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Review of LLW Repository Ltd's “Requirement 2” submission

Overview

Executive Summary

We authorise LLW Repository Limited, the current operator of the Low Level Waste Repository near Drigg, Cumbria (LLWR), to dispose of solid low-level radioactive waste (LLW) in Vault 8 of the LLWR, and to discharge from the site gaseous and liquid effluents associated with disposal operations. LLW Repository Ltd has planning permission to construct Vault 9 at the site to store LLW, but does not have planning permission or authorisation for the disposal of LLW to Vault 9.

In Schedule 9 of the current authorisation we set a number of legal requirements for the operator to carry out improvements or supply us with additional information by defined dates (e.g. reviews of best practice and establishing a research and development programme). In particular:

- Requirement 2 states that the operator, by 1 May 2008, must “provide the Agency with a full report of a comprehensive review of national and international developments in best practice for minimising the impacts from all waste disposals on the site. This shall include a comprehensive review of options for reducing the peak risks from deposit of solid waste on the site, where those risks arise from potential site termination events (e.g. coastal erosion and glaciation) and potential future human action.”
- Requirement 6 states that, by 1 May 2011, the operator must “update the Environmental Safety Case(s) for the site covering the period up to withdrawal of control and thereafter.”

LLWR Repository Ltd delivered their response to Requirement 2 on 1 May 2008. As well as directly addressing Requirement 2, LLW Repository Ltd’s submission provides a useful update on their performance assessment and their strategy for optimisation at the LLWR.

This report presents the findings of our assessment of LLWR Repository Ltd’s submission in fulfilling Schedule 9 Requirement 2 and our comments on their progress towards fulfilling Schedule 9 Requirement 6.

The key elements of the submission are:

- (a) *A review of national and international best practice for minimising the impacts from waste disposals, including a review of options for reducing the peak risks.*
In our view this work has substantially satisfied Requirement 2, but we have also identified some areas for further work to contribute to the full updated Environmental Safety Case (ESC).
- (b) *A proposed interim strategy for risk management at the site which leaves the trench wastes undisturbed, but incorporates the installation of a final site cap, a cut-off wall around the site and vertical drains below the disposal area as part of the closure plan.*
We accept this as a reasonable interim position, although we note some uncertainty around the acceptability of vertical drains in the light of developments in groundwater protection regulations.
- (c) *A ‘toolkit’ of further risk management technologies, identified by LLW Repository Ltd’s review.*
These technologies will be assessed as understanding of the site develops, leading to a more definite optimised risk management strategy and closure plan. We agree that further assessment of technologies is needed. For example, while we accept LLW Repository Ltd’s conclusion that full retrieval of all of the trench wastes may be ruled out on a number of grounds, we expect LLW Repository Ltd to investigate further the possibility that the wastes that contribute to the higher risks could be selectively retrieved. We expect LLW Repository Ltd to develop a more detailed and explicit plan of how the toolkit and its application will be pursued, including how stakeholders will be engaged in the process.
- (d) *Substantial advances in knowledge about the existing inventory of waste in the trenches, including the specific locations of some particular waste streams.*
We welcome this work, which has led to a reasonable understanding of the waste inventory. However, we believe some further work is needed to characterise the uncertainty surrounding the estimated inventory. This additional work should include an investigation of anecdotal evidence about past disposal practices. More importantly, we now expect LLW Repository Ltd to give more attention to efforts that will improve their understanding of the inventory of radionuclides in wastes that are likely to be consigned to the LLWR in the future. This work

should focus particularly on those waste streams that seem most likely to make a significant contribution to the risks from the vaults.

- (e) *A proposed methodology for defining the radiological capacity of the site, and an interim proposal that the radiological capacity be the reference inventory presented in the submission.* We agree that, apart from a specific concern about the assessment of human intrusion scenarios, the proposed methodology is generally reasonable. Pending the completion of the full ESC and the finalisation of the UK National LLW Strategy, we are also satisfied that the proposed interim radiological capacity can be used for the time being as a working basis without significantly affecting the environmental risks from the site. However, we expect LLW Repository Ltd to provide a definitive proposal on radiological capacity as part of the full updated ESC in 2011. This proposal must be underpinned with comprehensive assessments that must also be included in that ESC.
- (f) *A performance update that indicates substantially lower estimated impacts than those presented in the 2002 Post Closure Safety Case (especially for the trenches).* In most cases impacts estimated in the performance update fall below our regulatory guidance levels as specified in the environment agencies' Guidance on Requirements for Authorisation (GRA) for near surface disposal. We agree that this is a useful update and we note the lower estimated risks. However, the scope of the performance update is too limited for us to reach any conclusion about whether the estimated impacts satisfy our criteria specified in the GRA.
- (g) *A comprehensive review of evidence and predictions concerning the future evolution of the site, leading to a strong conclusion that the facility is highly likely to be destroyed by coastal erosion within a few thousand years. Erosion of the site could begin as early as 750 years from now.* In view of the importance of this issue, we commissioned an independent expert to review the work presented by LLW Repository Ltd. Our review and the conclusions of the independent expert largely confirm that LLW Repository Ltd's conclusion is robust.

On the basis of our review of LLW Repository Ltd's submission, we have reached the following conclusions:

- (a) Schedule 9 Requirement 2 has been substantially satisfied.
- (b) Since LLW Repository Ltd has not yet provided us with adequate information to allow the radiological capacity of the site to be set definitively, we cannot yet authorise LLW disposals to Vault 9. The methodology for setting a radiological capacity proposed by LLW Repository Ltd in the Requirement 2 submission may provide a suitable basis to achieve this authorisation, but it will need to be supported by an adequate full ESC.
- (c) Since LLW Repository Ltd has not yet provided us with a risk management study that demonstrates definitively that future impacts will be as low as reasonably achievable (ALARA), we currently deem it inappropriate to construct the final cap over the trenches and Vault 8. The necessary demonstration may be achievable using the 'Best Practicable Environmental Option' methodology described in the Requirement 2 submission, but we will need to see evidence that the risk management options identified in the 'toolkit' – such as the selective retrieval of wastes that contribute to the higher risks – have been fully and systematically analysed, using adequately robust data and taking into account the views of stakeholders.

The likely destruction of the facility by coastal erosion within a few thousand years is clearly a key issue. We will therefore pay particular attention to whether the full ESC adequately demonstrates, in relation to erosion of the facility, that:

- the specific requirements within the GRA are met (including measures to ensure that radiation dose constraints and risk and dose guidance levels to the public are complied with during the operation of the site and after its closure);
- the risks presented by the site are optimised;
- all necessary measures are taken to contain the wastes while the site is under operational management.

If this demonstration is supported by robust analysis, then we will accept that coastal erosion at some point in the future is an acceptable risk.

While the quantitative assessment is only one element of the ESC, it is an important one. The performance update in the Requirement 2 submission indicates doses and risks are within the relevant guidance levels specified in the GRA, with the exception of the conditional risk associated with the 'well scenario'. However, the full ESC will need to update and expand upon the performance update considerably. The full ESC will need to supply a robust demonstration that doses and risks from all scenarios and pathways are consistent with the guidance levels. This demonstration will need to:

- show that the assessment of impacts – particularly those associated with coastal erosion of the facility – is sufficiently comprehensive and soundly based;
- show that the risk from the well pathway, calculated with an adequately specified and justified model, is sufficiently low;
- show that the risks from all pathways remain sufficiently low when all of the relevant uncertainties, and the heterogeneity of the wastes, have been adequately taken into account;
- provide adequate evidence that the approaches, models and data used for the assessments are sufficiently reliable in the way they have been used.

In summary, LLW Repository Ltd has substantially satisfied Requirement 2 and has also made considerable progress towards Requirement 6. However, a substantial amount of work is still needed to complete a full ESC that is adequately underpinned by appropriate evidence and analysis. Our detailed review comments indicate the areas where we expect to see improvements. In our view, it will be challenging for LLW Repository Ltd to achieve these improvements by the deadline of 1 May 2011, but we do believe they are achievable. Authorisation of further disposal at the LLWR, beyond that authorised in Vault 8, will not be given until a satisfactory environmental safety case is produced and we will continue to require an acceptable case to be produced for past disposals.

This document is out of date and was withdrawn 07/11/2017

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Executive Summary

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1 Introduction

1.1 Site history

- 1.1.1 The Low Level Waste Repository near Drigg, Cumbria (LLWR) is located six miles south of the Sellafield site in the northwest of England. Radioactive waste disposal began at the site in 1959 when the LLWR was managed by the United Kingdom Atomic Energy Authority (UKAEA). The LLWR site occupies around 100 hectares; waste disposal operations take place in the northern 40 hectares of the site. During the early period of disposal operations, solid low level radioactive waste (LLW) was tipped and buried in shallow, clay-lined trenches, a practice similar to that used now in the landfill industry. Between 1959 and 1995, approximately 800,000 m³ of waste was disposed in seven trenches. These trenches are now covered by an interim earth cap, which incorporates a plastic membrane to minimise water ingress.
- 1.1.2 In 1986 the House of Commons Environment Committee published a report on radioactive waste (House of Commons, 1986). In response to the report's recommendations, the LLWR operator at the time, British Nuclear Fuels plc (BNFL), made major changes to disposal operations. Since 1988, wastes have been disposed of in containers emplaced in an engineered concrete vault (Vault 8). Typically, the waste is put into steel drums which are then compacted into 'pucks'. These pucks are packed into freight containers that conform to published standards of the international standards organisation ISO. The wastes in full containers are encapsulated in cement grout before being placed in the vault. Vault 8 has a total capacity of 200,000 m³; at the time of writing it is nearly full. The current operator of the LLWR, LLW Repository Ltd, plans to build additional vaults to accept further waste, subject to receiving planning permission from Cumbria County Council.

1.2 Regulatory background

- 1.2.1 The Environment Agency of England and Wales (the Agency; also referred to as "we" and "us") is responsible for authorising disposal of radioactive waste under the amended Radioactive Substances Act 1993 (RSA 93). In accordance with government policy, we periodically review authorisations for the disposal of radioactive waste. When we review an authorisation, we consider a wide range of information, including our conclusions from reviews of the environmental safety cases (ESCs) produced by the operators of a disposal facility.
- 1.2.2 The Health and Safety Executive (HSE), through its Nuclear Installations Inspectorate (NII), regulates nuclear safety. It ensures that radioactive waste on nuclear licensed sites is managed, conditioned and stored safely. The NII also has regulatory responsibility for accident risk management.
- 1.2.3 In 1999, we started a review of the RSA 93 authorisation for the LLWR, which was then held by BNFL. At that time, however, BNFL had not updated the impact assessment carried out in the 1980s by the National Radiological Protection Board (NRPB, now part of the Health Protection Agency, HPA). Our review was therefore unable to assess the potential impact of the site from existing and future (predicted) disposals. Consequently, in January 2000 we changed (varied) the LLWR authorisation and required BNFL to provide information about the environmental safety of the LLWR during its operational lifetime (Operational Environmental Safety Case, OESC) and after its final closure (Post Closure Safety Case, PCSC). BNFL submitted these two ESCs in September 2002 (BNFL, 2002a and 2002b). Between 2002 and 2005 we carried out a detailed assessment of the safety

cases (Environment Agency, 2005a) which raised a number of criticisms, many of which were formally recorded in Issue Assessment Forms (IAFs)¹.

- 1.2.4 Following the review of the 2002 ESCs, we reviewed the RSA 93 authorisation and in May 2006 granted a new one (Environment Agency, 2006a) to the operator, which by that time had become known as British Nuclear Group Sellafield Limited (BNGSL). In addition to the ESCs submitted by BNFL in 2002, this authorisation review also took account of the legislation and guidance in effect at the time (RSA 93, and the UK environment agencies' Guidance on Requirements for Authorisation (the GRA), Environment Agency *et al.*, 1997). Our concerns regarding the safety cases presented in 2002 led us to authorise disposals only to Vault 8, and required the operator to deliver an updated ESC by May 2011.
- 1.2.5 The LLWR site is now owned by the Nuclear Decommissioning Authority (NDA) and is operated on behalf of the NDA by a Site Licence Company (SLC). The SLC was initially BNGSL, but the authorisation was transferred in 2007 to a new SLC, LLW Repository Ltd, with no major changes to the authorisation. This change in SLC paved the way for the NDA to open the operation of the site to competitive tender. In 2008 United Kingdom Nuclear Waste Management Ltd (UKNWM Ltd) was awarded a contract from the NDA to manage and operate the LLWR. Shares in the SLC were transferred to UKNWM Ltd on 1 April 2008 and the SLC continues to be known as LLW Repository Ltd.
- 1.2.6 LLW Repository Ltd is currently authorised to dispose of solid low-level radioactive waste in Vault 8 of the LLWR, and to discharge from the site gaseous and liquid effluents associated with the LLW disposal operations. LLW Repository Ltd has planning permission to construct Vault 9 at the site to store LLW, but does not have planning permission or authorisation to dispose of LLW to Vault 9.
- 1.2.7 In Schedule 9 of the current authorisation we set a number of legal requirements for the operator to carry out improvements or supply us with additional information by defined dates (e.g. reviews of best practice and establishing a research and development programme). This report relates to our review of LLW Repository Ltd's work to fulfil Schedule 9 Requirement 2 and their progress towards fulfilling Schedule 9 Requirement 6.
- 1.2.8 Requirement 2 states that the operator, by 1 May 2008, must "provide the Agency with a full report of a comprehensive review of national and international developments in best practice for minimising the impacts from all waste disposals on the site. This shall include a comprehensive review of options for reducing the peak risks from deposit of solid waste on the site, where those risks arise from potential site termination events (e.g. coastal erosion and glaciation) and potential future human action."
- 1.2.9 In discussions with LLW Repository Ltd we agreed that, in addition to the specifics of Requirement 2, their response would also aim, as far as possible, to address the wider expectations expressed in our 2006 Decision Document (Environment Agency, 2006a), to:²
- (a) demonstrate that best practice is being applied to keep the peak risks from the site as low as reasonably achievable (ALARA);
 - (b) substantiate a proposal for the radiological capacity of the site (the maximum amount of waste that could be disposed of while still maintaining the site's environmental safety).

¹ Issue Assessment Forms (IAFs) are detailed records of concerns raised as part of the Environment Agency's review of BNFL's 2002 environmental safety cases. In a systematic manner they record issues that we expect the operator of the LLWR to address prior to submission of the next fully updated ESC in 2011.

² In section 4.6 of the Decision Document (Environment Agency, 2006b) we stated that "we will not authorise LLW disposals to the proposed Vault 9, until ... BNGSL has provided us with adequate information to allow the radiological capacity of the site to be determined ... and we will undertake a full review on the radiological capacity of the site and publish our findings." Later in the same section we stated that "we will not allow BNGSL to construct the final cap over the existing Vault 8 and trench disposals until BNGSL has provided us with the outcome of a wide-ranging risk management study ... that demonstrates that future impacts will be As Low As Reasonably Achievable (ALARA)." The latter decision is clearly reflected in Requirement 2. We have interpreted the former decision also to be reflected in Requirement 2 as it comes from the same section of the Decision Document. We have confirmed to LLW Repository Ltd that this is the case and they have agreed to include their proposals on radiological capacity in their Requirement 2 submission.

- 1.2.10 Requirement 6 states that, by 1 May 2011, the operator must “update the Environmental Safety Case(s) for the site covering the period up to withdrawal of control and thereafter.” This update should address our criticisms of the 2002 ESCs and supporting programmes (Environment Agency, 2005a, 2005b, 2006b). It should also take account of developments since the 2002 ESCs were produced, such as evolution of operating practices, additional information about the site, the design of the repository and the waste inventory, changes in ownership, and developments in government policy (Defra, 2007) and regulatory guidance (Environment Agency *et al.*, 2008).
- 1.2.11 Since 2006, we have had regular dialogue with LLW Repository Ltd about progress towards meeting the Schedule 9 requirements. We expected the information in LLW Repository Ltd’s response to Requirement 2 would provide some indications of progress on the updating of the ESC, and so serve as a milestone for assessing progress towards the 2011 deadline for the submission of the ESC.

1.3 Objectives of our review

1.3.1 The main objectives of this review are to:

- (a) assess whether the information supplied by LLW Repository Ltd represents a satisfactory response to Requirement 2;
- (b) identify from the information supplied any immediate implications for the conditions of LLW Repository Ltd’s authorisation;
- (c) assess the information supplied against the new regulatory guidance (Environment Agency *et al.*, 2008³), and to provide additional guidance to LLW Repository Ltd on its programme to develop an ESC that appropriately addresses the requirements of the GRA;
- (d) identify any additional assessment that we might need to carry out, such as independent R&D, model development, conduct of independent calculations, or examination of further documents, so that we can effectively and efficiently assess the ESC when it is provided.

1.4 LLW Repository Ltd’s submission

1.4.1 On 1 May 2008, LLWR Repository Ltd delivered to us five volumes setting out its response to Requirement 2:

- i. Volume 1 (LLW Repository Ltd, 2008a) summarises the submission and directly addresses the issues raised in Requirement 2;
- ii. Volume 2 (LLW Repository Ltd, 2008b) summarises the “comprehensive review of options for reducing the peak risks from deposit of solid waste on the site”;
- iii. Volume 3 (LLW Repository Ltd, 2008c) summarises developments in characterising the inventory and near field processes;
- iv. Volume 4 (LLW Repository Ltd, 2008d) summarises developments in site understanding (including geology, hydrogeology and coastal evolution);
- v. Volume 5 (LLW Repository Ltd, 2008e) summarises updates (since the 2002 ESCs) to LLW Repository Ltd’s assessment of the future performance of the facility.

1.4.2 These five volumes refer to a large number of supporting documents that provide details of the analyses, assessments and evidence that underpin the arguments presented in the top level volumes. In our assessment of LLWR Repository Ltd’s submission we have also

³ A consultation draft of the GRA for near surface disposal was issued in May 2008 (Environment Agency *et al.*, 2008), and a final version (Environment Agency *et al.*, 2009) in February 2009. In conducting this review we had access to the consultation draft, and initial indications of modifications likely to be made in finalising the GRA for near surface disposal. The final version was published as we were finalising our documentation of this review, and so was not explicitly taken into account. However, we do not believe that any differences between the consultation draft and the final version would significantly alter any of our conclusions or recommendations.

reviewed the supporting documentation to the extent we considered necessary for us to establish the soundness of the submission.

1.5 Our review

1.5.1 Our review considers LLW Repository Ltd's submission primarily in relation to:

- (a) Schedule 9 Requirement 2;
- (b) the April 2008 consultation draft of the environment agencies' Guidance on Requirements for Authorisation for near surface disposal, as an indication of progress towards meeting Schedule 9 Requirement 6; and
- (c) the IAFs from the review groups participating in our review of the 2002 ESCs.

This report and our four other main review reports (Environment Agency, 2009a-d) present our findings in relation to Requirement 2, the GRA/Requirement 6, and any general or significant observations arising from our consideration of the IAFs. Our full review of the submission against the IAFs will be reported separately to LLW Repository Ltd as part of our continuing dialogue leading up to the delivery of the full ESC due in 2011.

1.5.2 We report here on our technical review of LLW Repository Ltd's response to the technical authorisation requirement we set out in the RSA 93 authorisation granted to the LLWR operator in 2006. This does not constitute a review of LLW Repository Ltd's authorisation, although it will be taken into account in the periodic review of the authorisation, which is due to be completed in early 2009. This review may also provide input into future periodic reviews.

1.5.3 We have aimed in our review to identify all significant issues arising from the Requirement 2 submission and supporting documents. Where we do not comment on a particular point in the submission or accompanying documentation, it is unlikely (based upon the information presented to us at this stage) that we would raise that point as an issue in the future (particularly in our review of the full ESC). However, this cannot be taken as an absolute guarantee; we reserve the right to revisit any issues that we think warrant attention at any time in the future.

1.5.4 Where we have made recommendations to LLW Repository Ltd in this and the four other main review reports, we have classified them to assist in the prioritisation of action:

- (a) **Category A**
Relatively major issues for which the appropriate course of action is not immediately obvious. For these issues, we expect LLW Repository Ltd to provide substantial additional information, evidence or analysis in the full ESC. We also expect LLW Repository Ltd to report to us on their progress between now and delivery of the ESC. Such reporting might, for example, include detailed plans of action, descriptions of proposed approaches, models or data, or results from interim or provisional analyses.
- (b) **Category B**
Relatively major issues for which it is fairly clear what needs to be done. For these issues, we expect LLW Repository Ltd to provide substantial additional information, evidence or analysis in the full ESC. We will keep these issues under a degree of review via the regular dialogue between ourselves and LLW Repository Ltd and we will provide further guidance if requested. However, we will not require LLW Repository Ltd to report formally on progress.
- (c) **Category C**
Issues for which LLW Repository Ltd will need to provide some additional information, evidence or analysis in the full ESC, and report some or all of this to us between now and delivery of the ESC. Generally, we estimate the effort needed to address Category C recommendations will be substantially less than for Category A.
- (d) **Category D**
Issues for which LLW Repository Ltd will need to provide some additional information, evidence or analysis in the full ESC, without the need for formal reports on progress.

Generally, we estimate the effort needed to address these points will be substantially less than for Category B.

Where our recommendations or other observations are not assigned to any of the above categories, we do not expect or require a specific response from LLW Repository Ltd. Nevertheless, LLW Repository Ltd may wish to consider these points as suggestions because they may, individually or collectively, affect our general confidence in the ESC or the ease with which we can review it. For example, individual typographical errors in reports may be considered trivial, but if persistent or present in large numbers, they could affect our confidence in the quality controls applied by LLW Repository Ltd.

- 1.5.5 We recognise that some of the issues raised in our review may be at least partly addressed in the updated and expanded Safety Case Approach document that LLW Repository Ltd produced at the end of 2008 (Baker *et al.*, 2008), but we have not included consideration of the Approach document in this review.
- 1.5.6 Our review mirrors the structure of LLW Repository Ltd's submission. Our four separate technical review documents address Volumes 2–5 of the submission (and the supporting documentation). This overarching review document presents a summary of the key findings from our technical reviews and provides specific comments on any additional aspects presented in Volume 1 of the submission.
- 1.5.7 A specific sub-section of this summary review addresses the key issue of coastal erosion and our additional review of the evidence provided by LLW Repository Ltd. We conclude this overview report with our overall conclusions in relation to Requirement 2 and make recommendations relating to the delivery of the updated ESC due in 2011.

This document is out of date and was withdrawn 01/11/2017

2 Our review of the submission

2.1 Introduction

2.1.1 We have reviewed Volumes 2–5 of LLW Repository Ltd's submission, along with relevant further reports supporting those volumes. As noted earlier, these detailed reviews are documented in separate reports (Environment Agency, 2009a–d). This section focuses on the main issues arising from those reviews. It summarises the main conclusions and recommendations from each of those reviews, provides some commentary on these conclusions and recommendations in the context of the overall review, and addresses the points arising directly from our review of Volume 1. We present the key findings of the technical reviews of Volumes 2–5, before those of Volume 1 because much of Volume 1 of the submission summarises work described in more detail in Volumes 2–5.

2.2 Volume 2: Options for reducing future impacts

2.2.1 Volume 2 describes and briefly evaluates a wide range of technologies that have been used or proposed around the world that might conceivably be applied at the LLWR – particularly to the trenches – to help reduce the long term impacts from the buried waste. It goes on to describe the process used by LLW Repository Ltd to evaluate systematically which of the technologies (if any) could be beneficial at the LLWR. The advantages and disadvantages of applying these technologies are discussed; the optimum strategy for managing the risks from the site is consequently outlined.

2.2.2 On the basis of this work, LLW Repository Ltd identify some technologies that they think should be applied (e.g. a substantial final cap over the site). They effectively rule out several options on the grounds that they would not be beneficial. The complete retrieval of all waste from the trenches is notably eliminated because it would involve major disruption and expense, would expose workers to significant risks, and would require large amounts of waste to be re-disposed in another facility. The use of coastal defences to protect the LLWR from erosion is also ruled out because it would be impossible to guarantee that such defences would be maintained over the necessary timescales. LLW Repository Ltd also identify a range of technologies that might be beneficial (individually or in combination) depending on precise circumstances. They propose to treat these technologies as a 'toolkit', to be selected and applied, if and when appropriate, as more detailed information is obtained. The toolkit technologies include:

- (a) selective retrieval or *in situ* immobilisation of specific wastes that contribute significantly to the overall risk;
- (b) construction of vertical drains and an underground cut-off wall around the site to divert radionuclides in leachate downwards to greater depth;
- (c) retention of institutional control over the site.

Provisionally, LLW Repository Ltd propose that the optimum strategy would involve construction of a cap, vertical drains and a cut-off wall, but no retrieval or further immobilisation of emplaced waste. However, this strategy is presented as an interim position, subject to further investigation and optimisation, which must take account of new information and developments in understanding which may arise as work continues towards the fully updated ESC in 2011.

2.2.3 The overall response to Requirement 2 relies heavily on reductions in the *assessed* risks which were calculated in the performance update (as compared to those calculated in the 2002 PCSC). The response does not place much emphasis on proposals that would reduce the *actual* risks (e.g. by retrieving or immobilising wastes). Indeed, at times the submission seems to blur the distinction between assessed and actual risks. (Though we accept that it is entirely legitimate for LLW Repository Ltd to consider potential actions to

reduce actual risks in the context of the best available information on the assessed risks). Any action will inevitably incur costs and have some negative impacts; these have to be weighed against the likely reduction in risks. If the full ESC were to confirm that the levels of assessed risk were similar to those suggested by the performance update (Volume 5), i.e. broadly acceptable, then clearly there would be less incentive to consider intrusive methods to reduce risks than if risks were at the less acceptable levels calculated for the 2002 PCSC. However, in the absence of such confirmation, we consider that Requirement 2 refers primarily to options to reduce the actual risk, and our recommendations for follow up work arising from Requirement 2 are based on that premise. LLW Repository Ltd may choose to adjust their response to those recommendations on the basis of developing confidence (or otherwise) in their risk assessments, but they would do so at their own risk

2.2.4 In Volume 2, LLW Repository Ltd review national and international developments in best practice for minimising the impacts that arise from past disposals in the trenches at the LLWR. This review covers different options for reducing the peak risks from the deposit of solid waste on the site. LLW Repository Ltd have investigated options for reducing the peak risks from the groundwater and gas pathways, from potential site termination events and from possible human action in the future. In this respect LLW Repository Ltd's response goes beyond the scope of Requirement 2. Additionally, LLW Repository Ltd has used the reviews of best practice and options to outline a proposed optimum strategy for the site, subject to some further developments. Our overall assessment is that the work reported in Volume 2 substantially satisfies Requirement 2 and in some respects goes beyond it. However, it falls short of what we will expect from the full ESC, particularly for the following reasons:

- (a) The review of options for reducing the peak risks needs to be developed further. LLW Repository Ltd have developed and briefly characterised a reasonable set of 'tools' – potentially useful methods that might contribute to risk reduction measures. However, LLW Repository Ltd now need to define and compare systematically the specific, coherent options for reducing risks.
- (b) The review of national and international developments needs to be complete and up-to-date. Some potentially relevant and reasonably well known examples have not been mentioned or have been considered only briefly. It is not clear whether these are simple omissions or whether LLW Repository Ltd has considered these examples and judged them not to be sufficiently relevant. All relevant examples will need to be documented in detail and taken into account in the consideration of potential detailed strategies.
- (c) Although stakeholders have been engaged, the structure of the process to date has given stakeholders limited scope for active and meaningful participation in decision making.

2.2.5 We therefore conclude that LLW Repository Ltd has substantially satisfied Requirement 2. We note that there are some minor areas specific to Requirement 2 that need further work, but we consider that these issues are best addressed as part of the on-going work programme towards the full ESC. However, further work will also be needed so that the full ESC addresses in more detail some of the issues arising from Requirement 2. First and foremost, LLW Repository Ltd need to develop and implement a detailed follow-up action plan to apply the methodology developed in the work to date. This plan should include details of how they intend to:

- (a) identify more specifically any gaps and uncertainties in their knowledge and understanding of the site, the wastes, the technologies and the impacts that have hindered meaningful comparison of specific risk reduction options to date. This should include, but is by no means limited to, investigating the anecdotal evidence concerning past disposal practices in the LLWR trenches;
- (b) address those gaps and uncertainties sufficiently to allow robust decisions to be made;
- (c) reconsider and compare the applicability of different technologies (and combinations of technologies) for reducing risks to provide soundly based assessments of the best practicable option;

- (d) involve stakeholders in the process in such a way that they can understand and meaningfully contribute to decision making.

In formulating this action plan, we would expect LLW Repository Ltd to make their review of national and international developments comprehensive, and complete their review of risk reduction options by defining an optimised strategy for the site.

- 2.2.6 Where the work so far has identified potentially useful technologies that are not currently considered 'available', the follow-up action plan should aim to identify any advance(s) in the technology that should trigger a re-evaluation of its applicability. The plan should indicate whether LLW Repository Ltd intend to:

- (a) actively support R&D to achieve the relevant advance(s);
- (b) monitor progress on an existing or planned programme of R&D elsewhere;
- (c) wait for the relevant advance(s) to arise from an as yet unknown source;
- (d) discount from further evaluation.

The plan should also set out LLW Repository Ltd's strategy for monitoring and assessing potentially useful technologies that may emerge in the future. In particular they should outline mechanisms by which they will keep up-to-date about the 'state of the art', identify emerging technologies that merit closer attention and feed them into the system described above for already identified technologies.

2.3 Volume 3: Inventory and near field

Inventory

- 2.3.1 Volume 3 describes work to improve the understanding of the existing and future inventory of waste disposed of in the LLWR. It also presents LLW Repository Ltd's current 'best estimate' of the inventory. For the trenches, a major programme of work has been carried out to review all of the significant sources of documentary evidence and use them to identify as accurately as possible not only what wastes are in the trenches, but also where specifically in the trenches particular waste streams or radionuclides (particularly those that contribute most to the long term risks from the site) are concentrated. For the future inventory, some improvements have been made to modelling what wastes are expected to be sent to the LLWR and the characteristics of those wastes. However, LLW Repository Ltd acknowledge that further work is needed on this aspect of the inventory.
- 2.3.2 We welcome the work related to the LLWR inventory presented in Volume 3. Compared to previous analyses, it provides more detailed and robust data on the inventory overall and the specific location of particular waste streams. It provides a useful input to LLW Repository Ltd's response to Requirement 2 and we expect it to provide an important input into the further evaluation of options for reducing risks associated with wastes in the trenches. In particular, it should provide valuable information on which to base more detailed assessments of the costs and benefits of the possible selective retrieval of specific wastes.
- 2.3.3 In our view a major limitation of the work presented in the Requirement 2 submission is its lack of a systematic treatment of uncertainty. This concern extends to the reporting and treatment of inventory uncertainty. It is clear from Volume 3 and from our dialogue with LLW Repository Ltd that considerable uncertainties remain concerning the disposal inventory in the LLWR. We did not require this submission to address these uncertainties systematically and comprehensively, but we expect the full ESC to cover uncertainties in detail. However, we recognise the fundamental differences between the uncertainties associated with the inventory of the trenches and those for the vaults, and we expect LLW Repository Ltd's approaches to differ accordingly.
- 2.3.4 In the case of the trenches, the uncertainty about the disposed inventory is entirely due to imperfect knowledge. The work reported in Volume 3 has derived an inventory for the

trenches that seems to be the best level of knowledge that can reasonably be obtained from the documentary sources available. The people who have worked at the LLWR offer another potential source of knowledge and we welcome LLW Repository Ltd's programme of work to contact and elicit information from such individuals. In particular we welcome LLW Repository Ltd's plans to investigate the extent and reliability of anecdotal evidence that suggests that documentary sources may not accurately reflect some of the disposals made in the past. It was clear to us from the stakeholder workshops held in the course of the work described in Volume 2 that these questions are important concerns for local stakeholders. We also believe it is important that the accuracy of the documentary sources is demonstrated to establish confidence that the inventory in the trenches is sufficiently well understood. We expect the full ESC to incorporate any necessary changes to the assessment inventory for the trenches that stem from the results of this elicitation exercise. The changes should be made in an open and traceable manner, and the ESC should use the results to help define and address any remaining uncertainties.

- 2.3.5 Assuming that the elicitation work is completed satisfactorily and the results are adequately reflected in the ESC, we agree with LLW Repository Ltd's view that significant further investigation to improve the general understanding of the radiological inventory of the trenches is unlikely to produce a proportionate benefit. We agree that any remaining uncertainty associated with the inventory in the trenches can, and may best, be addressed by the usual methods in the safety assessment. However, it is our view that further work to improve understanding of specific areas of the trenches may provide a valuable input to decisions on whether or not selective retrieval or localised *in situ* remediation might be beneficial. We also note that further investigation of the non-radiological composition of the trenches wastes may be needed to support the non-radiological assessment and/or near field understanding.
- 2.3.6 Most of the uncertainty associated with the inventory for the vaults relates to wastes that have not yet been disposed of, specifically in terms of their composition and form, and whether they will in fact be disposed of at the LLWR. LLW Repository Ltd therefore have a degree of control over this uncertainty and should be able to reduce it significantly. Information in the Requirement 2 submission (and supporting documents) and from wider dialogue suggests that the national inventory data for many future LLW streams are poorly justified and must be regarded as significantly uncertain. We do not expect LLW Repository Ltd to duplicate the work undertaken to compile the national inventory, but we do expect them to engage with consignors to improve their understanding of key waste streams destined for the LLWR. We would expect LLW Repository Ltd to focus on those waste streams that contribute significantly to the highest risks and determine whether the content of key radionuclides may have been overstated. However, we will also expect LLW Repository Ltd to demonstrate that it has balanced potential overstatement with due consideration of the possibility that some radionuclides in some waste streams may have been under-reported.
- 2.3.7 Once LLW Repository Ltd have improved confidence in their understanding of the composition of key future waste streams, we will expect to see explicit consideration of the options for the disposal of the waste streams that are thought to create particular challenges in the ESC (likely to be those with higher content of certain long-lived radionuclides). For any waste stream that contributes significantly to assessed risks (or doses from human intrusion) that approach or exceed the guidance levels specified in the GRA, we will expect to see explicit demonstration that disposal at the LLWR represents the best practicable environmental option (BPEO) for that waste stream. However, we recognise that it will not necessarily be LLW Repository Ltd's responsibility to demonstrate all of these points.

Near field

- 2.3.8 Volume 3 also describes how LLW Repository Ltd's understanding and modelling of near field conditions in the trenches and the vaults has progressed and how near field conditions are likely to evolve over time. Compared to the 2002 PCSC, the major innovation described in Volume 3 is an improved understanding of the origins and nature of the historic wastes

in the trenches that contain most of the existing inventory of uranium. Taking account of the processes to which uranium residues from Springfields were subjected, LLW Repository Ltd have concluded that most of the uranium remaining in the wastes would be contained in a fluoride matrix and so would not readily dissolve in groundwater in the near field. On the basis of this understanding, together with site monitoring data on concentrations of fluorides and uranium, LLW Repository Ltd have revised their model for uranium dissolution which now gives what they believe is a more realistic representation of the processes expected to occur. This change reduces the predicted rate at which uranium is released from waste in the trenches, which ultimately leads to lower estimates of future doses via the groundwater pathway.

- 2.3.9 We consider the lack of a systematic treatment of uncertainty to be a major limitation in the work on the near field presented in the Requirement 2 submission. As noted earlier, all of the near field work would benefit from a more comprehensive analysis of uncertainty, but we particularly expect LLW Repository Ltd to cover key uncertainties in areas such as the engineering performance assessment and the assumptions about water flows that come from this assessment, and the representation of solubility and sorption.
- 2.3.10 Some aspects of the modelling of the near field described in Volume 3 have been reviewed and, in some cases, updated or improved since the 2002 PCSC and OESC. LLW Repository Ltd generally claim that these are improvements on the 2002 assessments; this may well be the case, but all the changes in the modelling should be adequately substantiated. For example, if LLW Repository Ltd intend to use their model for uranium residue leaching in the full ESC, we recommend that they provide further justification for the model and its parameters. This further justification might come from more evidence to support the correctness of the model, or a discussion of alternative conceptual models that demonstrates a robust overall approach.
- 2.3.11 The work reported in Volume 3 incorporates some modelling approaches, assumptions and data that were used for the 2002 assessments; it is not always clear whether these remain valid in the context of the new elements. In some cases, we found that LLW Repository Ltd continue to use elements of the 2002 assessments that we strongly criticised in our review of the 2002 safety cases, but the issues we raised have not been addressed. We do not believe that this necessarily leads to any grossly misleading conclusions in the Requirement 2 submission, but for the full ESC we expect LLW Repository Ltd to demonstrate a more coherent treatment of the near field that is internally consistent and suitable for the systems being modelled. If any elements of the 2002 approach are retained we expect them to be fully integrated with updated elements and their validity to be demonstrated. Relevant issues from the IAFs must also be addressed. For example, we recommend that LLW Repository Ltd provide further justification to support their assumption that the vault system will remain extensively hyperalkaline over the anticipated lifetime of the facility, and hence that it is valid to represent the vaults as a cementitious environment in the long term. This justification will need to take account of all known and foreseen changes to the characteristics and assumed behaviour of the near field, including, for example, a lower cement to waste ratio resulting from possible options to optimise the use of the repository volume.

2.4 Volume 4: Site understanding

- 2.4.1 Volume 4 describes how LLW Repository Ltd's understanding of the geology and hydrogeology of the LLWR site, and of the future evolution of the site, has developed since the 2002 PCSC. The geological interpretation of the site has been reviewed and updated. Although there has been no fundamental change in understanding, the representation of the different strata has been changed in the conceptual model. The hydrogeological interpretation and models have also been reviewed and updated; again, there appears to have been no fundamental shift in understanding, but rather refinements and changes in emphasis. It is concluded that the regional groundwater flows generally from the site towards the sea (i.e. to the south-west) and that this is the dominant flow for most of the water that flows through the site. The near surface groundwater flow is more complex,

tending generally towards the south-east but locally in almost any direction, but this flow is estimated to be much smaller (especially with the proposed design, incorporating a cap, vertical drains and a cut-off wall). Observations of tritium in groundwater around the site have been used to provide a general check on the direction of regional groundwater flow, and more specifically to help identify near-surface flow paths.

- 2.4.2 Predictions about the potential evolution of the site have developed significantly since the 2002 assessments. On the basis of recent studies, LLW Repository Ltd conclude that the LLWR facility is almost certain to be destroyed by coastal erosion within a matter of thousands of years. Depending on certain assumptions about climate change and other factors, erosion of the facility is estimated to begin some time in the next 750 to 2500 years. The basic conclusion that the site will be eroded on timescales of this order is considered to be very robust. Apart from the obvious need to assess the consequences of such erosion, this conclusion profoundly affects many other aspects of the ESC by limiting the timescales that need to be considered. For example, calculations for the groundwater pathway are presented only up to 2500 years (compared to many tens of thousands of years in the 2002 PCSC); the engineered barrier system of caps, vaults, a cut-off wall and vertical drains is assumed to be at least partially effective over the whole duration of the assessment (which would be quite unrealistic for a timescale of tens of thousands of years); and no significant consideration is given to the possible effects of glaciation (which does not even begin to become a realistic possibility until at least 10,000 years from now).
- 2.4.3 It is important that LLW Repository Ltd provide a clear description of their overall approach to develop their understanding of the site. The approach should integrate information from site characterisation, modelling studies, facility design, construction and operation. For a full ESC, the breadth of activities and disciplines that will need to be employed is wider than those that were needed to respond to Requirement 2. For example, the site understanding for the full ESC will need to include adequate consideration of elements of geoscience not addressed explicitly in any detail in the Requirement 2 submission (e.g. geochemistry), and of the interface between conditions in the operational and post-closure phases. We emphasise that LLW Repository Ltd's approach to developing an understanding of the site should enable iteration of individual activities (e.g. refining the hydrogeological conceptual model) and the overall cycle (i.e. conceptual models of geology and hydrogeology, hydrogeological modelling, assessment). Their approach should link clearly to a forward programme.
- 2.4.4 We recommend that LLW Repository Ltd commit further effort to developing a clear understanding of the mechanisms controlling the release and migration of tritium within the groundwater. At present this source term is poorly understood (in terms of location, magnitude, release history and form), so attempts to compare observations with model output are of questionable value. We note that, even if LLW Repository Ltd determine that the post-closure safety of the site is not heavily dependent on the groundwater pathway, they still must consider the potential impacts during the remainder of the operational phase of the site.
- 2.4.5 LLW Repository Ltd should establish and report the hierarchy of models used to develop and support site understanding and to meet the wider requirements of the LLWR safety assessment programme. For example, LLW Repository Ltd have not adequately justified why they developed a site-scale model in isolation from other supporting models of a suitable maturity (e.g. regional, saline interface), nor have they adequately explained their reasons for adopting a steady-state model (as opposed to a transient model). LLW Repository Ltd should also consider the wider requirements of the safety case. For example, the links between the engineering performance assessment and safety assessment calculations should be carefully designed to ensure that interfaces between models are well defined and maintain consistency, and to build confidence in the ESC.
- 2.4.6 It is not required or necessary for the Requirement 2 submission to address uncertainty in full, however we note that the treatment of uncertainty within Volume 4 and the supporting documents would not be adequate for a full ESC. LLW Repository Ltd should identify, describe and prioritise sources of uncertainty, assess their effects on the safety

assessment, and establish and implement a coherent programme of actions to reduce any areas of uncertainty that have a significant impact on the safety assessment.

2.4.7 Our review has also identified several issues that are not critical to the response to Requirement 2, but we consider will need to be addressed for the Requirement 6 submissions. These issues are listed below:

- (a) The technical presentation of site understanding should be reviewed to provide a clear and balanced description of all aspects relevant to the ESC. To do this, LLW Repository Ltd will have to establish strong project management, to establish and enforce data freezes and to deliver high quality safety case documentation. LLW Repository Ltd should decide on the document hierarchy that best demonstrates site understanding in a clear and auditable manner. A document structure containing several sequential 'update' documents does not enable clear presentation (or audit).
- (b) LLW Repository Ltd should provide a clearer justification for their decision to use a lithofacies approach to the geological re-interpretation. They should ensure that the work to extend site understanding for the full ESC includes sufficient iterations between the geological and hydrogeological disciplines in the key areas of interest.

Additionally, we recommend that LLW Repository Ltd:

- (a) assess the quality of the underlying data used to support the geological and hydrogeological analyses in the light of a number of errors that have been identified in our review of the Requirement 2 submission (Environment Agency, 2009c);
- (b) ensure that the geological and hydrogeological analysis is based on all the available data, including results from on-going monitoring at the LLWR;
- (c) substantiate their approach to geological modelling and the reasons for selecting different software tools for regional and site scales;
- (d) review the source–pathway–receptor analysis (if it will continue to be used) to ensure that it provides a clear presentation of the analysis of potential routes by which radionuclides may migrate from the disposal facility to various receptors over the timescales of the ESC;
- (e) identify and assess whether additional measurements in the field are needed to support site understanding (e.g. to provide data on the height of the railway cutting and associated drainage features).

Tritium in groundwater

2.4.8 We do not consider that the tritium contamination observed in the upper and regional groundwater on and around the site presents a significant risk to human health or the environment, nor do we anticipate that it is likely to do so in the future. However, we expect LLW Repository Ltd to be able to explain the observed patterns of tritium based on their understanding of the site, and to use that understanding to:

- (a) provide assurance that unacceptable contamination with other radionuclides that are less mobile, but potentially present a greater risk, will not arise in the future;
- (b) justify their assumptions about future groundwater flows (particularly in the upper groundwater);
- (c) provide confidence in LLW Repository Ltd's predictive modelling of radionuclide transport from the LLWR.

2.4.9 We recognise that the Requirement 2 submission includes information that addresses these expectations to some degree. However, we were looking for LLW Repository Ltd's ability to explain the tritium data in terms of their understanding of the site to be more complete and precise. Given that this is the most obvious source of data on the real behaviour of radionuclides in the LLWR environment, it is surprising that it has not been subject to a more ambitious level of study and analysis. We would expect LLW Repository Ltd to clearly explain how they have used the information (and, if relevant, justify why they have decided further effort would not be helpful in the context of the ESC).

- 2.4.10 We also note that the information relating to the tritium plumes is somewhat dispersed among different documents and seems to be given relatively little prominence. Again, given that these are the most obvious data against which assumptions and models might be tested, this seems odd (even if it is technically adequate). LLW Repository Ltd might wish to consider addressing more directly what uses they have made of the tritium information, for example by summarising the different references to it in a separate sub-section in the Site Understanding section of the ESC.

2.5 Volume 5: Performance update

- 2.5.1 Volume 5 updates the 2002 PCSC assessment of the LLWR's long term performance. Although this is not a complete updated assessment, it does include a number of changes to the scenarios and pathways considered in the 2002 assessment and the ways in which they are modelled. Some of these changes stem from the adjusted assessment timescale (in light of the changed assumptions about erosion of the facility). Other changes (e.g. a revised approach to estimating doses from inhalation of radon due to the presence of radium in wastes) have been made following reviews of the previous assessment methods. The performance update calculates and presents estimates of doses and/or risks for four main cases ('base cases'): the groundwater pathway; the gas pathway; coastal erosion of the facility; and human intrusion.
- 2.5.2 Overall, the various changes generally reduce the estimated doses and risks considerably compared to the 2002 PCSC. According to the performance update, regulatory guidance levels are exceeded for the 'base cases' only in the case of a well being sunk into the regional groundwater at the site boundary south-west of the site (i.e. towards the coast). Even in this case, it is argued that the presented risk of $2 \times 10^{-5} \text{ y}^{-1}$ is conditional on the well existing at that particular location at that time, and that the actual risk (including the probability that there is a well) could be below the risk guidance level of 10^{-6} y^{-1} . Limited consideration of the possible effects of the heterogeneity of the waste suggests that regulatory criteria could be exceeded if people were exposed selectively to waste with above-average concentrations of radionuclides; it is argued that such situations are unlikely.
- 2.5.3 In a number of areas, the performance update represents significant progress compared to the 2002 PCSC. It goes some way towards addressing some of the issues we identified in our review of the 2002 PCSC (Environment Agency, 2005a). It also touches on some significant advances in understanding of the site and its impacts. However, as is acknowledged in the submission, there are issues that have not yet been addressed and others for which the advances claimed in the performance update need to be further underpinned.
- 2.5.4 The structure and presentation of the update itself and of the documentation describing it are substantially improved compared to the 2002 PCSC. We take some comfort that LLW Repository Ltd understand our expectations for the full ESC due in 2011. The key arguments are generally presented clearly and concisely, and in most cases the evidence to support arguments within the main volume and supporting documents is well signposted. There are some areas where we would expect improvement for the full ESC, as documented in our technical review of Volume 5 (Environment Agency, 2009d), but these are of a number and nature that might reasonably be expected in an interim update.
- 2.5.5 Our review of Volume 5 did not identify any fundamental flaws in the performance update that would grossly contradict LLW Repository Ltd's claims that the 2002 PCSC significantly overestimated some of the post-closure risks. However, as LLW Repository Ltd acknowledge, the performance update does not provide a complete assessment, and key examples of its weaknesses are outlined below. Therefore, while we agree that the performance update indicates that the risks might meet regulatory criteria, the full ESC will need to demonstrate much more robustly whether or not they do.

- 2.5.6 A fundamental requirement of the full ESC is to identify and address systematically the uncertainties associated with the performance of the disposal system. Our review of the 2002 PCSC identified a large number of issues relating to the treatment of uncertainty in many different areas of the case. LLW Repository Ltd acknowledge that the performance update for the Requirement 2 submission does not include a systematic treatment of uncertainty, and therefore the issues raised in relation to the PCSC have not been resolved. This was not explicitly required by Requirement 2, but we consider it to be a priority for the development of the ESC. We expect LLW Repository Ltd to provide us at an early date with details of their proposed strategy and approach for addressing uncertainty in the ESC. In the absence of such information in the Requirement 2 submission, we cannot with confidence agree or disagree with LLW Repository Ltd's claim that the performance update results are generally cautious.
- 2.5.7 LLW Repository Ltd also need to address more systematically the sensitivity of assessment results to waste heterogeneity and to changes in operation of the LLWR. Waste heterogeneity is discussed in various parts of the submission, but is not addressed systematically or coherently. We expect to see a more comprehensive analysis of heterogeneity and its effects in the full ESC. We recognise that this analysis will often rely on judgements, so dialogue with us during development of the approach may be helpful. The effects of changes in operation of the LLWR are barely addressed in the submission, despite clear statements of intent from LLW Repository Ltd⁴. The future inventory, and its behaviour, will be affected by proposed improvements to the segregation of VLLW from LLW, reductions in voidage (and hence grout content), increased flexibility in packaging, etc. We recognise that this is just one of a number of areas of uncertainty about the future inventory. However, they are matters over which LLW Repository Ltd have considerable control, and therefore we expect the ESC to consider the potential effects of these proposals. We suggest early dialogue with us to discuss LLW Repository Ltd's intentions and their anticipated effects on the ESC.
- 2.5.8 Given the fundamental shift to an assumption that the facility will be eroded within a few thousand years (see Section 2.7 below), we expect LLW Repository Ltd to provide a more carefully justified and robust assessment of the exposures that could arise when that erosion takes place. The exposure scenarios and models used in the performance update are essentially the same as those used in the 2002 PCSC, when they were designed to explore an emerging issue. Overall, we expect the assessment of coastal erosion in the ESC to be consistent with its status as the 'normal' or expected evolution of the site. We also expect LLW Repository Ltd to give specific attention to the following points identified from our review:
- No exposure scenarios have yet been defined for the 'increasing sediment' scenarios, reflecting a barrier-lagoon and/or expanded Ravensglass Bay. This is a significant omission from the Requirement 2 submission, which we will expect LLW Repository Ltd to rectify in the full ESC. This scenario could be significantly different from those already considered, for example in terms of both the types of individuals exposed and the distribution of radionuclides from the facility. We expect LLW Repository Ltd to provide us with updates to describe the proposed modelling approach and early indications of likely results (e.g. from preliminary calculations) for this scenario.
 - LLW Repository Ltd should clarify and justify the details of the assessment calculations used to estimate impacts during erosion of the facility. As a first step, we expect LLW Repository Ltd to explain the large differences between the results from coastal erosion scenarios in the 2002 PCSC and in the performance update, by itemising and justifying the differences between the calculations.
 - The activity concentrations assumed in calculations need to be more carefully considered. We accept that, for most exposed individuals, annual doses in a given year are likely to be determined by the average activity concentrations in waste exposed during that year. However, this average will change from year to year due to heterogeneity in the wastes being eroded. By analogy with other pathways, we expect

⁴ We note that the Requirement 2 submission was in the final stages of preparation at the time these proposed changes were being formalised in site Lifetime Plans.

the peak risk to be calculated for the year in which the average concentration exposed is highest. We recognise that the timing and size of that peak in the average concentration will be uncertain, but we expect LLW Repository Ltd to consider explicitly the time variation in risks during erosion.

- (d) In addition, we expect LLW Repository Ltd to consider the possibility that individual discrete items from the LLWR might be found on the beach following erosion, e.g. by considering potential doses to a 'beachcomber'. This possibility may be adequately covered elsewhere in the assessment (e.g. by a human intrusion scenario), but we wish to be reassured that all possibilities that are reasonable in the context of the wider assessment have been covered. For example, LLW Repository Ltd might consider whether pieces of insoluble calcium fluoride matrix containing uranium from the trenches might appear on the beach.
- (e) We recognise that risks resulting from waste after it has been dispersed into the sea are likely to be lower than those from other pathways. However, for completeness, we expect LLW Repository Ltd to assess these risks as part of the 'normal evolution' scenario.

2.5.9 At the same time, we do not regard erosion of the facility on the timescales described by LLW Repository Ltd as an absolute certainty. For the Requirement 2 submission, we accept that it was reasonable to focus on risks and doses up to the expected time of erosion. However, in the full ESC we will expect LLW Repository Ltd to assess the potential effects that a delay in erosion – either for a relatively modest time, a very long time or indefinitely – may have on impacts via the various pathways. This consideration should be proportionate, given that such a course of events is of low likelihood. We will take account of the low likelihood of delayed erosion when we decide on whether the indicated level of impacts is acceptable.

2.5.10 We agree with LLW Repository Ltd that further attention should be given to the well pathway in the groundwater scenario. The assessment of this pathway must provide a reasonable and robust indication of the risk associated with this possibility. In the light of the simplistic nature of the assessment, we do not consider the conditional risks from the well pathway calculated for the Requirement 2 submission to be a major concern in relation to the risk guidance level – the calculations are generally pessimistic and they are conditional risks. However, these calculations highlight two broader concerns:

- (a) LLW Repository Ltd need to obtain a more reliable understanding of future waste streams. In particular, it is important to have reliable estimates for wastes with significant levels of long-lived mobile radionuclides such as C-14, Cl-36 and Np-237. LLW Repository Ltd ultimately will need to ensure that the suitability of such waste streams for disposal in the LLWR are carefully assessed.
- (b) In view of legislative trends, notably the Groundwater Daughter Directive, we may have to consider not only what the updated calculations for the well pathway indicate about risks to humans, but also whether they indicate adequate protection of groundwater as a resource.

2.6 Volume 1: Managing liabilities and future disposals

2.6.1 Volume 1 presents an overview of the overall response to Requirement 2. It summarises key features of the work which are described in detail in Volumes 2–5. Volume 1 also addresses more directly the specific points of Requirement 2 and the wider aim of the submission to demonstrate progress towards the full ESC due in 2011. This section comments only on points not already addressed in the above sections on Volumes 2–5.

2.6.2 The radiological capacity of the site is the major issue that is predominantly addressed in Volume 1. The performance update of the Requirement 2 submission suggests that the reference inventory largely meets the regulatory dose and risk criteria. LLW Repository Ltd therefore propose that the reference inventory be considered the radiological capacity of the site for the time being, and that the LLWR Conditions for Acceptance (CFA) remain unchanged. However, the performance update is not a full ESC, and significant

forthcoming developments – notably the NDA's National LLW Strategy and Plan – might also need to be taken into account. LLW Repository Ltd therefore conclude that this should only be an interim position, and that the radiological capacity and CFA should be reconsidered, and set more definitively, based on the full ESC in 2011. Generally, we consider this to be an appropriate position, but a more detailed discussion is given in Section 3.2 below.

- 2.6.3 We welcome LLW Repository Ltd's descriptions of its engagement with stakeholders, but note that this does not include any reference to national NGOs or interest groups (other than NuLeAF) or to the general public outside west Cumbria. These groups might not be LLW Repository Ltd's primary concern, and might not routinely take great interest in the LLWR, but we note that a number of such groups did respond to our last consultation on the authorisation in 2005. They might therefore be considered as interested stakeholders.
- 2.6.4 We do not agree with LLW Repository Ltd's interpretation that impacts from the trenches should be compared with criteria for intervention. The disposals in the trenches are not considered to be complete and the whole LLWR is still subject to authorisation. Criteria for practices therefore still apply for the site as a whole. Consequently, we expect LLW Repository Ltd to assess the impacts associated with the trenches after the end of the period of authorisation (i.e. after institutional control over the site is assumed to end) in the form of risks rather than doses and to compare them to the risk guidance level of 10^{-6} y^{-1} . The exception to this is the potential impacts of human intrusion, which should be expressed as doses and compared to the dose guidance levels.
- 2.6.5 In a similar context, LLW Repository Ltd's statement that doses from the trenches are lower than UK average doses from natural background is a reasonable observation but we note that this does not have any regulatory significance.
- 2.6.6 LLW Repository Ltd refers in the submission to groups and projects within LLW Repository Ltd other than the Lifetime Project (now the ESC Project), and to some of their documents (e.g. design documents from the Modular Vaults Project). In the full ESC, however, we recommend (**Category D recommendation** – see paragraph 1.5.4 for an explanation of categories) that LLW Repository Ltd include more information on the interactions of the ESC with other projects, such as Modular Vaults, Monitoring and Consignor Support. This could help to demonstrate that the ESC is based consistently on the best information from supporting work and that the ESC is used to inform decisions on other projects, and to provide a fuller picture of the context for the full ESC.
- 2.6.7 We note LLW Repository Ltd's observation that certain radionuclides, such as Cl-36 , are difficult to determine reliably in waste streams. However, we stress that this does not mean that it can be ignored. We expect LLW Repository Ltd to obtain the best information they reasonably can on the presence of key radionuclides in future waste streams and address any residual uncertainties in appropriate ways.

2.7 Coastal erosion

- 2.7.1 LLW Repository Ltd's submission makes a fundamental assumption that the LLWR is very likely to be destroyed by coastal erosion within a few thousand years. This erosion is projected to occur more quickly as climate change leads to increases in sea level, but the facility is estimated to be eroded within several thousand years even in the unlikely event that the sea level did not rise. Although there is still considerable uncertainty about the exact timing of this erosion and exactly how it will proceed, estimates suggest that there is little chance of the facility surviving for as long as 10,000 years. This fundamental assumption is supported by a body of work, notably the supporting reports by Thorne and Kane (2007) and Halcrow (2008). We agree with LLW Repository Ltd that such an assumption has profound implications for the development of a full ESC for the LLWR. These implications are apparent from the results of the 2002 PCSC, in which the peak risks from the site were estimated to arise after several tens of thousands of years.

- 2.7.2 Given the importance of this assumption, we need to be as sure as we reasonably can be that the assumption of coastal erosion is robust, and supported by the best available scientific and engineering understanding in the fields of climate change and coastal processes. These are already very specialised fields, and the timescales of relevance to the LLWR are far greater than those commonly used when specialist knowledge and techniques are applied. Our specialist Shoreline Management Group therefore reviewed the evidence provided by LLW Repository Ltd to support its Requirement 2 submission. The group concluded that LLW Repository Ltd's assumptions were thorough and sound. We also commissioned an independent expert review of the underpinning work (Cooper, 2009), which confirmed that the work presented by LLW Repository Ltd was based on an appropriate combination of the best knowledge and techniques currently available and was robustly reasoned. The independent review also concluded that the set of scenarios proposed by Thorne and Kane (2007) appears to provide an envelope that encompasses all of the reasonably conceivable evolutions of the site.
- 2.7.3 We therefore conclude that it would be reasonable for the ESC to be based on the assumption that the LLWR is likely to be destroyed by erosion within several thousand years.
- 2.7.4. This being the case, we expect the assessment of the impacts associated with the erosion of the facility to be appropriate for the 'normal' or expected evolution of the site. As discussed in more detail in our review of Volume 5 of the submission, we found that the assessment presented by LLW Repository Ltd in the performance update did not meet this expectation. We do not necessarily require more sophisticated models if there are not the data to support them, but we do expect a robust, thoroughly underpinned assessment that takes full account of the information available and the uncertainties (including the effects of waste heterogeneity). We provide some more specific recommendations linked to this more general expectation in Section 2.6 of our review of Volume 5 (Environment Agency, 2009d).
- 2.7.5 The above discussion refers to the evolution of the site in the absence of any human action or unforeseen natural event that might, for example, reverse trends in climate change or provide long-term protection of the coastline (and/or the facility) against erosion. Such events could significantly delay or even prevent erosion of the facility. We do not consider these possibilities provide a sensible basis for planning, but we cannot rule them out; LLW Repository Ltd should not entirely disregard them in the ESC.
- 2.7.6 We will therefore expect the full ESC to include some assessment of potential impacts if the facility were to survive significantly longer than expected. This assessment should, however, be proportionate given that any such impacts are unlikely to be realised. We will take account of this low likelihood when we review the results from such assessments. We discuss this issue in more detail in our review of Volume 5 (Environment Agency, 2009d).
- 2.7.7 In summary, LLW Repository Ltd has presented us with information, based on current scientific knowledge, that coastal erosion will almost certainly disrupt the LLWR site near Drigg within thousands of years, perhaps beginning as early as 750 years. Based on this information from LLW Repository Ltd, we believe that the potential for disruption of the site by coastal erosion at some point in the future is an acceptable risk provided that:
- (a) the specific requirements within the GRA are met, including efforts to ensure that radiation dose constraints and risk targets to the public both during the operational and post closure periods are met;
 - (b) the risks presented by the site are optimised;
 - (c) while the site is under operational management, all necessary measures are taken to contain wastes.

We will continue to require LLW Repository Ltd, through its ESC, to demonstrate that numerical and non-numerical criteria and requirements are adequately met. Subject to these conditions being satisfied, we may in the future authorise further disposals of LLW to the site. We will assess any future submissions from the site to make sure future risks

remain acceptable.

This document is out of date and was withdrawn 07/11/2017

3 Our position with respect to Requirement 2

3.0.1 Schedule 9 Requirement 2 of the LLWR RSA 93 authorisation required LLW Repository Ltd to “provide the Agency with a full report of a comprehensive review of national and international developments in best practice for minimising the impacts from all waste disposals on the site. This shall include a comprehensive review of options for reducing the peak risks from deposit of solid waste on the site, where those risks arise from potential site termination events (e.g. coastal erosion and glaciation) and potential future human action.” This requirement was time limited to within two years of the effective date of the authorisation. LLW Repository Ltd delivered their submission in response to Requirement 2 to us on 1 May 2008, within that defined two year limit.

3.0.2 When we advised LLW Repository Ltd on the scope of Requirement 2, we also stated that two further statements made in our Decision Document related to the LLWR RSA 93 authorisation (Environment Agency, 2006b) were also relevant:

(a) In Section 4.6 of the Decision Document we stated that “we will not authorise LLW disposals to the proposed Vault 9, until... BNGSL has provided us with adequate information to allow the radiological capacity of the site to be determined... and we will undertake a full review on the radiological capacity of the site and publish our findings.” These statements were not explicitly reflected in any requirement attached to the authorisation, and there is therefore no time limited requirement on LLW Repository Ltd. Furthermore, although Vault 9 is now under construction, LLW Repository Ltd has not to date applied to us for authorisation to dispose of LLW to Vault 9. Therefore, there is currently no formal requirement on LLW Repository Ltd concerning radiological capacity, until they wish to apply for an authorisation for further disposals at the LLWR.

(b) We also stated that “we will not allow BNGSL to construct the final cap over the existing Vault 8 and trench disposals until BNGSL has provided us with the outcome of a wide-ranging risk management study... that demonstrates that future impacts will be As Low As Reasonably Achievable (ALARA).” Again, these statements were not explicitly reflected in any requirement attached to the authorisation, although Requirement 2 does, at least in part, address this. To date LLW Repository Ltd has not sought agreement from us to construct the final cap and so there is no formal requirement on LLW Repository Ltd to satisfy the wording from the Decision Document at this point. In particular it should be noted that, while the Decision Document refers to demonstrating that future impacts will be ALARA, Requirement 2 does not explicitly require this.

3.0.3 Schedule 9 Requirement 6 requires LLW Repository Ltd to “update the Environmental Safety Case(s) for the site covering the period up to withdrawal of control and thereafter” by 1 May 2011. Clearly the deadline for this requirement has not yet been reached.

3.0.4 In light of the above, during the course of our ongoing dialogue with LLW Repository Ltd, we agreed that, in addition to the specifics of Requirement 2, two main elements could usefully be addressed directly in LLW Repository Ltd’s Requirement 2 response:

- (a) A demonstration that best practice is being applied to keep the peak risks from the site ALARA. We expect this demonstration to have two strands: firstly, a review of best practice nationally and internationally along with a demonstration of how this informs LLW Repository Ltd’s decisions and actions; and secondly, a BPEO-type study to identify an optimised risk management strategy for the long-term future of the site.
- (b) A substantiated proposal concerning the radiological capacity of the site (the amount of waste that could be disposed of while still allowing a satisfactory environmental safety case to be made).

- 3.0.5 The Requirement 2 submission also provides a 'progress report' on LLW Repository Ltd's work towards meeting Requirement 6 (a full updated ESC by 1 May 2011). This work has, to some extent, become more prominent than Requirement 2 itself, and is reinforced by the preliminary or interim nature of the conclusions reached in the Requirement 2 submission. Our overview comments on the Requirement 2 submission in the context of progress towards delivering Requirement 6 are provided separately in Section 4.

3.1 Best practice review and risk management

- 3.1.1 Requirement 2 required LLW Repository Ltd to carry out a comprehensive review of national and international developments in best practice for minimising impacts from disposals. This work was to include a comprehensive review of options for reducing the peak risks. We have also stated that before we would consider it appropriate for LLW Repository Ltd to construct the final cap, we require LLW Repository Ltd to demonstrate that best practice is being applied to keep the peak risks from the site as low as reasonably achievable (ALARA). LLW Repository Ltd's Requirement 2 submission addresses the former requirement but goes beyond it in pursuit of the latter. LLW Repository Ltd have interpreted the requirements to refer primarily to the peak risks from the trenches, which were estimated in the 2002 PCSC to be significantly higher than those from the vaults. We agree with this approach (although the application of best practice to keep the risks from the vaults ALARA also needs to be addressed, as discussed later in this section).
- 3.1.2 In our view, LLW Repository Ltd have presented reviews of the type described in Requirement 2, but have not yet demonstrated that peak risks will be ALARA. As discussed in our review of Volume 2 (Environment Agency, 2009a) and in Section 2.2 above, we conclude that the work described in LLW Repository Ltd's submission meets Requirement 2, but does not yet meet the more demanding requirement implied by the Decision Document (Environment Agency, 2006b).
- 3.1.3 As noted before, in order to focus on priority areas, we and LLW Repository Ltd have agreed that the Requirement 2 submission should be primarily concerned with:
- (a) demonstrating that best practice is being applied to keep the peak risks from the *trenches* ALARA;
 - (b) providing a substantiated proposal for the radiological capacity of the *vaults*.
- 3.1.4 The radiological capacity is fundamentally a limitation concept that represents the maximum inventory that can be accepted to the site. We consider that the effective 'radiological capacity' of the *trenches* is the existing inventory (i.e. no more waste may be added to the trenches). However, the final state of the trenches should be such as to keep the risks from the trenches ALARA. Once the optimum final state for the trenches is determined definitively, it will be possible to define an optimum inventory which will not exceed the existing inventory (the 'radiological capacity'). This optimum inventory might be the same as the existing inventory (reduced only by radioactive decay), or it might be significantly lower (e.g. if the optimised solution were to include selective retrieval of some wastes).
- 3.1.5 The element not covered by the above is the optimisation requirement for the vaults. The full ESC will need to demonstrate that the design, operations, waste acceptance criteria and closure plan will be such that the risks from the vaults are ALARA. LLW Repository Ltd's submission refers to their intention to optimise the design and closure plan for the vaults, and we will expect to see details of this process in the full ESC. However, we will also expect to see evidence that:
- (a) LLW Repository Ltd will operate the vaults in such a way that reasonable opportunities are taken to reduce post-closure risks, for example by emplacing wastes that could give high doses in the event of human intrusion near the bottom of the vault (**Category D recommendation**);

- (b) disposal in the LLWR represents the BPEO for the planned future wastes, particularly in the cases of long-lived wastes in general and of specific waste streams that might contribute significantly to the overall risks from the vaults (although this is likely to be more the responsibility of consignors than LLW Repository Ltd).

3.1.6 We recognise that the information provided to date on optimisation of the vault design and closure plan is provisional and will be modified following detailed optimisation studies. Nevertheless, we consider it appropriate to note the following:

- (a) The final cap appears likely to be a critical element of the closure plan, and LLW Repository Ltd appear to be taking a reasonable approach to its design and planning. We stress that the ESC should accurately reflect the intended design and timing of the final cap and that LLW Repository Ltd needs to make sure that the final cap assumed in the ESC can actually be constructed (technically and in relation to the necessary permissions) (**Category D recommendation**).
- (b) Institutional control is likely to be an important element of an optimised closure plan. We cannot accept reliance on institutional control measures beyond a limited period (up to a few hundred years at most) for which LLW Repository Ltd can show that the effectiveness of such measures can reliably be maintained. However, we agree with LLW Repository Ltd that properly planned and implemented institutional control measures may still provide worthwhile benefits over extended timescales, beyond those for which they can be absolutely relied upon.
- (c) LLW Repository Ltd have taken a sensible approach of including in the performance updates their indications of the performance of the LLWR with and without an effective cut-off wall. If the optimised design does include a cut-off wall, we will expect (**Category D recommendation**) the full ESC similarly to indicate the potential impacts if the cut-off wall works as planned, but also if it does not. We await LLW Repository Ltd's final conclusions about the need for and expected effectiveness of cut-off walls.
- (d) We are less comfortable with LLW Repository Ltd's position regarding vertical drains. The Requirement 2 submission does not explore the consequences of installed, but ineffective, vertical drains, nor the absence of drains, nor does the submission provide evidence that they can be relied upon to be effective. We note that there is some regulatory uncertainty about the acceptability of vertical drains in principle. We therefore advise LLW Repository Ltd to ensure that the facility can perform adequately even if vertical drains are not used or are ineffective. We recommend that LLW Repository Ltd keep us informed (**Category C recommendation**) about any developments in their views on the use or otherwise of vertical drains.

3.1.7 We are also aware of LLW Repository Ltd's intention to 'optimise' the capacity of the LLWR by, for example, improving the segregation of waste and diverting suitable wastes to other routes. LLW Repository Ltd will need to take account of all of the implications of such changes when optimising the protection provided by the vaults.

3.2 Radiological capacity

3.2.1 We agree with LLW Repository Ltd's approach to focus primarily on the radiological capacity of the vaults. Fundamentally, the concept of radiological capacity links to the limitation element of the radiological protection principles. Vault 8 was designed, built and operated under a regulatory regime broadly similar to that in place today. For example, a risk target of 10^{-6} y^{-1} was introduced in regulatory guidance issued in 1984 (Department of the Environment *et al.*, 1984), three years before Vault 8 was built. Furthermore, LLW Repository Ltd can largely control what is disposed of in the vaults, and this is the simplest way of controlling the long-term risks from disposals. Limitation is therefore a key element for regulating the vaults; radiological capacity is an important tool for applying the limitation principle. The trenches, on the other hand, were designed, constructed, and mostly operated under regulatory conditions that did not include the 10^{-6} y^{-1} risk target. Furthermore, LLW Repository Ltd cannot alter the content of the trenches except by taking action to remove or alter the characteristics of waste currently in the trenches. We therefore consider robust application of the ALARA principle to be a more appropriate

regulatory tool than limitation for the trenches. Although the term is not really correct in this context, the 'radiological capacity' of the trenches is effectively the inventory that is already in them (as discussed in the previous section).

- 3.2.2 LLW Repository Ltd's general approach to determining a radiological capacity is also reasonable. Fundamentally we require them to demonstrate that an acceptable ESC can be made for disposal of an inventory equal to the radiological capacity. This can be achieved either by working back from calculated impacts and risk/dose criteria to an inventory or (as LLW Repository Ltd have done) by choosing an inventory and seeking to demonstrate that it satisfies the relevant criteria.
- 3.2.3 We agree with LLW Repository Ltd that the performance update does not provide a sufficiently robust basis for setting a definitive radiological capacity for the vaults, and that any decisions that are taken now should be subject to review in the light of the full ESC. We note LLW Repository Ltd's view that this re-evaluation might allow the relaxation of some current limits (e.g. on Co-60 and I-129), but we stress that such matters cannot be pre-judged and that we will consider the case on its merits when it is presented.
- 3.2.4 LLW Repository Ltd propose to keep the LLWR Conditions for Acceptance (CFA) of waste as they are at present (LLW Repository Ltd, 2008f) until a definitive radiological capacity is set based on the full ESC (which is unlikely to be before 2013). They justify this decision on the basis that the outcome of the performance update shows that the risks from the vaults are within regulatory criteria except for C-14, and that this higher risk would be prevented by the current CFA. We note in addition that the calculated risk from C-14 depends on the disposal of a future waste stream that appears currently to be particularly poorly understood and that might never be sent to the LLWR. LLW Repository Ltd acknowledge that the performance update is incomplete, particularly in its treatment of uncertainty, so we do not consider this justification to be particularly compelling. However, the main risk associated with LLW Repository's proposed approach is that waste may be accumulated at the LLWR (stored primarily in Vault 9) but it cannot be disposed of there. Operational controls will ensure that the waste does not pose a significant environmental risk while it is being accumulated and stored, and therefore any risk will be largely a business risk to LLW Repository Ltd rather than an environmental risk. Therefore, we have no reason to object to the proposal. We suggest as a precaution, however, that LLW Repository Ltd check whether any wastes scheduled to be sent to the LLWR during this period are of a nature likely to pose particular challenges to the ESC.
- 3.2.5 We do, however, disagree in principle with LLW Repository Ltd's proposal to exclude doses from human intrusion from consideration in setting radiological capacity. We expect LLW Repository Ltd (**Category A recommendation**) to propose, in broad terms, appropriate scenarios for us to approve. Once appropriate scenarios have been agreed, we intend to determine which criterion (from the range of dose guidance levels specified in the CRA) we consider appropriate to apply to each scenario, taking account of the plausibility of the scenarios. We expect this process to be completed before the full ESC is submitted, and we will therefore require proposals from LLW Repository Ltd in good time to allow that process to occur.
- 3.2.6 Requirement R8⁵ of the consultation draft GRA for near surface disposal (Environment Agency *et al.*, 2008) clearly requires the operator to consider, and implement where appropriate, measures to reduce the chance of human intrusion. Quite separately, the operator must consider the consequences of human intrusion "on the basis that it is likely to occur". Furthermore, para. 6.3.42 of the consultation draft indicates that the doses associated with human intrusion scenarios are "likely to be important in deriving facility-specific authorisation limits and conditions, such as inventory limits and allowable activity concentrations for specified radionuclides." Of course we could not expect LLW Repository Ltd to take account of guidance they had not seen prior to submission. Furthermore, the doses assessed by LLW Repository Ltd as indicators of the highest reasonable potential

⁵ It should be noted that the equivalent requirement in the final version of the GRA (Environment Agency *et al.*, 2009) is Requirement R7.

impact of human intrusion for the proposed vault inventory are below the dose guidance levels and so would not affect the radiological capacity. Nevertheless, in principle our assessment of an appropriate radiological capacity will take account of the potential consequences of human intrusion scenarios that we consider to be reasonable.

- 3.2.7 We require an assessment of possible human intrusion events to indicate the potential consequences of a class of essentially unpredictable (possibly currently unforeseen) phenomena that cannot be absolutely ruled out over the timescales of interest and that could bypass most or all of the designed barriers in a disposal facility. We consider that human intrusion is the most likely and readily imaginable example of such phenomena and therefore provides the most appropriate basis for selecting a range of representative events to assess. We also consider it is likely that at least some of the measures that might be used to reduce the likelihood of human intrusion (including, most obviously, increasing the depth of disposal) may also be effective against other phenomena in this class. In interpreting Requirement R8, we will take account of this broader protective intent as well as the direct assessment of human intrusion.
- 3.2.8 In applying Requirement R8 to near surface disposal, we must take account of the fact that the single most obvious and robust way to significantly reduce the likelihood of human intrusion (i.e. by putting the waste at a depth beyond the reach of most currently observed human activities) has not been employed for the LLWR. We can accept this situation provided that the most obvious and robust measures to significantly reduce the potential consequences of human intrusion, including limiting the inventory of radionuclides, are employed to prevent consequences that would be unacceptable if they occurred today.
- 3.2.9 Unacceptable consequences are defined by the dose guidance level in the range of 3–20 mSv/y⁶. The GRA indicates that the lower end of this range is favoured for chronic, long-term consequences whereas the higher end applies to short term, acute consequences. The range might also be used to take some account of likelihood, for example by applying the higher end of the range to consequences that were plausible but very unlikely. However, such an interpretation would also have to take account of the other considerations set out in this review.
- 3.2.10 Conceptually, the radiological capacity is linked to the principle of limitation rather than that of optimisation for radiological protection. As such, we expect radiological capacity considerations to be based on the standard of proof expected in limitation cases rather than that for optimisation. Fundamentally, we expect the operator of a near surface disposal facility to limit the inventory disposed so that there is a fundamental physical upper bound on the potential consequences that could arise from any conceivable event.
- 3.2.11 Therefore, when we discuss with LLW Repository Ltd the relevance of human intrusion scenarios to the setting of a radiological capacity for near surface disposal:
- we will give due consideration to reasonable and soundly based probability arguments that take account of the nature of the wastes accepted for disposal;
 - we are only likely to accept probability arguments that are based on the depth of the waste if they are supported by very robust arguments (we are particularly unlikely to accept such arguments as a basis for discounting potential consequences towards the higher end of the dose guidance level range);
 - we are unlikely to accept probability arguments based on claims about the performance of other engineered barriers or administrative measures.

⁶ The consultation draft of the GRA (Environment Agency *et al.*, 2008) specified a range of 3–30 mSv/a, but this range has been reduced to 3–20 mSv/a in the final version (Environment Agency *et al.*, 2009).

3.3 Summary

- 3.3.1 In summary, we consider LLW Repository Ltd to have substantially satisfied Schedule 9 Requirement 2 and have presented considerable work beyond the specific scope of Requirement 2.
- 3.3.2 The best practice review and BPEO work has eliminated some options for managing the risks associated with the site (for example, the wholesale retrieval of all wastes from the trenches), but we conclude that LLW Repository Ltd need to consider more detailed and specific risk management strategies for the full ESC. This work should use the best information available about the techniques and about the LLWR wastes (particularly the inventory and its distribution) to identify more definitively the strategy that makes risks from the site as low as reasonably achievable (ALARA). We therefore do not yet consider it appropriate for LLW Repository Ltd to construct the final cap over the existing Vault 8 and trench disposals.
- 3.3.3 LLW Repository Ltd have provided a reasonable analysis and a legitimate proposal concerning the radiological capacity of the site, and we agree with their view that this is necessarily an interim position. We agree that LLW Repository Ltd need to provide a more definitive and robust proposal for the site's radiological capacity for the full ESC. We therefore cannot yet authorise LLW disposals to Vault 9.

This document is out of date and was withdrawn on 11/1/2017

4 Recommendations in relation to the environmental safety case

- 4.0.1 We emphasise that the information presented in the Requirement 2 submission and previously gives us confidence that the configuration and management of the LLWR site make the site safe at present and this should remain the case under the current management regime. The issues raised in this review concern the safety of the site in the more distant future; we wish to ensure that the site remains safe even if and when management control over the site is lost or withdrawn.
- 4.0.2 In a number of areas, the Requirement 2 submission displays significant progress since the 2002 PCSC. It goes some way towards addressing some of the issues we have identified previously (Environment Agency, 2005a). It also presents some significant advances in understanding the site and its impacts. However, there are some issues that we have raised in the past which still have not yet been addressed. Some advances in understanding claimed in the performance update also need to be further underpinned.
- 4.0.3 The Requirement 2 submission does not represent a complete ESC. In addition to the issues not fully addressed, as discussed above (for example, the treatment of uncertainty), the full ESC will also need to address a broader range of issues. In particular, Requirement 2 referred specifically to the post-closure period and LLW Repository Ltd's submission therefore focused on that aspect. LLW Repository Ltd will need to address all aspects of the environmental safety of the LLWR in the full ESC, including in particular the operational period up to closure.
- 4.0.4 The structure and presentation of the submission itself and of the documentation describing it are substantially improved compared to the 2002 PCSC. This improvement suggests that LLW Repository Ltd understand our expectations for the full ESC due in 2011. The key arguments are generally presented clearly and concisely, and in most cases the trail of argument and evidence within the main volume and supporting documents is well signposted. There remain some areas where we expect improvements for the full ESC, as documented in this report and in our technical reviews of Volumes 2–5 (Environment Agency, 2009a–d), but these appear to be of a number and nature that might reasonably be expected in an interim update.
- 4.0.5 We welcome the independent peer review process that LLW Repository Ltd has introduced since we granted their RSA 93 authorisation in 2006. We recognise that the review team has provided worthwhile and technically sound feedback to LLW Repository Ltd on its Requirement 2 submission. However, the feedback seems to have been provided too late for LLW Repository Ltd to respond to it fully and thereby improve their submission. As a result, many of the issues that we raise were also noted by the peer reviewers but not acted upon, presumably due to lack of time. The full benefit of the peer review process has therefore not been realised. We expect LLW Repository Ltd (**Category D recommendation**) to make any necessary adjustments to the peer review process to make better use of the peer reviewers' advice in preparing the full ESC submission.
- 4.0.6 We have summarised our technical comments on the content of the Requirement 2 submission as evidence of progress towards a full updated ESC in previous sections of this report. We present them in more detail in our four other technical review reports on Volumes 2–5 (Environment Agency, 2009a-d) of the submission. We will provide additional feedback to LLW Repository Ltd through our dialogue between now and 2011.
- 4.0.7 We emphasise that our recommendations necessarily focus on areas in which we have identified weaknesses or omissions in the submission. This should not be interpreted as indicating an overall negative impression of LLW Repository Ltd's submission.

- 4.0.8 Overall, our review of the Requirement 2 submission indicates that LLW Repository Ltd must address some significant challenges to produce an ESC by May 2011 that will provide an adequate basis for us to authorise future disposals at the LLWR. However, from the submission and from our associated dialogue we conclude that there is a realistic chance that LLW Repository Ltd can successfully achieve this.

This document is out of date and was withdrawn 07/11/2017

5 Other Schedule 9 requirements

- 5.0.1 The Requirement 2 submission addresses some, but not all, of the aspects that must be covered in the full ESC. Some of these other elements have been or are being addressed in the context of other Schedule 9 requirements.
- 5.0.2 Requirement 5 required LLW Repository Ltd to prepare a document stating how it will address the findings of our review of the 2002 PCSC and OESC. This document was delivered to us in November 2006. We provided some comments on it, but we consider that Requirement 5 has been satisfied.
- 5.0.3 Requirements 11 and 13 required, respectively, “a comprehensive assessment of the impact of its radioactive discharges and disposals on ecosystems and wildlife species” and “a review that considers the nature, quantities and sources of foreseeable emissions of non-radioactive substances from the installation into each environmental medium, and a description of any foreseeable significant effects on the environment”. In each case, LLW Repository Ltd have delivered a report to address the requirement; we have made comments on these assessments and we expect LLW Repository Ltd to address our comments in the updated assessments that will form part of the full ESC. We consider that Requirements 11 and 13 have been satisfied, but we will judge whether the updated assessments are acceptable when we review the full ESC.
- 5.0.4 Requirements 1 and 3 require two specific optimisation studies to be provided by 1 May 2009. Requirement 1 calls for a comprehensive review to determine whether the current disposal practices for waste generated on the site continue to represent the BPEO, together with an action plan that will implement any necessary changes identified by the review. Requirement 3 demands that the means used to assess the activity of radionuclides in disposals are comprehensively reviewed to determine compliance with the authorisation. The review should discuss national and international developments in best practice. We will review LLW Repository Ltd’s response to each of these Requirements, and we expect the two studies (modified if necessary to take account of our comments) to be incorporated into the full ESC.
- 5.0.5 Requirement 4 states that LLW Repository Ltd must establish and carry out a programme of research and development to support Requirements 1, 2 and 3. This includes a requirement to report annually to us on this programme, and we have maintained (and will continue to maintain) dialogue with LLW Repository Ltd regarding the adequacy of their R&D programme to support the ESC.
- 5.0.6 Requirements 7 and 8 require LLW Repository Ltd to, respectively, “establish a comprehensive programme of monitoring to confirm the integrity of both the interim cap covering past disposals, and the bentonite cut-off wall constructed to the north and east end of the disposal area” and “establish and implement a monitoring programme to determine the extent of groundwater contamination around the site arising from LLW disposals”. These two requirements are also subject to annual review, and we will continue to discuss these separately with the LLW Repository Monitoring Project. With reference to Requirement 6, we will expect these monitoring programmes to be co-ordinated with the ESC so that monitoring data are used in the development, calibration and validation of models used in the ESC, and the findings of the ESC are used to identify and prioritise areas for improvement in the monitoring programmes.
- 5.0.7 Requirements 9, 10 and 12 called for LLW Repository Ltd to address specific issues regarding compliance with the GRA and/or the authorisation. They required LLW Repository Ltd:
- (a) to develop CFA that are consistent with the assumptions made in the environmental safety cases;

- (b) to develop and implement a strategy for the long-term maintenance and active management of records associated with the deposit of low-level waste on the site;
- (c) to ensure that all environmental systems and equipment that are required to be maintained/tested in compliance with the authorisation are categorised, clearly labelled and are clearly identifiable within a written maintenance schedule.

In each case, LLW Repository Ltd have responded to the specific requirement, we have reviewed their response, and we consider the specific requirement to be satisfied. However, it should be noted that these specific requirements also imply on-going obligations on LLW Repository Ltd to maintain and apply the required systems.

- 5.0.8 Requirement 14 requires LLW Repository Ltd to develop a detailed programme of the work leading up to and including the demolition of the facilities previously used for storing bulk plutonium-contaminated material (PCM). A programme has been developed and detailed BPEO/BPM assessments have been conducted for the wastes arising during the clean out, decontamination and demolition of the facilities. We therefore consider this requirement to have been satisfied. The programme showed plans for demolition of all relevant buildings over the next few years, but funding constraints are likely to delay this work.

6 Conclusions

- 6.0.1 This document gives an overview of our full review of LLW Repository Ltd's submission against Schedule 9 Requirement 2 of their RSA 93 authorisation. Additionally, it goes further by considering related requirements detailed in our 2006 Decision Document (Environment Agency, 2006b). We also use our review of the submission as an opportunity to review LLW Repository Ltd's progress towards delivery of a fully updated ESC in 2011.

- 6.0.2 As well as directly addressing Requirement 2, LLW Repository Ltd's submission provides a useful update on their performance assessment and their strategy for optimisation at the site. The key elements of the submission are as follows:

- (a) *A review of national and international best practice for minimising the impacts from waste disposals, including a review of options for reducing the peak risks.*
In our view this work has substantially satisfied Requirement 2, but we have also identified some areas for further work to contribute to the full updated Environmental Safety Case (ESC).
- (b) *A proposed interim strategy for risk management at the site which leaves the trench wastes undisturbed, but incorporates the installation of a final site cap, a cut-off wall around the site and vertical drains below the disposal area as part of the closure plan.*
We accept this as a reasonable interim position, although we note some uncertainty around the acceptability of vertical drains in the light of developments in groundwater protection regulations.
- (c) *A 'toolkit' of further risk management technologies, identified by LLW Repository Ltd's review.*
These technologies will be assessed as understanding of the site develops, leading to a more definite optimised risk management strategy and closure plan. We agree that further assessment of technologies is needed. For example, while we accept LLW Repository Ltd's conclusion that full retrieval of all of the trench wastes may be ruled out on a number of grounds, we expect LLW Repository Ltd to investigate further the possibility that the wastes which contribute to the higher risks could be selectively retrieved. We expect LLW Repository Ltd to develop a more detailed and explicit plan of how the toolkit and its application will be pursued, including how stakeholders will be engaged in the process.
- (d) *Substantial advances in knowledge about the existing inventory of waste in the trenches, including the specific locations of some particular waste streams.*
We welcome this work, which has led to a reasonable understanding of the waste inventory. However, we believe some further work is needed to characterise the uncertainty surrounding the estimated inventory. This additional work should include an

investigation of anecdotal evidence about past disposal practices. More importantly, we now expect LLW Repository Ltd to give more attention to efforts that will improve their understanding of the inventory of radionuclides in wastes that are likely to be consigned to the LLWR in the future. This work should focus particularly on those waste streams that seem most likely to make a significant contribution to the risks from the vaults.

- (e) *A proposed methodology for defining the radiological capacity of the site, and an interim proposal that the radiological capacity be the reference inventory presented in the submission.*

We agree that, apart from a specific concern about the assessment of human intrusion scenarios, the proposed methodology is generally reasonable. Pending the completion of the full ESC and the finalisation of the UK National LLW Strategy, we are also satisfied that the proposed interim radiological capacity for the time being can be used as a working basis without significantly affecting the environmental risks from the site. However, we expect LLW Repository Ltd to provide a definitive proposal on radiological capacity as part of the full updated ESC in 2011. This proposal must be underpinned with comprehensive assessments that must also be included in that ESC.

- (f) *A performance update that indicates substantially lower estimated impacts than those presented in the 2002 Post Closure Safety Case (especially for the trenches).*

In most cases impacts estimated in the performance update fall below our regulatory guidance levels as specified in the environment agencies' Guidance on Requirements for Authorisation (GRA) for near surface disposal. We agree that this is a useful update and we note the lower estimated risks. However, the scope of the performance update is too limited for us to reach any conclusion about whether the estimated impacts satisfy our criteria.

- (g) *A comprehensive review of evidence and predictions concerning the future evolution of the site, leading to a strong conclusion that the facility is highly likely to be destroyed by coastal erosion within a few thousand years. The erosion process could begin as early as 750 years from now.*

In view of the importance of this issue, we commissioned an independent expert to review the work presented by LLW Repository Ltd. Our review and the conclusions of the independent expert largely confirm that LLW Repository Ltd's conclusion is robust.

6.0.3 On the basis of our review of LLW Repository Ltd's Requirement 2 submission, we have reached the following conclusions:

- (a) Schedule 9 Requirement 2 has been substantially satisfied.
- (b) Since LLW Repository Ltd has not yet provided us with adequate information to allow the radiological capacity of the site to be set definitively, we cannot yet authorise LLW disposals to Vault 9. The methodology for setting a radiological capacity proposed by LLW Repository Ltd in the Requirement 2 submission may provide a suitable basis to achieve this authorisation, but it will need to be supported by an adequate full ESC.
- (c) Since LLW Repository Ltd has not yet provided us with a risk management study that demonstrates definitively that future impacts will be as low as reasonably achievable (ALARA), we currently deem it inappropriate to construct the final cap over the trenches and Vault 8. The necessary demonstration may be achievable using the 'Best Practicable Environmental Option' methodology described in the Requirement 2 submission, but we will need to see evidence that the risk management options identified in the 'toolkit' – such as the selective retrieval of wastes that contribute to the higher risks – have been fully and systematically analysed, using adequately robust data and taking into account the views of stakeholders.

6.0.4 The likely destruction of the facility by coastal erosion within a few thousand years is clearly a key issue. We will therefore pay particular attention to whether the full ESC adequately demonstrates that:

- the specific requirements within the GRA are met (including measures to ensure that radiation dose constraints and risk and dose guidance levels to the public are met during the operation of the site and after its closure);
- the risks presented by the site are optimised;

- all necessary measures are taken to contain wastes while the site is under operational management.

If this demonstration is provided and robustly underpinned, then our position is that coastal erosion at some point in the future is an acceptable risk.

6.0.5 While the quantitative assessment is only one element of the ESC, it is an important one. The performance update in the Requirement 2 submission indicates doses and risks within the relevant guidance levels specified in the GRA, with the exception of the conditional risk associated with the 'well scenario'. However, the full ESC will need to update and expand upon the performance update considerably. The full ESC will need to supply a robust demonstration that doses and risks from all scenarios and pathways are consistent with the guidance levels. This demonstration will need to:

- show that the assessment of impacts – particularly those associated with the erosion of the facility – is sufficiently comprehensive and soundly based;
- show that the risk from the well pathway, calculated with an adequately specified and justified model, is sufficiently low;
- show that the risks from all pathways remain sufficiently low when all of the relevant uncertainties, and the heterogeneity of the wastes, have been adequately taken into account;
- provide adequate evidence that the approaches, models and data used for the assessments are sufficiently reliable in the way they have been used.

6.0.6 In summary, LLW Repository Ltd has substantially satisfied Requirement 2 and has also made considerable progress towards Requirement 6. However, a substantial amount of work is still needed to complete a full ESC that is adequately underpinned by appropriate evidence and analysis. Our detailed review comments indicate the areas where we expect to see improvements. In our view, it will be challenging for LLW Repository Ltd to achieve these improvements by the deadline of 1 May 2011, but we do believe they are achievable. Authorisation of further disposal at the LLWR, beyond that authorised in Vault 8, will not be given until a satisfactory environmental safety case is produced and we will continue to require an acceptable case to be produced for past disposals.

List of abbreviations

ALARA	As low as reasonably achievable
BNFL	British Nuclear Fuels plc
BNGSL	British Nuclear Group Sellafield Limited
BPEO	Best practicable environmental option
BPM	Best Practicable Means
CFA	Conditions for Acceptance by LLW Repository Ltd of radioactive waste for disposal at the LLWR
Defra	Department for Environment, Food and Rural Affairs
ESC	Environmental safety case
GRA	Guidance on Requirements for Authorisation
HPA	Health Protection Agency
HSE	Health and Safety Executive
IAF	Issue assessment form
ISO	International Organization for Standardization
LLW	Low level waste
LLWR	Low Level Waste Repository near Drigg, Cumbria
NDA	Nuclear Decommissioning Authority
NGO	Non-governmental organisation
NII	Nuclear Installations Inspectorate
NRPB	National Radiological Protection Board
NuLeAF	Nuclear Legacy Advisory Forum
OESC	Operational environmental safety case
PCM	Plutonium contaminated material
PCSC	Post-closure safety case
R&D	Research and development
RSA 93	Radioactive Substances Act 1993 (as amended)
SLC	Site licence company
UKAEA	United Kingdom Atomic Energy Authority
UKNWM	United Kingdom Nuclear Waste Management Ltd
VLLW	Very Low Level Waste

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