improvements that Westinghouse has identified, in addition to new materials which may have become available following the GDA process (Ref. 26).

86 Similar findings are recorded in the Mechanical Engineering Assessment (Ref. 27) and the Reactor Chemistry Assessment (Ref. 28).

2.4.4.2.1 Conclusions

87 As there is a correlation between the levels of activity in the primary circuit with those in the waste, I endorse the conclusions of the Radiological Protection Assessment and the associated findings.

2.4.4.3 Information on the Source Term

88 The definition and appropriate use of the source term is an important stage in understanding and deriving the safety requirements of any nuclear activity. This source term often takes the form of a radioactive inventory plus any other parameters relevant to that particular nuclear activity. In the PCSR, radioactive inventories are used in a number of different assessment areas, and radioactive inventories may be manipulated to address specific purposes. For example, in some areas worst case inventories may be used, whereas in others more realistic inventories are required.

89 This aspect has been the subject of a detailed assessment in the Radiological Protection Assessment Report (Ref. 26). The assessment concludes that the evidence presented satisfied the regulatory expectations regarding derivation of the source term, identification of assessments where the source term was used, use of the source term consistently across assessment areas, and use of the source term in specific assessment areas. No GDA assessment finding was identified.

90 For the RW&D assessment this is important as I want to know that the wastes I have assessed are consistent with the assumptions that Westinghouse has made elsewhere. In demonstrating a consistent approach Westinghouse has shown that there is no reason to believe that the wastes are not consistent with the assumptions made elsewhere.

2.4.4.4 The Suitability of the Liquid and Gaseous Waste Processing Systems

91 The solid waste process, assessed in my report is directly influenced by the proposals for the liquid and gaseous waste processing system. So far as is reasonably practicable discharges should be reduced. Generally this is interpreted as requiring the radioactive waste producers to concentrate and contain their radioactive wastes.

92 Figure 3, is a simplified flow diagram, produced by the Environment Agency, of the liquid and gaseous waste routes for an AP1000, it shows the relationship with the solid waste processing systems.

93 Section 4 of this report provides details of my assessment of the solid waste aspects. The assessment of the liquid and gaseous waste processing systems is a fundamental part of any RW&D assessment. Therefore it might appear anomalous that it is not considered directly within this report. The reason is that it is reported in a lot of detail in the Environment Agency's assessment and the Reactor Chemistry Assessment (Ref. 28). I have summarised the outcome of those assessments here and provided an overview of the outcomes.

2.4.4.4.1 The Environment Agency Assessment

- 94 The Environment Agency will grant permits for discharges from an AP1000. As part of their assessment process they have required Westinghouse to undertake BAT assessments of the quantity of radioactive waste produced by an AP1000 and for the subsequent abatement processes. I have mirrored the Environment Agency's assessment (Ref. 15) of this aspect, see Section 4.1.
- 95 For gaseous radioactive wastes the Environment Agency concluded (Ref. 15) that the AP1000 utilises the BAT to minimise discharges of gaseous radioactive waste:
- during routine operations and maintenance;
 - from anticipated operational events.
- 96 The Environment Agency also concluded that for some aqueous wastes the AP1000 has no suitable treatment technique. Westinghouse left the treatment of these wastes as a matter for future operators to determine.
- 97 The Environment Agency has also identified a number of findings that a licensee would need to address. These include requirements for further BAT assessments, on a site specific basis to show that discharges have been minimised and to provide a mass balance on the flow of carbon 14.

2.4.4.4.2 The Reactor Chemistry Assessment

- 98 Whereas the Environment Agency was looking at the suitability of the selected processes the Reactor Chemistry Assessment (Ref. 28) has considered the likelihood of the equipment operating as stated by Westinghouse.
- 99 For the gaseous waste systems the assessment concludes that the calculations for the gaseous waste systems appear conservative. The design is based on well proven and mature technologies with many years of experience in PWRs. The assessor is content that an adequate case has been made.
- 100 For the liquid waste systems the assessment concludes that the design uses well proven techniques for chemical treatment of the liquid wastes. The assessor is content with the design described from a reactor chemistry perspective.

2.4.4.4.3 Conclusions

- 101 The Environment Agency has identified that further information will be required from a future licensee on some aqueous wastes. Otherwise the Environment Agency and the Reactor Chemistry Assessments indicate that the liquid and gaseous waste processing systems for an AP1000 are broadly suitable. When a licensee is developing their operating regime it will be important to optimise the operation of these aspects. I have agreed with the Environment Agency and the reactor chemistry assessors that it is appropriate to capture this as a finding in my report. So:

***AF-AP1000-RW-04:** the licensee shall optimise the operation of the chemical volume control system and the liquid, gaseous and solid waste management processes to ensure that the risks associated with their operation and the management of the resulting wastes are as low as reasonably practicable prior to first fuel load.*

2.4.5 Integration with other Assessment Topics

2.4.5.1 Radiological Protection

- 102 Radioactive waste operations, decontamination and decommissioning typically involve a lot of operator intervention. Therefore these are of interest to me and the Radiological Protection assessors. So over the past eighteen months I have been working very closely with them.
- 103 This is an efficient and effective approach as there are a number of similar but distinct lines of enquiry. For example waste handling tends to be a relatively high dose activity. With both disciplines working together we are sure that all aspects are covered and that Westinghouse is asked one set of questions relative to both disciplines.
- 104 In this case close working means running joint intervention plans; raising joint technical queries and regulatory observations, holding joint meetings with Westinghouse and undertaking a number of benchmarking visits. My Technical Support Contractor (TSC), React Engineering, has been undertaking a number of these assessments on behalf of the Radiological Protection assessors and myself.
- 105 An overview of where we have worked together is provided below. The specific outputs of our assessments are detailed in our individual assessment reports.
- 106 Radioactive Waste Operations: These are typically labour intensive as waste is sorted and conditioned for disposal. Whilst the background doses may be low the associated collective dose can be some of the largest for a site. Working together has allowed us to examine the balance between the benefits in waste minimisation, segregation etc, and the associated dose. In GDA the Radiological Protection assessors and I have looked in a lot of detail at the operations carried out in the waste management facilities. We have also noted that there will be joint interest in the movement of fuel. However, this has been identified, primarily as a site specific issue (Ref. 13) so there has not been so much scrutiny by us.
- 107 One area of our joint assessment is the design, layout and operation of the Waste Treatment Building. We arranged a series of benchmarking visits to international sites to see how these types of facilities are operated, see Section 3.9.
- 108 Benchmarking is a significant aspect of the assessment as both radiological protection and radioactive waste can be affected by the decisions taken by the operators, irrespective of the basic plant design. Benchmarking provides the Regulators with the assurance that there are radioactive waste management techniques that can be operated in a safe and environmental aware manner.
- 109 Through these interactions we have identified the size of the Waste Treatment Building associated with the AP1000 as too small. Through our interactions with Westinghouse we have been able to agree that this does not have to be a GDA issue as they will design alternative facilities, off of the nuclear island to accommodate all of the waste operations for any future site. This is a practicable approach because for the sites identified in the UK more than one AP1000 would be constructed at each. Therefore combined waste management facilities for all of the plants would be provided. This requirement is captured as an Assessment Finding (**AF-AP1000-RW-06**), this has been developed with the radiological protection assessors, see Section 4.2. Westinghouse was able to show the suitability of this approach during the benchmark visit they arranged for us.
-

- 110 Decontamination: This covers a range of activities. It includes major primary circuit decontamination, cleaning of spills, general housekeeping and the operation of the laundry.
- 111 For operations the radiological protection assessors are interested in the doses associated with the installation, operation, dismantling and maintenance of decontamination equipment. I am interested in the ability to decontaminate and the wastes produced by the decontamination process.
- 112 A similar approach is taken for decontamination during decommissioning. However, there is likely to be a very aggressive decontamination process on the active circuits prior to any decommissioning. So we are also interested in the residual activity after this specific decontamination process as it is a significant influence on the overall doses from the decommissioning activities and the quantities of Intermediate Level Waste (ILW) and Low Level Waste (LLW) produced.
- 113 Decommissioning: This covers all of those activities that occur after the reactor ceases operation. The radiological protection assessors and I are interested in the ability to safely decommission the reactor. We are specifically interested in those areas that could lead to the need for direct operator action in a high dose area.
- 114 Our joint regulatory approach has meant that Westinghouse has been able to provide one submission for each of decommissioning and decontamination that adequately addresses the concerns raised by each topic.

2.4.6 Out of Scope Items

- 115 The joint position statement on the RW&D assessment (Ref. 13) clarifies the minimum position for GDA so that the output is meaningful and without exclusions. For those facilities not on the nuclear island we sought confidence, through the GDA process, that the spent fuel and waste can be retrieved, transported, and disposed of at the end of storage. Therefore we did not require detailed designs, but required evidence to show that the chosen route is suitable.
- 116 Westinghouse has supported this evidence by a detailed plan showing when waste management facilities will be developed, see section 3.8. It should be noted that whilst it was the responsibility of Westinghouse to develop this plan it is for the licensee to implement the plan.

3 WESTINGHOUSE'S SAFETY CASE

3.1 Introduction

117 This section provides a high level overview of the safety case for RW&D put forward by Westinghouse. As such it contains no assessment or judgement by me, this can be found in Section 4.

118 Westinghouse has provided me with a number of documents to show that RW&D can be managed safely. Figure 2, taken from this documentation, outlines the waste processes for solid waste for an AP1000. The activities shown are covered in the discussions below.

119 The reactor is the source of the radioactive material in the waste. In the safety documentation it is assumed that the reactor operates for 60 years. Over this period the documentation includes arguments that the generation of waste is avoided. Where waste is generated the quantity will be minimised and, where practicable segregated at source. In addition Westinghouse has provided evidence that there is a disposal route for all waste generated.

120 The AP1000 includes an at-reactor spent fuel pool and ancillaries designed to allow the safe receipt of fresh fuel, transfer into the reactor, transfer out of the reactor, management in the pool during reactor shutdown, storage prior to dispatch to the long term store and dispatch to the longer-term store. This facility will have a longer operating life than the reactor as it is used to receive fresh fuel before the start of reactor operations and will be used to store spent fuel from the end of reactor operations prior to dispatch to a longer-term storage facility.

121 The Radwaste Building will house the processing and packaging systems for operational wastes, other than spent fuel. The processing and packaging system is based on proven and internationally recognised technologies. The waste is processed into standard packages for safe handling. The Radwaste Building includes a buffer store for wastes prior to processing. After processing ILW waste is dispatched to an on-site, interim long-term store and LLW dispatched to a disposal facility.

122 An ILW storage facility will be provided that allows waste packages to be retrieved, inspected and, if necessary, refurbished. The storage facility will be designed to allow it to be maintained. At the end of the storage period the waste packages will be sent for disposal. The type of disposal will be dependant upon the waste package's level of radioactivity at the time of disposal.

123 For spent fuel Westinghouse propose the use of the Holtec HI-STORM 100U spent fuel storage system for long-term on-site storage. At the end of the storage period the spent fuel will be prepared for, and then dispatched to, a geological disposal facility.

124 As identified in Section 2.4 I have looked at nine different aspects of the Westinghouse safety submission. The rest of this section discusses the Westinghouse safety submission relevant to each of these aspects.

3.2 The Identification of the Wastes that an AP1000 Will Produce

125 Westinghouse detail the potential waste arisings for an AP1000 over a number of documents, these are outlined below.

- 126 In support of their *AP1000 Integrated Waste Strategy document* (Ref. 29) Westinghouse has produced a BAT report (Ref. 30). The objective of this report is to provide assurance that the AP1000 design meets the requirement for application of BAT.
- 127 The evidence provided in the BAT report (Ref. 30) includes the following information:
- Identification of those AP1000 systems that are designed and standardised and those subject to ongoing design (for example, radwaste treatment system).
 - A description of the history of AP1000, the alternative techniques that were considered during development and the improvements made to aid the BAT justification.
 - An inventory of each significant waste stream
 - The abatement technologies, process control, monitoring techniques, and management techniques used to prevent or minimise releases.
 - BAT forms for key radionuclides to demonstrate that the AP1000 design makes comprehensive use of the best techniques for prevention, minimisation, and abatement of radioactive emissions and discharges.
 - A description of the methodology being applied to the radioactive waste systems.
- 128 A small number of radionuclides are identified as significant and have been assessed in detail by Westinghouse. These are tritium, carbon-14, nitrogen-16, strontium-90, iodine-131, caesium-137, plutonium-241, noble gases and beta particulates.
- 129 For the specific radionuclides identified more detailed information has been provided in "BAT forms". These contain information on:
- The source of the radionuclide and the process in which it is produced;
 - The source activity including the design basis and the realistic source term;
 - The techniques for minimisation at source (optioneering) where screened options are scored against the listed criteria to justify that the chosen option(s) is BAT;
 - The downstream abatement techniques, identifying the options considered and the reason for the chosen option.
 - The normal and maximum emissions for gases and liquids;
- 130 Figure 1 reproduces Table 4-6 from the BAT assessment (Ref. 30). The table summarises the main solid radioactive waste produced by the AP1000.
- 131 Westinghouse assert that the information presented demonstrates that the Best Available Techniques are being applied in the design of the AP1000 to minimise radioactive wastes at source and to minimise the impacts of the disposal of wastes into the environment.
- 132 The *UK AP1000 NDA Data Sheet Submission* (Ref. 31) contains all the datasheets provided to the RWMD to allow them to perform the Disposability Assessment for the waste generated by an AP1000.
- 133 Westinghouse also acknowledge that the data provided to the RWMD represented the best information available at the time of issue. Subsequently further data became available and was used for other aspects of the AP1000 GDA submission. Because the more recent data represented a general improvement in expected waste characteristics, e.g. reduced activity, the data provided to RWMD represented a bounding case.
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134 The process mass balance for AP1000 solid waste (Ref. 32) provides a comprehensive calculation of the number of waste packages that the AP1000 will produce.

135 Westinghouse has also provided evidence to show that the calculations about the wastes produced by an AP1000 are consistent with other source terms used in the design. Their response to regulatory observation RO-AP1000-083 (Ref. 33) details the control of the source term, consistency and its derivation.

3.3 Westinghouse Plans for Conditioning and Storage of the Wastes

136 The documentation provided by Westinghouse covers all of these areas, therefore they are discussed together here.

137 Westinghouse has produced the draft of Chapter 26 of the AP1000 Pre-construction Safety Report (Ref. 34). This shows that the wastes arising from the proposed generic design and management of the AP1000 design pose no unacceptable risks. Whilst I have not performed an assessment of the final version of the chapter I recognise that the draft document represents a good overview of Westinghouse's arguments, these are outlined below.

138 The chapter starts with a summary of the AP1000 Waste Management Facilities and then outlines the Radioactive Waste Management Strategy. Some general information on discharges to air and water is followed by detailed descriptions of the systems for processing gaseous, liquid and solid wastes, including their discharge or disposability. Having described the systems, their responses to external and internal hazards are collated. A brief description of record-keeping is followed by their overall conclusions. These are:

- Westinghouse has produced an Integrated Waste Strategy (Ref. 29) to address the radioactive wastes and spent fuel produced by the AP1000 plant, which is appropriate for the assessment of a generic design.
- The wastes may be contained and cooled where necessary.
- Gaseous and liquid radioactive waste may be handled safely, with discharges that are ALARP.
- Solid radioactive wastes may be handled safely.
- As far as can be ascertained during a GDA, all wastes are or will be disposable.
- BAT (Ref. 30) is used throughout.

3.3.1 Operational Wastes, Other Than Spent Fuel

139 Westinghouse has produced the *UK AP1000 Radioactive Waste Arisings, Management and Disposal document* (Ref. 35), to demonstrate how the Solid Waste Management Strategy is to be implemented.

140 The report details the functional requirements of the Radioactive Waste Management facilities that are proposed to support the AP1000. A description of the design selection processes undertaken to date and a basis for further development of the engineering design and safety case of the waste management facilities are also provided.

141 The *Radwaste Treatment Options Study Report* (Ref. 36), focuses on the treatment of solid waste specifically ILW Ion Exchange resins, ILW filter bed media and LLW mixed general wastes. The report documents all options considered and describes the

systematic approach taken to then produce a shortlist of viable candidate options and ultimately through a detailed analysis to arrive at the recommended reference design option.

142 The report recommends that:

- Compaction is adopted as design option for the treatment of LLW.
- Cement Encapsulation is adopted as the reference design for predisposal treatment of ILW.
- A plan is developed to undertake development work during the post GDA design stage to address the particular issues associated with dimensional stability of organic resins and thereby underpin the acceptability of the cemented ILW product for long term disposal.
- The design proposals are to be flexible where possible to maximise the potential to accommodate a change in process technology in the event that techniques that are more beneficial in waste volume reduction performance e.g. Vitrification or Controlled Oxidation become proven for application to the waste streams considered.

143 The *UK AP1000 Radioactive Waste Management Case Evidence Report for Intermediate Level Waste*, UKP-GW-GL-055 (Ref. 37) addresses the intermediate level waste (ILW) stream arising from AP1000 operation, maintenance, and eventual decommissioning. It is discussed in more detail in Section 3.8.1.

144 The *UK AP1000 Radwaste Preliminary Safety Statement* (Ref. 38) provides a justification, in principle, of the safety of the proposed designs and processes for handling the LLW and ILW, and demonstrates that the safety criteria will be achieved. The document presents the hazard management strategies, preliminary fault schedule, and preliminary hazard analyses. In addition, it presents the optioneering, demonstrates that the most practicable options have been selected, and highlights any significant outstanding issues.

145 The response to Regulatory Observation RO-AP1000-74, actions A1 to A3 (Ref. 39) discusses the treatment, storage and disposal options for a range of ILW. It also discusses the information needed to underpin the performance of the waste packages and the storage system and how this information can be obtained. Finally the report looks at the maintenance of the storage system.

146 Westinghouse's response to our Regulatory Observation RO-AP1000-86 (Refs 40 and 41) provides an overview of the radioactive waste management facilities. The first part of the response (Ref. 40) presents details about radioactive waste management activities and facilities in the AP1000 plant. It describes the activities, showing their expected locations, and describing some of the related considerations included in the development of the AP1000 design. Westinghouse state that the information provided demonstrates that the current AP1000 layout represents an optimum solution balancing space, efficiency, flexibility, cost, minimization, and simplification. Each of the layouts described reflects significant design input and iteration, including multiple meetings and workshops between Westinghouse, relevant design partners, interested utilities, and AP1000 customers.

147 The second part of the response (Ref. 41) builds on the statements made in the first part and addresses the concerns of the Regulators raised in a meeting in Pittsburgh in August 2010.

148 Both parts of the response (Refs 40 and 41) state that the Radwaste Building footprint and layout may change during specific site detail design, once an exact radioactive waste handling regime has been agreed. It is also noted that the owning utility may choose to increase the building size or embrace a contractual radioactive waste management system.

3.3.2 Spent Nuclear Fuel

149 The response to Regulatory Observation RO-AP1000-74, actions A1 to A3 (Ref. 39) discusses the use of the Holtec HI-STORM 100U spent fuel storage system, which consists of:

- the HI-STORM 100U underground vertical ventilated module;
- the fuel assembly multi purpose transfer flask; and
- the HI-TRAC transfer flask.

150 The report also discusses the information needed to underpin the performance of the spent fuel and the storage system and how this information can be obtained. Finally the report looks at the maintenance of the storage system.

151 The *UK AP1000 Radioactive Waste Management Case Evidence Report for High Level Waste*, UKP-GW-GL-056 (Ref. 42) addresses the High Level Waste (HLW) stream arising from AP1000 operation, maintenance, and eventual decommissioning. It is discussed in more detail in Section 3.8.2.

152 Westinghouse has submitted two papers to support their claims that fuel can be encapsulated for disposal, these are summarised below.

153 *Disposal of Spent Fuel from German Nuclear Power Plants – Paper Work or Technology?* (Ref. 43) states that the technical features for the direct disposal of spent fuel from German nuclear power plants have been thoroughly investigated and a reference concept has been established. Facilities are in operation or could be operated from the technical point of view.

154 *Encapsulation: When, where, how and why?* (Ref. 44) is an SKB publication about the Swedish proposals for encapsulating spent fuel prior to disposal. It covers the encapsulation process, the requirements placed on the design and operation of the encapsulation plant and quality inspection to be certain there are no defects that could jeopardize safety

155 Other aspects of short term spent fuel storage are dealt with elsewhere, see Section 2.4.4.

3.4 Westinghouse Proposals for the Disposal of the AP1000 Wastes

156 Westinghouse has worked closely with the Nuclear Decommissioning Authorities Radioactive Waste Management Directorate (RWMD) on the disposability of the wastes from an AP1000. The work undertaken by RWMD was against their published specification (Ref. 10).

157 As stated in Section 2.1, Background, the UK Government has stated (Ref. 6) that consideration of new build should assume that spent fuel is sent for direct disposal. It has therefore been included in the analysis of disposability performed by Westinghouse in conjunction with RWMD.

3.4.1 Operational Wastes, Other Than Spent Fuel

158 In the UK the Environment Agency issues the permits for the disposal of radioactive waste. They have assured me, based on the information contained in reference 45, that the LLW produced by an AP1000 can be disposed of.

159 All of the ILW identified in Section 3.2 has been assessed by RWMD for its suitability for disposal in a Geological Disposal Facility (GDF). RWMD's detailed response was provided to Westinghouse in their disposability assessment of solid waste arisings from new build (Refs. 46 and 47). A public summary of the disposability assessment is provided in (Ref. 48), which is available on the NDA's website.

160 Westinghouse has reviewed the disposability assessments produced by RWMD (Ref. 49) and confirmed their acceptance of the findings. A further report on the disposability of the spent fuel and ILW was provided in February 2010 (Ref. 35). This report identifies when the outputs from the disposability assessment will be addressed.

3.4.2 Spent Nuclear Fuel

161 The reports identified for the operational wastes also cover the spent fuel produced by an AP1000.

162 In addition I have a copy of the published report produced for the Nuclear Industry Association (NIA) by RWMD (Ref. 50). This looks at four aspects of spent fuel management:

- a centralised storage facility;
- a centralised packaging plant;
- alternative cask types;
- alternative disposal concept options which are optimised for spent fuel from new nuclear power stations.

163 It discusses the implications of adopting the approaches; noting that the studies have been pitched at a high level and further work is needed to develop the options.

3.5 Decommissioning

164 The *AP1000 Decommissioning Plan*, UKP-GW-GL-795 (Ref. 51) provides Westinghouse's suggested approach to decommissioning. This is discussed in the following sub-sections.

3.5.1 Principles Underpinning the Design

165 The report outlines a number of areas where the principles that underpin the AP1000 design are discussed. These areas include: minimising the generation of radioactive waste; preventing the spread of contamination; ALARP; BAT; operation and maintenance; plant modification; skills and training; radiation risk reduction; minimisation of discharges during decommissioning; passively safe storage of ILW and HLW; learning from experience; plant design; decontamination; shielding and ventilation; working area and personnel monitoring programmes; and design features supporting decommissioning.

- 166 The AP1000 specific design features which facilitate decommissioning are identified as:
- Separation of radioactive and non-radioactive equipment and minimisation of radioactive systems.
 - The modular design and construction allowing modules to be removed in a similar manner to the way that they were installed. However, some segmentation of the modules may be required to facilitate lifting operations due to the additional weight of concrete added during the construction process.
 - The polar crane structure has sufficient capacity to handle heavy equipment with the addition of a larger capacity hoist module. In addition, the polar crane can accommodate the upper assembly of the steam generators between the girders.
 - Where practicable, floor slabs have been designed to support the weight of equipment during the decommissioning process.
 - The plant layout ensures as far as possible, that there is space to remove whole plant items and modules. Laydown areas have also been provided for protecting and wrapping potentially contaminated equipment prior to transportation to the site decontamination and sorting facility(s).
 - Access routes for equipment have been considered in the design. Routes are available through equipment hatches and temporary access through the steel containment is easily provided and controlled.
 - The design facilitates sampling during the decommissioning process.
 - Specific equipment at the lower levels has been provided with removable shielded hatch covers; for example, CVS demineralisers.
 - Removable gratings have been used for floors to facilitate the transport and handling of equipment.
 - The design allows sections of plant to be isolated and decommissioned independently of others where appropriate. In particular service systems will be provided with isolation valves to allow areas to be decommissioned and taken out of service without affecting ongoing service supplies needed elsewhere.
 - The plant electrical power distribution has been arranged with decommissioning in mind. Prior to decommissioning, a new electrical supply to the ILW store will be installed which will also supply the Radwaste building. This will allow the main nuclear island to be dismantled whilst retaining the use of the Radwaste building.
 - All sumps are plate lined, welding is minimised and surfaces treated to limit crud retention.
- 167 The report also recognises that decommissioning will also be facilitated through the use of modelling to optimise dismantling tasks and through the incorporation of lessons learned and best available techniques.

3.5.2 Decommissioning Logistics

- 168 Westinghouse details the steps involved in decommissioning an AP1000, these are:
- Stage 1
 - Removal of fuel from the reactor to interim storage.
-

- Cleaning, decontamination, and surveying of all areas to facilitate dismantling and removal from site of all readily removable radioactive items.
- Preparation for the chemical decontamination of active circuits.
- Decontamination of active circuits.
- Establishment of new radiation control areas based on the above actions as work progresses.
- Demonstration that radioactive waste systems are in working order for use during decommissioning.
- Stage 2
 - Conversion of fuel handling building into an interim waste storage, decontamination, waste reduction, packaging, and processing area for ILW.
 - Component removal to the interim storage areas of all active equipment with the exception of the reactor pressure vessel and the internals. The concrete and steel shield will remain in place.
 - Radiation and security controls.
- Stage 3
 - Removal and dismantling of the reactor pressure vessel and internals.
 - Cutting, processing, and removal of active and clean concrete in the containment vessel and fuel handling building.
 - Dismantling of the containment vessel and shield building.
 - Dismantling of the auxiliary building.
 - Dismantling of the temporary waste facilities.

169 The report discusses the shielding issues associated with decommissioning and the use of remote operations. It puts forward arguments that the sequence can be seen to be a logical one that leads to a progressive reduction in hazards, does not foreclose options and is feasible. The section concludes with a strategy for the safety systems.

3.5.3 Timings of Decommissioning

170 Westinghouse set out their baseline assumption that an AP1000 will be promptly decommissioned.

3.5.4 Hazards and Challenges

171 The report provides details on the Hazards and Challenges expected to be met during the decommissioning of the AP1000. Details are first provided of the Westinghouse experience of decommissioning. The significant radiation, industrial and toxic hazards are identified.

172 The report discusses the areas where the greatest risks are likely to be encountered; the means of identifying the risks; and the control measures that can be put in place to control the risk.

173 The section on remote or manual handling gives reasons why a licensee may want to use robotics and the areas where robotics are likely to be used. It also identifies that small low dose items would be removed manually.

3.5.5 Status of Plant Prior to Decommissioning

174 Westinghouse assumes that the AP1000 will be decommissioned immediately after operation. All necessary support facilities (e.g. power, utilities, cooling, shielding, ventilation systems, effluent treatment, drainage, security etc.) would be operational and maintained. Nuclear fuel would be present in the reactor and the at-reactor spent fuel pool. There would be some LLW, ILW and spent fuel generated during normal plant operations present in their dedicated storage locations on-site. Chemical inventories on-site would be at low levels and tanks would contain residual unused chemicals. Some accumulation of potentially radioactive corrosion products is expected in the radioactive water systems.

175 It is recognised that the first activity will be to characterise the plant condition in terms of chemical, physical and radiological condition. As many facilities would have radioactive, hazardous or mixed wastes the characterisation gives an important insight into the handling of these and the actions to ensure efficient and timely disposal.

176 The management activities prior to closure are also discussed.

3.5.6 Disposability Assessment

177 The report identifies that the wastes from decommissioning will be either: large volume components; small volume components; or material from the demolition of plant modules. The processes for dealing with these wastes include:

- Immobilisation in cementitious grout within a 3m³ RWMD approved box.
- Compaction (possible super compaction) into a 200l drum and placed into HHISO container.
- Placement in “baskets” in a RWMD approved box (possibly grouted).
- Monitoring and swabbing (over period of time) with potential cleaning / decontamination or size reduction.
- Size reduction and placement in HHISO.
- Collection in 200l drum.

178 After conditioning the waste can either be sent for:

- Storage in site ILW store until UK repository becomes available.
- Transportation to LLW repository.
- Recycle or free issue (release/clearance from regulatory control).

179 An overview of the processes for handling spent fuel, ILW and LLW is provided. The sensitivity of these processes to the waste form, the volume and decontamination are discussed.

3.5.7 Decontamination

180 Decontamination will be used to reduce the contamination levels of materials. Wastes will be segregated into different types to allow use of different decontamination routes. The majority of the waste arisings from the decommissioning of small and large volume components will undergo swabbing / monitoring to determine their activity and, if necessary, would be subject to decontamination. This could be repeated if necessary.

181 Prior to demolition, reactor building structural modules would be monitored to assess the contamination levels of the steel and concrete and, if necessary decontaminated. This will be aided by the use of concrete walls with decontaminable coating and steel surfaces with surface finishes that will prevent penetration of contamination. The response to TQ-1097 (Ref. 52) indicates that only one module is likely to be activated; it should be possible to dispose of this as LLW.

3.5.8 Use of BAT and Waste Management Hierarchy in Decommissioning

182 The *AP1000 Decommissioning Plan*, UKP-GW-GL-795 (Ref. 51) includes the commitment to select decontamination techniques to minimise the waste produced and to reduce the radiological waste classification during decommissioning.

3.5.9 Decommissioning Plans and Programmes

183 The annex to the Decommissioning Plan (Ref. 51) provides a detailed breakdown of the decommissioning activities. The activities are broken down into a number of work packages which relate directly to the various AP1000 systems being decommissioned. An example of a sequence for these work packages is provided and an overview of the main activities described.

3.6 Knowledge Management

184 Westinghouse's response to TQ-AP1000-906 (Ref. 53) describes the processes and systems for creation, identification, protection, retention, retrieval, and disposition of Westinghouse records.

185 On record types and retention the document details the Document Management Directory (DMD), a comprehensive, on-line index of record types, and its predecessor the Records Flow Schedules.

186 It details the Electronic Document Management System (EDMS) for the long term storage of business and quality records. Westinghouse also maintains quality and business records in hard copy and microfilm format.

3.7 The Radioactive Waste Management Case

187 Westinghouse has produced two cases, one for operational wastes other than spent fuel and the other for spent fuel. These are dealt with separately below.

3.7.1 Operational Wastes, Other Than Spent Fuel

188 The *UK AP1000 Radioactive Waste Management Case Evidence Report for Intermediate Level Waste*, UKP-GW-GL-055 (Ref. 37) demonstrates that a suitable Radioactive Waste Management Case (RWMC) could be prepared by the licensee. The report presents a

series of statements plus references to supporting information. Westinghouse notes that the report is not an RWMC; rather, it is a key to the information required to produce the RWMC.

189 UKP-GW-GL-055 (Ref. 37) addresses the intermediate level waste (ILW) stream arising from AP1000 operation, maintenance, and eventual decommissioning. It also aims to identify the interdependencies between the major documents that will be issued as part of the GDA process to support the RWMC and to identify where additional detail is needed and how this additional detail will be developed (for example, during detailed design).

190 UKP-GW-GL-055 (Ref. 37) concludes that the evidence provided is consistent with the level of detail required at this stage of the GDA. It outlines some areas where additional development work or research is required to adequately fulfil the information requirements. However, Westinghouse state that these do not impact on the current status of the design, and are issues that will be resolved through the natural progression of the detailed design of the facilities.

191 Westinghouse believes that there is sufficient information to allow licensees to produce a detailed RWMC for ILW during the site licensing phase.

3.7.2 Spent Nuclear Fuel

192 The *UK AP1000 Radioactive Waste Management Case Evidence Report for High Level Waste*, UKP-GW-GL-056 (Ref. 42) demonstrates that a suitable Radioactive Waste Management Case (RWMC) could be prepared by the licensee. Like the ILW report it presents a series of statements plus references to supporting information. Westinghouse notes that the report is not an RWMC; rather, it is a key to the information required to produce the RWMC.

193 UKP-GW-GL-056 (Ref. 42) addresses the high level waste (HLW) stream arising from AP1000 operation, maintenance, and eventual decommissioning. It also aims to identify the interdependencies between the major documents that will be issued as part of the GDA process to support the RWMC and to identify where additional detail is needed and how this additional detail will be developed (for example, during detailed design).

194 UKP-GW-GL-056 (Ref. 42) concludes that the evidence provided is consistent with the level of detail required at this stage of the GDA. It outlines some areas where additional development work or research is required to adequately fulfil the information requirements; however, these do not impact on the current status of the design, and are issues that will be resolved through the natural progression of the detailed design of the facilities.

195 Westinghouse state that in relation to HLW storage and disposal, there is confidence in coping with the long-term storage requirements without major technical issues. Their confidence is built on the extensive industrial experience gained in spent fuel storage, and especially on the recent development of dry storage systems. Quoting IAEA TECDOC-1532 (Ref. 54) the report states that storage in canisters under inert conditions is now the preferred option for away from reactor HLW storage, giving advantages such as passive cooling features and a modular mode of capacity increase.

196 Westinghouse believes that there is sufficient information to allow licensees to produce a detailed RWMC for HLW during the site licensing phase.

3.8 The Plan for the Development of the Waste Management Facilities

- 197 *The Long Term Storage of AP1000 ILW and Spent Fuel in the UK* (Ref. 39) presents a plan that has been produced by Westinghouse to provide a potential credible work programme that a licensee could utilise to demonstrate disposability through the life of the power station. In producing the plan Westinghouse have held discussions with licensees and the Nuclear Decommissioning Authority's Radioactive Waste Management Directorate (RWMD); an informal review of the draft response was performed by RWMD to provide confidence in the validity of the content.
- 198 The plans presented in the report map the stages in the Letters of Compliance against the stages in the development of the site; the safety case and the underpinning research. The research and actions associated with the development of the waste management strategy is tabulated. The report presents a high level hazard analysis of spent fuel storage as a starting point for a much more detailed hazard study to be performed by the licensee during the design phase of the storage facilities. Westinghouse have also provided an indication of how maintenance and utility services will be incorporated into the ILW and spent fuel facilities
- 199 The report indicates that for ILW operational wastes, Westinghouse would anticipate that a licensee could achieve a Final Stage Letter of Compliance (LoC) prior to first fuel load. The waste conditioning strategy and packages would be determined by the licensee. Westinghouse identify that not all of the research would be complete before the Final Stage Letter of Compliance was issued.
- 200 For spent fuel Westinghouse indicate that a Final Stage letter of Compliance could be achieved before fuel is placed into long-term storage, with a Conceptual Stage LoC achieved prior to first fuel load.
- 201 For the facilities described in the report, Westinghouse states their belief that the integrity of the wastes can be maintained over the entire storage period. They also recognise that a licensee will need to provide a demonstration that this is the case for whatever ILW and spent fuel facilities they propose to utilise.

3.9 Supporting Site Visits

- 202 The safety case put forward identifies a number of options for operating the AP1000 that are relevant to the RW&D assessment. To support the claims made in the safety case about the different methodologies a number of site visits were arranged
- 203 During GDA, sites were visited in France, Germany, Sweden, UK and USA. On these sites operation of waste management facilities, training and maintenance facilities, decommissioning activities, at-reactor spent fuel pool operations and mobile plant were observed. I have used the knowledge gained to inform my assessment.
- 204 The visits were successful in establishing that different operational approaches can be successfully implemented. The relevant examples are referenced in the assessment text. However these can be summarised into the following generic learning points for RW&D:
- Flexible processing systems allow the plant to use best practice that is developed over its lifetime.
 - Space is needed in the waste management facilities to provide flexibility in dealing with the waste items a plant may produce over its operating life.
 - There is a lot of experience of operating spent fuel pools with techniques well developed.

- There is a lot of experience of operating spent fuel dry stores with techniques well developed.
- Staged risk reduction based on pre-planned decommissioning stages is a good approach to decommissioning.
- The plants location (infrastructure, policies, etc.) will influence the approach to waste management.
- Waste processing and management is simpler if there is a defined end point.
- Waste containers, their contents and the associated processes need to be shown to produce a product that can be disposed of in the UK.

205 More details of the different visits can be found in Table 2 of this report.

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- 206 Westinghouse has produced documentation to underpin their claims that wastes from new build reactors can be safely managed; this includes conditioning, storage and disposal.
- 207 The approach adopted by Westinghouse is to show that there is an option available for processing and storing the wastes produced by an AP1000. It will be the responsibility of the licensee to undertake the process optimisation and identify the preferred option. To do this they will need to undertake an optimisation process that considers a range of waste management options. I judge that Westinghouse's approach is a suitable position from which the licensee could develop their optimisation process.
- 208 There is a lot of experience of operating PWRs, both in the UK and internationally. The wastes they produce are well understood and the industry has developed different ways of dealing with them. The wastes produced by the AP1000 are similar to those produced by these other PWRs.
- 209 My assessments of the specific areas identified in Section 2.4 are discussed below.

4.1 Have the Wastes that an AP1000 Will Produce been Identified?

4.1.1 Assessment

- 210 The AP1000 will produce a range of different wastes over its lifecycle. My assessment is only considering the radioactive wastes, although I note Environment Agency is considering both the radioactive and non-radioactive wastes. My assessment of the reactor lifecycle starts with the introduction of radioactive material on to the site and finishes once all nuclear material has been removed from the site.
- 211 The way that the AP1000 is operated will affect the quantity and proportions of radionuclides in the different waste types. I recognise that changes in the operating regime will also affect other areas of operation and that these will need to be optimised. To indicate typical effects of different operating regimes I, together with colleagues, commissioned AMEC to produce a report on practices used in Pressurised Water Reactors, see Section 2.4.3. It is very important to stress that the output of the AMEC report is not meant to indicate which technologies and practices are the best; this is something a licensee will substantiate prior to first fuel load. Instead it provided me with a baseline of background information to undertake my assessment against.
- 212 Westinghouse also arranged a number of site visits to show that waste management processes, currently used internationally, can deal with the potential wastes that arise from the operation of an AP1000. Following these visits I judge that there are a range of waste management options able to deal with the possible wastes produced by an AP1000.
- 213 The Disposability Assessments (Refs 46 and 47) undertaken for Westinghouse by the RWMD also looked at the waste produced by an AP1000. They enhanced the radionuclide data supplied for their assessment. I judge that this enhanced data is sufficiently similar to the information presented on the waste to mean that the disposability assessments are applicable for the range of wastes that an AP1000 will produce.
- 214 I was also interested whether the source terms used to predict the wastes were consistent with the source terms used in other areas. The report produced by Westinghouse (Ref. 33) on the use of source terms shows that these are consistent (see Section 2.4.4.3).

4.1.1.1 Operational Wastes, Other Than Spent Fuel

- 215 My assessment of the operational wastes was completed during Step 3. Additional information on wastes became available during Step 4, such as TSC reports and additional information from Westinghouse on decommissioning and decontamination wastes. Therefore this section is an update of the assessment in the Step 3 report. In compiling the update I have completed a high level review of the revised documents to check that they are broadly equivalent to those documents that underpinned the Step 3 report.
- 216 The aim of my assessment has been to check that the information presented is a suitable representation of the wastes an AP1000 would produce. This is important as it underpins the other areas I assess in this report.
- 217 Westinghouse's documentation provides a lot of detail of the wastes produced by an AP1000 (Refs 29, 30, 31 and 32). They identify the waste origin; waste physical description; nature of radioactive material; annual arising; total arising; waste classification at time of generation; main radionuclides; and hazardous substances.
- 218 As part of the Environmental Assessment Westinghouse has produced a detailed Best Available Techniques report (Ref. 30) and an Integrated Waste Strategy (Ref. 29). These provide evidence of the Westinghouse analysis that underpins their statements about the wastes that an AP1000 will produce.
- 219 The Best Available Techniques report (Ref. 30) includes a detailed analysis of the origin of the radioisotopes that are discharged from the reactor and the techniques that affect the eventual discharge route. I consider this to be an important document as it establishes that the AP1000 has minimised the amount of radioactive waste produced (SAP – RW.2) and is unlikely to produce a radioisotope that would undermine the long term management of the wastes.
- 220 I recognise that the licensee will make choices about the way that the reactor is operated and this will probably cause variations in the wastes produced compared with those detailed in Table 4-6 of the BAT report (Ref. 30).
- 221 Working with the Reactor Chemistry assessors and referencing the AMEC report (Ref. 21) I am aware of approaches that might change the wastes produced. Examples include changes in the addition of zinc to the primary circuit, or the ageing of the reactor. It is not expected that these changes could produce waste for which there is no foreseeable management and disposal route. I have not included the need to confirm the wastes that will be produced as a specific finding. Instead it is included in the discussions in the subsequent sections and, where relevant, included in those findings.
- 222 Taken together these provide the necessary evidence that the operational wastes detailed in Table 4-6 of the BAT report (Ref. 30), reproduced in this report as Figure 1, are a suitable basis for assessment.

4.1.1.2 Large Waste Items

- 223 During the Step 3 assessment I looked specifically at how large waste items, such as a reactor pressure vessel head would be handled. Westinghouse provided outline information about this. During Step 4 this aspect of the assessment has been incorporated into the decommissioning assessment and is dealt with there.
-

4.1.1.3 Spent Fuel

224 The *UK AP1000 NDA Data Sheet Submission* (Ref. 31) provides details of the radionuclide content of the fuel and the amount used in a reactor. For GDA the fuel assessed is fresh uranium oxide fuel whose isotopic composition depends upon the initial enrichment and the fuel management regime to which it is subject in the reactor. Whilst the average core region fuel burn-up is less than 65 GWd/tU, it is assumed that all fuel has seen 65 GWd/tU for the disposability assessment and storage regimes.

225 Prior to disposal the spent fuel will be stored in an at-reactor cooling pool for a period of time, followed by interim stores on the site. So at the time of disposal the thermal output of the fuel will have reduced. Assuming that all fuel has seen 65 GWd/tU leads to it requiring the longest storage period of the fuel at the reactor site prior to disposal. It is likely that much of the fuel will have a lower burn-up and so could be disposed of sooner.

226 Therefore for GDA the level of information provided on spent fuel is sufficient. I recognise that at a site specific stage a more detailed analysis may be required to show how long spent fuel having different burn-ups would need to be stored on site.

4.1.2 Findings on Whether the Wastes That an AP1000 Will Produce Have Been Identified

227 The AP1000 will produce a range of different wastes over its lifecycle. The way that the AP1000 is operated will affect the quantity and proportions of radionuclides in the different wastes. Recognising these constraints I judge the evidence provided by Westinghouse shows that the operational wastes detailed in Table 4-6 of the BAT report (Ref. 30), reproduced in this report as Figure 1, are a suitable basis for assessment.

228 For GDA the fuel assessed is fresh uranium oxide fuel assumed to have seen 65 GWd/tU. I judge this is sufficient information for my assessment. I recognise that this is a high burn up for spent fuel, so at a site specific stage a more precise analysis will be required.

229 Recognising these constraints I have not placed any specific findings on the licensee to confirm the wastes the as-built AP1000 will produce, this will be dealt with as normal regulatory business by both the Environment Agency and ND. However, a licensee should recognise the importance of resolving the uncertainties early so as to underpin their work on the waste management practices identified later in this report. They should also recognise that this will be part of the optimisation process discussed in Section 2.4.4.4.

4.2 Westinghouse Plans for Short term Storage and Conditioning of the Wastes

4.2.1 Assessment

230 SAP RW.3 indicates that the accumulation of radioactive waste on site should be minimised. Once the AP1000 is licensed this will be a mandatory requirement under Licence Condition 32. So in this area of the assessment I am looking to see that the plans of Westinghouse provide for a short period of storage and then suitable conditioning.

231 Conditioning should allow the wastes to be segregated and characterised (SAP – RW.4) so as to properly inform decisions about its subsequent management. Furthermore where waste is being packaged into a form that is intended to be suitable for final disposal, it should be sufficiently characterised to properly inform subsequent decisions about its suitability for disposal.

232 In accordance with SAP RW.5 the conditioning process should also produce a product with the following characteristics:

- The waste form and its container is physically and chemically stable.
- The package is compatible with the long-term management strategy for the waste, which may include the need for further characterisation, treatment or conditioning, a prolonged period of storage, or disposal.
- The radioactive waste is immobile.

4.2.1.1 Operational Wastes, Other Than Spent Fuel

233 For most of the wastes produced by an AP1000 the design intent is to use a mobile facility to process them. Therefore, in line with the SAPs detailed above, the level of proof that I am looking for in the submission is a demonstration that:

- there are conditioning processes that could be used without raising unacceptable safety or environmental issues; and
- there is sufficient short term storage space.

234 The information provided by Westinghouse (Refs 35, 36, 37, and 38) gives a high level overview of the short term storage facilities and the proposed approach to conditioning.

235 During the site visits hosted by Westinghouse they showed the space required for processing wastes and the short term storage of wastes, this provided evidence of the areas that I had identified for assessment:

- were consistent with the requirements of the disposability assessment;
- that waste was not being unnecessarily created; and
- that the generation and accumulation of radioactive waste was being minimised.

236 Looking at the layout drawings presented during a meeting in Pittsburgh Westinghouse were not able to satisfy me that the Radwaste Building associated with an AP1000 was large enough to undertake all activities. My concerns are associated with compliance with the Ionising Radiation Regulations, specifically regulation 8, restriction of exposure and 29 keeping and moving of radioactive substances. My concerns here were that the design did not ensure that operator exposure would be restricted as far as reasonably practicable, that the storage of wastes were not sufficiently segregated from the other activities. I was also concerned that an operator would have difficulty complying with Licence Condition 32 to make and implement adequate arrangements for minimising the total quantity of radioactive waste accumulated on the site at any time

237 Westinghouse accepted my concerns and agreed that the design would need to be reviewed and modified on a site specific basis. As noted in Refs 40 and 41, they argued that this would be an appropriate time to undertake this review and redesign. Furthermore it is likely that the identified UK sites would each house more than one AP1000, and waste treatment facilities would be shared across a site. I accept this argument as the final decision on the utilisation of the space in the waste treatment facilities is for the licensee to justify as part of its licensing submissions. This is captured in assessment finding AF-AP1000-RW-06 detailed below.

4.2.1.2 Spent Fuel

238 The detailed assessment of the at-reactor fuel pool was undertaken as part of the Criticality Assessment and is reported in the Radiological Protection Assessment report (Ref. 26), see Section 2.4.4.

239 The information provided by Westinghouse on the encapsulation of spent fuel (Ref. 43 and 44) is sufficient to show that packaging for disposal should be feasible. As this facility would not be required for several tens of years I do not believe that there is any benefit in pursuing this issue further within GDA.

4.2.2 Findings on Plans for Short Term Storage and Conditioning of the Wastes

240 Westinghouse has been through a detailed process to select an appropriate option for the processing of wastes arising from an AP1000. The implementation of this has been compromised by a drive to minimise the available space.

241 The licensee will have to develop waste management facilities that provide sufficient space to store wastes prior to processing; segregate processing activities and avoid any cross contamination between storage and processing activities. This will require a number of steps to be undertaken, but will ultimately result in the design of a new facility.

242 A safety case will be required for the new facilities, which will include a revised optimisation the process for conditioning wastes, to confirm that the selected process is appropriate for the site and the new facilities. This requirement is captured in the following Assessment Finding:

***AF-AP1000-RW-06:** the licensee shall produce a safety report for the revised Radwaste Building, the associated processing and long-term storage of the ILW. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases (Ref. 5). The safety report will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

4.3 Westinghouse Plans for Long Term Storage

4.3.1 Assessment

243 SAP RW.5 indicates that radioactive waste storage should include the following characteristics:

- The need for active safety systems to ensure safety should be minimised.
- The need for monitoring to ensure safety should be minimised.
- There should be no need for prompt intervention to maintain the facility in a safe condition.
- The design, construction standards, construction materials, and maintenance and inspection provisions of the storage facility should take account of the anticipated storage duration (including ageing and degradation) to ensure that the facility continues to meet its safety function.
- The storage environment should avoid degradation that may render the waste unsuitable for long-term management or disposal.

- The storage facility should be designed and operated so that individual packages can be inspected and retrieved within an appropriate period of time. This may include the need for reserve storage space.
- The storage facility should be designed and operated to enable timely intervention in the event of unexpected faults or accidents.
- Appropriate provisions should be available for dealing with radioactive waste or its packaging that shows signs of unacceptable degradation.

244 I have used these requirements to judge the acceptability of the Westinghouse proposals for long-term storage.

4.3.1.1 Operational Wastes, Other Than Spent Fuel

245 The information provided by Westinghouse on the long term management of wastes, other than spent fuel (Refs 35, 36, 37, and 38) is to a greater level of detail than our published expectations (Ref. 13). Therefore I have only assessed those aspects of that were required to meet our published expectations (Ref. 13). I have made no judgement on the other sections, such as the suitability of the optimisation process.

246 During the site visits arranged by Westinghouse I have observed some of the storage options. This supported the assertions in the documentation that these processes could be undertaken in a safe and environmentally acceptable way.

247 The information provided by Westinghouse provides a storyline for their choice of waste management options and the reasons why they believe that this is a suitable and safe choice. I would expect a licensee to use this information to underpin its development of the site specific waste management approach. The licensee will need to show that it has selected an optimised process against an agreed set of design principles. A number of design principles are identified within the documentation; these will need to be correlated into a single cohesive set by the licensee at the start of the design process.

4.3.1.2 Spent Nuclear Fuel

248 For GDA the spent fuel is treated as a waste. SAP RW.5 states that radioactive waste should be stored in accordance with good engineering practice and in a passively safe condition. For very long term storage, Westinghouse indicate that the fuel may have to be stored for 100 years and it is challenging to meet the principle established in SAP RW.5 over this timescale.

249 I have required Westinghouse to provide more detail on their proposals for the long term storage of fuel. This is because of the time constraints that RWMD have placed on their ability to dispose of the fuel and the implications this has on its management. Whilst adopting these consequential timescales as targets I also want Westinghouse to demonstrate that safety can be maintained beyond these dates, should it be necessary.

250 The information provided by Westinghouse on the long term management of spent fuel (Ref. 42) is to a level of detail broadly in line with our published expectations (Ref. 13).

251 During the site visits arranged by Westinghouse the dry storage option was observed. This supported the assertions in the documentation that the Holtec processes could be undertaken in a safe and environmentally acceptable way.

252 The work NNL undertook for me (Ref. 19) also supports the Westinghouse assertions that if correctly treated the fuel can be stored for the required periods and be suitable for transport after storage.

253 SAP RW.5 is supported by explanatory text. Much of the evidence this explanatory text would require is beyond the requirements of GDA. For me the key aspect that I expected Westinghouse to show within its GDA submission were:

- The waste form and its container should be physically and chemically stable.
- The package should be compatible with the long-term management strategy for the waste, which may include the need for further characterisation, treatment or conditioning, a prolonged period of storage, or disposal.
- The radioactive waste should be immobile.
- The need for active safety systems to ensure safety should be minimised.
- The need for monitoring to ensure safety should be minimised.
- There should be no need for prompt intervention to maintain the facility in a safe condition.
- The design, construction standards, construction materials, and maintenance and inspection provisions of the storage facility should take account of the anticipated storage duration (including ageing and degradation) to ensure that the facility continues to meet its safety function.
- The storage environment should avoid degradation that may render the waste unsuitable for long-term management or disposal.
- The storage facility should be designed and operated so that individual packages can be inspected and retrieved within an appropriate period of time. This may include the need for reserve storage space.
- The storage facility should be designed and operated to enable timely intervention in the event of unexpected faults or accidents.
- Appropriate provisions should be available for dealing with radioactive waste or its packaging that shows signs of unacceptable degradation.
- no external controls are relied upon to prevent criticality

254 The arguments presented by Westinghouse show that these aspects can be met and that fuel can be stored for the required periods.

255 I also acknowledge that there remains a small residual risk that the fuel is not in a suitable state for transport. To alleviate this risk it will be an important aspect of the storage option selected that:

- the transfer of the fuel from the at-reactor spent fuel pool to the long-term store does not adversely affect the long term performance of the fuel, cladding or support structure;
- the fuel can be monitored so that any detected changes can be acted upon; and
- there is sufficient space for maintenance, repair or replacement of the equipment and the fuel.

256 To complement the design of the storage facility it will also be important for the licensee to have programmes in place to:

- research the evolution of the fuel, cladding and support structure to build confidence that it is not undermining the ability to transport the fuel;
- learn from the international experience on the long term management of spent fuel so that any potential remediation can occur early; and
- work with RWMD to optimise the storage periods so that transport can occur as soon as reasonably practical.

257 This is reflected in the findings at the end of this section. Furthermore there are indications of increased international interest in research to underpin cases for long-term fuel storage. This work will be a valuable addition to the topic.

4.3.2 Findings on Plans for Long Term Storage

258 Westinghouse has provided a comprehensive review of their proposed process for the management of LLW and ILW. This is more detailed than I had expected within GDA. There are a number of benefits for the licensee in providing this level of detail. The site visits arranged by Westinghouse supported the assertions in the documentation that these processes could be undertaken in a safe and environmentally acceptable way. However, I believe that an assessor would have difficulty linking the documentation to gain assurance that all faults and hazards had been addressed. Whilst this is not required for GDA, a licensee would need to ensure that the case they put forward is cohesive.

259 The optimisation process undertaken by Westinghouse for their long-term storage options for wastes will need to be revisited to show that it is suitable for the site. So:

AF-AP1000-RW-06: the licensee shall produce a safety report for the revised Radwaste Building, the associated processing and long-term storage of the ILW. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases (Ref. 5). The safety report will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.

260 For spent fuel Westinghouse has provided a report detailing one option for the long-term storage of fuel and the work that a licensee would have to perform to show that the fuel would remain suitable for transport to a disposal facility. A licensee would have to build on this work to develop a suitable site specific approach

261 Therefore the licensee will be required to undertake a number of actions associated with the development of the long-term spent fuel interim storage facilities. These include:

AF-AP1000-RW-09: the licensee shall produce a safety report for the long-term storage of spent fuel. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases (Ref. 55).

It shall also detail the proactive inspection regime for the spent fuel in on-site storage that builds on existing knowledge and experience, allows the spent fuel to be retrieved and inspected within a reasonable time frame and limits the number of fuel assembly lifts. The safety report will be submitted to the Regulators prior to first fuel load.

4.4 Westinghouse Proposals for the Disposal of the AP1000 Wastes

4.4.1 Assessment

262 In the UK the Environment Agency issues the permits for the disposal of radioactive waste. They assessed the suitability of the wastes produced by an AP1000 for disposal (Ref. 15). I accept their opinion that the design is not expected to produce wastes for which there is no foreseeable disposal route. As such I have not considered the disposability of the wastes in detail.

263 The disposability of the wastes arising from decommissioning activities is covered in the following section.

4.5 Decommissioning

4.5.1 Assessment

264 I asked Westinghouse to base their case on currently available technology but it is likely that techniques will develop as more experience is gained in decommissioning PWRs throughout the world. Indeed, services continue to develop to accommodate a growing international demand e.g. the decontamination and recycling of steam generators (Ref. 56).

265 I was supported in my assessment of the AP1000 by the Radiological Protection assessor (Ref. 26) and React Engineering Ltd (Ref. 57). The assessment consisted of a series of meetings with Westinghouse, a visit to a plant in Europe to discuss their decommissioning plans and the provision of a detailed decommissioning plan. Based on this information I judge that Westinghouse have made adequate provision within the design of the AP1000 to allow the plant to be decommissioned.

266 I did not consider the demolition of the civil structure as this was covered by the civil engineering and external hazards assessment of the AP1000 (Ref. 24).

267 I based my assessment on the Safety Assessment Principles DC.1 – DC.6 detailed in Table 2. Using these I produced an intervention plan. This was supplied to Westinghouse, who subsequently structured their report using similar headings. The individual interventions are discussed below.

268 At the start of the assessment I agreed with Westinghouse that they could leave scope within their response to incorporate the future input of a licensee. As a result there are four findings to update the decommissioning information with site specific data, see AF-AP1000-RW-11 to AP1000-RW-14. I judge that this is acceptable as the input of a licensee should enhance the decommissioning strategies. It should be noted that this approach does not relieve Westinghouse of any responsibilities under the CDM regulations.

4.5.1.1 Decommissioning Principles Underpinning the AP1000 Design

269 UKP-GW-GL-795 (Ref. 51) outlines four high level generic principles underpinning decommissioning of the AP1000 and details a number of supporting principles. Whilst I accept that the major principles are covered I did not find it straightforward to follow which of the principles were the most significant. It is probable that a licensee would have similar difficulties.

270 Westinghouse also provided evidence of how the design facilitates application of the principles. One area that was not clear in this was how the licensee would deal with the complexity introduced by the compact nature of the design.

271 I therefore support Reacts conclusion that before major construction the principles need to be clarified by the licensee and shown that they do not undermine the decommissioning methodology for the reactor (see actions AF-AP1000-RW-14 below).

272 Westinghouse has not provided evidence of the process for incorporating decommissioning into the design. During design a process should be in place to incorporate the decommissioning needs (SAP- DC.1, Table 2). As there was no evidence of the process, Westinghouse demonstrated, through detailed exchange, that the AP1000 has features to help decommissioning. I am therefore satisfied that there was an informal process in place during the design of the AP1000.

4.5.1.2 Decommissioning Logistics

273 UKP-GW-GL-795 (Ref. 51) provides a proposed three stage decommissioning approach for the AP1000. This appears logical and well thought through.

4.5.1.3 The Timing of Decommissioning

274 Westinghouse states a preference for immediate decommissioning. This is ND's preferred option (SAP – DC.3, Table 2).

275 Westinghouse has not provided any sensitivity analysis to a change in this assumption. UKP-GW-GL-795 (Ref. 51) does identify the systems which need to remain operational during the various stages of decommissioning. A prospective licensee should use this information to assure themselves that there is flexibility within the design to allow decommissioning to be delayed, if it should prove necessary.

4.5.1.4 Hazards and Challenges

276 Within this section I am looking for evidence, which demonstrates that decommissioning of an AP1000 can be safely undertaken (SAP – DC.4).

277 Chapter 27 of the draft PCSR (Ref. 58) discusses some of the challenges and hazards associated with decommissioning. UKP-GW-GL-795 (Ref. 51) provides further clarification. They also outline hazard identification techniques and the criteria for assessing whether to use remote or manual techniques.

278 This is a good start to providing the evidence I expect. A licensee will need to continue the development of the potential hazards and challenges as they develop the decommissioning strategy.

4.5.1.5 Assumed Plant Status at Decommissioning

279 UKP-GW-GL-795 (Ref. 51) places an expectation on the licensee to maintain plant conditions. This is reasonable as it is in the licensee's interests to do so.

280 In developing its decommissioning strategy I would expect a licensee to provide clarity and justification of the assumed plant status at the cessation of power operations and the underpinning allowances made for any reasonably foreseeable abnormal operations.

281 The AMEC report (Ref. 22) indicates that these can include spent fuel pool faults, minor leaks and releases.

4.5.1.6 Disposability Assessment

- 282 The reports outline how the Disposability Assessment presented in the GDA submission aligns with the baseline decommissioning plans. It explains the waste routes out of the building and the sensitivity of the wastes to different decommissioning techniques. The effects of decontamination and the generation of secondary wastes are also discussed.
- 283 In developing their decommissioning strategy I would expect a licensee to confirm that the wastes arising from decommissioning are consistent with the disposability assessments for the AP1000 wastes (Refs 46 and 47).

4.5.1.7 Decommissioning Plans

- 284 I have taken the plan presented in UKP-GW-GL-795 (Ref. 51) as the baseline plan. This provides a very detailed decommissioning sequence with indicative timescales taking the whole lifecycle into account, including disposal of the site waste stores and the potential cooling of fuel before emplacement into a long-term dry store. The sequence is broken down on a system by system basis, and appears to provide a comprehensive list of all key systems in the design. It provides confidence that the overall decommissioning programme is achievable. Importantly it also highlights which systems need to remain operational or be modified in order to support decommissioning, e.g. ventilation and containment systems. As such it will provide a sound basis for the licensee to develop their detailed decommissioning plans.

4.5.2 Findings on Decommissioning

- 285 Westinghouse has produced a very detailed decommissioning sequence underpinned by reasoned arguments showing that the sequence is credible. This will provide a good basis for a licensee to develop the decommissioning plan. Westinghouse also recognises that the proposals for decommissioning need to be developed by a licensee. I have captured these in the following Assessment Findings:

AF-AP1000-RW-11: *the licensee shall develop a set of decommissioning principles and revise the decommissioning methodology presented in UKP-GW-GL-795 (Ref. 51), to reflect these). The principles will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

AF-AP1000-RW-12: *the licensee shall show that the design has the capacity to allow decommissioning to be delayed; any changes shall be incorporated into a revision of the decommissioning methodology presented in UKP-GW-GL-795 (Ref. 51). The revised methodology will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

AF-AP1000-RW-13: *the licensee shall identify the potential hazards and challenges present during decommissioning and revise the decommissioning methodology presented in UKP-GW-GL-79 (Ref. 51), to reflect these. The revised methodology will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

- 286 A copy of the revised decommissioning methodology will be submitted to the Regulators prior to the start of construction of the reactor.

287 As Westinghouse were not able to show a formal process for incorporating decommissioning into the design:

AF-AP1000-RW-14: *the licensee shall review the construction activities to identify any actions that could be taken during construction that would be beneficial to the decommissioning process. (For example is it appropriate to leave lifting lugs on vessels?) A copy of the written review will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

288 Apart from the enhancements identified above, there is no specific finding associated with the updating of the decommissioning information. It is an explicit requirement of License Condition 35 that a licensee shall make arrangements for the production and implementation of decommissioning programmes for each plant. Therefore a licensee will have to update the information as part of their process for implementing arrangements for License Condition 35.

4.6 Knowledge Management

4.6.1 Assessment

289 SAP RW.7 requires information that might be required now and in the future for the safe management of radioactive waste to be recorded and preserved. There is a similar SAP for decommissioning (DC.6). This requires that throughout the whole life-cycle of a facility the documents and records that might be required for decommissioning purposes should be identified, prepared, updated and retained.

290 In their response to TQ-AP1000-906 (Ref. 53), Westinghouse described their internal processes for retaining records. I have discussed this with the Management for Safety and Quality Assurance assessor and agreed that a licensee would need to specifically address the requirements of SAPs RW.7 and DC.6. Both SAPs state the need to preserve or retain records. Given that the site could have an operational life in excess of one hundred years the effort required to address these requirements should not be underestimated.

4.6.2 Findings on Knowledge Management

291 I have agreed with the Management for Safety and Quality Assurance assessor that there should be a specific finding in my report about the management of information for waste and decommissioning. So:

AF-AP1000-RW-03: *The licensee shall implement a records management procedure for waste management and decommissioning that incorporates:*

- *The methods for identifying the types of record to be retained;*
- *the requirement for the production, long-term management, maintenance and preservation of records for spent fuel and Intermediate Level Wastes; and*
- *details of how institutional knowledge of the facility will be generated and maintained throughout its life-cycle so that it is accessible during decommissioning.*

292 A copy of the procedure will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.

4.7 The Radioactive Waste Management Case

4.7.1 Assessment

- 293 I was supported in my assessment of Westinghouse by Babcock Ltd (Ref. 59). The assessment was of the two Westinghouse reports UKP-GW-GL-055 (Ref. 37) and UKP-GW-GL-056 (Ref. 42).
- 294 These reports are structured around the appendix of the joint guidance on RWMCs (Ref. 60). The appendix provides a list of the headings that an RWMC should address. By populating this structure with references to the supporting documentation Westinghouse has shown that an RWMC could be produced.
- 295 Based on this information I judge that Westinghouse have provided sufficient information on the life cycle of the waste to be able to produce comprehensive Radioactive Waste Management Cases (RWMC(s)).
- 296 Of the wastes that Westinghouse has identified an AP1000 producing only the ILW rod cluster control assemblies and certain other core components are not included in the disposability assessments. This exception is subject to a Regulatory Observation (RO-AP1000-74).
- 297 At the time of writing this report the RO had not been closed as information was still outstanding. Once this information is available it should be sufficient to allow a licensee to include all waste streams in the RWMC. I am not particularly concerned about this as it should be possible to dispose of these wastes with the fuel. It is therefore a finding, see AF-AP1000-RW-01.
- 298 In the introduction to Section 4 of this report I identified that Westinghouse had elected to show only one means of dealing with the wastes from an AP1000. This is an acceptable approach for GDA. However, a licensee will have to go through an optimisation process when developing their site specific waste management systems, see Section 4.2. If, as a result of this optimisation a different waste management process is selected then a new RWMC will need to be developed. So I have included an Assessment Finding to review the RWMC and update it to reflect the selected waste management options following this optimisation step, see AF-AP1000-RW-02.
- 299 Within their report (Ref. 59) Babcock identify a number of areas where the RWMC could be improved. I recognise that these are areas that a licensee may wish to address. This can be done during the optimisation step discussed above.

4.7.2 Findings on the Radioactive Waste Management Case

- 300 The information on the life cycle of the waste provided by Westinghouse should be sufficient to produce a comprehensive RWMC for the selected process. However, additional information is required on the disposal of the rod cluster control assemblies. So:

AF-AP1000-RW-01: the licensee shall produce an updated disposability assessment for all the waste produced by an AP1000, including spent fuel and the disposal of rod cluster control assemblies. A copy of the written assessment will be submitted to the Regulators prior to first fuel load.

- 301 In the introduction to Section 4 of this report I identified that Westinghouse had elected to show only one means of dealing with the wastes from an AP1000. Furthermore in section 4.2 I identified that a safety report with an associated waste management optimisation

process was required for the revised Radwaste Building. This will require an update to the Radioactive Waste Management Case, so:

AF-AP1000-RW-02: *the licensee shall produce a site specific Radioactive Waste Management Case for all of the wastes that their AP1000 will produce. A copy of the Radioactive Waste Management Case will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

4.8 The Production of a Credible Plan for the Waste Management Facilities

4.8.1 Assessment

302 In May 2009 the Environment Agency, Department for Transport and ND published a joint strategy that detailed the anticipated outcomes for the Generic Design Assessment (GDA) of radioactive waste proposals (Ref. 13). This proposed that for those storage facilities not on the nuclear island Westinghouse should develop a strategy that included a detailed plan with key milestones. The plans would be underpinned by descriptions of:

- the types of facility that could be used;
- when facilities will be developed and constructed; and
- the research needs that are required to ensure the waste and spent fuel can be safely managed on sites, transported and disposed of.

303 Whilst the plan is a very simple document it is important to Westinghouse, licensees and the Regulators as it provides a baseline to the implementation of the proposed waste management strategy. So for the plan to be credible the underpinning documentation, identified in the bullets above has to be substantive, logical and plausible.

304 It would also be acceptable for a licensee to adopt an alternative strategy than that presented in the plan. Where a licensee chooses to do this they would need to show that the baseline they had established in their plan was broadly equivalent to, or better than, that presented here and could be realised in a suitable timescale.

305 Where a substantive item or activity has not been included in the plan I have accepted that the item or activity will be available prior to the first fuel loading. If the licensee wishes to delay the implementation beyond this date they will need to agree the revised date with the Regulator.

306 This section of the assessment report deals with the plan provided by Westinghouse in their response to RO-AP1000-074.A4 (Ref. 39). This was the culmination of a process that had been developed across the whole of GDA, which includes:

- The disposability assessment undertaken by the Radioactive Waste Management Directorate of the Nuclear Decommissioning Authority (RWMD).
- The response to RO-AP1000-60, 22 February 2010 (Ref. 61).

307 The Environment Agency reviewed the RWMD disposability assessment and the response to RO-AP1000-60 (Ref. 61) and concluded that interactions through the course of the GDA process have identified a range of issues that will need to be addressed in the future programmes of Westinghouse and/or the licensee. The Environment Agency noted the provisional plan as to how these issues will be addressed through future work. In due course, the Environment Agency will want to see more definitive assessments to confirm how all of the ILW and spent fuel will be conditioned for disposal, that the selected conditioning methods represent the application of Best Available Techniques

(BAT), and that in their conditioned forms the ILW and spent fuel will continue to be disposable (Ref. 15).

308 The response to RO-AP1000-74 (Ref. 39) includes two plans, the first for ILW is Figure 1 and the second for the spent fuel is Figure 5. These are discussed separately below.

309 I note that the plans do not include actions associated with LLW. I have discussed this with the Environment Agency and judge this is acceptable because Westinghouse have obtained evidence that LLW can be sent for disposal.

4.8.1.1 Plan for Dealing with ILW Wastes

310 The plan produced by Westinghouse is at a high level. For GDA this is acceptable. The information provided indicates that the timescales quoted are reasonable for the work that will need to be completed to realise the proposed strategy for the management of ILW.

311 Westinghouse has indicated that potential licensees can work with RWMD to gain a final stage Letter of Compliance for the ILW waste produced by an AP1000 prior to the first fuel load. Given that the disposability assessment for this waste indicates that it is broadly equivalent to wastes in the baseline inventory for a future repository this appears realistic.

312 I note that the plan did not include the Future Action Plan, Table 2 in the response to RO-AP1000-74 (Ref. 39). I would therefore expect these actions to be complete before cold operations, see Assessment Finding AF-AP1000-RW-05.

313 I conclude that Westinghouse have produced a credible plan for the implementation of their proposed ILW strategy, subject to Assessment Finding AF-AP1000-RW-05 below.

4.8.1.2 Plan for Dealing with Spent Nuclear Fuel

314 The plan produced by Westinghouse is at a high level. For GDA this is acceptable. The information provided indicates that the timescales quoted are reasonable for the work that will need to be completed to realise the proposed strategy for the management of spent fuel.

315 Westinghouse has indicated that potential licensees can work with RWMD to gain a final stage Letter of Compliance for the spent fuel produced by an AP1000 prior to its placement into long-term storage. The Disposability Assessment for the spent fuel indicates that it is broadly similar to other fuels in the baseline inventory for a future repository. We accept this analysis and the assurance that we have received from the Environment Agency that the spent fuel is disposable.

316 Given that this will be a significant addition to the baseline inventory used for planning the repository by RWMD, we have looked for additional evidence that the fuel can be sent for disposal and that the associated risks are being actively addressed. For me this means that actions are in place to reduce the timescales over which spent fuel would be stored before it can be sent for disposal. I believe that there is a simple correlation between the length of storage and the risk of fuel failure, so reducing the time reduces the risk.

317 I have checked this through the work I commissioned NNL to undertake. Their report indicated that the fuel should remain in a stable state where it is suitable for transport and disposal providing it is adequately cooled once it is removed from the reactor. At the time of disposal I would expect a licensee to be able to show that the fuel can be safely transported to a repository. This means that they would have to show that the fuel, in its

transport package, could withstand a worst case transport accident as indicated by the IAEA transport regulations (Ref. 62).

318 In the original disposability assessment the RWMD indicated that they expect fuel to be cooled for 100 years before it could be sent for disposal. Since then they have produced a report for the Nuclear Industries Association (Ref. 50). This report indicates that there are potential ways of reducing the timeframe over which spent fuel is cooled before it can be sent for disposal. This demonstration of RWMD and potential licensees working together to address an issue is welcome.

319 On the 13 December 2010 the RWMD provided representatives of the Department of Energy and Climate Change (DECC) and the Regulators a briefing on the development of their plans for the disposal of spent fuel. The information that I gained from this meeting has provided me assurance that RWMD have in place plans for developing the underpinning needed to validate the more detailed proposals that will come forward from licensees.

320 It also identified short-comings that a potential licensee would have to work closely with RWMD to address. The most significant of these was that new build fuel is not part of the baseline inventory and, as such, RWMD would not consider new build fuels in generic research. However, RWMD would undertake specific research funded by a licensee that supports disposal of its spent fuel.

321 I conclude that Westinghouse has produced the basis for the development of a credible plan for the implementation of their proposed spent fuel strategy. The plan still has areas that need to be revised or extended; these are identified in Assessment Finding AF-AP1000-RW-07 below.

4.8.2 Findings on the Production of a Credible Plan for the Waste Management Facilities

322 Westinghouse has developed a high level plan for the implementation of the waste management options for both ILW and spent fuel. These are in sufficient detail to meet the expectations set out in our level of design paper (Ref. 13). The plans are linked to the actions established in the overall assessment of RW&D. Where actions have not been identified on the plan these are identified in my findings below.

323 The licensee to implement the plan for the ILW waste management facilities set out in RO-AP1000-074.A4 (Ref. 39) and the following specific matters:

AF-AP1000-RW-05: *the licensee shall identify the evidence necessary to underpin their ILW storage and disposal strategy, the activities needed to secure this evidence and the time needed for these activities. The provision of this evidence and associated activities will be detailed on a plan that will link the evidence needed with the construction activities for all on site facilities required to manage the ILW over its lifetime. The plan will be submitted to the Regulators prior to cold operations.*

AF-AP1000-RW-06: *the licensee shall produce a safety report for the revised Radwaste Building, the associated processing and long-term storage of the ILW. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases (Ref. 5). The safety case will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

- 324 Westinghouse has indicated that a licensee could work with RWMD to gain a final stage Letter of Compliance for the spent fuel produced by an AP1000.
- 325 On the 13 December 2010 the RWMD provided me assurance that plans are in place for developing the underpinning information needed to validate the more detailed proposals that will come forward from a licensee. It also identified short-comings that a potential licensee would have to work closely with RWMD to address (see action **AF-AP1000-RW-08** below).
- 326 I conclude that Westinghouse have produced the basis for the development of a credible plan for the implementation of their proposed spent fuel strategy. The plan still has areas that need to be revised or extended on a site specific basis:

***AF-AP1000-RW-07:** the licensee shall identify the evidence necessary to underpin their spent fuel storage, transport and disposal strategy, the activities needed to secure this evidence and the time needed for these activities. The provision of this evidence and associated activities will be detailed on a plan that will link the evidence needed with the construction activities for all on site facilities required to manage the spent fuel over its lifetime. The plan will be submitted to the Regulators prior to the pouring of nuclear island safety related concrete.*

***AF-AP1000-RW-08:** the licensee shall produce a plan, with RWMD input, for the work necessary to reduce the on-site storage period for the spent fuel produced by the reactor so that the fuel can be transported as soon as reasonably practical. The plan will be submitted to the Regulators prior to the first fuel load.*

***AF-AP1000-RW-09:** the licensee shall produce a safety report for the long-term storage of spent fuel. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases (Ref. 55).*

It shall also detail the proactive inspection regime for the spent fuel in on-site storage that builds on existing knowledge and experience, allows the spent fuel to be retrieved and inspected within a reasonable time frame and limits the number of fuel assembly lifts. The safety report will be submitted to the Regulators prior to first fuel load.

***AF-AP1000-RW-10:** the licensee shall substantiate why a conceptual stage Letter of Compliance is suitable and sufficient for the start of reactor operations. The written substantiation will be submitted to the Regulators prior to first fuel load.*

4.9 Overseas Regulatory Interface

- 327 HSE's Strategy for working with Overseas Regulators is set out in (Ref. 63) and (Ref. 64). In accordance with this strategy, HSE collaborates with Overseas Regulators, both bilaterally and multinationally.

4.9.1 Bilateral Collaboration

- 328 HSE's Nuclear Directorate (ND) has formal information exchange arrangements to facilitate greater international co-operation with the nuclear safety regulators in a number of key countries with civil nuclear power programmes. These include:

- the US Nuclear Regulatory Commission (US NRC);
- the French L'Autorité de sûreté nucléaire (ASN); and
- the Radiation and Nuclear Safety Authority of Finland (STUK)

4.9.2 Multilateral Collaboration

329 ND collaborates through the work of the International Atomic Energy Agency and the OECD Nuclear Energy Agency (OECD-NEA). ND also represents the UK in the Multinational Design Evaluation Programme (MDEP) - a multinational initiative taken by national safety authorities to develop innovative approaches to leverage the resources and knowledge of the national regulatory authorities tasked with the review of new reactor power plant designs. This helps to promote consistent nuclear safety assessment standards among different countries.

330 In the RW&D assessment information has been shared with the following Overseas Regulators through a series of interface meetings:

- we have looked at different aspects of the long term management of spent fuel with the US NRC;
- we have considered the approach to the long term management of wastes with SSM; and
- we have discussed the development of the new reactor at Okiluoto with STUK.

331 The outputs of these interactions have given me the confidence that the issues we are addressing on RW&D in the UK are broadly similar to those in other countries. Whilst the way of dealing with the issues is influenced by the regulatory regime of a country, it is clear that all the Regulators are working towards similar means of resolving the identified RW&D issues.

4.10 Interface with Other Regulators

332 I have worked very closely with the Environment Agency through the whole of the Generic Design Assessment. Future operators of the AP1000 will require a permit from the Environment Agency to make discharges of radioactivity to the environment and dispose of radioactive wastes. Therefore the interests of the Environment Agency are similar to my interests on radioactive wastes.

333 This is an efficient and effective approach as there are a number of similar but distinct lines of enquiry. For example the liquid processing treatments will dictate the radioisotopes discharged and those consigned via solid waste processing. With both Regulators working together we are sure that all aspects are covered and that Westinghouse is asked one set of questions relative to both disciplines.

334 In this case close working means running joint intervention plans; raising joint technical queries, regulatory observations and regulatory issues; holding joint meetings with Westinghouse; undertaking a number of benchmarking visits and reviewing our respective assessments. I have ensured that my TSCs, React Engineering and Babcock Limited, are aware of the Environment Agency's requirements when undertaking their work.

335 My assessment report is laid out to answer a number of questions. An overview of the specific interactions that I have had with the Environment Agency is detailed below.

4.10.1.1 Have the Wastes That an AP1000 Will Produce Been Identified?

- 336 Westinghouse responded to Environment Agency requests for a Best Available Technique assessment (Ref. 30) and an Integrated Waste Strategy (Ref. 29). I worked closely with the Environment Agency during their interaction with Westinghouse to agree these. This process showed that Westinghouse had identified all waste streams that an AP1000 will typically produce.
- 337 Subsequently I have asked Westinghouse to provide additional assurance that these wastes streams are not unacceptably perturbed by any demands for decontamination or the decommissioning process.

4.10.1.2 Are There Suitable Plans for Conditioning and Storage?

- 338 The Environment Agency has looked in detail at the management and disposal of LLW. We have agreed that there are no issues with the management of these wastes.
- 339 I have kept the Environment Agency informed of my assessment of these aspects for other wastes and the associated benchmarking visits that I have undertaken. I have been able to advise the Environment Agency that Westinghouse has provided evidence giving confidence that wastes can be maintained in a suitable condition during on-site storage such that they will remain acceptable for disposal.

4.10.1.3 Are Wastes Disposable?

- 340 The Environment Agency asked Westinghouse to obtain a disposability assessment for the higher activity wastes produced by an AP1000. I have used the outputs from the disposability assessment to inform my assessment of the conditioning and storage proposals.
- 341 The Environment Agency has said that the AP1000 is not expected to produce waste for which there is no foreseeable disposal route. I have told the Environment Agency that I judge that Westinghouse can manage their higher activity wastes in a manner that meets the requirements set out in the disposability assessment.

4.10.1.4 Can an AP1000 Be Safely Decommissioned?

- 342 My TSC, React Engineering Ltd, has undertaken a detailed assessment of the submission on decommissioning made by Westinghouse (Ref. 57). The contract technical specification with React Engineering Ltd was agreed with the Environment Agency before it was placed. React Engineering Ltd produced a final report confirming that AP1000 can be safely decommissioned that has informed my assessment of the Westinghouse submission and the Environment Agency's assessment.

4.10.1.5 Can a Radioactive Waste Management Case Be Produced for an AP1000?

- 343 I have contracted Babcock Ltd to assess the evidence reports for ILW and spent fuel (Refs 37 and 42) produced by Westinghouse. This assessment is against the requirements of the joint regulatory guidance detailed in Section 2.2.2. I have to provide the report produced by Babcock Ltd to the Environment Agency to inform their assessment of the Radioactive Waste Management Case Mapping Document.
- 344 The Environment Agency and I have shared the outputs of our assessment of the document and agreed the associated findings.

4.10.1.6 Is There a Credible Plan for the Development of Waste Management Facilities?

345 Westinghouse has produced a consolidated plan for the development of the waste management facilities and the eventual sending of the waste to the disposal site. This plan addresses the Environment Agency's requirements and those of the HSE.

346 In the assessment of the plan I have had a number of meetings with the Environment Agency assessors on how the plan addresses our expectations. Consequently we have agreed the associated findings.

5 CONCLUSIONS

347 This report presents the findings of the Step 4 Radioactive Waste and Decommissioning (RW&D) assessment of the Westinghouse AP1000 reactor.

348 I am satisfied that Westinghouse has provided a sufficient level of evidence against each of the questions identified in Section 2.4 for my assessment to be meaningful. The questions were:

- Has Westinghouse identified all of the wastes that an AP1000 will produce?
- Does Westinghouse have suitable plans for conditioning of the wastes?
- Are there any safety issues with Westinghouse plans for short term storage?
- Are there any safety issues with Westinghouse plans for long term storage?
- Has Westinghouse shown that wastes are disposable?
- Can an AP1000 be safely decommissioned?
- Are there suitable proposals for knowledge management?
- Can a Radioactive Waste Management Case be produced for an AP1000?
- Is there a Credible Plan for the Development of Waste Management Facilities?

349 I have worked with colleagues in ND on the following issues:

- The design of the at-reactor spent fuel pool.
- Material selection.
- Information on the Source Terms.
- The suitability of the liquid and gaseous waste processing systems

350 Again I am satisfied that Westinghouse has provided a sufficient level of evidence to show there are no significant issues for RW&D in these areas.

351 Using the AMEC report correlating public concerns against specific industrial incidents (Ref. 22) I have reviewed my assessment findings. This has not identified any additional areas that need to be addressed in my assessment.

352 To conclude, I am broadly satisfied with the claims, arguments and evidence laid down within the PCSR and supporting documentation for the RW&D. I consider that from a RW&D view point, the Westinghouse AP1000 design is suitable for construction in the UK. However, this conclusion is subject to satisfactory implementation, on a site specific basis, of the proposed plan for the development of waste management facilities (Ref. 39) put forward in GDA. The plan will need to be updated as the GDA Design Reference is supplemented with additional details on a site-by-site basis.

5.1 Key Findings from the Step 4 Assessment

353 The findings from my assessment of the Westinghouse proposals for RW&D fall into four broad categories: generic findings; findings for ILW; those for spent fuel and decommissioning.

354 The first generic finding is to develop the disposability assessment for all wastes, including spent fuel and the rod cluster control assemblies.

- 355 The second generic finding is to produce a revised Radioactive Waste Management Case, as set out in the joint regulatory guidance (Ref. 60), for all of the wastes that the reactor will produce.
- 356 The third generic finding is on knowledge management. Successful waste management and decommissioning requires accurate information to be available to the operator and the decommissioning team. This is explicitly recognised in license condition 32 that requires records to be kept of radioactive wastes accumulated on nuclear licensed sites. The finding requires the licensee to develop the necessary systems to achieve this.
- 357 The Reactor Chemistry assessors, the Environment Agency and I recognise that the wastes and discharges from the reactor will be a function of the way that the reactor is operated. So the second category includes a finding to optimise the operation of the chemical volume control system and the liquid, gaseous and solid waste management processes to ensure that the risks associated with their operation and the management of the resulting wastes are as low as reasonably practicable.
- 358 The remaining findings are similar for the ILW and spent fuel categories. The findings are for the continued development of the technical basis for their long term management. This includes the development of the specific facilities for the processing and long term storage of wastes and research to show waste remains suitable for continued storage, transport and disposal. As some of these activities will stretch over a number of decades the findings also call for the development of a number of associated plans.
- 359 The final category is associated with the decommissioning of the AP1000. During GDA we agreed that Westinghouse could defer the development of some aspects until a licensee had been identified. The first three findings in this category are associated with the outstanding work. They are for the development of a set of decommissioning principles; to look at the possible affects of a delay in decommissioning; and to identify the potential hazards and challenges associated with decommissioning.
- 360 The last finding is to review the construction activities to identify any actions that could be taken during construction that would be beneficial to the decommissioning process. This is necessary as Westinghouse were not able to show a formal process for incorporating decommissioning into the design, so I am not convinced that simple actions, which could be taken during construction have been fully considered.
- 361 I conclude that the detailed Assessment Findings listed in Annex 1 should be programmed during the forward programme of this reactor as normal regulatory business.

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Table 1

Relevant Safety Assessment Principles for Radioactive Waste and Decommissioning Considered During Step 4

SAP No.	SAP Title	Assessed Category *	WENRA **	IAEA ***
DC.1	Design and operation	S3	D-12, D-13	
DC.2	Decommissioning strategies	S3	D-14 to D-25	
DC.3	Timing of decommissioning	S3		
DC.4	Planning for decommissioning	S3		5.68
DC.5	Passive safety	S3		
DC.6	Records for decommissioning	S3	D-10, D-11	
ENM.1	Strategies for nuclear matter	S3	S-62 to S-65	6.90
ENM.4	Control and accountancy of nuclear mater	S3		6.92
ENM.5	Characterisation and segregation	S3		
ENM.6	Storage in a condition of passive safety	S3	S-19, S21 to S-38	6.91, 6.97, 6.98
ENM.7	Retrieval and inspection of stored nuclear mater	S3	S-35 to S-38	6.91
RW.1	Strategies for radioactive waste	S3		6.90
RW.2	Generation of radioactive waste	S3		
RW.3	Accumulation of radioactive waste	S3		
RW.4	Characterisation and segregation	S3	D-43, D-44	
RW.5	Storage of radioactive waste and passive safety	S3	S-19, S21 to S-38	6.91, 6.92
RW.6	Passive safety timescales	S3	S-20, S-22	
RW.7	Records for management of radioactive waste	S3	S-15 to S-18	

* S3 = Assessment commences at STEP 3 or 4

** The WENRA reference levels are met by the relevant SAP, but not in a one to one correlation. A number of the Wenra reference levels are relevant to the operation of the facilities, it is not appropriate to address these at this stage.

*** IAEA NS-R-1 sub paras (7) is for Licence Applicants

Table 2
Key Learning Points from Site Visits

Ref.	Description	Key Learning Points
A	A review of spent fuel facilities associated with an operational reactor.	The conditions of acceptance of the disposal facilities drive particular waste management practices at a plant. The plants location (infrastructure, policies, etc.) will influence the approach to waste management.
B	A review of the waste management facilities associated with an operational reactor. This also allowed access to the proposed ILW waste packages.	Flexible processing systems allow the plant to use best practice that is developed over its lifetime. Waste processing and management is simpler if there is a defined end point. A countries waste management infrastructure significantly influences the approach adopted by the plant.
C.	A review of the waste management and spent fuel facilities associated with an operational reactor.	The plants location (infrastructure, policies, etc.) will influence the approach to waste management. Evaporators designed for specific effluent types can be used successfully. They can be operated safely and effectively to reduce the quantity of radioactive waste for disposal. A countries waste management infrastructure significantly influences the approach adopted by the plant. There is a lot of experience of operating spent fuel dry stores with techniques well developed.

Table 2

Key Learning Points from Site Visits

Ref.	Description	Key Learning Points
D	A review of the waste management and spent fuel facilities associated with an operational reactor.	<p>There should be good segregation of liquid waste streams.</p> <p>The discharge tanks should have some contingency.</p> <p>Flexible processing systems allow the plant to use best practice that is developed over its lifetime.</p> <p>Modern waste water reduction and abatement techniques can help reduce fresh water demands.</p> <p>Systems need to take account of realistic fault scenarios.</p> <p>Reducing the number of discharge points makes their management easier.</p> <p>Don't underestimate the complexity of dealing with hydrogen gas streams.</p> <p>Waste containers, their contents and the associated processes need to be shown to produce a product that can be disposed of in the UK.</p> <p>Abatement systems need to reflect progressive discharge reduction.</p> <p>Sampling regimes should be tailored to the time needed for response.</p>
E	A review of the waste management and spent fuel facilities associated with an operational reactor.	<p>The conditions of acceptance of the disposal facilities drive particular waste management practices at a plant.</p> <p>The plants location (infrastructure, policies, etc.) will influence the approach to waste management.</p>
F	A reactor actively being decommissioned	<p>Staged risk reduction based on pre-planned decommissioning stages is a good approach to decommissioning.</p> <p>Early planning for decommissioning will allow the re-use of equipment used in operations and maintenance.</p> <p>Parallel workfaces and cross-over operations allow for prompter decommissioning.</p> <p>Early consideration should be given to waste reduction, decontamination, segregation and recycling.</p> <p>International operational experience feedback should be actively sought when developing decommissioning methodologies.</p>

Table 2

Key Learning Points from Site Visits

Ref.	Description	Key Learning Points
G	A review of the operation of the spent fuel facilities at an operational reactor.	There is a lot of experience of operating spent fuel pools with techniques well developed. The fuel pool can be designed to minimise the lifts of heavy items and the need for large scale decontamination of transfer flasks. Even with innovative designs it is possible to minimise the potential for leaks.
H	A review of PWR training and maintenance facilities.	Robots have been developed and used for repetitive jobs in high dose environments, such as steam generator inspection and maintenance. Plant mock ups aid training and therefore reduce potential doses. Complex fuel handling tasks of long fuel assemblies can be achieved.
I	A review of the radiological protection and waste management facilities associated with an operational reactor and the plans for decommissioning.	It is good practice to have a waste plan, which identifies the disposal route for all wastes. A standard identification system that allows waste to be traced back to its originator and identifies the waste type helps onward processing and records management. A central storage facility for fuel and the use of a ship to transport it can be publicly acceptable. Waste processing and management is simpler if there is a defined end point. A countries waste management infrastructure significantly influences the approach adopted by the plant. A single fixed facility can operate effectively and deal with the waste from a number of reactors. To have confidence in the decommissioning approach the plant needs to be characterised. For example, the operator needs to know the level of contamination in concrete or the background doses. The mapping of the radiological condition of the plant can take significant resource.

Table 2
Key Learning Points from Site Visits

Ref.	Description	Key Learning Points
J	A review of the waste management and spent fuel facilities associated with an operational reactor.	<p>Flexible processing systems allow the plant to use best practice that is developed over its lifetime.</p> <p>The relevant legal requirements drive particular behaviours or practices at a plant, these can change over time.</p> <p>Evaporators designed for specific effluent types can be used successfully. They can be operated safely and effectively to reduce the quantity of radioactive waste for disposal.</p> <p>The minimisation of Stellite™ reduces doses to workers and appears to be practical from an engineering point of view.</p> <p>Drying materials can be achieved with minimal effects on the off-site discharges, but giving a significant reduction in solid volume.</p> <p>There is a lot of experience of operating spent fuel dry stores with techniques well developed.</p> <p>With a suitably shielded design, access into containment can be achieved with minimal dose.</p> <p>Waste management facilities do not need to be in a single complex, it can be successfully implemented on island sites around the plant.</p> <p>Space is needed in the waste management facilities to provide flexibility in dealing with the waste items a plant may produce over its operating life.</p> <p>The amount of space needed in the health physics laboratories needs to be sufficient to provide adequate separation between different activities, processes and samples.</p>
K	A review of waste management and maintenance facilities.	<p>Waste containers, their contents and the associated processes need to be shown to produce a product that can be disposed of in the UK.</p> <p>It is important that the ion exchange resin contains no other objects.</p> <p>Where work is on a campaign basis, with long periods between campaigns, doses can be managed effectively by the use of a dedicated team who work frequently with the equipment on different sites.</p> <p>Contamination traps can be designed out of mobile decontamination machines.</p> <p>Items with high doses that require maintenance can be designed with quick release fixings.</p>

Figure 1: Summary of Main Solid Radioactive Waste Produced by the AP1000 (Part 1)

Description of Waste	Radioactive Waste Classification	Frequency	Normal Volume per Unit Frequency (m ³)	Maximum Volume per Unit Frequency (m ³)	Volume per Life of Plant (m ³)
Spent fuel rods	HLW	40%/18 months	13.7		549
Ion exchange resin	ILW	Annual	7.8	15.6	561
Gray rod cluster	ILW	Once/20y	7.3		147
Wet granular carbon	ILW	Annual	0.6	1.1	41
Filter cartridge	ILW	Annual	0.2	0.4	14
Compactable paper, tape, clothing, plastic, elastomers	LLW	Annual	135	206	8924
Non-compactable metallic items, glass, wood	LLW	Annual	6.6	10.6	445
Condensate Polisher spent resin	LLW	Annual	3.9	7.7	81
Dry granular carbon	LLW	Annual	0.3	3.3	54
HVAC filter – uncompacted fibreglass/metal	LLW	Once/3y to Once/5 y	2.7		47
HVAC filter – granulated charcoal	LLW	Once/10y	4.9		29
Electrodeionisation Unit – resin/membrane module	LLW	Once/12y	1.7		13
Heat exchanger insulation	LLW	Once/60y	8.4		8.4

Figure 1: Summary of Main Solid Radioactive Waste Produced by the AP1000 (Part 2)

Table 4-6 (cont.)					
SUMMARY OF MAIN SOLID RADIOACTIVE WASTE PRODUCED BY THE AP1000					
Description of Waste	Radioactive Waste Classification	Frequency	Normal Volume per Unit Frequency (m ³)	Maximum Volume per Unit Frequency (m ³)	Volume per Life of Plant (m ³)
Filter gaskets – compressible rigid plastic	LLW	Annual	0.1		5.4
Valve packing – compressible rigid plastic	LLW	Once/5y	0.5		5.4
Wet granular particles – sludge	LLW	Annual	0.03	0.1	2.4
Heat exchanger – compressible rigid plastic	LLW	Once/60y	1.6		1.6
Mechanical pump seal – SiC	LLW	Once/5 y to Once/30y	0.05		0.3
Various tank gaskets – compressible rigid plastic	LLW	Once/18month to Once/20y	0.02		0.1
Degassifier Separator – canned pump	LLW	Once/60y	0.06		0.06
Resin transfer screw pump	LLW	Once/10y	0.003		0.017
Heat exchanger gaskets	LLW	Once/60y	0.01		0.01

Figure 2: Westinghouse Radioactive Waste Stream Flow Diagram

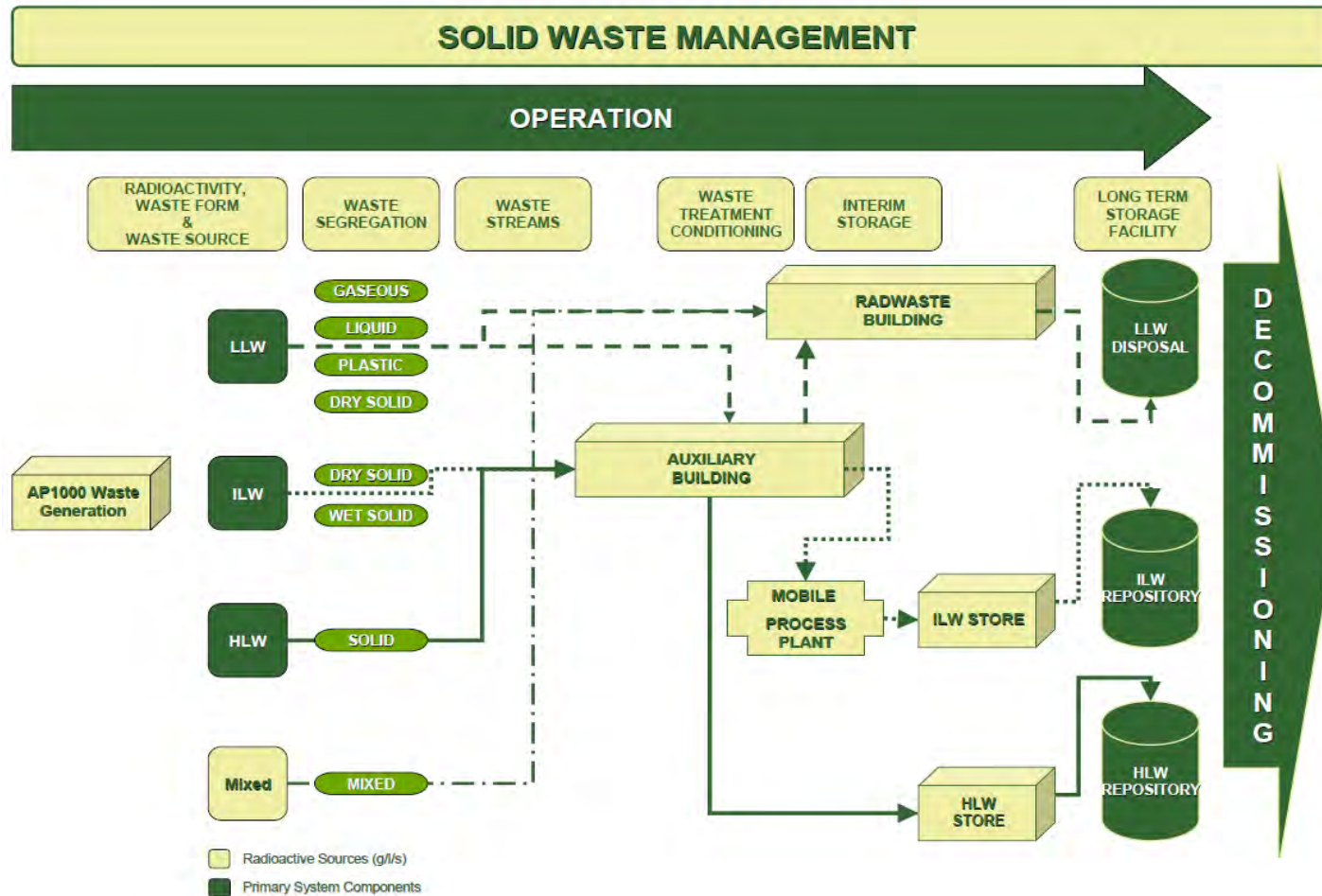
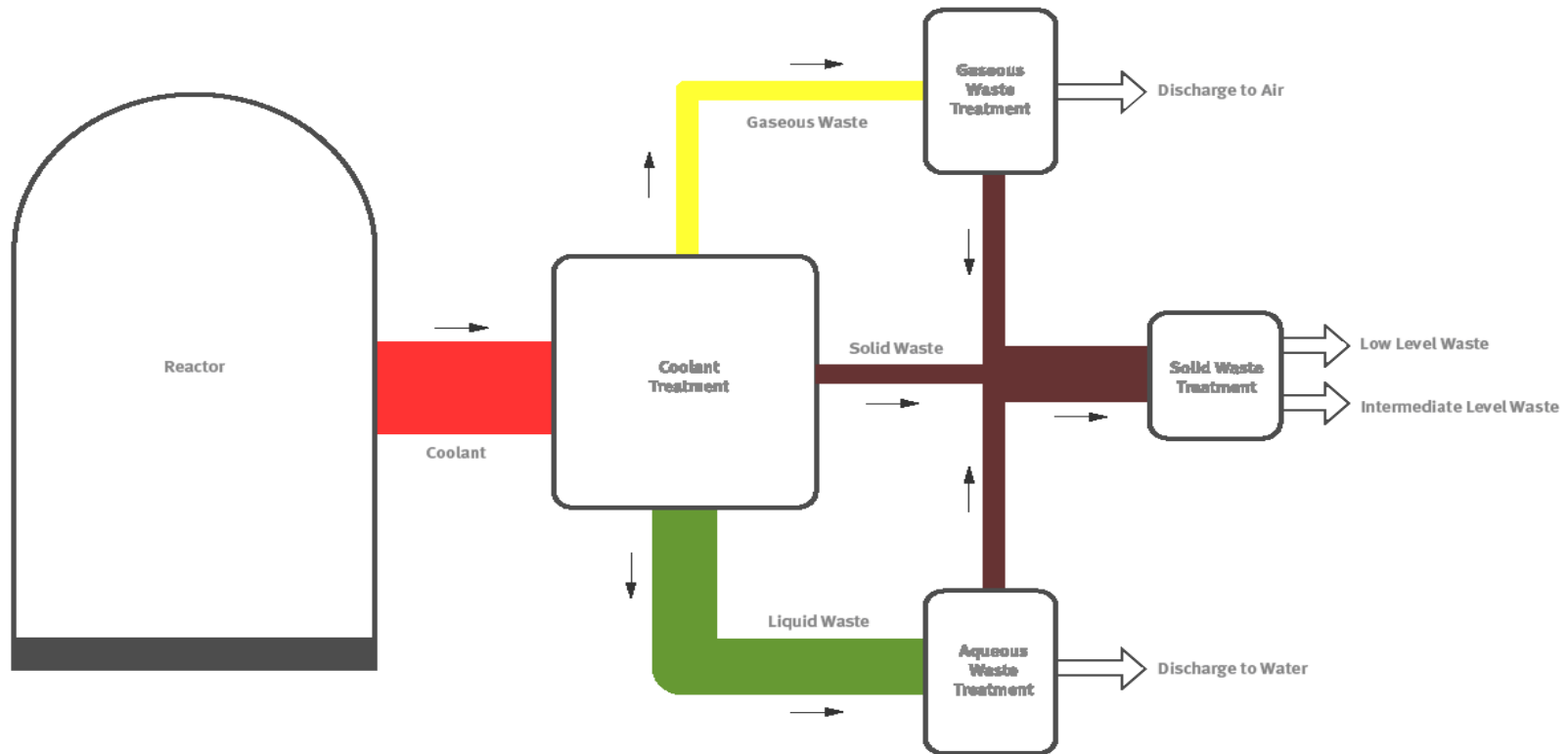


Figure 3: Simplified Flow Diagram of the Liquid and Gaseous Waste Routes



Annex 1

**Assessment Findings to be Addressed During the Forward Programme as Normal Regulatory Business
Radioactive Waste and Decommissioning – AP1000**

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-AP1000-RW-01	The licensee shall produce an updated disposability assessment for all the waste produced by an AP1000, including spent fuel and the disposal of rod cluster control assemblies.	The disposability assessment will be submitted to the Regulators prior to milestone 13, fuel load.
AF-AP1000-RW-02	The licensee shall produce a site specific Radioactive Waste Management Case for all of the wastes that their AP1000 will produce.	The site specific Radioactive Waste Management Case will be submitted to the Regulators prior to milestone 3, nuclear island safety related concrete.
AF-AP1000-RW-03	The licensee shall implement a records management procedure for waste management and decommissioning that incorporates: The methods for identifying the types of record to be retained; the requirement for the production, long-term management, maintenance and preservation of records for spent fuel and Intermediate Level Wastes; and details of how institutional knowledge of the facility will be generated and maintained throughout its life-cycle so that it is accessible during decommissioning.	A copy of the procedure will be submitted to the Regulators prior to milestone 3, nuclear island safety related concrete.
AF-AP1000-RW-04	The licensee shall optimise the operation of the chemical volume control system and the liquid, gaseous and solid waste management processes to ensure that the risks associated with their operation and the management of the resulting wastes are as low as reasonably practicable.	A copy of the report on the optimisation process and outcomes will be submitted to the Regulators prior to milestone 13, fuel load.
AF-AP1000-RW-05	The licensee shall identify the evidence necessary to underpin their ILW storage and disposal strategy, the activities needed to secure this evidence and the time needed for these activities. The provision of this evidence and associated activities will be detailed on a plan that will link the evidence needed with the construction activities for all on site facilities required to manage the ILW over its lifetime.	The plan will be submitted to the Regulators prior to milestone 10, cold operations.

Annex 1

**Assessment Findings to be Addressed During the Forward Programme as Normal Regulatory Business
Radioactive Waste and Decommissioning – AP1000**

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-AP1000-RW-06	The licensee shall produce a safety report for the revised Radwaste Building, the associated processing and long-term storage of the ILW. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases (Ref. 5).	The safety report will be submitted to the Regulators prior to milestone 3, nuclear island safety related concrete.
AF-AP1000-RW-07	The licensee shall identify the evidence necessary to underpin their spent fuel storage, transport and disposal strategy, the activities needed to secure this evidence and the time needed for these activities. The provision of this evidence and associated activities will be detailed on a plan that will link the evidence needed with the construction activities for all on site facilities required to manage the spent fuel over its lifetime.	The plan will be submitted to the Regulators prior to the start of milestone 3, nuclear island safety related concrete.
AF-AP1000-RW-08	The licensee shall produce a plan, with RWMD input, for the work necessary to reduce the on-site storage period for the spent fuel produced by the reactor so that the fuel can be transported as soon as reasonably practical.	The plan will be submitted to the Regulators prior to milestone 13, fuel load.
AF-AP1000-RW-09	The licensee shall produce a safety report for the long-term storage of spent fuel. The report will contain information at least equivalent to that of a Preliminary Safety Case as defined in Guidance on the Purpose, Scope and Content of Nuclear Safety Cases (Ref. 55). It shall also detail the proactive inspection regime for the spent fuel in on-site storage that builds on existing knowledge and experience, allows the spent fuel to be retrieved and inspected within a reasonable time frame and limits the number of fuel assembly lifts.	A copy of the report on the optimisation process and outcomes will be submitted to the Regulators prior to milestone 13, fuel load.
AF-AP1000-RW-10	The licensee shall substantiate why a conceptual stage Letter of Compliance is suitable and sufficient for the start of reactor operations.	The written substantiation will be submitted to the Regulators prior to milestone 13, fuel load.

Annex 1

**Assessment Findings to be Addressed During the Forward Programme as Normal Regulatory Business
Radioactive Waste and Decommissioning – AP1000**

Finding No.	Assessment Finding	MILESTONE (by which this item should be addressed)
AF-AP1000-RW-11	The licensee shall develop a set of decommissioning principles and revise the decommissioning methodology presented in UKP-GW-GL-795 (Ref. 51), to reflect these.	A copy of the revised decommissioning methodology will be submitted to the Regulators prior to milestone 3, nuclear island safety related concrete.
AF-AP1000-RW-12	The licensee shall show that the design has the capacity to allow decommissioning to be delayed; any changes shall be incorporated into a revision of the decommissioning methodology presented in UKP-GW-GL-795 (Ref. 51).	A copy of the revised decommissioning methodology will be submitted to the Regulators prior to milestone 3, nuclear island safety related concrete.
AF-AP1000-RW-13	The licensee shall identify the potential hazards and challenges present during decommissioning and revise the decommissioning methodology presented in UKP-GW-GL-795 (Ref. 51), to reflect these.	A copy of the revised decommissioning methodology will be submitted to the Regulators prior to milestone 3, nuclear island safety related concrete.
AF-AP1000-RW-14	The licensee shall review the construction activities to identify any actions that could be taken during construction that would be beneficial to the decommissioning process.	A copy of the written review will be submitted to the Regulators prior to milestone 3, nuclear island safety related concrete.

Note: It is the responsibility of the Licensees / Operators to have adequate arrangements to address the Assessment Findings. Future Licensees / Operators can adopt alternative means to those indicated in the findings which give an equivalent level of safety.

For Assessment Findings relevant to the operational phase of the reactor, the Licensees / Operators must adequately address the findings during the operational phase. For other Assessment Findings, it is the Regulators' expectation that the findings are adequately addressed no later than the milestones indicated above.

Annex 2

GDA Issues – Radioactive Waste and Decommissioning – AP1000

There are no GDA Issues for this topic area.