



# Review of LLW Repository Ltd's 2011 environmental safety case: Safety case management

Issue 1, 15 May 2015

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# Executive summary

The Environment Agency is responsible for regulating the disposal of radioactive waste in England under the terms of the Environmental Permitting (England and Wales) Regulations 2010. As part of its current environmental permit we required LLW Repository Ltd to submit an Environmental Safety Case (ESC) for the Low Level Waste Repository (LLWR) in west Cumbria to the Environment Agency by 1 May 2011 (the 2011 ESC).

Our review of the 2011 ESC is documented in an overview report, which is supported by 5 technical review reports that cover the main topic areas of the ESC in more detail. This technical review report covers our review of LLW Repository Ltd's management of the 2011 ESC and the LLWR as an operational site. We address a wide range of topics related to how LLW Repository Ltd has developed and presented the 2011 ESC, managed its production and implementation, addressed some of the broader technical issues associated with it, considered further enhancements to the case and engaged with others whilst doing this. Ultimately we have focused on how LLW Repository Ltd has developed and will implement the ESC to ensure continued safety at the site now and into the future.

In our review, we considered whether these aspects of the 2011 ESC meet the principles and requirements set out in our guidance on requirements for authorisation of near-surface disposal facilities for solid radioactive waste (GRA). That guidance sets out what we would expect to see in an ESC.

We consider the overall quality of the 2011 ESC in the area of safety case management to be good. The structure of the ESC and clarity of arguments is generally clear and coherent with good referencing to underpinning reports.

We are satisfied that LLW Repository Ltd has engaged effectively throughout the development of the ESC and has taken the GRA guidance on following a 'process by agreement' (Requirement R1) into account in formulating its engagement with us and others. We were provided with documentation at relevant stages in the process and the processes and timing of future reviews of the ESC have been defined and agreed with us.

We sought further clarity from LLW Repository Ltd on its stakeholder engagement during the 2011 ESC production and review process. Having provided further information and having enhanced its engagement processes, we are satisfied that LLW Repository Ltd has met the expectations within the GRA (Requirement R2) regarding dialogue with local communities and others and has allowed for flexible, early, ongoing, open and inclusive engagement that encouraged 'challenge' from a wide range of relevant stakeholders. We are satisfied that the process facilitated our involvement. We are supportive of LLW Repository Ltd's commitment to dialogue with stakeholders and the priority it gives to this area of work.

We consider that LLW Repository Ltd has presented an adequate and proportionate ESC in accordance with the GRA (Requirement R3). We have commented on specific GRA expectations across our other ESC technical review reports, however, we are satisfied there are no significant omissions taking into account further information provided to us during our review. We welcome the integrated approach the company has adopted to evaluating the environmental performance of the site. We note that there are some inconsistencies between the assessment models used for the period of authorisation and post-closure assessment period as they are based on different assumptions. However, the assumptions used were claimed to be cautious and the inconsistencies are not significant and can be addressed in future updates to the ESC.

In relation to environmental safety culture and expectations of LLW Repository Ltd's management systems within the GRA (Requirement R4), we raised a number of further questions to support the information provided within the 2011 ESC. Overall we are able to conclude that LLW Repository Ltd operates with a positive environmental safety culture and has a suitable management system in place, although we identified a number of areas where there is scope for continued improvement.

We are satisfied that a positive environmental safety culture is demonstrated through LLW Repository Ltd's policies, processes, approaches, communication activities, provision of environmental resource and scrutiny from the LLW Repository Ltd Board.

We are reassured that LLW Repository Ltd's management system is well established and mature, having developed over a number of years with oversight from us. Overall we consider the management systems to be comprehensive, fully integrated and clearly documented. We support the fact that specific project management arrangements were put in place during development of the 2011 ESC, including a dedicated Project Team, Project Manager, Project Execution Plan and other quality, peer review and engagement procedures.

We paid particular attention in our review to LLW Repository Ltd's planned future ESC related resources, competency, knowledge and succession planning, in addition to the management of ESC records, due to their importance to the ongoing effective management, implementation and upkeep of the ESC. We are reassured that GRA expectations are adequately met by a number of ongoing measures to enhance the ESC Project Team and to make sure all ESC records are effectively captured. We support LLW Repository Ltd's current development of a new low level waste tracking system, which will meet the needs of the current 2011 ESC, waste acceptance criteria and environmental permit. We also consider independent peer review to be an important part of developing a robust ESC and welcome the company's use of both a UK based independent peer review group process and an international peer review group.

In addition to specific GRA Requirements, this review also addressed a number of broader issues of relevance to the production of an ESC, such as presentation, approach, use of safety functions, management of uncertainties, forward programmes of work, waste acceptance criteria, capacity management and implementation of the ESC. We are satisfied, following provision of further information in some cases, that each of these areas has been adequately addressed and support demonstration that GRA Requirements have been met.

However, we identified a number of areas with scope for improvement, including, but not limited to:

- improved use of audit trails within the ESC reports, for instance to show the progression of design optimisation over time
- scope for developing less reliance on models and increased emphasis on alternative lines of argument such as increased use of monitoring, experimental or analogue data where practical
- further development of safety function approaches
- development of a more systematic approach to addressing uncertainties
- capture of learning from the 2011 ESC and previous ESCs within a forward programme of work
- presentation of assessments related to the Extended Disposal Area in a more integrated manner

We are satisfied that the proposed changes to the LLWR Waste Acceptance Criteria (WAC) are consistent with the assumptions made in the 2011 ESC and subsequent updates and will be sufficient to achieve acceptable doses and risks to people and the environment. A 'sum of fractions' approach to managing radiological capacity over the lifetime of the site has been proposed and we believe it has been appropriately implemented within the WAC. We welcome further controls proposed on higher activity particulate materials and discrete items, which we required LLW Repository Ltd to consider the need for and which we believe are appropriate.

We are satisfied that LLW Repository Ltd has put in place adequate plans to implement the WAC and associated procedures. The company must also effectively implement broader aspects of the ESC on site, such as change control procedures, operational procedures and tools, addressing stored waste and engineering development. We are satisfied that LLW Repository Ltd has demonstrated these requirements will be met through a broad implementation plan and the implementation of key procedures.

Overall we judge that the GRA Requirements related to safety case management have been adequately met. Expectations detailed within the GRA have all been demonstrated to be met, supported by a range of further information provided during our review.

We have identified a number of areas where further improvements can be made to make sure that the LLW Repository Ltd's ESC continues to meet the requirements of the GRA.

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# 1. Introduction

## 1.1. Introduction

The Environment Agency is responsible for regulating the disposal of radioactive waste in England under the terms of the Environmental Permitting (England and Wales) Regulations 2010 (EPR10) as amended (and before that was responsible under the terms of the Radioactive Substances Act 1993 (RSA 93) as amended). In accordance with government policy, we periodically review environmental permits for the disposal of radioactive waste. During this process we consider a wide range of information, including the conclusions from our reviews of the Environmental Safety Case (ESC) produced by the operator of the disposal facility concerned.

The Low Level Waste Repository (LLWR) near Drigg, Cumbria is the UK's primary facility for the disposal of solid low level radioactive waste (LLW). As a result of a major review of the LLWR ESC undertaken between 2002 and 2005, we included a requirement in the current LLWR environmental permit for the operator, LLW Repository Ltd, to 'update the Environmental Safety Case(s) for the site covering the period up to withdrawal of control and thereafter' (Schedule 9 Requirement 6). We received the updated ESC on 1 May 2011 (the 2011 ESC). We have subjected this ESC to a rigorous technical review using suitably qualified and experienced personnel.

The aims of the review were:

- to determine the adequacy of the 2011 ESC as a submission against Schedule 9 Requirement 6 of the current LLWR environmental permit
- to provide an Environment Agency view on the technical adequacy of the 2011 ESC
- to use as a major input to a forthcoming regulatory decision on permitting the LLWR for further disposal of radioactive waste
- to identify potential areas of improvement to the 2011 ESC, to guide LLW Repository Ltd

In our review, we have considered whether the 2011 ESC is based on sound science and engineering and meets the principles and requirements set out in the most recent environment agencies' guidance on requirements for authorisation (GRA) of near surface disposal facilities (Environment Agency et al. 2009). The GRA explains the requirements that we expect an operator to fulfil in applying to us for a permit to operate such a facility. It includes our radiological protection requirements and provides guidance on the nature of the ESC we would expect to see.

On 28 October 2013 LLW Repository Ltd made an application to the Environment Agency to vary the existing environmental permit under the EPR10 to dispose of further waste at the repository. This application covered an extended disposal area, which would allow sufficient capacity for the LLWR to accept a significant proportion of the UK's LLW predicted to be generated out to around 2130 (excluding lower activity LLW that could be diverted to other facilities). The application is in line with the proposals set out in the 2011 ESC, incorporating any subsequent modifications since the ESC submission. The proposal is to design, operate and close the facility in accordance with the 2011 ESC and subsequent changes described within the environmental permit application.

Our review of the 2011 ESC is intended to provide technical underpinning of our decision on LLW Repository Ltd's permit variation application. We will only permit further disposals at the LLWR if we are convinced that these disposals will not present an unacceptable risk to people and the environment. That is, the 2011 ESC needs to demonstrate that the short-term and long-term environmental impacts from past and proposed future disposals, taken together, will be acceptable.

## 1.2. The 2011 ESC submission

LLW Repository Ltd submitted the 2011 LLWR ESC to the Environment Agency on 1 May 2011. The 2011 ESC comprised the following hierarchy of documents:

- Level 0 - A non-technical summary, not aimed at regulators



- Level 1 - A single top level main report (143 pp) summarising the main arguments and the broad lines of evidence supporting them
- Level 2 - 16 topic reports (of 50 to 250 pp each) setting out in more detail the evidence to support the main arguments
- Key Level 3 - 95 underpinning reports (mostly 50 to 200 pp) identified by LLW Repository Ltd as being 'key'
- Other Level 3 - Several hundred other references referred to in the above documentation but not identified as 'key'

The Level 1 and 2 documents form the core of the 2011 ESC, with additional detailed information contained in Level 3 documents. During our review, we needed to extensively scrutinise many of the Level 3 documents in order to understand the safety arguments. The Level 0, 1 and 2 documents plus the 'key' Level 3 documents are available from relevant public registers and, at the time of writing and during our consultation period, from the LLW Repository Ltd internet site at: <http://llwrsite.com/national-repository/key-activities/esc/esc-documentation/>

LLW Repository Ltd has informed us that it is continuing to investigate potential options for the future design, operation and long-term management of the LLWR. We are also aware that the Nuclear Decommissioning Authority (NDA) and Site License Companies (SLCs) have been reviewing their procedures for estimating and reporting future LLW arisings to improve the accuracy of future inventory data. However, the scope of our review has comprised only the 2011 ESC as submitted, together with supporting documentation and further information provided up to and including the date of the environmental permit variation application made in October 2013. Any subsequent proposals to change the basis of the ESC will be addressed separately.

### 1.3. The review process

We have carried out a detailed technical review of the 2011 ESC. The review comprised an assessment of whether the ESC arguments, outlined in the Level 1 report, adequately address the requirements of the GRA and whether the evidence provided supports the arguments.

We have reviewed lines of evidence and underpinning information, judged by our suitably qualified and experienced reviewers to be of importance to the ESC to the depth considered necessary to determine their validity, including tracing data and assumptions back to original empirical evidence. We have pursued other lines of evidence and underpinning information considered to be of less importance in less depth. We have completed a detailed review of the Level 1, Level 2 and important Level 3 documentation, also referring to other Level 3 documents to the extent that they underpin the ESC.

Environment Agency (2015a) provides further information on our approach to the review and the process we have used.

The primary test of the acceptability of the 2011 ESC as a whole, or of an individual document, was whether it meets Schedule 9 Requirement 6 of the current site permit and satisfies the relevant principles, requirements and guidance in the GRA. Where potential deficiencies or other issues were identified during our review, they were categorised as follows:

- A Regulatory Issue (RI) is a deficiency sufficiently serious that, unless or until it is resolved, we will either: (a) not grant a permit; or (b) grant a permit constrained by major limiting conditions (as distinct from information or improvement conditions) defined by us to mitigate the consequences of the RI.
- A Regulatory Observation (RO) is a deficiency not sufficiently serious to prevent our issuing a permit but sufficiently serious that, unless or until it is resolved, we will include an improvement or information condition in the permit requiring defined actions on defined timescales to resolve it (or to demonstrate suitable and sufficient progress towards resolving it). Related ROs may be grouped into a single improvement or information requirement. (We may also apply minor limiting conditions in the permit until it has been resolved.) An RO can become an RI if the condition is not met.

- A Technical Query (TQ) is a deficiency not sufficiently serious for us to require defined action by LLW Repository Ltd but sufficiently significant for us to request action. An individual TQ is unlikely to become an RO even if not addressed, but a number of unresolved TQs may accumulate into an RO.
- Any other further information or points of clarity considered to be worth requesting of LLW Repository Ltd are designated as Minor Comments. LLW Repository Ltd was requested, but not required, to provide responses to these to enable us to conclude our review of the 2011 ESC. However, LLW Repository Ltd did provide responses whenever requests for further information were made.

For each RI, RO and TQ we have generated an Issue Resolution Form (IRF), which records and tracks the issue and its resolution. IRFs are detailed records of concerns raised as part of our review of the 2011 ESC. Each IRF defines one or more actions. We have expected LLW Repository Ltd to provide a substantive response to the action(s) specified on the IRF by a specified date(s).

The IRFs form a substantial element of our review output. LLW Repository Ltd has provided responses on each IRF; where appropriate this may be a summary of the response, referring to more detailed information in supporting documentation. Each IRF also records our evaluation of the response. An issue has only been closed out when we have determined that the response from LLW Repository Ltd adequately addresses it. Where appropriate, we raised further actions or queries so we could close the IRF. All IRFs have now been closed.

We recognise that the 2011 ESC is a complex submission involving a wide range of technical assessments that will evolve and improve in the future as technology and understanding advances. Certain details will also be developed further as the site advances, for example towards construction of the final engineered cap over the waste. Within our review we therefore identify important areas which we believe will benefit from further work, development or clarification in the future. These areas are identified as Forward Issues (FIs). These represent areas of work that we believe it is important for LLW Repository Ltd to progress as part of its forward improvement plan. FIs address areas where we expect continued improvement in the ESC and its implementation. We will require LLW Repository Ltd to engage with us on these FIs, to put in place formal mechanisms to track and address them and, as necessary, incorporate work to address them in its forward programmes of work and report to us on progress and when it believes the FIs have been fully addressed. We will expect the outcome of FIs to be considered within any subsequent updates to the ESC.

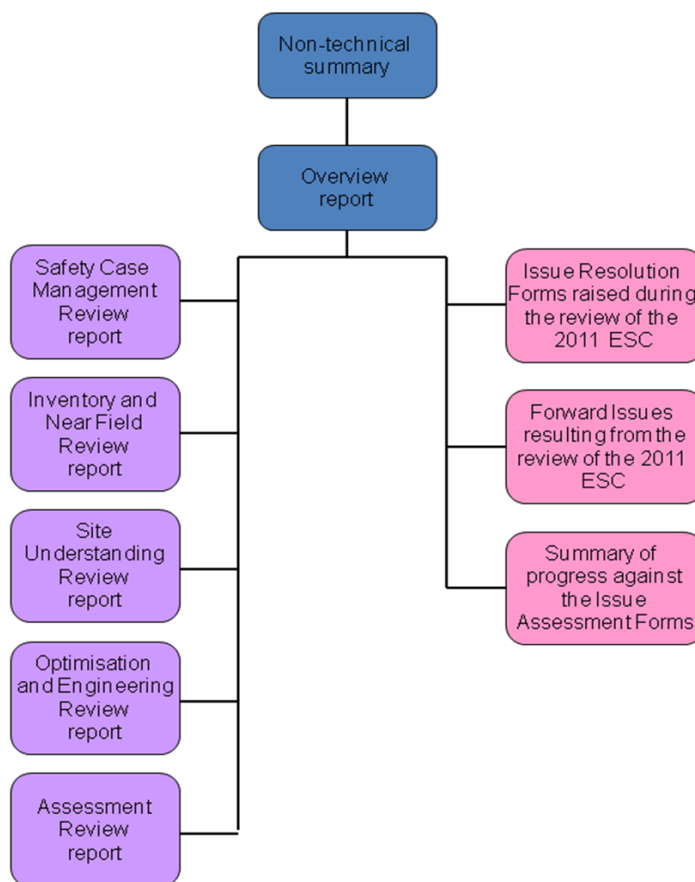
Throughout the review, we also made a number of specific recommendations to LLW Repository Ltd. Recommendations represent areas where we see scope for possible improvement or development, but which are relatively minor in nature relative to FIs. These recommendations are numbered and highlighted in this document. As a matter of good practice we expect LLW Repository Ltd to address these recommendations and will expect a mechanism to be put in place to track them.

It is important to note that these FIs and recommendations do not represent the only areas of work that we will expect LLW Repository Ltd to progress and are not intended to represent a comprehensive scope for forward work. We will require the company to develop its own forward programme of work as necessary to maintain and improve the ESC; our FIs and recommendations should only form part of that programme. LLW Repository Ltd's forward programme of work must be informed by a wide range of inputs, for example monitoring data, research and development, improvements in technology and continuous improvement.

This report is necessarily focused on the negative, bringing out areas where we have raised concerns, or have remaining concerns, or expect further action or permitting requirements. We do not necessarily comment on areas we are content with and we do not list everything we have reviewed. The length of discussion on any particular topic may depend on the degree of interaction between us and LLW Repository Ltd and does not necessarily reflect the significance of the issue. However, we have made positive comments where we believe that the treatment of issues represents good practice.

## 1.4. ESC review deliverables

The output from our review of the 2011 ESC is a series of review reports that will provide technical underpinning to future permitting decisions. The document hierarchy is illustrated in Figure 1.



**Figure 1 The Environment Agency review of the 2011 ESC: Document structure**

The main document is the overview report of the technical review (Environment Agency 2015a). It provides our conclusions on the extent to which LLW Repository Ltd's 2011 ESC demonstrates to our satisfaction that existing and proposed future disposals meet the requirements set out in the GRA, as well as whether Schedule 9 Requirement 6 has been met satisfactorily. The overview report includes background information on the history of the LLWR and regulatory requirements. It also describes our review process in greater detail.

The overview report is supported by 5 technical review reports, which provide more detailed conclusions on the technical adequacy of the 2011 ESC as a basis for permitting future disposals. These reports cover the following topic areas: Safety Case Management (this report); Inventory and Near Field (Environment Agency 2015b); Site Understanding (Environment Agency 2015c); Optimisation and Engineering (Environment Agency 2015d); and Assessments (Environment Agency 2015e). The IRFs resulting from each of the topic area reports are collated in a standalone report (Environment Agency 2015f).

Forward Issues that are raised as a result of our review of the 2011 ESC are also collated in a separate report (referenced as ESC-FI-xxx) (Environment Agency 2015g). We will agree with LLW Repository Ltd when and how it addresses these issues through our normal regulatory interactions and will track progress made to resolve them.

We documented concerns from our review of the previous LLWR Operational Environmental and Post-Closure Safety Cases (the 2002 ESCs; British Nuclear Fuels Ltd (BNFL) 2002a,b) on Issue Assessment Forms (IAFs), which are similar to the IRFs. We report our review of LLW Repository

Ltd's progress in addressing actions raised in the IAFs in Environment Agency (2015h). Any actions that we consider have not been fully addressed in the 2011 ESC are taken forward in the FIs or recommendations.

We have also prepared a non-technical summary of our review of the 2011 ESC (Environment Agency 2015i).

Together the documents describing the review of the 2011 ESC summarise the findings of our review and provide information to support consultation on our draft decision about the future permit for the LLWR.

We welcome any comments on our review findings. Such comments could be provided in response to our forthcoming consultation on permitting the LLWR.

## 2. Our review

### 2.1. Overview

This report is one of 5 technical assessment reports that support the overview report of our review of the 2011 ESC and cover the main topic areas of the ESC in more detail. It addresses the management of the 2011 ESC and the LLWR as an operational site, as well as broader issues that are relevant to all areas of the 2011 ESC. It addresses a wide range of topics related to how LLW Repository Ltd has developed and presented the 2011 ESC, managed its production and implementation, addressed some of the broader technical issues associated with it, considered further enhancements to the case and engaged with others whilst doing this.

Our review has focused on the main Level 1 report (LLW Repository Ltd 2011a) and the Level 2 Management and Dialogue Report (LLW Repository Ltd 2011b) and a number of the references therein. However, we also address a number of issues that we have found presented in a range of the Level 2 and Level 3 reports, as well as considering the presentation and clarity of the 2011 ESC as a whole. We also requested other documentation from LLW Repository Ltd to support our review where necessary. A number of the areas addressed within this report are the subject of our routine regulation of the site and therefore some reference is made to audits or inspections that we carried out.

This report represents a summary of a detailed technical review of the above areas of the 2011 ESC. The main reference point for this review has been the principles and requirements of the GRA and to an extent it is structured to reflect this, although it goes wider, addressing other key areas of importance to the ESC, such as the approach to assessment, treatment of uncertainty and the forward programme.

We raised a series of IRFs as part of our review. This was to challenge, clarify or seek further evidence in areas where we considered the case submitted fell short, for example, where we considered that the requirements of the GRA were not fully addressed, or where we took the view that technical arguments or conclusions required further evidence to support them. These IRFs are summarised in Appendix 1 of this report and presented in full in a separate report (Environment Agency 2015f).

LLW Repository Ltd satisfactorily addressed all the IRFs raised in the safety case management area during the course of our review and we have closed them. Nevertheless we have identified a series of recommendations and FIs where we consider there is scope for LLW Repository Ltd to make further improvements or pursue developments to the ESC in the future. Whether we made a recommendation or raised a FI depends on the environmental consequences in the absence of any further work. Tables summarising the recommendations and FIs are respectively presented in Appendix 2 and Appendix 3 of this report. We also assessed whether the information presented was sufficient to address technical issues that we raised previously in our assessment of the 2002 ESCs (Environment Agency 2005a). A summary of how LLW Repository Ltd has addressed these issues can be found in a separate report (Environment Agency 2015h).

The following sections detail our review, focussing on those areas we deemed important to the 2011 ESC. We highlight why we raised certain issues with reference to the GRA requirements and indicate whether we consider relevant requirements or issues have been adequately addressed. Elements of this report relate to other technical review areas and reference is made to our other review reports where relevant, in particular, the Assessment Report (Environment Agency 2015e), especially in relation to radiological capacity, waste acceptance criteria, addressing uncertainties and safety functions.

### 2.2. Requirement R1 – Process by agreement

Requirement R1 of the GRA (Environment Agency et al. 2009) states, 'The developer should follow a process by agreement for developing a disposal facility for solid radioactive waste' (GRA paragraph 5.2.3). Section 37 of the Environment Act 1995 allows the environment agencies to provide early regulatory advice and assistance to the developer of a new facility and to charge for

that service. The LLWR is not a new facility and so a process by agreement is not required. However, the LLWR is an operational site which is permitted under the Environmental Permitting (England and Wales) Regulations 2010 (as amended) and therefore charging mechanisms for the provision of advice are already in place. We agree charges annually with LLW Repository Ltd, which includes for our work reviewing the 2011 ESC and permitting the site operator. Elements of the process and expectations detailed within the GRA against Requirement R1 remain relevant as guidance on our expectations for engagement. We welcome the fact that LLW Repository Ltd has taken this guidance into account and has indicated, primarily within the Management and Dialogue report, how it has addressed these expectations (Section 2 of LLW Repository Ltd 2011b). Overall we consider that LLW Repository Ltd has complied consistently with these expectations.

GRA Requirement R1 seeks early and effective engagement from the operators with the Environment Agency to make sure sufficient attention is focused on regulatory requirements. We are satisfied that LLW Repository Ltd has engaged effectively with us throughout the development of the 2011 ESC and in preparation for review of the environmental permit. This interaction has enabled us to clearly define our regulatory expectations and effectively engage with other stakeholders, including the planning authority regarding planning permission at the site.

Effective engagement was achieved through a number of mechanisms such as monthly ESC liaison meetings and other regulatory liaison meetings involving interested parties such as the planning authorities, local councils, the Nuclear Decommissioning Authority (NDA) and the Office for Nuclear Regulation (ONR). In particular, we welcome LLW Repository Ltd's continuing commitment to the monthly ESC liaison meetings which have been held since early 2007. These meetings prove valuable for sharing information, clarifying expectations and agreeing approaches. These meetings have been well attended and meeting minutes provide traceability and transparency. We recommend that this liaison continues to support the development of future updates to the ESC (**Recommendation SCM1**). Written communication has been used by both parties to clarify issues or positions where appropriate.

GRA Requirement R1 also indicates that the timing and nature of submissions should be agreed with the Environment Agency, along with a forward work programme and necessary review points to make sure we remain informed, able to discuss regulatory issues and able to provide advice as necessary. Although the LLWR is currently permitted, this environmental permit only allows disposal into Vault 8 of the facility and therefore LLW Repository Ltd must seek an environmental permit variation to allow continued disposals. A prerequisite for this was for the company to submit an updated ESC by May 2011 and also to address a number of other Improvement Conditions, detailed within Schedule 9 of the environmental permit (Environment Agency 2010a) (see Section 2.18.2 of this report). Therefore, the company's forward work programme was, in part, already defined. Otherwise, we were satisfied that LLW Repository Ltd put in place a suitable programme to meet our expectations, which allowed us to remain informed, discuss issues and advise on our expectations of various submissions. We are satisfied that the programme took account of comments that we raised as part of our review of the 2002 LLWR ESCs.

To support an environmental permit review for an operational facility we expect the operator to submit an updated ESC '...that includes, for example:

- knowledge gained during construction and operation of the facility
- new understanding gained from on-going site characterisation work
- results of continuing research and development studies
- experience from similar facilities in other countries
- technological advances in the characterisation, conditioning and packaging of radioactive waste.' (GRA paragraph 5.5.4)

We are satisfied that the 2011 ESC has addressed each of these areas, although we make specific comments elsewhere (Environment Agency 2015b, 2015c, 2015d, 2015e). On the basis of this ESC we will subsequently review the environmental permit for the site and determine necessary limits and conditions to ensure continued protection of people and the environment.

LLW Repository Ltd proposes to operate the site for disposals for at least another 100 years and the 2011 ESC lays out the expected development of the site through to closure and the end of active institutional control and eventual revocation of any environmental permit in force (which could be a further 100 to 300 years after final disposals). Site development will be done in accordance with the site development plan (Section 3.4 of LLW Repository Ltd 2011a) and details are provided in various reports (LLW Repository Ltd 2011c, d). The ESC recognises the need for ongoing engagement with the Environment Agency and others throughout this period. The 2011 ESC also recognises our expectation that the ESC is a living case that will develop with the site and that this development must be supported by a forward programme of work (LLW Repository Ltd 2011a and 2011p). The 2011 ESC describes how it is integrated into LLW Repository Ltd's management systems such that it is used to manage operations at the site (LLW Repository Ltd 2011b).

GRA Requirement R1 expects the operator of a facility to agree with us the timing and scope of periodic reviews of the ESC. For the immediate future LLW Repository Ltd has proposed annual, periodic (approximately every three years) and major (approximately every ten years) reviews (ESC-RO-SCM-001 and LLW Repository Ltd 2013a), with the exact timing of major reviews to be agreed with us. We agree these proposals are appropriate and will require review as we consider necessary through any environmental permit.

After waste disposals end, we will require the operator to submit a post-operations ESC to show that the facility can be closed in a way that allows the principles and requirements of the GRA to be met. Then, to support a final request to revoke any environmental permit, we will expect the operator to submit a final ESC to demonstrate that the facility meets the principles and requirements of the GRA. This may be submitted some time after closure of the facility if there is a period of active institutional control (currently anticipated to be at least 100 years after final disposals). We would only revoke the environmental permit for the site if we were satisfied with this final ESC. In respect of the trenches, these are partially completed disposals, in that we expect further engineered barriers to be put in place to protect the waste. We are satisfied that the 2011 ESC provides a good framework and basis for the development of a post-operational ESC, but we expect the ESC to be subject to further review as the site is developed and a final ESC submitted that addresses the trenches and vault disposals once any active institutional control period has ended.

## 2.3. Requirement R2 – Dialogue with local communities and others

Requirement R2 of the GRA (Environment Agency et al. 2009) states, 'The developer should engage in dialogue with the planning authority, local community, other interested parties and the general public on its developing environmental safety case' (GRA paragraph 5.7.1). Paragraphs 5.7.2 to 5.7.7 go on to outline expectations that dialogue will be carried out:

- widely
- flexibly to meet stakeholder needs and expectations
- early and on an ongoing basis
- so as to address technical, social and economic issues of interest
- to facilitate challenge
- involving us to make sure engagement is open, inclusive and constructive, and to enable us to explain our processes and requirements

LLW Repository Ltd identifies its stakeholders and describes how they are engaged and on what topics in Section 3 of the Management and Dialogue Report (LLW Repository Ltd 2011b) and with reference to its stakeholder engagement plan (Paulley 2010). Detail is also provided on the engagement process associated with the ESC and expectations outlined for engagement through the environmental permitting process (post-ESC submission).

We are satisfied that LLW Repository Ltd's engagement plan and actions meet the expectations in the GRA for a flexible, early, ongoing, open and inclusive means to engage with all relevant stakeholders. 'Engagement' has allowed 'challenge' and for social, economic and technical issues



to be raised. We input to this engagement process to explain our role and regulatory processes. The process has allowed key issues to be raised and discussed at a range of fora.

However, we were unclear how LLW Repository Ltd had defined its stakeholder list to make it appropriate to the scale and scope of the development being proposed and we therefore asked for further clarity through an IRF (ESC-TQ-SCM-003). In response, LLW Repository Ltd explained more fully its process for defining its stakeholder lists and what inputs it had used to make sure it was suitably comprehensive. We were satisfied this provided sufficient evidence that a suitably robust stakeholder list had been used.

We consider LLW Repository Ltd's stakeholder engagement plan represented good practice in a number of areas such as the definition of engagement with internal stakeholders and its Peer Review Group (PRG) and the use of open days to inform and engage with the local community. However, we also considered it to be weaker in relation to engagement with local and national non-governmental organisations (NGOs) and broader national stakeholders. We therefore raised an IRF (ESC-RI-SCM-002) seeking improved engagement in these areas. LLW Repository Ltd responded with a number of enhancements to its engagement plan and in particular made sure potentially interested NGOs were informed and given the opportunity to engage. Specifically we welcomed targeted communications to interested groups (when the ESC was submitted to us) and an open day held in Drigg Village Hall in September 2012 for the community. We consider it important that LLW Repository Ltd continues to make efforts to maintain engagement with a wide range of potentially interested parties throughout the period of operation of the site (**Recommendation SCM2**).

We also recognise the wide range of interactions LLW Repository Ltd has with its customers, including for instance at the annual consignor conference. We believe good interaction in this area remains important to help make sure Waste Acceptance Criteria (WAC) can effectively be met and understood. We believe that in particular, following any changes to the WAC, LLW Repository Ltd should provide support to consignors to understand the background to any changes, their meaning and appropriate ways to help ensure compliance and adoption of good practice (**Recommendation SCM3**).

We support LLW Repository Ltd's involvement in international groups and conferences as a way to share and learn good practice. Overall we welcome the company's commitment to dialogue, the priority given to this area of work and consider that adequate engagement is being done.

## 2.4. Requirement R3 – Environmental safety case

Requirement R3 of the GRA (Environment Agency et al. 2009) relates to the need for an ESC to support the environmental permitting of a facility for the disposal of solid radioactive waste. An ESC is defined as 'a set of claims concerning the environmental safety of disposals of solid radioactive waste, substantiated by a structured collection of arguments and evidence. It should demonstrate that the health of members of the public and the integrity of the environment are adequately protected' (GRA paragraph 6.22).

The aim of the 2011 ESC was to make an integrated and consistent evaluation of the environmental performance of the LLWR over its lifetime. This contrasts with the 2002 submission in which separate assessments were made for the period of authorisation (the Operational Environmental Safety Case, or OESC) and the post-closure period (the Post-Closure Safety Case, or PCSC). We welcome this integration, but note that there are some inconsistencies between the assessment models used for the period of authorisation and post-closure assessment period as they are based on different assumptions (Environment Agency 2015e). However, the assumptions used were claimed to be cautious and the inconsistencies are not significant and can be addressed in future updates to the ESC.

Requirement R3 of the GRA lays out expectations of what the 2011 ESC should address and refers to further chapters of the GRA. In general terms, the ESC should demonstrate a clear understanding of the evolution of the disposal facility in its geological setting. It should also demonstrate consistency with the principles for solid radioactive waste disposal (set out in Chapter 4 of the GRA) and that management, radiological and technical requirements set out in Chapter 6 of the GRA are met. We discuss whether or not these expectations have been addressed, and to



what degree, in our technical review (this report and Environment Agency 2015a, 2015b, 2015c, 2015d and 2015e).

Requirement R3 additionally refers to Chapter 7 of the GRA for further, more detailed guidance on the content of an ESC. The ESC should include an environmental safety strategy supported by detailed arguments to demonstrate environmental safety. It should 'present a top level description of the fundamental approach taken to demonstrate the environmental safety of the disposal system. It should include a clear outline of the key environmental safety arguments and say how the major lines of reasoning and underpinning evidence support these arguments' (GRA paragraph 7.2.2). There are a number of aspects that we consider are particularly important in preparing an ESC and we have taken these into account during our review of the 2011 ESC:

- the disposal system consists of multiple components or barriers; the ESC should include an explanation of and substantiation for, the environmental safety functions provided by each part of the system
- when environmental safety needs to be assured over very long timescales, quantitative risk assessments are unlikely to be sufficient on their own to establish the ESC. We expect the ESC to use multiple lines of reasoning based on a variety of evidence, leading to complementary safety arguments
- whilst uncertainties are not in themselves obstacles to establishing the ESC, we expect the ESC to explicitly take them into account and consider where they may be reduced or their effects lessened or compensated for
- we expect modelling studies to be an important part of the quantitative environmental safety assessment, being used to help in understanding the characteristics and behaviour of the overall disposal system and its component parts
- expert judgement is essential in gathering and interpreting evidence and applying it to develop the ESC and use in the supporting qualitative and quantitative models. In situations where expert judgement is needed to complement or develop arguments or to compensate for data gaps, we would expect appropriate elicitation procedures to be used

The ability of the 2011 ESC to meet these requirements is discussed as necessary across our ESC technical review. During the review of the 2011 ESC, we raised and LLW Repository Ltd responded to, a number of IRFs (Environment Agency 2015f). Some of these responses required a substantial amount of technical work. In addition, the LLWR ESC Project team maintains an ongoing technical programme of work. Work carried out since submission of the 2011 ESC has resulted in updates to a number of topic areas. A summary of updates in the period 2011-2013 is provided in the Developments Report (LLW Repository Ltd 2013b). This document supports the company's application to vary its existing environmental permit and sets out changes in the ESC since its publication in May 2011. Although the Developments Report is a useful document, the existence of a substantial body of relevant technical work that post-dates the submitted 2011 ESC means that the current ESC is no longer made in a single suite of documents. To ensure transparency, LLW Repository Ltd should make sure that the audit trail of all documentation supporting the current ESC is clearly signposted, dating back to the publication of the 2011 ESC in May 2011 (**Recommendation SCM4**).

In general we conclude that LLW Repository Ltd has taken appropriate account of the GRA in preparing the 2011 ESC. Overall, we are satisfied that the ESC presented is proportionate to the expected disposal inventory at the facility. LLW Repository Ltd's aim is now to implement the ESC as a 'live' safety case within its general processes for maintenance of safety cases and formal change control. (Management of the ESC is discussed further in Section 2.7 and 2.17.)

## 2.5. Presentation and structure

As stated in the GRA: 'The environmental safety case should demonstrate, using a structure based on clear linkages, how the environmental safety strategy is supported by the detailed arguments and how the arguments are supported by evidence, analysis and assessment. Internal consistency within the environmental safety case needs to be established and maintained' (GRA paragraph 7.2.3).

Chapter 7 of the GRA provides guidance on the content, but not the structure, of an ESC. LLW Repository Ltd states that the ESC is made in the main (Level 1) report (LLW Repository Ltd 2011a) and the 16 Level 2 documents (LLW Repository Ltd 2011e). The Level 1 report was intended to outline the plan for the development of the LLWR and the main qualitative arguments concerning environmental safety and how this is achieved. The Level 2 reports were intended to present the evidence that underpins the safety arguments, referring to more detailed and quantitative evidence. The Level 2 documents cover the main subject areas of the ESC.

This structure seems a logical way to divide the information. LLW Repository Ltd prepared all these documents to a standard format, which has improved readability.

The main 2011 ESC report (LLW Repository Ltd 2011a) outlines the approach taken by LLW Repository Ltd to achieve and demonstrate environmental safety and presents the safety arguments. The company presents the safety arguments, which it considers in summation to form the ESC, under the headings of: management and dialogue; system characterisation and understanding; optimisation and site development plan; and assessment. This is a logical structure that allows linkage to the 14 requirements of the GRA. A high level summary of control measures and their functions is also provided. The Level 2 Report on Addressing the GRA (LLW Repository Ltd 2011e) also provides a clear map of where GRA requirements are addressed within the whole ESC submission to aid with navigation.

The Level 1 and 2 documents form the core of the 2011 ESC, with additional detailed information contained in Level 3 documents. During our review, we needed to extensively scrutinise many of the Level 3 documents in order to understand the safety arguments. In a number of areas we felt that the Level 1, 2 and key Level 3 documents did not make the case on their own and so we needed to ask for extra documents during our review. This resulted in an increase in the amount of time and effort required for us to review the 2011 ESC. Because many Level 3 documents were written by contractor organisations, there was a great deal of repetition between them and a loss of clarity where information in an older document had been superseded. We note that the majority of documents were dated 2011, although some of them had been prepared earlier and, therefore, it was not always obvious where information was the latest available. We also found some minor discrepancies in information provided between different reports.

We consider that LLW Repository Ltd could have improved the presentation of understanding of the geosphere, as there were a number of iterations of the geological and hydrogeological models during recent years. For example, the parallel development of the geological conceptual model and the 3D geological model in early 2010 led to inconsistencies between the two models and the need for a further iteration of the 3D model in September 2010 (Smith 2011). However, the early 2010 3D model was used for the development of the hydrogeological model, necessitating a retrospective assessment of the implications of the updated 3D model as a conceptual uncertainty (Hartley et al. 2011). Furthermore, we note that Hartley et al. (2011) state that the September 2010 3D geological model is not an improvement over the early 2010 model in certain ways, as it contradicts the hydrogeological data (for example, with respect to the thickness of lithostratigraphic unit B2, monitored water levels and site observations). These caveats and their significance are not discussed elsewhere in the ESC.

An example of discrepancies between different ESC documents concerns the assumed distribution for the probability of a well serving an isolated dwelling, which was used in the well pathway calculations. The elicitation report (Jackson et al. 2011) recommends use of a log-triangular distribution with values of 0.03, 0.1, 0.3 km<sup>-2</sup> whilst the distribution quoted in the radiological calculations for the groundwater pathway (Kelly et al. 2011) is 0.03, 0.1, 3 km<sup>-2</sup>. We asked LLW Repository Ltd to clarify which upper limit was used in the assessment calculations in an IRF (ESC-TQ-ASO-009). The company confirmed that the discrepancy was due to a typographical error that did not affect the assessment calculations.

We expect to see continued efforts by LLW Repository Ltd to improve the structure and clarity of reporting in future assessments, learning from experience in developing this ESC, including feedback from ourselves, for example relating to site characterisation (see Environment Agency 2015c), and the Peer Review Group (PRG). We anticipate further learning will also come from the implementation of the ESC and ongoing management of the site against it.

We also found a number of instances in which the audit trail is unclear. For example, the engineering design includes measures to avoid overtopping (or 'bath-tubbing') of leachate over the vault walls and into the near-surface environment. Paulley and Egan (2011) state that, 'bath-tubbing concepts are substantially more likely to lead to discharges to surface or upper ground water systems. The principle was also agreed that these discharges are more likely to lead to impacts to receptors than discharges to deeper water systems'. Although the groundwater assessment includes model results supporting this statement (Kelly et al. 2011), it refers to the specific model runs as the 'stream pathway' (making no clear link to bath-tubbing or overtopping) making the audit trail unclear. Similarly, the link is not made in the Level 2 assessment of long-term radiological impacts (LLW Repository Ltd 2011i).

Similarly, the audit trail for the elicitation of uncertainties in key assessment data (for example, relating to evolution of the waste, engineering performance and groundwater flows) is unclear. The elicitation process itself, and the decisions arrived at, are comprehensively documented by Jackson et al. (2011), however, the supporting information that was made available to participants in the elicitation process (and on which the decisions were based), has not been made available. We therefore found it difficult to determine the evidence-base of decisions made during this process (Environment Agency 2015d).

Overall, despite a number of difficulties in using the ESC to trace evidence and audit trails, the presentation of the 2011 ESC is a significant improvement on the 2002 cases. We found the documentation sufficient and comprehensive enough to complete our technical review, subject to a number of requests for clarification and further information. We believe the documentation is sufficiently robust to serve as a basis for a 'live' ESC in support of operations at the LLWR. However, to improve clarity and the efficiency of review, future ESC submissions should aim, as far as possible, to include all relevant information to 'make the case' without the need for us to request further information (**Recommendation SCM5**).

## 2.6. Approach

The technical approach to development of the 2011 ESC is set out in Baker et al. (2008). The approach presented is suitable and consistent with the requirements of the (then draft) 2009 GRA. The approach includes an appropriate balance between qualitative and quantitative arguments and emphasis on the need to justify optimisation, robustness and an adequate level of site characterisation and system understanding. This approach has been refined during the development of the ESC. An example of change is that the 2011 ESC does not evaluate understanding of the system performance in terms of safety functions as proposed by Baker et al. (2008). This issue is discussed further in Section 2.8.

A dedicated ESC Project Team at the LLWR led the bulk of the work presented in the 2011 ESC over the period 2008 to 2011. This work built on technical work presented in the 2002 PCSC and OESC and work subsequently carried out in the period leading up to submission of an interim performance assessment and update on the optimisation strategy for the LLWR, which was prepared in response to Schedule 9 Requirement 2 of the environmental permit in May 2008 (see Section 2.18.2).

Throughout the development of the 2011 ESC, the ESC Project Team took the role of 'intelligent customer' for any technical work being carried out by contractors. We are content that the ESC Project Team closely managed any contractor work, which it specified in detail. The team set up an ESC framework contract with a number of organisations with specialist expertise in the development of ESCs. Four contractors carried out the bulk of the technical work: Galson Sciences Ltd, the National Nuclear Laboratory, Quintessa Ltd and Serco Technical and Assurance Services<sup>1</sup>. Although these organisations employ suitably qualified and experienced staff and have significant knowledge of the LLWR, the reliance on the knowledge of contractors was of concern to us early on in the ESC production process (see Section 2.7.4 for further discussions).

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<sup>1</sup> In 2012, AMEC acquired Serco Technical and Assurance Services.

We consider that in a number of places in the 2011 ESC there is a tendency to rely on the output from models and quantitative arguments rather than the qualitative arguments and evidence from site. LLW Repository Ltd notes that the performance assessment will be heavily reliant on the use of its models and their outputs as a measure of acceptable performance, in particular for the post-closure period (Baker et al. 2008). However, we find that there is sometimes an over-reliance on the results of dose and risk calculations to demonstrate safety in the long-term. This contrasts with the GRA which states that 'where environmental safety needs to be assured over very long timescales, it is likely this will only be achieved through multiple lines of reasoning based on a variety of evidence, leading to complementary environmental safety arguments' (GRA paragraph 7.3.6). Estimates of dose and risk can only be regarded as broad indicators of environmental safety and should be supported by other lines of argument. Although we consider that the 2011 ESC adequately demonstrates the long-term safety of the LLWR based on the output of assessment models, we expect a future submission to aim to make fuller use of alternative lines of reasoning wherever reasonable to do so (**Recommendation SCM6**).

We also expect that all work that supports the ESC 'needs to follow good engineering practice, for reasons of both quality management and optimisation. This will usually mean applying tried and tested methods, except where the technology used in the construction and operation of a disposal facility is at the leading edge of engineering practice' (GRA paragraph 6.2.27). We note that some aspects of the proposed engineered barrier system, in particular the underlying drainage layer proposed for future vaults, may be considered novel and at a conceptual stage<sup>2</sup>. However, the long-term performance of the engineered barrier is almost entirely based on elicited data rather than site-specific data.

Over the operational period of the site we expect to see elicited data supplemented and supported by empirical data (site and, where appropriate, experimental data) wherever practical and beneficial to do so (**Recommendation SCM7**). We also identified that there is no clear mechanism for reviewing and updating the elicited data used to inform the 2011 ESC. We set out our expectations for the review and update of elicited data in ESC-FI-029.

We note that the 2011 ESC was not clear on how the presented conceptual design would be taken forward and the detail developed through to the point of construction (Environment Agency 2013d). To set out our expectations for the further development of the engineering design we raised an IRF (ESC-RO-SUE-009), which asked LLW Repository Ltd to prepare a detailed engineering forward plan that was aimed at reducing uncertainty associated with the engineering system, including site-based performance assessment activities (monitoring and trials), experimental and desk-based activities. We received the forward plan in May 2013 (Shaw 2013) and we will be continuing to liaise with LLW Repository Ltd to make sure that the forward plan meets our expectations (Environment Agency 2015d and ESC-FI-026).

We consider it positive that the 2011 ESC generally focused on 'important' issues, an improvement over the 2002 ESCs and we continue to expect this focus. For example, we support the focus on a shorter timescale given the expectation of coastal erosion within a few hundred to a few thousand years. However, areas of focus should continue to be reviewed and other scenarios not ignored, such as delayed coastal evolution, which must be considered proportionately (**Recommendation SCM8**).

## 2.7. Requirement R4 – Environmental safety culture and management systems

Requirement R4 of the GRA (Environment Agency et al. 2009) states, 'The developer/operator of a disposal facility for solid radioactive waste should foster and nurture a positive environmental

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<sup>2</sup> Conceptual means that LLW Repository Ltd has assessed the performance of a realistic engineering design that could be constructed in the 2011 ESC. We have assessed the design against the requirements of the GRA. LLW Repository Ltd will need to carry out further detailed design and design justification work before construction.

safety culture at all times and should have a management system, organisational structure and resources sufficient to provide the following functions: (a) planning and control of work; (b) the application of sound science and good engineering practice; (c) provision of information; (d) documentation and record keeping; (e) quality management' (GRA paragraph 6.2.5).

GRA Paragraphs 6.2.6 to 6.2.40 go on to detail more specific expectations regarding environmental safety culture and management systems. Key amongst these is an expectation that:

- appropriate individual and collective attitudes and behaviours within LLW Repository Ltd and within suppliers are established and reinforced by the management system
- the management system is capable of ensuring sufficient protection to people and the environment against radiological and non-radiological hazards both at the time of waste disposal and in the future, in a proportionate manner
- the management system will be effective in addressing leadership, policy and decision making, availability of competencies, provision of sufficient resources, continuous learning, succession planning and knowledge management
- the management system will be adapted over the lifetime of the facility, undertaking reviews as necessary
- the written systems should show how environmental safety culture and environmental safety is directed and controlled

These issues are primarily addressed within LLW Repository Ltd's Management and Dialogue Report (LLW Repository Ltd 2011b), sections 4 to 9, along with supporting references. To support this core information LLW Repository Ltd also refers to the Main Report (LLW Repository Ltd 2011a) and also other specific sections of other reports addressing engineering (LLW Repository Ltd 2011d), optimisation (LLW Repository Ltd 2011c), the period of authorisation (LLW Repository Ltd 2011f), near field (LLW Repository Ltd 2011g), hydrogeology (LLW Repository Ltd 2011h) and long-term radiological assessment (LLW Repository Ltd 2011i).

Within the Management and Dialogue report, LLW Repository Ltd makes a clear commitment to develop and maintain a positive environmental safety culture, which is formalised within its Environment, Health, Safety and Quality (EHS&Q) Policy Statement as approved by the LLW Repository Ltd Board (LLW Repository Ltd 2011b). The policy states, 'nothing is more important than the protection of the environment and the health and safety of the workforce, contractors and the public'. The company goes on to describe how its management systems and organisational structure promote a positive environmental safety culture (discussed further below). The company also describe a number of mechanisms used to directly promote a positive culture and good awareness such as the use of staff open days, employee induction and environmental refresher training, an 'Environment Day' in 2010, use of a range of communications methods and the development and use of environmental indicators which are reviewed at key meetings.

Section 4.2 of the Management and Dialogue report provides a clear description of how environmental safety is managed as an integral part of a wider management system, with the management system being documented within the LLWR Management System Manual (LLW Repository Ltd 2010a). LLW Repository Ltd states that this manual 'comprises the policies, processes, procedures and working instructions needed to deliver the safe, secure, environmentally responsible and cost-effective clean up of the nuclear legacy, the management of storage and disposal of waste on the LLWR site and the subsequent decommissioning or redundant nuclear plant'. It is explained that at a working level the Manual is supported by a series of repository site procedures (RSPs) and a list of key EHS&Q roles and post holders. The management system is subject to a detailed annual review of EHS&Q described in the Management and Dialogue report.

The management system is well established, having been developed from systems previously used at the Sellafield site. LLW Repository Ltd has applied significant effort to rationalise it since 2008 to make sure it is fit for purpose for the LLWR as a separate organisation. We consider that this process has delivered significant improvements over the years and resulted in a management system that is generally robust and fit for purpose. However, there remains an ongoing need to tailor the management system to the requirements of the site, to continue to rationalise where



possible, to adapt to new processes such as the implementation of the ESC and to continue to make improvements based on learning. We therefore recommend that LLW Repository Ltd continues to regularly review and update the management system with this in mind (**Recommendation SCM9**).

The Management and Dialogue report describes how the ESC Project is managed under the wider Integrated Management System using a dedicated ESC Project Team, which is managed by the ESC Project Manager who reports directly to the Managing Director. We support this arrangement, the 'ownership' of the ESC by the Management Director and the clear line of reporting to the Managing Director for this important area of work. LLW Repository Ltd describes a number of specific project arrangements such as use of a Project Execution Plan (LLW Repository Ltd 2011j), specific project quality assurance and data management procedures (LLW Repository Ltd 2010b), peer review processes and use of an internal stakeholder engagement plan. We welcome the fact that the importance of internal stakeholders is recognised and discussed. We consider that the ESC must become a 'live' management tool for the LLWR and it is therefore vital that it is understood, accepted and integrated into all areas of the business.

Although the GRA requires demonstration of an adequate management system and a positive environmental safety culture within the ESC, we are also able to draw on wider evidence from our ongoing regulation of the LLWR as a well established permitted site in this respect. Wider evidence is discussed in Section 2.18 of this report. This, for example, refers to a recent management arrangements audit which identified a range of topic areas to be satisfactorily managed including organisational baselines, environmental leadership, environmental assurance and performance and learning from experience (Environment Agency 2013).

Overall we are satisfied that the LLW Repository Ltd operates with a positive environmental safety culture and has a suitable management system in place. The following sections address specific aspects of LLW Repository Ltd's management system and environmental safety culture in more detail and identify a number of areas where we believe there remains scope for improvement in the future.

### **2.7.1. Organisational structure**

Within LLW Repository Ltd's Management and Dialogue report, Section 4.2.1, an adequate explanation is provided of the organisational structure, with reference to the Management System Manual (LLW Repository Ltd 2010a) for more detail. The organisational structure is managed as a 'live' document, aligned to the operational baseline and is reviewed monthly providing evidence it remains as a 'live' issue.

The documents demonstrate that consideration has been given to the organisational needs in terms of environmental safety responsibilities, with the Management System Manual detailing the role and functions of LLW Repository Ltd. It is noted that the structure was implemented in 2008 following a due diligence review done by the new parent body organisation (PBO) to reflect the changing role of LLW Repository Ltd as a manager of both waste disposal and waste services. We accept that the structure therefore reflects both current and foreseeable operations, with the ability to adjust as required.

The structure presented is essentially a hierarchical one with a number of key environmental roles identified within it. The Management System Manual identifies how the key 'delivery' areas of the business are supported by cross-business functions including Safety, Regulatory Liaison and Governance and Science and Engineering. A team is dedicated to supporting compliance with the environmental permit and other requirements. Key environmental roles are supported by role specifications.

The documents demonstrate how an unbroken chain of responsibility flows from all staff to the Managing Director and the Board. Key roles and responsibilities are clearly defined and these roles and responsibilities are reflected in the relevant site procedures. The Management System Manual also details relevant committees and fora used to make management decisions and discharge certain duties.

### 2.7.2. Leadership

The GRA seeks evidence that the Board, directors and managers of an operator provide strong leadership and sustain high standards of environmental safety (GRA paragraph 6.2.11). LLW Repository Ltd's Management and Dialogue report indicates that the Board approve its EHS&Q policy which commits to high standards and it is indicated that LLW Repository Ltd strives to show that environmental messages come 'from the top', with messages being communicated via a range of means. It is explained how the Head of Safety, Regulatory Liaison and Governance sits on the LLW repository Ltd board providing a key link on environmental performance issues. Furthermore, the organisational structure is established to provide managerial oversight of environmental matters and to make sure of appropriate input to various committees such as the Management EH&S Committee.

Overall we consider that the 2011 ESC adequately demonstrates appropriate leadership in relation to environmental safety. However, we did not consider that the ESC provided adequate evidence of how the Board was practically involved in promoting safety and environmental performance, driving a positive environmental culture and ensuring through monitoring this is achieved. We therefore asked for further evidence to be provided through an IRF (ESC-TQ-SCM-001).

In response, LLW Repository Ltd referred to the make-up of the Board which includes an Independent Safety Director (ISD), with documented environmental responsibilities and the Executive EH&S Director. LLW Repository Ltd provided evidence that the Board is made aware of environmental issues, responsibilities and the environmental permit. The company also provided evidence that the Board is actively involved in reviewing and contributing to environmental matters on a routine basis. In particular, the ISD has a role in testing and challenging environmental performance. The Managing Director provides direct leadership through face to face briefings which include environmental matters. Executive Board members provide leadership through their day to day roles. We were satisfied that this provides sufficient re-assurance of environmental leadership. This evidence was further supported by a management arrangements audit carried out in November 2013 (Environment Agency 2013) which identified evidence of good practices and of improvements in EH&S being actively driven by the Managing Director, with the awareness and support of the Board.

### 2.7.3. Capable and forward-looking organisation

The GRA requires that an operator is capable and forward-looking, to maintain environmental safety of the disposal system. Roles, responsibilities, accountabilities and performance standards for environmental safety should be clear and not conflict with business roles, responsibilities, accountabilities and objectives (GRA paragraph 6.2.12).

To achieve this LLW Repository Ltd explains that it has a hierarchical structure with separate teams that address key business functions. Following a review in 2008, LLW Repository Ltd developed its organisational structure to specifically meet the needs of an organisation managing waste treatment and disposal contracts (LLW Repository Ltd 2011b).

LLW Repository Ltd's Management and Dialogue Report and supporting Management System Manual (LLW Repository Ltd 2010a) detail accountabilities and responsibilities of senior managers. These provide clear recognition of key environmental responsibilities and roles. As required by the environmental permit (Environment Agency 2010a), LLW Repository Ltd defines key EH&S role holders, including qualified experts. Specifically LLW Repository Ltd has defined a number of key role holders which make sure a degree of independent (and un-conflicted) oversight of EH&S matters, such as the Head of Safety, Regulatory Liaison and Governance and the Head of Science and Engineering. LLW Repository Ltd also employs an Independent Site Inspector, to undertake audits with a degree of independence from other site activities (LLW Repository Ltd 2011b). The Managing Director is accountable for environmental authorisations, with other senior managers being accountable to the Managing Director.

LLW Repository Ltd explained that the ESC will be used as a tool to support future management decision concerning the facility (LLW Repository Ltd 2011a). Matters of environmental safety throughout the lifecycle of the disposal facility are a key consideration of the ESC Manager (LLW Repository Ltd 2013a).

A management of change process is operated (LLW Repository Ltd 2011b) whereby significant changes in the organisation are assessed by the LLWR safety committees before implementation to make sure that they have been adequately considered and that environmental impacts are acceptable and regulatory requirements are met, such that the environmental safety of the disposal facility is secured on an ongoing basis. Additionally, to make sure the site continues to adapt, improve and is forward-looking, we welcome the fact that other processes are operated such as an EHS&Q improvement plan and operating experience feedback, along with LLW Repository Ltd's membership of a number of fora, networks and working groups aimed at improving practice.

We note that regarding the 2011 ESC and its implementation LLW Repository Ltd will need, to some extent, to re-focus its efforts away from ESC development towards practical implementation on site (for example construction), support to disposal operations and decisions (for example waste acceptance) and ongoing ESC maintenance. We support the fact that LLW Repository Ltd has addressed how the ESC Project Team will support these areas of work and will use their experience to support site operations, whilst maintaining awareness of the ESC and development of skills and experience associated with it. We believe this has the potential to strengthen any ESC Project Team involved in future reviews.

Overall we accept that the expectations within the GRA have been adequately met.

#### **2.7.4. Resources and competences**

The management system must enable LLW Repository Ltd to 'develop and maintain the resources and competences needed to ensure environmental safety' and to show how such a trained, qualified and experienced workforce is maintained (GRA paragraph 6.2.13). To address these requirements LLW Repository Ltd points to the role of its Human Resources and Training Manager in defining overall site training needs, supporting the management team in workforce planning and organisational development and maintaining an organisational baseline, which is 'a controlled document representing the structure and capability of the organisation to comply with relevant safety legislation' (LLW Repository Ltd 2011b). This organisational baseline is updated on a monthly basis and defines a number of key EH&S roles including qualified experts (under the environmental permit), Radiation Protection Advisors and Intelligent Customers. We agree that these measures, supported by the wider management system are adequate.

LLW Repository Ltd 'needs to be a capable operator in its own right and able to oversee and manage the work where it uses contractors' (GRA paragraph 6.2.14). The company indicates this is achieved and that all responsibilities against the environmental permit are discharged by site personnel under direct line management control. Where contractors are used, LLW Repository Ltd indicates that this is done under appropriate standards and arrangements within documented procedures and that sufficient in-house expertise is maintained to act as an informed and intelligent customer. Generally we are satisfied this is the case and that appropriate arrangements are in place.

However, to support these claims, we considered further evidence should be provided that this was the case for expertise to support the ESC now and in the longer term. We therefore asked for this further information in a series of IRFs (ESC-RI-SCM-001 and ESC-RI-SCM-001b), which also addressed wider issues such as maintenance of knowledge (see Section 2.7.7). We sought evidence of the LLW Repository Ltd's ability to ensure continual availability of adequate up-to-date expertise and knowledge to maintain, interpret and periodically update the ESC.

In response, LLW Repository Ltd provided further details of its arrangements for maintaining adequate expertise and knowledge in relation to the ESC. For example, the company indicated that it had already increased the size of the ESC Project Team and that it planned further increases. It was also merging key teams such as the ESC and monitoring teams. We were satisfied that the further information provided sufficient evidence that the company could act as a capable operator in its own right. Nonetheless, we recognise that LLW Repository Ltd is a relatively small organisation that cannot reasonably maintain a large pool of ESC skills. Additionally, we recognise other challenges the company may face, such as difficulties in recruiting into specialist posts and maintaining capabilities in the periods between major ESC campaigns and reviews. Therefore, within ESC-RI-SCM-001b we make a number of recommendations regarding



continued access to necessary contractor skills, maintenance of sufficient skills to manage, implement, develop and maintain the ESC and to be cautious in any reliance on other technical expert support or advice from the parent body organisation (PBO) (**Recommendations SCM10, SCM11 and SCM12**; see Appendix 2 and Environment Agency 2015f).

We expect that, 'all work that supports the environmental safety case needs to apply sound science ... and to follow good engineering practice' (GRA paragraphs 6.2.26 and 6.2.27). Thus LLW Repository Ltd should be able to make informed judgements about the quality of science carried out both in house and by its contractors and to maintain awareness of relevant national and international scientific developments. The recommendations above are intended to make sure that LLW Repository Ltd maintains the capability to make informed judgements about the quality of science being applied to the ESC. We welcome the fact that the company, as outlined in its response to ESC-RI-SCM-001 and ESC-RI-SCM-001b, undertakes activities such as presenting at national and international conferences, participating in international projects such as BIOPROTA and DISPONET and supporting IAEA initiatives on near-surface disposal to develop, maintain and keep up-to-date the knowledge of the ESC Project Team of national and international best practice.

'Under the management system, the developer/operator of the disposal facility will need to maintain relevant competences over the lifetime of the facility, including any period of authorisation after closure' (GRA paragraph 6.2.15). To address this requirement LLW Repository Ltd refers to its management of change procedures and a requirement on the Managing Director to make sure deputies are identified for key EHS&Q posts and roles and that longer term succession plans for roles are maintained. We accept that these measures, supported by the wider management system, are adequate for this purpose. We welcome the fact that LLW Repository Ltd identifies that ESC technical specialists are part of the succession plan for the ESC and will therefore be available to continue to develop and apply the ESC as a site management tool into the future.

### 2.7.5. Policy and decision making

The GRA requires that, 'The policies of the organisation and decisions at all levels that affect environmental safety should be rational, objective, transparent and prudent' and 'the reasons for the choice made need to be recorded' (GRA paragraph 6.2.16). Section 4.2.2 of the ESC Management and Dialogue report outlines how LLW Repository Ltd uses its EH&S Committee as the prime means to achieve this, advising the Managing Director as necessary, with the Managing Director holding 'overall responsibility for fulfilment of the requirements of the environmental permit'. The approaches to develop policies and make decisions at management level are reasonable and are supported by appropriate environmental and independent input. At a broader level LLW Repository Ltd describes within the ESC Management and Dialogue report how various teams and functions of the organisation interact to make and record decisions.

LLW Repository Ltd provides guidance on how policies should be formulated, scrutinised, endorsed and authorised by the Managing Director, Directors of the Board or committees within the Management System Manual (LLW Repository Ltd 2010a).

Specifically regarding key decisions made during the development of the ESC, LLW Repository Ltd states that, 'Decisions taken during development of the LLWR that affect environmental safety are recorded in the 'Engineering Design' and 'Optimisation and Development Plan' reports. These reports give the reasons for the choices made and include the other choices considered and reasons why they were rejected' (LLW Repository Ltd 2011e). We agree that this is the case and that these reports provide an adequate record of the decisions taken and those choices rejected. However, as noted elsewhere (Environment Agency 2015d), we believe the clarity of the documentation supporting the optimisation, engineering design and elicitation processes could be improved further to provide a more complete and transparent record.

### 2.7.6. Learning

LLW Repository Ltd states that, 'We ensure that lessons are learnt from internal and external sources, both in the UK and abroad, through the operating experience feedback (OEF) process, which involves capturing relevant information from events (and other operational experience) from across the site, from other parts of the organisation and from outside the company, nationally and internationally, and reviewing the information for learning points for communication and/or action to

prevent further events' (Section 4.4 of LLW Repository Ltd 2011b). Section 4.4 and 5.4 of the report goes on to explain how LLW Repository Ltd learns from events, other organisations, operational experience, peer review and data analysis, interacting with other organisations in doing so. The processes involved appear robust and effective to ensure continuous improvement in all aspects that affect environmental safety.

It is evident that LLW Repository Ltd has made efforts to learn from national and international experience and provide reference to national and international fora that are engaged on environmental safety case development. Links to national (for example Dounreay) and international radioactive waste repositories (for example, Centre de l'Aube) to share learning and experience have been made. LLW Repository Ltd indicates that it has benchmarked its engineering design against other international and national radioactive waste disposal facilities, standards and techniques (Section 2.4 of LLW Repository Ltd 2011d).

LLW Repository Ltd explains how reporting is encouraged across the organisation (LLW Repository Ltd 2011b and 2011d); how issues, events, learning and suggestions are captured, reviewed, communicated and actions raised and implemented as necessary. The company also explains how an annual management review is used to review learning in the round and, where necessary, to include further improvements within an improvement plan approved by the EH&S Committee and the LLW Repository Ltd Board; the actions resulting from this being monitored through the EH&S Committee and Board. LLW Repository Ltd uses quarterly scrutiny meetings to review and analyse data and trends including OEF, with the aim of driving continuous improvement. We are satisfied that these processes are robust in meeting the expectations of the GRA. This conclusion was further supported by a management arrangements audit carried out in November 2013 (Environment Agency 2013) which addressed learning from experience and identified some aspects of good practice in this area.

Specifically regarding the ESC, LLW Repository Ltd explains how it has used peer review processes to provide independent challenge and advice. We support this as good practice.

LLW Repository Ltd provides examples of how learning from events has been captured, reviewed and actions taken to prevent re-occurrence and to make improvements to management systems in Section 5.4 of the Management and Dialogue report (LLW Repository Ltd 2011b). We accept this as evidence of effective OEF. Through our review we identified that learning may be possible from the tsunami that occurred in Japan in March 2011 and required LLW Repository Ltd to respond to an IRF seeking information on the possibility and likely scale of any tsunami impacting the repository over the site's lifetime (ESC-TQ-SCM-002). A satisfactory response was provided, indicating an extremely low possibility of a significant tsunami event at the LLWR. This response referred to the company's input to the European Union (EU) Fukushima stress tests (LLW Repository Ltd 2011v).

One key area of learning not specifically addressed within the 2011 ESC is that which could potentially be gained from review of the whole 2011 ESC development process to help inform subsequent updates at major reviews. We expect that LLW Repository Ltd's approaches will drive such a review and learning to be carried out. However, due to the importance of learning from such a large, long timescale and complex project we have raised an FI to make sure a thorough review of learning is carried out and reported to us before any subsequent major review of the ESC (ESC-FI-021).

We believe this review (ESC-FI-021) should also address learning and information available from the 2002 ESCs. We note that within the 2011 ESC LLW Repository Ltd chose not to use certain information generated in support of the 2002 cases that may have remained relevant, or partially relevant, for example certain engineering performance data. We believe there is potential value in reviewing what information was generated for the 2002 cases to see if it would further support and underpin the 2011 ESC and future iterations of the ESC.

#### **2.7.7. Succession planning and knowledge management**

LLW Repository Ltd must identify all the key areas in which it requires competency and to develop a strategy for succession planning and knowledge management in all these areas. The capabilities and competencies of the organisation must never be dependent on the understanding and skills of

too limited a number of people in any such area' (GRA paragraph 6.2.20). Section 4.3 of the 2011 ESC Management and Dialogue Report outlines how LLW Repository Ltd has addressed these expectations through the management system.

LLW Repository Ltd states, 'Relevant competencies are to be maintained over the lifetime of the facility, including any period of authorisation after closure through the management of change procedures. It is the Managing Director's responsibility to make sure that a deputy is identified for all key EHS&Q posts and roles and longer term succession plans for roles are maintained; these are reviewed during the annual management review meetings. It is the responsibility of the management team, supported by the Human Resources and Training Manager, to make sure that there is adequate training of personnel with an intelligent customer capability and that there are arrangements for succession planning'. In addition LLW Repository Ltd explains that an organisational baseline is maintained and updated monthly and that, specific to the ESC Project Team, technical specialists are part of the succession plan for the ESC intelligent customer role.

We accept that the above approach is reasonable. However, due to the importance of the ESC to the management of the site, its scale and complexity, we asked for further information on this topic specific to the ESC Project Team and its long-term maintenance and access to skills and knowledge (see IRFs ESC-RI-SCM-001 and ESC-RI-SCM-001b). We were satisfied that within the responses to these IRFs, LLW Repository Ltd demonstrated it had sufficient succession planning and knowledge management in place for the ESC Project Team, although we have raised a number of further recommendations in this important area (**Recommendations SCM10, SCM11 and SCM12**).

### 2.7.8. Management system functions

The GRA states that management system functions, 'should be based on principles derived from national and international standards' (GRA paragraph 6.2.21). In accordance with this expectation LLW Repository Ltd states that, 'Our management arrangements are certified to BS EN ISO 9001:2008, BS EN ISO 14001:2004, and OHSAS<sup>3</sup> 18001:2007. Our systems and processes are subject to periodic surveillance visits by Lloyds Register' (LLW Repository Ltd 2011e). We consider that these systems are appropriate to meet the requirements of the GRA.

### 2.7.9. Work supporting the environmental safety case

The GRA states that, 'The management system needs to be effective in all work that supports the environmental safety case' (GRA paragraph 6.2.22). Our views on a number of aspects of the management system are discussed elsewhere in this report. The management system as a whole is addressed by LLW Repository Ltd within Section 4.2 of the Management and Dialogue Report and LLW Repository Ltd states that 'all work supporting the ESC is addressed by our Management Systems Manual and supporting documents that are applied to all our work activities' (LLW Repository Ltd 2011e). We agree that it is appropriate for work supporting the ESC to be managed against general site procedures. It is reported that the recording of such work is achieved through the 2011 ESC documentation and Level 3 supporting reports.

The management system LLW Repository Ltd presents is structured so that policies, processes, procedures and records are included within an integrated management system which covers all key business control and assurance activities. This consists of the Repository Site Manual (LLW Repository Ltd 2010a), Safety Management Prospectus and cascades down to policies, a process model and repository site procedures which provide a description of a specific way to carry out a series of activities in a given process, including compliance with the environmental permit. LLW Repository Ltd's management arrangements are certified (Section 2.7.8), and are subject to a detailed annual review (LLW Repository Ltd 2011b). The ESC is managed under this same integrated management system, using a standalone team with interfaces to the rest of the organisation. ESC project specific documents include a Project Execution Plan (LLW Repository Ltd 2011j) and Data Management Forms (see Section 2.7.15). These management systems

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<sup>3</sup> Occupational Health and Safety Management Systems.

appear effective and proportionate in addressing the activities of the site from operations through to the period following closure.

The GRA goes on to state that the management system should demonstrate compliance with operational limits and conditions within the authorisation (now the environmental permit), that levels of radioactivity in the environment and discharges should be monitored and assessed and that prospective and retrospective dose assessments should be completed (GRA paragraph 6.2.23). These expectations are addressed by LLW Repository Ltd within Section 5.1 of the Management and Dialogue report and Section 5 of the report on Environmental Safety during the Period of Authorisation (LLW Repository Ltd 2011f).

Compliance with operational limits and conditions within the environmental permit are comprehensively addressed within the RSP 02.01 suite of documents on arrangements for compliance with the environmental permit (LLW Repository Ltd 2011k, 2011l, 2011m and 2011n), the Environmental Clearance Certificate (LLW Repository Ltd 2010c) and, for disposals, the WAC (LLW Repository Ltd 2013f). Between them, these documents detail responsibilities, accountabilities, arrangements, records, requirements for disposal in line with the environmental permit and ESC and also specify relevant Operating Rules, Operating Instructions and Environmental Equipment necessary to ensure compliance. We are satisfied that these arrangements are adequate, although we note that these documents will need to be regularly reviewed and updated to make sure they remain consistent with the ESC and any varied environmental permit that may be issued. Associated with any changes, training of relevant staff will be necessary.

LLW Repository Ltd's Environmental and Technical Manager is responsible for monitoring and assessing radioactive discharges from the LLWR and levels of radioactivity in the environment. RSP 02.01.02 (LLW Repository Ltd 2011m) details monitoring done, which is also summarised in the ESC Monitoring report (LLW Repository Ltd 2011o). We are satisfied that the management system makes sure adequate monitoring and assessment of the environment and discharges are undertaken. However, monitoring needs will evolve as site understanding and assessment develops and we therefore welcome requirements within the management system to review monitoring needs and data regularly (LLW Repository Ltd 2011m). Changes to the monitoring programme should be consistent with the site's long-term monitoring strategy (Environment Agency 2015c).

We note that RSP 02.01.02 requires retrospective dose assessments to be completed as required by the environmental permit. Prospective dose assessments are reported within LLW Repository Ltd (2011f) and are discussed further within our review report on Assessments (Environment Agency 2015e).

### **2.7.10. Planning and control of work**

'All work that supports the environmental safety case needs to be properly planned and controlled' (GRA paragraph 6.2.24). In Section 5.2 of the Management and Dialogue report LLW Repository Ltd explains how it has achieved this using a dedicated ESC Project Team and ESC Project Manager who are part of the LLWR management team. The initial project scope was defined through a review carried out in 2008 which defined a revised work schedule, in four phases, leading up to submission of the 2011 ESC. This schedule was then controlled using a Project Execution Plan (LLW Repository Ltd 2011j). LLW Repository Ltd held periodic status reviews and made changes to the programme as required, outputs being recorded in ESC reports, Level 3 documentation and a forward work programme (LLW Repository Ltd 2011a). We are satisfied that work has been appropriately planned and controlled since 2008. We have been able to keep abreast of this process through our monthly ESC liaison meetings held with LLW Repository Ltd.

In Section 5.3 of the Management and Dialogue report LLW Repository Ltd describes its change control processes used to ensure quality and appropriate decision making. RSP 1.27, 'Modification to or experiment on existing plant' (LLW Repository Ltd 2008a), explains the plant modification proposal process whereby any temporary or permanent change to existing buildings, plant or processes, including changes to a safety case, are assessed, categorised, authorised and reviewed as required by the LLWR MEHSC (Management Environment Health and Safety Committee), which includes a representative of the environmental team. A modification category is



defined for each change, based on 'routine operating conditions and the most significant potential environmental consequences which may arise from realistic (foreseeable and credible) fault or accident scenarios, but not worst-case scenarios'. The assessment considers the potential consequences arising from the modification being inadequately implemented or misconceived and addressed by asking 'what might go wrong?' and 'what might the consequences be?'. Modifications consider all stages of the operations from preparation through to decommissioning. The ESC Manager signs off all relevant modifications to make sure that ESC assumptions and requirements for environmental performance have been adequately considered. The Environmental Team representative at the MEHSC will further check that all relevant modifications have been considered by the ESC Manager. We consider this change control process to be robust and tried and tested through use at the LLWR and other nuclear sites.

The ESC itself also needs to be subject to change control and within Section 5.3.2 of the Management and Dialogue report LLW Repository Ltd states, 'Once the ESC is integrated into our Management System, it will be subject to change control.' We raised an IRF (ESC-RO-SCM-001) requiring LLW Repository Ltd to provide a programme detailing how a robust change control process would be developed and then to provide a robust change control process for the ongoing management of the ESC and its relationship to site operations. In response LLW Repository Ltd provided an implementation plan (LLW Repository Ltd 2012a) and subsequently a new procedure for the management of the ESC, including change control (LLW Repository Ltd 2013a).

These documents addressed our expectations regarding documenting a change control procedure, for example, issues that must be considered and addressed in updating the ESC, what new information may need to be assessed, the need for development of assumptions, analyses and assessments and ongoing peer review. Regarding effecting changes, the procedure addresses the assessment of significance, notification of the Environment Agency, changing the ESC and recording changes along with the update of associated documentation such as WAC and the Environmental Clearance Certificate. Update of tools (for example an issues register) and records are also addressed. Change control is further discussed in Section 2.17.

'Planning considerations need to include protection against and mitigation of the effects of, human error and unplanned events' (GRA paragraph 6.2.25). LLW Repository Ltd indicates that it operates a continued operational safety report (COSR) that addresses unplanned events through the use of hazard and operability studies (HAZOPs). These address safety and environmental assessment and address issues such as flooding and the minimisation of radiological releases. This and other processes, such as event reporting and review, provide evidence that planning considerations do address the risk of unplanned events and errors occurring. LLW Repository Ltd also provides evidence that it has adequate processes in place to address discovery of any errors or events.

### **2.7.11. Applying sound science and good engineering practice**

All work that supports the ESC needs to 'apply sound science' and 'follow good engineering practice for reasons of both quality management and optimisation' (GRA paragraphs 6.2.26 and 6.2.27). LLW Repository Ltd claims to have met these criteria through use of suitably qualified and experienced staff, instigating a thorough process of technical review of reports and use of national and international peer review (LLW Repository Ltd 2011e).

We agree that the 2011 ESC contains many examples of the application of sound science and we welcome the fact that staff maintain awareness of scientific developments that may have a bearing on the ESC, for example through attendance of relevant national and international fora. We also welcome the post-2011 strengthening of the ESC Project Team to make sure that suitably qualified and experienced staff are available (see Section 2.7.4). We accept that the ESC is on the whole based on 'sound science', to the degree that scientific judgement has underpinned the engineering design and assessment modelling. However, we note that science, technology and the understanding of repository systems (and their safety assessment) is advancing. We expect LLW Repository Ltd to maintain up-to-date knowledge of this science such that it can be applied in the context of the LLWR. We also expect the company to further develop the detail of its engineering designs before implementation (Environment Agency 2015d). For this reason we consider a robust and comprehensive forward programme of work to be vital to the continued application of sound

science and engineering good practice. We therefore welcome LLW Repository Ltd's identification of forward programmes of work (LLW Repository Ltd 2011a and 2011p) and will supplement this with recommendations and the identification of FIs where we believe there is scope for further developing the robustness of the ESC and supporting information.

LLW Repository Ltd states that it is 'committed to ensuring the application of good engineering practice' through use of processes and procedures that are considered good practice at other sites (LLW Repository Ltd 2011b). We agree that, in general, good practice is used in the design, construction and validation of engineered structures on the site. However, we queried the extent to which the performance of individual components of the engineered barrier system has been assessed, in particular relating to novel features such as the vault basal lining system (Environment Agency 2015d). We also note that, post-submission of the 2011 ESC, the performance of the interim trench cap has been shown to be significantly poorer than assumed in the ESC, although this has now been taken account of within the 2011 ESC (LLW Repository Ltd 2013b). LLW Repository Ltd will need to complete and substantiate further detailed designs as they progress towards construction. These more detailed designs will require demonstration that they are optimised. We require LLW Repository Ltd to demonstrate to us that the required engineering performance of engineering features will be achieved before construction (see ESC-FI-001, 023, 024, 025, 026 and 027) and will review more detailed aspects of the design as they are finalised, at defined review points. At the level of detail presented within the 2011 ESC we accept the proposals do represent good engineering practice.

### **2.7.12. Passive safety**

After the end of the period of authorisation the ESC 'will need to rely entirely on features of the disposal system that do not depend on human intervention or on any engineered system requiring the operation of electrical circuits or mechanical moving parts' (GRA paragraph 6.2.29). The 2011 ESC is in accordance with this requirement in that safety after the end of the period of authorisation does not rely on human actions. Degradation of the engineered barriers over time is included in the assessment models; using elicited performance data (see Section 2.9).

During the period of authorisation we consider that it is 'good engineering practice for the developer/operator of the disposal facility to aim for passive safety as far as reasonably practicable, but some active engineered systems and/or human actions will be necessary for much or all of this period' (GRA paragraph 6.2.30). We believe the ESC is in accordance with this paragraph as some of the main controls during the period of authorisation are passive, noting that active control is needed in areas such as leachate management.

### **2.7.13. Providing information**

Paragraphs 6.2.34 to 6.2.36 of the GRA refer to the expectation that operators provide the Environment Agency with any information necessary to assess the environmental safety case in an agreed format and in a timely manner. Section 2.2 of this report discusses LLW Repository Ltd's engagement with us during development of the ESC. We are broadly satisfied that this engagement process with us on the content and form of required information submissions, was sufficient. This ultimately led to submission of the 2011 ESC in a form agreed with us, supported by more detailed information within Level 2 and Level 3 documents.

### **2.7.14. Documentation and record keeping**

The developer/operator will need to set up and maintain a comprehensive system for recording information on all aspects of the project affecting the environmental safety case' (GRA paragraph 6.2.37). This requirement covers a wide range of information types including data, information, knowledge and understanding. We recommend that LLW Repository Ltd applies strict definitions of relevant terms as different types of records will require management in different ways (**Recommendation SCM13**).

Duplicates of these records must be kept in diverse locations and in a durable form. Section 9 of the Management and Dialogue report addresses these expectations and demonstrates that satisfactory records management procedures are in place, referring to how records are kept in diverse forms and are controlled by relevant procedures (LLW Repository Ltd 2011q) and using appropriate systems. Specific records management processes for the ESC are discussed.

However, at the point of submission of the 2011 ESC we noted that long-term records management of LLWR data, including the ESC, were particularly important to the LLWR, as a community may wish to retain knowledge and memory of past disposals indefinitely. We noted that much of the data supporting the ESC had been generated by contractors and was not, at that point in time, all actively controlled by LLW Repository Ltd. We therefore required LLW Repository Ltd to prepare a plan of how it intended to apply records management procedures to all ESC records so as to comply with LLWR procedures and environmental permit requirements. We required this plan to address the scope of records considered, details of how the records will be actively managed and the timescales over which this will be achieved (see IRF ESC-RO-SCM-004). In response the company provided a memo outlining its proposals to collect together and manage contractor records and references, to align with NDA work to manage nuclear records in the long-term and develop a long-term records storage solution for nuclear records (Huntington 2012). This response provided adequate re-assurance that all LLWR records, including those generated as part of the ESC were being actively managed in an appropriate manner. The adequacy of LLW Repository Ltd's records management processes for the ESC were confirmed during a targeted audit carried out in 2011 (Environment Agency 2011).

However, noting the importance of these records to a disposal facility, we believe this is an area of work that warrants particularly close and ongoing attention to make sure all necessary records are captured and that no important records are lost. Records management systems should ensure records remain accessible and current and that careful consideration is given to their management to make sure they remain safe (for example duplicates, durable) and usable.

Although LLW Repository Ltd has demonstrated a robust, if developing, records management system for the present and short to medium-term, we expect a long-term strategy for the management of all necessary records to be developed and maintained, so as to demonstrate compliance with the environmental permit. In this regard the company points to the NDA developing an information management compliance programme (Huntington 2012), with a view to developing a long-term records storage solution for nuclear records to manage its obligations with respect to public records. The company indicates its involvement in this programme and also states its intent to make sure its procedures are consistent with the NDA requirements for records management. LLW Repository Ltd states, 'LLWR will continue to manage its records whilst the environmental permit is in place, but, on withdrawal of the permit, all these records will be transferred to the NDA for management'.

We support the fact that LLW Repository Ltd is engaged with this NDA project and has committed to make sure that records management procedures are consistent with the outcome. However, we note that the company remain at this time responsible for ensuring appropriate long-term records management, including those for the period post-closure. We therefore expect the company to continue to engage with the NDA's Information Management Compliance Programme, but at the same time to make sure an LLWR specific long-term records management strategy is developed to meet the needs of the LLWR, considering issues such as the need for long-term retention of data local to the LLWR site, how long-term records will be linked to the site and its end-use in the longer-term (post-closure) and how the strategy is made compatible with any wider NDA long-term records storage solution (**Recommendation SCM14**). Regarding LLW Repository Ltd's involvement in the NDA's information management compliance programme we consider it important that the differences in nature and use of records generated from a disposal facility are recognised when compared to other NDA decommissioning sites. We note that after the end of the period of authorisation of the site we expect the repository records to be included in a 'public archive' (Environment Agency et al. 2009) and thought will be required as to how any NDA centralised repository of nuclear site information can meet the possible needs for local information to support the site's end-state.

Irrespective of NDAs development of an information management compliance programme, we consider that it remains LLW Repository Ltd's responsibility to understand, own and manage LLWR records; NDA's work may support this. We therefore expect LLW Repository Ltd to maintain

a watching brief on improved methods of records management from national and international experience<sup>4</sup> and to keep considering how it can best use these means (**Recommendation SCM15**). Additionally, the company should review records management associated with all ESC records, following completion of the ESC and its initial implementation (**Recommendation SCM16**).

Contractor generated records in support of the 2011 ESC, records generated 'in-house' and records generated by previous operators of the site (in relation to the 2002 ESCs and earlier) must all be owned and actively managed by LLW Repository Ltd in compliance with requirements in its environmental permit. For records related to the 2011 ESC generated by contractors, the company details activities that it is undertaking to bring relevant data 'in-house', as well as tasks to make sure all relevant supporting data and references are captured within the ESC records (Huntington 2012). The company must also make sure it has ongoing access to records related to the 2002 ESCs, some of which we understand are still managed by Sellafield Ltd on LLW Repository Ltd's behalf. We believe all data and records generated in support of the ESC should ideally be owned and held by LLW Repository Ltd, such that it can be effectively managed and access is guaranteed. To this end we require that LLW Repository Ltd, following completion of the 2011 ESC and on an ongoing basis, makes sure that all records supporting the ESC are captured within a comprehensive records management system and that, wherever practicable, records are brought 'in-house' such that they can be actively managed in support of the site during operations and post-closure. Where records cannot practically be brought 'in-house', robust mechanisms should be put in place to ensure continued access to those records and to make sure they are maintained in an equivalent manner to other records retained under the sites environmental permit (see FI ESC-FI-022).

### 2.7.15. Quality management

The GRA (paragraphs 6.2.38 and 6.2.39) indicates that a quality management system should be used by the operator, regularly audited and that the system should allow all information to be traced back to source. LLW Repository Ltd addresses these requirements directly in Section 7 of the Management and Dialogue report, but also elsewhere within the 2011 ESC where data and information management are discussed.

LLW Repository Ltd uses a quality management system that is part of its integrated management system and which is documented in a number of procedures (LLW Repository Ltd 2009a and 2009b). An internal audit and inspection programme is described which identifies necessary actions, which are subsequently trended and reviewed. Additionally an independent site inspector conducts a rolling five-year inspection programme. The site operates under an accredited quality management system in line with BS EN ISO 9001: 2008 and systems are audited by Lloyds Register against the requirements of BS EN ISO 9001: 2008, BS EN ISO 14001:2004 and OHSAS 18001:2007. Where specialist contractors have been used to support the ESC, LLW Repository Ltd's contractor selection process considered quality assurance and certification to BS EN ISO 9001:2008 (LLW Repository Ltd 2011b). LLW Repository Ltd controlled contracts using relevant site procedures (LLW Repository Ltd 2006 and 2009c) and the ESC Project Team conducted audits of contractors focusing on procedures and approaches applied to check and verify calculations. To ensure traceability of data, LLW Repository Ltd refers to data management forms (discussed further below) and the recording of data within Level 2 and 3 documents within the 2011 ESC.

The systems described above generally represent an appropriate, robust and comprehensive quality management system. However, due to the significance of the ESC to the management of the site, we queried an apparent lack of specific arrangements to audit the ESC project and its outputs in an IRF (ESC-RO-SCM-003). In response LLW Repository Ltd described a review completed on its assurance arrangements and a number of enhancements implemented as a result across the site and in relation to the 2011 ESC specifically. Specific enhancements included

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<sup>4</sup> For example NEA RK&M Project on the preservation of records, knowledge and memory across generations, <http://www.oecd-nea.org/rwm/rkm/>



introduction of independent inspection of projects (including the ESC) on a rolling basis, new requirements on process owners to regularly audit procedures and two-yearly assurance reviews of key legislation. We are satisfied that LLW Repository Ltd has carried out a sufficient review of its internal audit arrangements and identified improvements that will make sure the 2011 ESC and the work to develop it is adequately considered. We will expect LLW Repository Ltd to continue to keep the adequacy of the internal audit programme under review.

During our wider review of the 2011 ESC a further concern was identified. As discussed in our report (Environment Agency 2015e), the extent to which quality assurance procedures have been applied to the modelling work therein was less apparent. This was queried in IRF ESC-RO-ASO-007. We also requested further information on how the various models interact and how model output is transferred between different models. In response, LLW Repository Ltd provided a memo outlining the key assessment models and codes used in the ESC and summarising model assurance measures, collated from other parts of the ESC (Shevelan 2013a). We consider that the response improves the clarity of the 2011 ESC. LLW Repository Ltd should consider incorporating such information in future versions of the ESC (**Recommendation SCM17**). We note that good practice would be to include provision of an assessment model flow chart, or similar, to illustrate the linkages and flow of information between the various models.

LLW Repository Ltd has used data management forms for the specification and justification of data and associated uncertainties used in the assessment calculations. An ESC Project Team procedure specifies that all data used in the assessment calculations should be consistent with the entries in the data management forms (LLW Repository Ltd 2010b). We consider that use of such a system is consistent with current best practice and that the forms themselves represent an improvement above the overly detailed parameter input forms used in the 2002 PCSC. However, we note that data for only 17 parameters are included in the forms submitted with the 2011 ESC (LLW Repository Ltd 2011r). We expect that data management forms are used to record all data used in the assessment calculations to maintain a transparent audit trail, and recommend that this is done in future iterations of the safety assessment (**Recommendation SCM18**).

From 2008, a comprehensive database (Monitor Pro 5) was set up by LLW Repository Ltd to contain all environmental monitoring data and to aid a consistent approach to data access and processing, management, quality control issues and programme definition. The company is adding checked and validated past groundwater quality data retrospectively (LLW Repository Ltd 2011o). The company used quality assured data from this database in the 2011 ESC to inform the development of the geological and hydrogeological conceptual and mathematical models and to assess the extent of contamination in groundwater and surface water. We carried out an audit in 2011 which, amongst other areas, examined the generation, storage and transfer of geological and environmental information used to support the 2011 ESC. The audit did not find any significant issues and confirmed that the systems in place were robust and comprehensive (Clarke 2011).

In June 2013 we audited LLW Repository Ltd's contractors who prepared the hydrogeological flow model and the groundwater pathway assessment model. The aim of the audit was to gain confidence that the calculations were carried out under a suitable quality assurance regime and that relevant procedures were adhered to. We concluded that the contractor organisations have well established quality management systems that their staff were knowledgeable of and that these systems were actively used during the production of ESC materials (Fairhurst 2013). We observed a number of positive points, including significant effort being dedicated to undertaking checks on the quality of input and output data and the use of 'sense checking' to complement the assessment calculations. LLW Repository Ltd's internal programme of contractor audits highlighted the importance that it placed on assuring quality in the 2011 ESC.

We identified a number of areas for improvement in future assessments (Fairhurst 2013). We recommended that LLW Repository Ltd has in place a programme of audits to support its future work programme (both in research programmes and in the production of the next version of the ESC). This should include coverage of production of all ESC related work, whether produced in-house or externally. LLW Repository Ltd should formalise and incorporate into its own quality systems, its processes for undertaking audits to improve the transparency of action tracking. We also recommended that spreadsheets used in calculations are locked; to avoid inadvertent

modifications being made to entries. We wrote to LLW Repository Ltd to make these recommendations following completion of our audit.

Overall we are satisfied that the LLWR is operated using suitable quality management arrangements and that where enhancements and improvements can be made, these are being actively pursued by LLW Repository Ltd.

### 2.7.16. Peer review

The GRA recommends that peer review should be used to supplement other approaches to quality management and identify lapses or weaknesses in technical quality: 'Peer review is important both to quality management and to the application of sound science and good engineering practice' (GRA paragraph 6.2.40). Consistent with this guidance, LLW Repository Ltd instigated two programmes of peer review.

Firstly, LLW Repository Ltd set up an independent peer review group (PRG) in 2007, comprising multi-disciplined suitably qualified and experienced reviewers. The PRG was involved in the review of the ESC development programme and of the 2011 ESC and supporting reports. This provided LLW Repository Ltd with the opportunity to respond to early concerns in subsequent technical work. The scope of the PRG review included Level 1 and 2 documents plus key supporting Level 3 documents of the 2011 ESC submission.

Bennett et al. (2011) provide a summary of the peer review process and its findings, including recommendations to LLW Repository Ltd for further work. The company's response to these findings is provided by Baker (2012a). Although the 2011 ESC submission includes reactions of the PRG to responses given by LLW Repository Ltd relating to interim findings raised during the development of the ESC (see Bennett et al. 2010), we consider that it would have been useful to see the PRG reactions to the response provided by Baker (2012a). We recommend that this is considered in future phases of the peer review process, ensuring transparency of all findings and demonstrating that these are closed out to the satisfaction of LLW Repository Ltd and ideally also the PRG (**Recommendation SCM19**).

We also note that there appears to be no mechanism in place to verify that identified actions resulting from the peer review process have been taken forward and closed by LLW Repository Ltd. A peer review tracking system should be an addition to the process (**Recommendation SCM20**).

In addition, LLW Repository Ltd convened an international peer review group (IPRG) with the aim of providing insights and perspectives from experts operating other disposal facilities (including LLW disposal facilities in Sweden, Spain and France). This team assessed the Requirement 2 submission (LLW Repository Ltd 2008b, 2008c, 2008d, 2008e and 2008f) and the approach to the 2011 ESC (Baker et al. 2008). A number of recommendations to LLW Repository Ltd were made, relating to the scope and timescales for the ESC (McCall 2010). In response to the review, the company stated that it had 'found the review process valuable and have made sure that, where appropriate, the key issues raised by IPRG are addressed in the 2011 ESC' (Jefferies 2011a). While the responses provided by the company appear reasonable, we note that they only cover the broader points raised by the IPRG, which were gathered together as recommendations, and do not address specific and detailed comments. As with the final outputs of the PRG, the reactions of the IPRG to the responses provided by LLW Repository Ltd are not given. This would have been helpful. We also note that the IPRG only reviewed the proposed approach to safety case methodology and not the engineering design or operational practice.

We welcome the use of peer review in this manner and note that it addresses historical concerns that the 2002 PCSC peer review team was brought in at such a late stage in the production of the 2002 PCSC that, in many instances, little could be done to rectify inadequacies in the underlying work.

During the development of the ESC project, the PRG noted, 'the PRG made a number of technical challenges to the developing safety case which in all instances received careful consideration'. It considered that LLW Repository Ltd's responses to comments 'were of high quality, almost without exception making clear any action that would be taken to address the comment or stating clear reasons why no action was considered necessary'. Bennett et al. (2011) provides a number of

examples of issues that the PRG raised that were subsequently addressed by LLW Repository Ltd. These include support for the reference design and greater clarity in the use of radiological capacity calculations to derive WAC.

We noted a few instances where the PRG disagreed with LLW Repository Ltd's response to their comments. We consider it incumbent upon LLW Repository Ltd to make sure it is satisfied that it has taken adequate account of the PRG comments and has therefore submitted a suitable ESC.

We note the conclusions of the PRG that it 'confirms that it was able to conduct its business with the required level of independence and considers that a very satisfactory process of peer review has been followed which may be regarded as an exemplar for the review of other environmental safety cases' (Bennett et al. 2011). We thus consider that the use of the PRG to support the 2011 ESC has been consistent with international practice and supports the use of sound science and engineering in the ESC. The benchmarking of the developing 2011 ESC against international practice carried out by the IPRG was also a useful exercise. We welcome the commitment made by LLW Repository Ltd (2011p) to continue the use of the PRG to review the technical work of the ESC Project Team from now. The recommendations of the PRG, as outlined in Section 3.6 of Bennett et al (2011) should be taken into account in the ESC forward programme (see Section 2.10) (**Recommendation SCM21**).

## 2.8. Safety functions

The GRA states that, 'The environmental safety case should include an explanation of, and substantiation for, the environmental safety functions provided by each part of the system. It should also identify which radionuclides each function is relevant to and the expected time period over which the function is effective' (GRA paragraph 7.3.3).

LLW Repository Ltd used a bottom-up approach to the construction of the models and scenarios used in the 2011 ESC based on identification of features, events and processes (FEPs) that are of relevance to the performance of the disposal facility (Lean and Willans 2010). FEPs are commonly used in the development of radioactive waste disposal programmes internationally. Nevertheless, we consider it good practice to complement this approach by using a 'top-down' safety function approach to define the roles of the various engineered and natural barrier systems in containing and isolating radionuclides. As noted by the Nuclear Energy Agency (NEA), 'each way, if seen in isolation, has advantages and limitations ... and the limitations of each way could or should be compensated by the advantages of the other' (NEA 2012).

In our review of the 2011 ESC we found no clear single description of the safety concept for the facility as a whole, such as why it is expected to be robust and safe; However, we were satisfied that the sum of the 2011 ESC does make this case, although we found it unnecessarily difficult to trace arguments. Without this clear overall description, we found it difficult to assess the significance that each part of the disposal system makes to the ESC and to determine the implications in the situation that one or more function is impaired. The 2011 ESC Main Report (LLW Repository Ltd 2011a) presents some elements of the safety concept such as the safety strategy and a list of safety arguments but these are focused on management arrangements. A summary of control measures and functions is provided, however, this contains no hierarchy, dependency or prioritisation of the listed functions, nor supporting reference to the other 2011 ESC reports where a clear understanding of the safety function may be found. Specifically, we consider that the summary has the following deficiencies (see IRF ESC-RO-ASO-005):

- it does not fully describe or reflect the full range of control measures and functions presented in the main body of the ESC
- it does not reflect the changing functions of control measures over the whole life of the facility
- it does not provide the reader with a linkage to presented evidence in the ESC

We therefore queried why a formal safety function approach had not been adopted for the 2011 ESC (ESC-RO-ASO-005). In response, LLW Repository Ltd noted that, although a formal safety function approach had not been presented in the ESC, nor an analysis of the performance of each barrier in turn, the requirements of the GRA had been met in that they had:

- developed conceptual models and understanding that cover the performance and evolution of each barrier in detail
- characterised the evolution of the properties of the barriers as a function of time
- understood the role of each barrier in controlling the performance of the overall system (Baker 2013a)

We agree that these are important inputs to analysis of safety functions and addressing the requirements of the GRA. However, we consider that a formal safety function approach would have taken this analysis further in terms of specifically assigning safety functions to components of the disposal system, adding clarity to the arguments presented and provided evidence for 'alternative lines of reasoning'. The IPRG also recommended a safety function approach for assessing the future functions of the repository and to aid in deriving a comprehensive set of scenarios (McCall 2010).

A high-level description of the safety concept is presented in the Main Report: 'the function of the LLWR ... is to contain the emplaced wastes and associated hazardous materials' (LLW Repository Ltd 2011a). LLW Repository Ltd states that, given that waste cannot be contained indefinitely, this statement could be modified to say that 'the objective is to contain the wastes, but where this is not possible the objective is that the system should act in a way that ensures that impacts to people and the environment are acceptable' (Baker, 2013a). Further information is then provided on the barriers in place with reference to timescales of operation and their performance and linking to sources of further information.

We consider that this analysis presents an improvement over the summary of control measures and functions provided in the 2011 ESC but still fails to capture certain key aspects of the safety concept. In particular, the ESC does not provide clarity on LLW Repository Ltd's view on the function and requirements of the final engineered cap; The company views the cap as providing the primary control on performance through restriction of infiltration, isolation of the waste and restricting the release of gas, with other engineered barriers (such as the basal drainage layer and cut-off wall) acting as secondary measures on which environmental performance is not dependent (defence in depth should the cap fail). LLW Repository Ltd does not present minimum timescales over which it expects the barriers to fulfil their functional role, nor do we consider that all the potential failure mechanisms on specific parts of the system have been discussed in adequate detail. This is a discrepancy that is discussed further in our review of the site engineering (Environment Agency 2015d).

The GRA is not prescriptive in terms of specifying how an ESC should describe and substantiate the environmental safety functions provided by each part of the system. We consider that the information presented in the 2011 ESC is sufficient to meet the requirements of the GRA. However, as noted above, we believe that use of a safety function approach would provide greater clarity on the roles and performance requirements of the various components of the disposal system, their relative contributions to overall safety of the facility and evidence for 'alternative lines of reasoning'. We recommend that such an approach is considered in future updates to the ESC (**Recommendation SCM22**). This could include a timeframes or nested timeframes approach to illustrating barrier performance. Such approaches are commonly used in high level waste and spent fuel geological disposal facility safety cases overseas and are considered good practice by NEA. Noting the presence of long-lived radionuclides at the repository, we believe there is also merit in considering applying this approach to an LLW facility.

## 2.9. Uncertainty

Managing uncertainties is a necessary and important part of establishing the ESC. As stated in the GRA, 'the developer/operator will need to account for uncertainties explicitly, analyse their possible consequences and consider where they may be reduced or their effects lessened or compensated for' (GRA paragraph 7.3.8). 'The developer/operator will need to demonstrate that the environmental safety case, for both the period of authorisation and afterwards, takes adequate account of all uncertainties that have a significant effect on the environmental safety case. This will mean establishing and maintaining:

- a register of significant uncertainties

- a clear forward strategy for managing each significant uncertainty, based on considering, for example, whether the uncertainty can be avoided, mitigated or reduced, and how reliably it can be quantified' (GRA paragraph 7.3.10)

Within the body of the 2011 ESC there is no systematic assessment of uncertainties, nor identification of 'significant uncertainties' as specified in the GRA. Instead, LLW Repository Ltd discusses key and significant uncertainties in a number of the Level 2 and 3 reports but has not systematically identified and assessed these uncertainties or presented them in a single location. For example, the Level 2 report on the assessment of long-term radiological impacts contains a list of five 'key uncertainties' (LLW Repository Ltd 2011i). Although the uncertainties in this list appear to be important, we queried whether this list could be considered comprehensive in terms of the uncertainties inherent in the modelling projections of the ESC (see IRF ESC-RO-ASO-004). In response, LLW Repository Ltd stated that the list should not be taken to be a comprehensive list of key uncertainties and that it had been identified using the author's judgement rather than using a systematic formal process (Baker 2012b).

Baker (2012b) refers to a FEP and uncertainties tracking system in which a comprehensive list of key uncertainties is presented. We received a copy of this system, consistent with the position presented in the 2011 ESC, in early 2013 (LLW Repository Ltd 2013c). In the system, LLW Repository Ltd has identified and prioritised those uncertainties that potentially need further work on the basis of their impact on the ESC. The system shows how each identified FEP has been considered in the 2011 ESC and allows the tracking of the key FEPs associated with each pathway and model. The system also provides a means by which significant uncertainties can be identified and rated according to expert judgement on its importance to sub-system performance and to record how the uncertainty is treated in the ESC. We consider that this system provides an excellent starting point for a register of significant uncertainties and that LLW Repository Ltd is to be commended for this. However, our review of the ESC would have been facilitated if LLW Repository Ltd had included the system with the 2011 ESC submission.

The 2011 ESC FEP list is defined at a relatively high level (see Lean and Willans 2010). Perhaps as a result of this, we found that the identified FEPs do not adequately cover a number of significant repository performance issues. Some of these issues only became apparent during our review of the 2011 ESC and include:

- uncertainties in near field conditions and engineering performance derived from the observed ISO freight container degradation mechanisms with linkage to cap failure, waste saturation and waste containment
- small scale waste heterogeneity relating to the nature and distribution of particulate and discrete items
- uncertainties in the management of leachate and the resultant impact of waste saturation and discharges to the under liner drainage layer

We also note that the system is also entirely focused towards the radiological assessment, for example there are no FEPs specifically relating to the presence of non-radiological hazardous items or asbestos, which we consider an omission. LLW Repository Ltd should make sure that the FEP list (and thus the Uncertainty Tracking System) includes all FEPs that are of relevance to repository performance and at a sufficient level of detail (see FI ESC-FI-008).

In the FEP and Uncertainty Tracking System, uncertainties in FEPs can be classed in several ways:

- FEP and uncertainty judgement: topic area expert's judgment on the 'local' importance of the uncertainty (indicates how important it will be to represent the uncertainty)
- Uncertainty management – importance: LLWR judged importance of FEP and uncertainty
- Uncertainty management – satisfaction level: LLWR judged satisfaction level with current treatment of FEP and uncertainty

LLW Repository Ltd does not provide guidance on what its interpretation of a significant uncertainty is. Consistent with GRA paragraph 7.3.10 (quoted above), we would interpret a significant uncertainty as one that has, or could have, a significant effect on the ESC. A total of 62 FEPs are classified in this manner (our interest would be greater for uncertainties rated as having

a significant impact on sub-system performance than for those with lower ratings). We note that a significant uncertainty does not in itself present a problem with meeting the GRA so long as (1) mitigation or reduction of the uncertainty is sought and (2) the ESC adequately takes account of those uncertainties, for example by applying cautious values, looking at variant cases or using probabilistic calculations.

We reviewed the FEPs and uncertainty tracking system to audit whether we considered that its rating system had been applied consistently and determine whether its recommendations for further work (and hence the forward programme) focused on those areas of greatest concern. Other than identifying the need for further work, we found no linkage between these areas of need and the forward programme. We also noted that if LLW Repository Ltd is content with the treatment of a particular FEP in the 2011 ESC it does not propose further assessment of whether the uncertainty can be mitigated or reduced, even where the uncertainty is considered high and/or with the potential to affect the ESC.

As part of the implementation of the 2011 ESC, LLW Repository Ltd will be developing an extensive forward programme of work. We will expect LLW Repository Ltd to review significant uncertainties and make sure that the forward programme includes activities aimed at mitigating or reducing them, where possible. We will therefore ensure that LLW Repository Ltd develops the forward programme to provide better management of uncertainties across the ESC. We welcome a commitment by LLW Repository Ltd (2013a) to review the FEPs and uncertainty tracking system in annual and major reviews of the ESC. This gives us confidence that the ESC, during site operations, will be based on an applicable and up-to-date FEP and uncertainty list and that there will be an opportunity to revisit all documented uncertainties.

Within the FEP and uncertainty tracking system LLW Repository Ltd does not categorise uncertainties into scenario uncertainty; conceptual uncertainty and parameter uncertainty, a conventional typology in radiological safety assessment. However, we note that the company has considered uncertainties in each of these categories within the 2011 ESC. We note that the omission of conceptual uncertainty and uncertainties relating to alternative lines of reasoning in the FEP and uncertainty tracking system, could lead to bias.

The near-surface GRA notes for conceptual uncertainty: 'In some areas ... there may be a number of alternative credible interpretations of the data. Therefore, no one conceptual model of the system can be regarded as uniquely valid. This is a further uncertainty and considering only one preferred conceptual model could significantly underestimate the actual overall uncertainty. We shall expect the developer/operator to show that the environmental safety case is not unduly sensitive to alternative interpretations or conceptual models' (GRA paragraph 7.3.25). If LLW Repository Ltd considers that conceptual uncertainty is not important, then it should present an argument to this effect (**Recommendation SCM23**).

The GRA notes for alternative lines of reasoning: 'To an extent appropriate to the radiological hazard presented by the waste, the environmental safety case should make use of multiple lines of reasoning based on a variety of evidence, leading to complementary environmental safety arguments. The evidence may be both qualitative and quantitative, supported where appropriate by robust numerical analyses. The reasoning and assumptions should be clear and the evidence supporting them traceable' (GRA paragraph 7.2.7). We see no discussion of uncertainties associated with alternative lines of reasoning, for example a safety function approach (as discussed in Section 2.8) or use of natural analogues. We note that alternative lines of reasoning will have their own accompanying uncertainties and we recommend that the company considers whether the register of significant uncertainties includes a section devoted to each such line of reasoning (**Recommendation SCM24**).

We consider that extending the list of uncertainties beyond those directly used for quantitative dose and risk projections could help also with a safety functional approach (see Section 2.8). This broader uncertainty management approach could enable testing and scrutiny of underpinning information about the assumed reliability of the performance of key barriers and engineering systems.

We have asked LLW Repository Ltd to clarify how it intends to use the tracking system as a management tool for FEPs and uncertainties (see ESC-FI-008). We would like to see better



linkage or alignment with key environmental safety issues. This can be achieved in future versions of the ESC.

One specific area of uncertainty relates to the use of elicited data in the 2011 ESC, which LLW Repository Ltd used in the assessment of the long-term performance of the facility, in particular relating to the performance of the engineered barriers. We recognise that it may be necessary to use data elicitation techniques where no other suitable sources of data are available. LLW Repository Ltd's use of a formal elicitation process using a group of subject matter experts in a workshop format is a suitable way by which to elicit these data. However, our review found that the presented documentation of this process is insufficiently comprehensive, giving us concerns about the way in which the process was managed (Jackson et al. 2011). In particular:

- Not all the assumptions made in each data elicitation exercise are clearly laid out or presented.
- It is not clear whether the experts necessarily understood the uses to which the data elicited from them would be put, or the level of importance of the data elicited to the overall ESC. It is virtually impossible for data elicited from experts to be unbiased and so experts need to be as well-informed as possible when exercising such judgments, so that their biases are consistent with the uses to which the data will be put.
- No details are provided on the nature and extent of information available to experts during the elicitation process.
- Limited site-specific material performance data is presented.
- Synergies between individual engineering components are not considered. Synergistic processes may improve the system performance as a whole.
- We consider there is a failure to adequately consider the effect of all reasonable gross failure mechanisms in the engineering.

LLW Repository Ltd has informed us that records of the elicitation meetings were made and kept. However, without access to underpinning information, we are concerned that if LLW Repository Ltd repeated one of the data elicitation exercises using a different panel of experts and relying only on the information recorded about the original run, the repeat exercise might return different results. Therefore, we have raised an FI (ESC-FI-029) which requires the production of documented processes for the future management of elicited data. We will expect the response to this FI to address, amongst other issues, details of how supporting information, assumptions and other relevant considerations are documented, to support decisions made.

We note that the PRG has also commented on the fact that expert views during the elicitation process are not always referenced back to traceable sources (Bennett et al. 2011). We agree with the PRG comment that, 'it may be useful to consider possible alternative approaches for at least some of the properties in future elicitations and to review any expected correlations between elicited properties for example where poor performance of one property leads to lower performance of another (for example high infiltration leading to early clogging of drains)'.

We also note that the elicitation process only deals with parameter uncertainties. We consider that parallel exercises would be useful to deal with modelling uncertainties, conceptual uncertainties and scenario uncertainties (**Recommendation SCM25**).

Because of the important role data elicitation plays in providing information to support the 2011 ESC, we consider it essential that any elicited data is fully owned by LLW Repository Ltd to enable timely review and update. The 2011 ESC does not detail how these data will be managed, updated and reviewed. We therefore recommend that LLW Repository Ltd develops a formal management system and review mechanism for information gained through elicitation processes. We have asked the company to address this within ESC-FI-029.

We note that, in common with other ESCs and to account for uncertainties, LLW Repository Ltd has designed supporting assessments to be as cautious as they need to be in their framing assumptions and choice of data. In reducing pessimisms (for example as done in updated calculations for the C-14 gas pathway), LLW Repository Ltd needs to make sure that the revised assumptions or data are 'realistic' in as far as this can be established, or demonstrably not optimistic, to help make sure that 'reducing pessimisms' is not biased over 'reducing optimisms'.

We note that pessimisms or optimisms may be implicit in the framing assumptions and not captured as uncertainties in the current LLWR approach. Good understanding and communication of significant uncertainties in the performance of the LLWR is integral to maintaining confidence in the ESC.

In summary, whilst we have identified a number of improvements that should be made to the assessment of uncertainties and demonstration that the 2011 ESC takes adequate account of all uncertainties that have a significant effect on the ESC, we believe that the relevant GRA requirements have been adequately met at this point in time. Uncertainty in specific aspects of the 2011 ESC (for example, in inventory, engineering performance, site understanding and assessment) is discussed in the other review group reports (Environment Agency 2015b, 2015c, 2015d and 2015e).

## 2.10. Forward programme

'The environmental safety case should be used to help specify a forward programme of improvement work, both to the environmental safety case itself and more broadly' (GRA paragraph 7.2.17). LLW Repository Ltd presents an overview of the future programme of work that is planned to maintain and update the ESC and reduce uncertainties in the 2011 ESC Main Report (LLW Repository Ltd 2011a). This discussion is at a high level and includes possible areas for future work with limited detail. We advised LLW Repository Ltd that we would expect to see further detail captured in a forward programme, which should demonstrate how it will provide both known and anticipated requirements for forward work and also maintain awareness of scientific developments with a bearing on the ESC (see IRF ESC-RO-SCM-005). In response LLW Repository Ltd submitted a document containing greater detail on the forward programme (LLW Repository Ltd 2011p).

LLW Repository Ltd plans to update and manage the 2011 ESC. As would be expected, the forward programme contains more detailed descriptions of activities being taken over shorter timescales (up to 5 years post-submission). We acknowledge that it would not be a worthwhile exercise to specify in detail the nature of the future work programme over the longer-term. Instead, we expect regular updates of the forward programme to take account of new information or opportunities.

We held discussions with LLW Repository Ltd regarding the scale and scope of the forward programme to support both implementation of the ESC and to address FIs and improvements that our ESC review identified. LLW Repository Ltd recognises this need, which is captured within its Lifetime Plans (see IRF ESC-RO-SCM-005).

LLW Repository Ltd stated that many of the suggestions for further work made by the PRG are in its forward programme. These include updating the period of authorisation assessment to remove some overly cautious assumptions and updating the coastal erosion assessment (LLW Repository Ltd 2011p). However, the forward programme is still at a relatively high level and we find it difficult to correlate commitments made elsewhere in the 2011 ESC with specific items in the forward programme. These include a commitment to review the correlations between elicited parameters to identify, for example, where poor performance of one parameter relating to a component of the engineered barrier system leads to lower performance of another and work on gaining improved understanding of the uncertainties associated with water flow and radionuclide release under partially-saturated conditions (Baker 2012a). Similarly, the FEP and uncertainty tracking system contains a number of entries detailing areas for further work under 'uncertainty management' but with no specific link to the forward programme. LLW Repository Ltd should make sure that all such commitments are systematically captured so that they are included in the forward programme.

We require LLW Repository Ltd to provide a more detailed forward programme following issue of any new environmental permit (see FI ESC-FI-004).

We raised a specific concern that the submitted 2011 ESC did not provide evidence on how the forward monitoring programme will be linked to the ESC to reduce key uncertainties (see IRF ESC-RO-SUE-007). LLW Repository Ltd's response presented examples of the key uses of monitoring data in the ESC and the potential approaches to addressing some of the key uncertainties in the ESC (Baker and Cummings 2012). We consider that the presented examples are broadly



reasonable, but do not cover all the uncertainties identified by the company as having a significant effect on the ESC and do not directly map onto FEPs (uncertainties may be covered by one or more FEP) (Environment Agency 2015c). We have raised an FI (ESC-FI-005) to request more information about how LLW Repository Ltd intends to use ongoing monitoring to reduce relevant key uncertainties in the ESC, recognising that this will not be possible in all areas.

The 2011 ESC incorporates a conceptual engineering design which meets the expectations set out in the GRA. However, the 2011 ESC does not lay out in detail how the high level design presented will be developed further and to the necessary detail for implementation (Environment Agency 2015d). To provide this information we required LLW Repository Ltd to prepare a detailed engineering forward programme that is addressed at reducing uncertainty associated with the engineering system, in particular any novel design aspects and developing the detailed design necessary for construction (see IRF ESC-RO-SUE-009). We requested that the forward engineering plan should, at a high-level, seek to deliver:

- clarity around the timescales for the development of more detailed engineering designs and underpinning work, along with regulatory interactions
- improvements to information provision on specific aspects of the design to remove regulatory uncertainty
- demonstration of long-term engineering performance using site and desk based investigations and studies
- commitment to appropriate optimisation and improvement of the existing engineering design before the detailed design stage and further construction

We received the forward engineering plan in May 2013 (Shaw 2013). It represents a substantial programme of work. In order to make sure that regulatory expectations associated with the forward engineering plan meet regulatory expectations, we have agreed with LLW Repository Ltd a series of stages where we will review the evolving detail of the engineering design (Environment Agency 2015d). We will continue to liaise with LLW Repository Ltd to make sure that the forward engineering plan meets our expectations (See ESC-FI-001, 023, 024, 025, 026 and 027).

In summary, we consider LLW Repository Ltd has adequately met the expectations detailed within the GRA for a forward programme of work, noting that we believe there is scope to refine the level of detail provided and correlation with commitments within the ESC and other documentation. The forward programme should take account of our 2011 ESC review findings including recommendations and FIs, along with any environmental permit requirements. A comprehensive forward programme of work must be maintained, which describes the nature and extent of work needed to continuously improve the ESC and facilitate construction.

## 2.11. Linkage to the 2002 environmental safety cases

We consider that the 2011 ESC provides a significant improvement over the 2002 PCSC and OESC. Although we considered that the 2002 cases provided, 'a broad indication of the impact of the repository', we concluded that they, 'fail to make an adequate or robust argument for continued disposals of LLW because:

- estimates of doses and risks from existing disposals to members of the public in the future significantly exceed current regulatory targets
- BNFL<sup>5</sup> indicates that the LLWR is likely to be destroyed by coastal erosion in 500 to 5,000 years
- the 2002 safety cases include insufficient consideration of optimisation and risk management, to demonstrate that impacts will be as low as reasonably achievable (ALARA)' (Environment Agency 2005a)

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<sup>5</sup> British Nuclear Fuels Ltd (BNFL) was the site operator at the time of submission of the 2002 PCSC and OESC.

An extensive programme of work has been carried out since 2002 to improve understanding of the performance of the facility. The Requirement 2 submission (under Schedule 9 of the environmental permit) in 2008 provided a useful update on LLW Repository Ltd's performance assessment and its strategy for optimisation at the LLWR and went some way towards addressing the deficiencies in the 2002 cases. In our review of the Requirement 2 submission we noted that, 'LLW Repository Ltd has substantially satisfied Requirement 2 and has also made considerable progress towards Requirement 6 [a requirement to provide an updated ESC]. 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' (Environment Agency 2009a). These improvements have, to a great extent, been addressed in the 2011 ESC.

We recognise that LLW Repository Ltd (and predecessor site operators) have achieved significant improvements in site understanding since 2002. Notable advances include:

- Improved understanding of the inventory of disposals, in particular relating to increased use of records to assess the trench inventory and locate disposals that are particularly significant in terms of containing key radionuclides.
- Improved conceptual understanding of the geology and hydrogeology of the site and its environs. Significant effort has also been made to understand the nature and rates of coastal change and the implications on erosion of the LLWR.
- Development of the Generalised Repository Model (GRM) for underpinning the conceptual understanding of the near field and its evolution over time. The GRM was developed from the DRigg Near field Kinetic (DRINK) model used in 2002 and has been verified and validated against a number of test cases. Numerical parameters in GRM are provided by experimental and underpinning modelling studies. In the 2011 ESC, LLW Repository Ltd uses the GRM to model chemical reactions and contaminant transport in the repository, underpinning the GoldSim assessment model.
- Provision of sound arguments and reasoning for all the key optioneering decisions supporting the 2011 ESC. We consider that an optimisation case has been made that meets Principle 2 and Requirement R8 of the GRA.

The 2011 ESC presents estimates of dose and risk for a reasonable range of plausible exposure scenarios and pathways. Central estimates of dose and risk are below levels of concern during both the period of authorisation and the post-closure period. More significant doses may arise from exposures to certain materials (such as higher activity particles) arising on the foreshore following coastal erosion of the facility by the retreating coastline or following human intrusion, however, these doses are associated with low likelihoods.

In 2002, coastal erosion was seen as only one potential end point for the LLWR and the effects of glaciation were also considered. Recent work on climate change, in particular the potential magnitude of sea level rise, coupled with improved understanding of the coastal processes operating in the vicinity of Drigg Beach, have led LLW Repository Ltd to conclude that coastal erosion of the site is a near certainty. LLW Repository Ltd predicts that erosion will begin in the period of a few hundred to a few thousand years from present. Thus this concern from the 2002 PCSC remains. However, the 2011 ESC assessment indicates that impacts associated with coastal erosion will be within acceptable levels (as discussed in the GRA).

However, in other areas, progression since 2002 has not been as significant. For example, in 2002 a detailed engineering performance assessment was undertaken. This comprised a systematic assessment of the potential behaviours of the disposal system, by assessing and linking related FEPs to identify failure sequences that could affect the performance of individual components of the closure system and eliciting the effect on near field flows. The output was a series of possible evolutions of the closure engineering, which were used to demonstrate that the system would meet its design objectives. LLW Repository Ltd did not repeat this exercise in the 2011 ESC for the updated engineering design; instead the performance of the engineered barriers was elicited by a group of experts without direct use of the previous body of work. However, LLW Repository Ltd informed us that the 2002 engineering performance assessment was not taken forward due to concerns about some technical aspects of it. As discussed in Section 2.9, we consider that this

elicitation process could have been more transparent. LLW Repository Ltd could have improved its understanding with reference to the previous body of work; despite changes in engineering design, many of the outputs of the 2002 engineering performance assessment would have been of relevance.

Another area where we consider the 2002 PCSC used better practice than the 2011 ESC relates to the documentation of assessment codes. LLW Repository Ltd acknowledges that it uses models and assessment codes to provide an important indicator of system performance. The 2011 ESC makes use of a substantial number of assessment codes; however, it does not contain a summary of the use of codes in the ESC, which would aid our understanding of how the various codes interact and how model output is transferred between different models. Numerical modelling was undertaken by a variety of contractor organisations and the 2011 ESC does not present evidence to show how LLW Repository Ltd specified quality assurance standards for model development and use, or assessed the strengths and limitations of each model and code. LLW Repository Ltd's response to our request for further information (see IRF ESC-RO-ASO-007) provided sufficient evidence to allow us to close this issue (see Section 2.7.15). In contrast, the suite of documents supporting the 2002 PCSC included a series of reports describing and justifying all the models used. The 2002 submission also included user guides and verification / validation reports for the codes used and an assessment model flowchart to summarise the linkages between the various models. We see this as representing best practice and recommend that LLW Repository Ltd seeks to improve documentation of model selection, usage and quality assurance in future assessments (see Recommendation SCM17).

Nevertheless, we have concluded that the 2011 ESC presents a more coherent and much improved case for the continued operation of the LLWR than the 2002 ESCs. However, LLW Repository Ltd should make sure that areas of good practice from the previous assessments are carried through to future ESCs (**Recommendation SCM26**).

## 2.12. Research and development

We expect the 2011 ESC to include details of the results of continuing research and development (R&D) studies (GRA paragraph 5.5.4). Under Requirement 4 of the current LLWR environmental permit, we required LLW Repository Ltd to establish and carry out a programme of R&D to support specific improvements in understanding of the ESC. We requested annual progress reports on the R&D programme in the period up to 2010. The last of these was presented in Baker (2010).

LLW Repository Ltd adopts a broad definition of what constitutes R&D, comprising all technical work that is carried out in support of the programme of environmental assessments except ESC development work, monitoring, safety assessment, optimisation and non-technical work (Baker 2010). The R&D programme was developed taking into account:

- recommendations from previous R&D programmes at the LLWR
- a series of technical workshops to discuss approaches in key technical areas
- output from the 2008 Schedule 9 Requirement 2 submission, including Environment Agency comments (Environment Agency 2009a, 2009b, 2009c, 2009d and 2009e)
- feedback from the PRG

With such a broad definition, we consider that the programme arguably goes beyond what would normally be considered R&D, for example: updating the inventory, undertaking a geophysical survey of the Drigg spit area, updating the 3D geological model and developing the hydrogeological model, all of which use tried and tested techniques. However, LLW Repository Ltd has commissioned more innovative work, including:

- uranium sorption experiments
- assessment of the physical form of uranium
- monitoring of the long-term trench and vault experiments
- assessment of the provenance of observed tritium in ground and surface water
- characterising the future evolution of the coast

- development of an empirical model to assess the relationship between radon concentrations in waste and concentrations that might arise in waste

Our comments on the adequacy of individual research areas are made in our review group reports.

We expect the ESC forward programme to include R&D to investigate key areas of uncertainty. We note that the forward programme does not include a specific task for R&D (LLW Repository Ltd 2011p), but we expect LLW Repository Ltd to undertake further R&D as necessary and which may include development and testing of novel techniques and technologies.

One area in which we consider that further R&D is required is that of underpinning the detailed design of the engineered cap and basal drainage layer (Environment Agency 2015d). Although we consider the overall design of both the engineered cap and basal drainage layer to be suitable, uncertainties remain that require further work to underpin the detail and increase robustness. We expect LLW Repository Ltd to use the results of past research as well as a forward R&D programme to remove uncertainty, as requested in FIs ESC-FI-023 and ESC-FI-026. The R&D programme should also consider key uncertainties in the 2011 ESC (as tabulated in the FEP and uncertainty tracking system) and take into account recommendations from our review of the ESC and PRG feedback. These expectations are raised in a FI (ESC-FI-004).

## 2.13. The Extended Disposal Area (EDA)

The main part of the 2011 ESC considers the reference disposal area (RDA), which comprises the seven trenches plus Vaults 8 to 14, covering what was formerly known as the 'consented area'. LLW Repository Ltd estimates that the entire RDA will have the physical capacity to accept all the UK's suitable LLW up to about 2080. LLW Repository Ltd has done another assessment to consider the effects of extending the disposal area to include a further 6 vaults (Vaults 15 to 20). This extended disposal area (EDA) could accept relevant LLW arisings up to about 2130.

The assessments for the EDA are documented in 12 Level 3 documents that cover the engineering design, modelling of the near-field evolution and hydrogeology, plus all of the assessment scenarios considered for the RDA during the period of authorisation and post-closure period. These assessments are summarised in LLW Repository Ltd (2011s).

LLW Repository Ltd uses the same models to assess the EDA as those used in the main RDA calculations and thus our comments on the RDA assessment are also of relevance to the EDA. We raise specific issues of relevance to engineering, near field, inventory and assessment for the EDA elsewhere in our review (Environment Agency 2015b, 2015d and 2015e).

The majority of arisings of C-14 are forecast to require disposal post-2070. The total predicted inventory of C-14 to Vaults 15 to 20 is approximately 3.5 times greater than predicted to Vaults 8 to 14. Similarly, over 40% of Cl-36 arisings are forecast to require disposal to the Vaults 15 to 20. Both these radionuclides are key contributors to risk via the groundwater pathway, and C-14 impacts via the gas pathway are projected to approach the risk guidance level (LLW Repository Ltd 2013d). Impacts via the groundwater pathway for the EDA repository are greater than for the RDA repository. However, gas pathway doses associated with Vaults 15 to 20 are lower than those associated with Vaults 8 to 14. This is because a lower amount of organic waste is projected for disposal to Vaults 15-20, due to the generation of an increasing proportion of decommissioning as opposed to operational waste at that time and hence there will be a lower production of carrier landfill gas. Projected impacts associated with both the EDA and RDA repositories are below the relevant guidance levels.

We note that LLW Repository Ltd's environmental permit variation application is based on disposal to an EDA repository (LLW Repository Ltd 2013e). This has led to some loss of clarity, given that the 2011 ESC is primarily based on the RDA repository, with the EDA assessments effectively forming an addendum. We note that LLW Repository Ltd has not assessed some of the scenarios for Vaults 15 to 20 to as great a level of detail as it has the RDA vaults, for example, fewer variant calculation cases have been considered. In addition, the company has not carried out a probabilistic assessment of the groundwater pathway for Vaults 15 to 20. However, we are satisfied that Vaults 15 to 20 have been adequately assessed and with an appropriate degree of caution, taking into account the other uncertainties associated with the EDA due to the period of

time before they would be expected to come into operation. We are satisfied that the EDA will be re-assessed taking account of developing understanding well in advance of any proposed disposals to Vaults 15 to 20 which would not begin for a number of decades. However, to avoid this issue in future, LLW Repository Ltd should make sure that future iterations of the ESC are fully representative of the proposals being made and that the ESC assesses the entirety of the proposals in a consistent manner (**Recommendation SCM27**). We expect LLW Repository Ltd to further improve the assessment for the existing and proposed repository in its entirety (that is, including Vaults 15 to 20) as understanding develops and uncertainties are reduced. Our expectations are discussed further in Environment Agency (2015e).

## 2.14. Asbestos

The current environmental permit allows the LLWR to receive radioactive asbestos for disposal, subject to meeting the LLWR's WAC (LLW Repository Ltd 2014). We reviewed the acceptability of such asbestos waste continuing to be permitted for disposal and concluded that continued disposal of asbestos waste at the LLWR following landfill good practice (in accordance with guidance on the Environmental Permitting (England and Wales) Regulations 2010 from Defra (2010) and the Environment Agency (2010b)) remains appropriate for radioactive asbestos<sup>6</sup>.

We asked LLW Repository Ltd to demonstrate that existing and future disposal of asbestos to the repository represent Best Available Technique (BAT). The company compared the level of protection offered by the repository to that of a non radioactive hazardous waste disposal site permitted to receive asbestos. LLW Repository Ltd made the case that current disposal practices for asbestos at the LLWR provide no less stringent protection than would be the case if regulations applying to landfills were applied (Baker 2013b). We consider that the BAT for past trench disposals is to leave the asbestos waste in-situ, and consider any retrieval disproportionate. For asbestos currently stored in Vault 8 and accepted under the existing WAC, we consider that the current disposal systems and procedures at the repository provide an equivalent, or better level of protection than would be the case in an equivalent non-radioactive hazardous landfill. We require no further environmental protection measures.

In the short-term, LLW Repository Ltd proposes continued receipt of waste containing radioactive asbestos and man-made fibres, subject to a variation application under the company's processes described within its WAC (LLW Repository Ltd 2014).

Separately to the ESC, LLW Repository Ltd reviewed the acceptability of asbestos and future controls via the WAC and is currently undertaking further work to assess the potential impacts of the disposal of asbestos should the waste become exposed through human intrusion or coastal erosion. The results of this work will inform the consideration of whether further waste acceptance controls are justified. We commend the work carried out to date and recommend that LLW Repository Ltd continues to develop its asbestos assessment in line with national developments in contaminated land and landfill disruption assessment (**Recommendation SCM28**).

## 2.15. Waste acceptance criteria and radiological capacity

LLW Repository Ltd's approach to setting WAC in the 2011 ESC is set out in LLW Repository Ltd (2011t). These proposals are revised in the Developments Report (LLW Repository Ltd 2013b). This section focuses on LLW Repository Ltd's overall approach to waste acceptance. Our review of the proposed approach to set the radiological limits and controls on non-radioactive substances in the WAC is provided in the Assessments Review report (Environment Agency 2015e).

The need for WAC is outlined in GRA Requirement R13: 'Waste acceptance criteria: The developer/operator of a disposal facility for solid radioactive waste should establish waste acceptance criteria consistent with the assumptions made in the environmental safety case and

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<sup>6</sup> Irrespective of our position, LLW Repository Ltd may decide that, for its own reasons, it does not wish to accept and / or dispose of asbestos waste at the site.



with the requirements for transport and handling and demonstrate that these can be applied during operations at the facility' (GRA paragraph 6.4.26).

WAC for the LLWR cover controls on waste form and physical composition of waste, biogeochemical properties of waste, controls to limit the radiological and hazardous inventories and implementation arrangements (some elements of the latter, for example packaging and transportation arrangements, are not covered by our regulation of the site but instead largely by ONR). The WAC are for waste producers and LLW Repository Ltd to use so they can assess waste for potential disposal at the LLWR and to manage any subsequent disposals. They are also provided to regulators and other interested parties to demonstrate the means of control of waste accepted for disposal at the site. They include consideration of all the necessary characteristics of the waste required to ensure the safe operation and long-term environmental performance of the site (LLW Repository Ltd 2011t). Many aspects of the WAC are defined through the ESC assessments.

The WAC have been developed and refined over the years, taking into account operational feedback and regulatory requirements. Proposed changes to the WAC, based on the output of the 2011 ESC, are outlined in Table 8.2 of LLW Repository Ltd (2011t). These changes are clearly linked to relevant ESC issues. However, this table has not been updated in the Developments Report, leading to some loss of clarity.

LLW Repository Ltd has proposed a number of changes to the WAC, which have been derived from the outputs of the 2011 ESC and subsequent studies and which, when enacted, will make sure the WAC remain consistent with the assumptions of the ESC. We note the following:

- As a result of its 2011 ESC (LLW Repository Ltd 2011t) LLW Repository Ltd has added a new requirement on consigners to characterise waste degradation, voidage and settlement properties. The updated WAC set a limit of 20% for total potential voidage (without prior agreement) (LLW Repository Ltd 2014). The company is also initiating a new emplacement strategy to make sure that all stacks are limited to the appropriate criteria of 20-35% voidage, dependant on total stack height.
- The current LLWR environmental permit excludes chemical complexing or chelating agents. After submission of the 2011 ESC, LLW Repository Ltd assessed the effects of a range of potential organic complexants on repository performance (Kelly and Berry 2013). The results of this study indicate that impacts on radionuclide migration from the LLWR would be relatively minimal (Environment Agency 2015b). LLW Repository Ltd is therefore proposing to accept limited quantities of complexants. A total vault capacity for aminopolycarboxylic acids, of which EDTA is the most common, is proposed.
- LLW Repository Ltd undertook an updated criticality assessment in the 2011 ESC (Putley et al. 2011). The assessment concluded that, because the fissile inventory of the LLWR is very small, the possibility of criticality is so remote that it can be discounted. LLW Repository Ltd proposes that limits on fissile radionuclides in the WAC are updated in line with the 2011 criticality assessment. LLW Repository Ltd considers that these limits are very conservative and that the grouted waste containers do not pose any significant probability of criticality, either during the operational period or post-closure. We agree with this view (Environment Agency 2015e).
- The effective implementation of the WAC is dependent on the ability of the waste consignor to appropriately characterise the physical, chemical and radiological properties of their waste. We will continue to expect LLW Repository Ltd to make sure (for example through audit) that consignors can, and are, effectively demonstrating that WAC requirements are met.
- The WAC state, 'It is not acceptable to purposely dilute waste or add shielding materials for the sole purpose of achieving compliance with the requirements of this Waste Acceptance Criteria.' This clause is unchanged from previous iterations. We recently issued guidance to LLW Repository Ltd on averaging and acceptance of higher activity waste (Fairhurst 2012) which we expect to be adhered to.
- Any liquid, before consignment, must be fixed in a solid matrix which will not result in release of any liquid under applied loads up to  $400 \text{ kN m}^{-2}$ . We are confident that the value is sufficiently conservative to prevent the generation of free liquid.



- For controls on explosive materials, we consider it important that the restriction can be applied to both a contaminated material (such as soil) as well as individual items exhibiting explosive properties. We also suggest that LLW Repository Ltd considers use of the definition of 'explosive' in our guidance on definition and classification of hazardous waste of 'substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene' (Environment Agency et al. 2013) (**Recommendation SCM29**). We are satisfied that there is sufficient control in place on potentially explosive materials.

Within its organisation, LLW Repository Ltd should ensure clear ownership of the WAC as well as ESC Project Team input to changes driven by non-ESC related considerations (for example, transport requirements) (**Recommendation SCM30**). LLW Repository Ltd should support consigners by making sure that changes are effectively implemented. Where LLW Repository Ltd have not done so already, we recommend that guidance and advice is provided to waste consignors to enable them to achieve full compliance with the WAC (see Recommendation SCM3). For example, we believe provision of guidance on issues such as what constitutes a corrosive material, a strong oxidising agent and how flammable liquids may be treated will aid consignors and the repository with compliance. We will address compliance with the implementation of these changes through our regulation of LLW Repository Ltd.

Our earlier review of the 2002 PCSC identified a number of deficiencies in the approach to development of the radiological capacity of the LLWR (Environment Agency 2005b). Since then LLW Repository Ltd has continued to develop its approach to the development of radiological capacity and the setting of radiological limits in the WAC. The majority of issues raised in our review of the 2002 PCSC have been addressed or are superseded by changes in approach.

LLW Repository Ltd is proposing to use the 'sum of fractions' approach as set out by the International Atomic Energy Agency (IAEA 2003) for the control of radioactivity in future disposals. This approach is described in detail in LLW Repository Ltd (2011t), but, in summary, it is a method to calculate disposal system capacity limits using representative assessment cases (to derive doses or risks), assessment criteria (such as regulatory dose or risk guidance levels) and taking account of the additive nature of impacts from different radionuclides. The approach represents industry good practice in setting capacity limits for near surface repositories and has been adopted for use at disposal sites in France, Spain and the USA. It has also been used in the UK for setting radiological capacity limits at some landfills receiving radioactive waste for disposal. We accept the sum of fractions approach as a valid way of deriving and controlling the radionuclide inventory during the operation of the site in terms of total capacity and radioactivity within individual consignments. We are satisfied that LLW Repository Ltd has appropriately implemented the 'sum of fractions' approach and presented appropriate WAC on this basis.

However, the sum of fractions approach only addresses waste at a level of total capacity or activity within a single consignment, it does not consider radioactivity that may be associated with individual items, or particles of waste that may be within that total or consignment (such as 'hot spots'). These items could potentially carry an activity sufficient to give rise to a significant assessed effective dose. We required LLW Repository Ltd to undertake further assessment of the potential for exposure to discrete items and active particles (see IRFs ESC-RO-ASO-006 and ESC-RI-ASO-010). The results of the assessment carried out by LLW Repository Ltd in response to these IRFs are consistent with our recent supplementary guidance on the future disposal of discrete items and particles to the LLWR (Smith 2014). From this assessment, LLW Repository Ltd determined further limits and controls for discrete items and active particles and included them in its WAC (Sumerling 2013a and 2013b, LLW Repository Ltd 2014). We support these limits as further control mechanisms on waste acceptance at the LLWR (Environment Agency 2015e), which will help make sure that waste is acceptable for disposal at all scales (site total capacity, consignment, items and particles).

As discussed in Environment Agency (2015e), in general we consider that LLW Repository Ltd has derived a set of radiological limits that are in line with current industry good practice and that are

based on the 'available headroom'<sup>7</sup> with respect to dose limits (for the period of authorisation) and risk and dose guidance levels (post-closure) as set out in Environment Agency's guidance. However, we have identified possible areas for continued improvement where the supporting assessments may be enhanced and made more robust. For example, we have asked LLW Repository Ltd to explore the assumption of a linear relationship between disposed inventory and risk (see FI ESC-FI-017) and we query whether further enhancements can be made to the consideration of probabilistic arguments to support groundwater pathway assessments post-closure (see FI ESC-FI-012).

We note that, whilst radiological limits were calculated for the RDA in the 2011 ESC, the environmental permit variation application is based on the disposal of waste in the EDA repository. LLW Repository Ltd presents updated limits in LLW Repository Ltd (2013b). As discussed in Section 2.13, this has led to some loss of clarity in the submission.

We consider that LLW Repository Ltd has established reasonable WAC for non-radiological components of disposals (Environment Agency 2015e and LLW Repository 2014). LLW Repository Ltd has derived specific capacity limits for certain key non-radiological pollutants and also established increased requirements for information provision on the non-radiological chemical component of materials disposed to the site. The further information being collected will assist in the future reduction of uncertainties associated with the non-radiological inventory.

LLW Repository Ltd has consulted consignors on revised WAC during 2012 and 2013 and new WAC were implemented in March 2014. The new WAC (LLW Repository Ltd 2014) reflect LLW Repository Ltd's position at the time of issue and hence have improved on proposals outlined in the 2011 ESC to some extent, as described in the Developments Report (LLW Repository Ltd 2013b).

In advance of any environmental permit variation being granted, LLW Repository Ltd can only implement changes which are consistent with the current environmental permit for the site and this is the case for the changes implemented within the March 2014 WAC. LLW Repository Ltd proposes to update the WAC further, should the environmental permit be revised in future to reflect the company's full proposals in the current 2011 ESC and Developments Report. So, for example, the current environmental permit prevents the disposal of any complexing or chelating agents and so changes to the WAC allowing the disposal of certain complexing and chelating agents would only be implemented after the issue of any environmental permit which removed the current restrictions. Similarly, the annual radiological capacity limits cannot be removed until any revised environmental permit is issued. Some changes that were implemented in the March 2014 WAC include for example:

- addition of activity limits for discrete items and controls on active particles
- updated proposals for managing hazardous materials, including a capacity based management system for certain named substances. Other substances, including asbestos and man-made fibres, will only be accepted for disposal on approval of a waste consignment variation form
- a new requirement for waste not to contain corrosive materials
- limits on total potential voidage
- a new requirement on consignors to characterise waste degradation, voidage and settlement properties

Any changes in position between issue of the 2011 ESC and the environmental permit variation application made in October 2013 are outlined and justified in the Developments Report (LLW Repository Ltd 2013b). We are satisfied that these changes are adequately justified and described, and supported by other studies as appropriate.

LLW Repository Ltd manages waste receipt using a comprehensive set of site procedures and management systems. Detailed review of these documents is outside the scope of this ESC

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<sup>7</sup> 'Available headroom' meaning additional radiological disposals that could be made before dose limits (during the period of authorisation) or risk and dose guidance levels (post-closure) are reached.

review; we have previously and will in future consider them through our ongoing regulation of the site.

Successful implementation of the WAC is reliant on detailed understanding and characterisation of a waste stream. Characterisation information needs to be obtained at an appropriate level so as to reflect variation within the waste across the waste stream, at individual consignment level and within individual consignments (such as discrete items). LLW Repository Ltd needs to make sure it is satisfied that consignor systems are capable of providing an appropriate level of characterisation through provision of instruction, guidance and audit (**Recommendation SCM31**).

In summary, we consider that the proposed changes to the WAC are consistent with the assumptions made in the 2011 ESC and subsequent updates and will be sufficient to avoid unacceptable doses and risks to people and the environment. Where there is a divergence between updates to the WAC proposed in the ESC and the WAC implemented in March 2014, the latter are more conservative in terms of potential impact (for example, with respect to acceptance of complexants) and remain consistent with the environmental permit currently in force. We are satisfied that LLW Repository Ltd has put in place adequate plans to implement the WAC and associated procedures (see Section 2.17 for further discussion). However, for those waste streams that are of the greatest potential significance in environmental safety terms (for example waste with high concentrations of Ra-226), we consider that emphasis should be placed on ensuring that the approach to disposal is optimised. We will monitor LLW Repository Ltd as it implements these plans, undertaking inspections and audits as necessary. Due to the extended operational periods the company proposes, we expect the radiological capacity of the site to continue to be aligned with the developing ESC.

## 2.16. Active institutional control

In the context of the 2011 ESC, the term 'active institutional control' is synonymous with the period of authorisation. The ESC assumes that the LLWR remains under active institutional control for a period of 100 years after final disposals (LLW Repository Ltd 2011a) (the GRA states that a period of active institutional control of 300 years is considered the maximum that can reasonably be claimed). During this time, the site boundary will be maintained to make sure there is no public access. An environmental permit will be in place that corresponds with the post-operational status of the site. Monitoring will be required during this period and remedial measures could be taken if deemed necessary, should any part of the facility be found to be performing outside the performance envelope considered in the ESC.

Arrangements for the period of active institutional control, covering aspects such as leachate management, monitoring and preparations for final facility closure and release of the site from control are outlined in the site development plan (LLW Repository Ltd 2011c).

In reviewing LLW Repository Ltd's proposals, we took into account the fact that final decisions about the manner of closure of the repository and any subsequent period of active institutional control need not be taken now or at any time in the near future. What must be done now is to implement measures and follow courses of action that will make particular approaches to closure and subsequent active institutional control easier. For example, early consideration should be given to monitoring or other infrastructure needed to support site closure.

Although the 2011 ESC considers a 100 year period of active institutional control, LLW Repository Ltd noted that longer controls over use of the site may be required to make sure that potential exposures to releases of C-14 labelled gas do not lead to unacceptable risks from use of the cap for smallholder farming. Impacts calculated in the ESC for the C-14 gas pathway exceeded the risk guidance level in the period up to 300 years post-closure (LLW Repository Ltd 2011i). However, LLW Repository Ltd acknowledged that these earlier calculations were highly cautious, a fact that we agreed with (Environment Agency 2015e). Further assessment, using more realistic assumptions, has resulted in a reduction in dose of nearly two orders of magnitude compared with the 2011 ESC dose calculations (LLW Repository Ltd 2013d). Peak annual doses are now assessed at approximately 3  $\mu\text{Sv}$  to a person representative of the group at greatest risk (a smallholder), with a corresponding annual risk of  $1.8 \times 10^{-7}$ , which is below the risk guidance level.

Thus, on the basis of the updated projections, extended controls to limit the cap area from smallholder farming will not be required.

The 2011 ESC takes no credit for potential measures to protect the LLWR from coastal erosion, either during or after the period of active institutional control. This is appropriate since the GRA requires that future generations 'are afforded the same level of protection as that applied at the time of disposal, without needing to take significant protective actions' (GRA paragraph 4.3.3). LLW Repository Ltd notes that some form of protection might in fact be practicable were sea-level rise to be at the low end of the anticipated range; although, it accepts that no practical steps can be taken to protect the site in the long-term from the expected effects of coastal erosion (LLW Repository Ltd 2011c).

Whether or not protection from coastal erosion is put in place, to enable an informed decision to be made on this issue we expect LLW Repository Ltd to remain fully informed on the topic. LLW Repository Ltd should keep under review developments in observation and modelling of climate change and the evolution of the local coastline and make sure that the ESC continues to reflect the best evidence about the likely fate of the site. We have discussed this issue further in other reports (Environment Agency 2015c).

Active leachate management and monitoring will take place during the period of active institutional control, 'for as long as necessary in order to fulfil regulatory or other stakeholder requirements regarding assurance of system performance' (LLW Repository Ltd 2011c). Monitoring requirements for this period are yet to be defined in detail. LLW Repository Ltd is undertaking a programme of work to reach a view on the framework and approach for long-term monitoring (Shevelan 2013b). We requested that this programme considers how monitoring requirements and priorities will change during the entire period of authorisation, ensuring that no actions are undertaken (such as site engineering) without considering the potential impact on monitoring requirements and ensuring that there is no undue impact in that respect. These issues are discussed further in Environment Agency (2015c).

LLW Repository Ltd states that, 'During the institutional control period, arrangements will be put in place to maintain knowledge of the hazardous nature of the facility following final closure. Through local consultation, a sustainable use of the site will be established consistent with the long-term environmental safety of the repository. The aim will be to provide a sustainable amenity to the local community and, also, thereby, help maintain knowledge and lower the likelihood of developments or uses that might lead to adverse impacts' (LLW Repository Ltd 2011a).

LLW Repository Ltd has reviewed potential strategies for the long-term control over the site and the maintenance of knowledge of the hazardous nature of the facility (Penfold et al. 2010). The institutional control strategies described in this report appear to be potential enhancements to the reference (baseline) strategy in the areas of: (1) Extended Site Control; (2) Enhanced Site Management; and (3) Enhanced Knowledge Retention. These could be implemented individually or in combination. Insufficient information is presented in the report to enable a choice to be made between the Extended Site Control strategy and the Enhanced Site Management strategy, or combinations of the two. As a minimum, LLW Repository Ltd needs to initiate an exploration of the programme of work that would be needed to enable this choice to be made on an informed basis (**Recommendation SCM32**). Although final decisions need not be made yet, we consider it desirable for LLW Repository Ltd to keep these enhancement options open. Any decision taken to pursue a course of action before facility closure that would foreclose one of these options, or make it more difficult to implement, needs to take this consideration into account.

An aspect that is not well discussed in Penfold et al. (2010) is whether, during the period of active institutional control, LLW Repository Ltd envisages that maintenance and remediation will be carried out routinely, or whether remediation will only be carried out in the event that a significant deterioration in performance is detected. This is an important aspect of the basic approach that needs to be discussed and substantiated properly (**Recommendation SCM33**).

For a near-surface disposal facility, one reason for a significant period of active institutional control is to monitor for changes in conditions in the facility and its close surroundings. If the changes do not happen in the manner and/or at the rate previously assessed, there is potentially a need for reassessment. Thus a 'final' ESC will potentially not exist until the end of active institutional control

because, up to that time, new data may become available that require the existing ESC to be amended.

The final cap design described in the 2011 ESC is not based on a clear end use of the site, which is a matter for LLW Repository Ltd, NDA and the planning authority. Our expectation is that any land use defined for the site will not detrimentally affect the safety functions of the facility, defined within the ESC. We recommend that LLW Repository Ltd considers the final land use of the site such that it can be made sure it is compatible with the final cap design, the wider ESC and assessment of habitats (**Recommendation SCM34**).

Maintaining detailed knowledge and tools or assessing safety performance, as well as retaining appropriate records (for example, inventory information and engineering details) must be an active feature of the management of the site through to the end of active institutional control (**Recommendation SCM35**) and beyond (also see Recommendation SCM14 in Section 2.7.14). Skills maintenance throughout the period of active institutional control will be required; this is a challenging issue and we would expect to see documentation dealing with this topic as part of a future ESC suite (**Recommendation SCM36**).

## 2.17. Implementation of the ESC

The current environmental permit for the LLWR requires that, 'The Operator shall design, operate and close the facility in accordance with the assumptions made in the most recent environmental safety cases, unless otherwise agreed in writing by the Agency' (Environment Agency 2010a). There is therefore a requirement on LLW Repository Ltd to implement the findings of the latest ESC as soon as practicable. This means ensuring that:

- WAC are consistent with the ESC, so far as the requirements of the permit allow
- procedures and processes are in place that are consistent with the ESC and that ensure the update of it and management against it
- change control processes are in place
- waste emplacement requirements and other operational requirements can be effectively implemented
- a forward programme of work is established and implemented (see Section 2.10)
- the final engineering design can be achieved, consistent with the ESC and required programs are in place to take the engineering described through to detailed design and construction

The above implementation requirements must also be consistent with any environmental permit in force. LLW Repository Ltd is therefore implementing the 2011 ESC as far as possible in line with the current environmental permit (LLW Repository Ltd 2012a), but full implementation will have to await any revised environmental permit issued following our review of the 2011 ESC, the environmental permit variation application (LLW Repository Ltd 2013e) and our decision.

In accordance with the above expectations we raised an IRF (ESC-RO-SCM-001) requiring LLW Repository Ltd to provide us with a programme detailing how it will develop and achieve a robust change control process for the ongoing management of the ESC and its relationship to site operations. In response LLW Repository Ltd provided an implementation plan (LLW Repository Ltd 2012a) and subsequently a new repository site procedure (RSP) addressing development and application of the ESC (LLW Repository Ltd 2013a). These responses effectively addressed areas we considered required further development and went further than requested, addressing broader areas associated with implementation. We are satisfied that LLW Repository Ltd has demonstrated a robust change control process for the ongoing management of the ESC and its relationship to site operations and additionally, demonstrated a commitment to broader effective implementation of the ESC.

The following sections address different aspects of implementation of the ESC at the LLWR.

### 2.17.1. Site procedures

LLW Repository Ltd developed and managed the 2011 ESC as a project through a Project Execution Plan (LLW Repository Ltd 2011j). The company has now withdrawn this Project

Execution Plan and replaced it with a new RSP on the development and application of the ESC (LLW Repository Ltd 2013a). The company used this procedure, which is largely based on existing nuclear safety case processes, to integrate the 2011 ESC into LLWR's change control processes (LLW Repository Ltd 2009d) and associated plant modification procedures (LLW Repository Ltd 2008a) which we consider give it a good basis. LLW Repository Ltd states the main purpose of the procedure is to 'ensure that the LLWR's Environmental Safety Case (ESC) is developed and applied such that the relevant requirements set out in the LLWR's environmental permit from the Environment Agency are met....'. The procedure addresses a wide range of topics relevant to the ESC including:

- appointment of an ESC Manager
- development and review of the ESC
- effecting change
- update of tools and records

We have reviewed this new procedure in discussion with LLW Repository Ltd (see IRF ESC-RO-SCM-001). We are satisfied that it addresses relevant implementation requirements; adequately addresses change control and ongoing management of the ESC and appropriately identifies roles and responsibilities. We welcome a number of areas it addresses including:

- a commitment to a fit-for-purpose development programme taking into account a wide range of inputs
- recognition of the need for ongoing optimisation of the facility
- identification of the need for assessment of new information as it becomes available
- establishment of ESC reviews (see Section 2.2). These reviews will be used to identify significant changes to the ESC or affecting the ESC, the need for significant review and update of the ESC and then to complete these major updates where required
- a commitment to ongoing independent peer review of the ESC
- recognition of the need to notify the Environment Agency of changes that might have, or might reasonably be seen to have, a significant impact on how compliance with the limitations and conditions of the environmental permit are achieved
- mechanisms to update and change the ESC and its implementation on site via the Environmental Clearance Certificate and associated documents
- update of the waste acceptance arrangements in line with the ESC
- the maintenance of tools such as the FEP and uncertainty tracking system and issues register

In particular, we consider the proposals for annual, periodic and major reviews of the ESC are important: the ESC must be developed as understanding develops, new information becomes available and also, given the long timescales of these proposals, as expectations and requirements placed on near-surface disposal facilities change. We support the tiered approach to review and expect LLW Repository Ltd to discuss the timing and scope of reviews with us as appropriate. Review timescales will need to take account of any environmental permit conditions.

In relation to change control we raised an IRF (ESC-RO-SCM-002) requiring LLW Repository Ltd to consider establishing trigger levels to flag changes in bulk properties of waste being disposed of at the LLWR that could potentially lead to volumes of waste with characteristics inconsistent with ESC assumptions. In response LLW Repository Ltd demonstrated that trigger levels would not be the most effective way to identify such changes, which could be more effectively managed through annual reviews (Baker 2012c). We agree with these conclusions.

We note that an important area of work for LLW Repository Ltd will be the implementation of the engineering design described within the 2011 ESC, including further optimisation. Site procedures will need to make sure that effective working arrangements are established between the design justification, optimisation and ESC processes. This will help facilitate good flow of information and feedback between the processes and ensure consistency of approach.



### **2.17.2. Implementation of Waste Acceptance Criteria (WAC)**

'The developer/operator of a disposal facility for solid radioactive waste should establish waste acceptance criteria consistent with the assumptions made in the environmental safety case and with the requirements for transport and handling and demonstrate that these can be applied during operations at the facility' (GRA paragraph 6.4.26). Technical aspects of waste acceptance criteria are discussed in Section 2.15 of this report, procedural aspects are discussed here.

LLW Repository Ltd states in its 2011 ESC Implementation Plan (LLW Repository Ltd 2012a), 'In order to ensure that only waste consistent with the assumptions and assessments of the 2011 ESC are accepted and hence the site is demonstrably safely operated, changes to the LLWR's waste acceptance arrangements are required. These changes include revisions to WAC and capacity management arrangements and the associated processes, procedures and forms'. The company notes that, in particular, this will require changes to software and tools to manage changed radiological and non-radiological capacity controls. The report explains that these changes are being implemented in two phases. The first phase will be completed before any revised environmental permit is issued and will implement those aspects of the 2011 ESC that do not conflict with the current environmental permit (for example, radiological controls on total vault activity and consignment limits (LLW Repository Ltd 2013b)). This phase was implemented in March 2014. The second phase will implement the full set of proposals in association with any revised environmental permit coming into effect, alongside any changes required by the revised environmental permit (for example, implementing the removal of annual limits, if accepted).

LLW Repository Ltd must develop and implement processes and tools to support implementation of any new WAC before they come into effect. Plans to achieve this are outlined in the 2011 ESC Implementation Plan (LLW Repository Ltd 2012a). This includes, for example, necessary software development, training and update of waste acceptance procedures. Some of these aspects are discussed further below.

Once any revised WAC are issued, they will be managed through the change control process described above and in LLW Repository Ltd (2013a). LLW Repository Ltd indicates that any changes to acceptance arrangements will be consulted upon with consignors and notes that we must be notified of these changes.

We are satisfied with the general approach to implementation of WAC being adopted by LLW Repository Ltd and expect arrangements to be kept up-to-date as soon as practicable in line with the current ESC and environmental permit requirements.

### **2.17.3. Addressing stored waste**

Under the current environmental permit for the LLWR (Environment Agency 2010a), waste can only be disposed in Vault 8 up to four ISO freight containers high. As Vault 8 is now virtually full, waste consignments currently accepted at the site are now stored in higher-stacked positions within Vault 8 and also stored in Vault 9. This stored waste is not 'legally disposed'. Waste stored at the site was accepted under the WAC in force at that time (LLW Repository Ltd 2012a).

Before any of this stored waste can be accepted for final disposal:

- an environmental permit for further disposal at the LLWR is required (as is planning permission from the local authority)
- an assessment must be made by LLW Repository Ltd of whether these stored waste meet any new WAC and environmental permit conditions
- where any of the stored waste does not meet the requirements of any new WAC, a BAT demonstration would be required to determine whether it could be disposed of at the site

LLW Repository Ltd would have to manage any stored waste that cannot meet these requirements via alternative means in line with BAT requirements.

If LLW Repository Ltd is successful in gaining an environmental permit and planning permission for further disposal and is able to demonstrate that it is BAT to dispose of this waste at the LLWR, its intention is to move some or all of the waste packages currently stored in Vault 9 to Vault 8. These packages would largely be moved into higher (than four-high) stacked positions (LLW Repository Ltd 2012a). Any movements into higher-stacked positions would be subject to satisfactory

demonstration that higher stacking would not lead to unacceptable settlement, as discussed further in Environment Agency (2015b and 2015d). Any higher stacking of waste would, in part, create the proposed restoration shape of the cap, minimising the need for further profiling material.

To support this intent LLW Repository Ltd proposes to undertake an assessment of the disposability of currently stored waste against the criteria described above, including those already in higher stacked positions. This will inform wider considerations of whether higher stacking of ISO freight containers should be implemented in Vault 8 in the site engineering programme (Shaw 2013 and Environment Agency 2015d). There is therefore some uncertainty at this time over the extent to which higher stacking in Vault 8 will be used and also the potential need to move some containers within Vault 8.

We support this initial approach to addressing stored waste at the site. As part of our determination of LLW Repository Ltd's environmental permit variation application and future permit compliance, (LLW Repository Ltd 2013e) we will consider further any requirements we need to place on LLW Repository Ltd when managing stored waste.

#### **2.17.4. Operational measures and controls**

LLW Repository Ltd needs a number of operational measures, controls and supporting tools to implement the ESC and the supporting WAC (LLW Repository Ltd 2012a and 2013b). Key amongst these are: 1) implementation of waste emplacement strategies; and 2) radiological capacity management using appropriate tracking systems.

LLW Repository Ltd states that, 'to optimise the potential for reducing impacts in the future but also to reduce cap degradation through settlement', emplacement strategies will be implemented (LLW Repository Ltd 2013b). A total of 6 emplacement requirements have been identified (LLW Repository Ltd 2013b). These emplacement strategies will be implemented in three stages, dependent on the vault location:

- Consignments that are not to be co-located (for example in the same or adjacent stacks) due to the specific activity of key radionuclides.
- Consignments that are to be excluded from within 5 m of the cap surface due to specific activity of key radionuclides.
- Limits on the total potential voidage within each stack of ISO freight containers to limit the potential for cap settlement.
- Limits on the metal content of waste in each stack of ISO freight containers to limit the potential for differential cap settlement.
- Exclusion of absorbed liquids from stack positions where the load on the absorbed liquid would exceed  $400 \text{ kN m}^{-2}$  (including cap and fill materials) to exclude the potential for release of the absorbed liquid.
- Control of waste types within stack positions with loads in excess of  $400 \text{ kN m}^{-2}$  (including cap and fill materials) to meet compression voidage requirements.

LLW Repository Ltd proposes to identify waste consignments that require application of one or more emplacement strategies as part of the waste acceptance process. Consignments will be flagged on the waste tracking system (WTS) and arrangements put in place to allow the operations team to identify, physically mark and ensure correct placement of such consignments. We are satisfied that LLW Repository Ltd has put in place plans to develop the appropriate processes to achieve effective emplacement. We will expect LLW Repository Ltd to deliver against these plans and to have the necessary control procedures in place as soon as practicable and before the final placement of containers.

Radiological capacity management is discussed in Section 2.15 and in our review of Assessments (Environment Agency 2015e). To effectively implement proposed radiological capacities LLW Repository Ltd plans to develop a new, fit-for-purpose, more flexible LLW tracking system (LLWTS) that will meet the requirements for ESC implementation (LLW Repository Ltd 2012a and 2013b). However, LLW Repository Ltd reports that a new system will take several years to develop and therefore, in the interim, current systems will be revised and updated to meet requirements. We expect LLW Repository Ltd to make sure any interim systems are robust. We will review the

adequacy of these interim systems through our ongoing regulation of the site. We support the development of a new, more flexible LLWTS that aligns fully to the updated ESC and any new environmental permit. We accept that development of a system will take time to achieve effectively. However, we expect the company to progress development of a tracking system as soon as possible, whilst gaining maximum benefit from it. We have sought development of such a system for a number of years and therefore will require LLW Repository Ltd to progress this issue through an FI (ESC-FI-020). This issue is also discussed in Environment Agency (2015b).

We are satisfied that LLW Repository Ltd's 2011 ESC implementation plan (LLW Repository Ltd 2012a) adequately drives the development of any new operational procedures or controls, along with any supporting tools. We will review progress against these plans through our ongoing regulation of the site. We expect LLW Repository Ltd to continue to look at how its implementation of the ESC can be improved and enhanced. In particular we suggest that, with the implementation of new and revised WAC, the company considers the adequacy of the checks it completes on waste transfers to the site to confirm that consignors have adequately interpreted and met the new requirements and have provided all the necessary waste information associated with those transfers. These checks could be desk-based or physical (**Recommendation SCM37**).

### 2.17.5. Engineering

Effective implementation of the 2011 ESC requires that the engineering proposed and assessed within the ESC can be constructed and performs as expected (for example the cap and cut-off walls). We fully reviewed the engineering elsewhere (Environment Agency 2015d), and we raised a number of recommendations and FIs. We are content that the proposed design is appropriate, but also consider that there is a need for further detailed design work, optimisation and testing before construction. To achieve this, LLW Repository Ltd developed a forward engineering programme (Shaw 2013) that specifies further development and design work that is required. We raised an FI (ESC-FI-026) which describes our expectations of the engineering programme. We will monitor progress of this detailed design work and will only allow construction if we are satisfied that adequately underpinned engineering is proposed.

## 2.18. Other information and evidence

This report and the associated suite of reports (Environment Agency 2015a, 2015b, 2015c, 2015d and 2015e) address our review of the ESC submitted by LLW Repository Ltd in May 2011. This review will form a key input to our final decision on the environmental permitting of LLW Repository Ltd following its application to vary its environmental permit and to dispose of further waste at the LLWR (LLW Repository Ltd 2013e). However, within the context of this report on safety case management it is worth highlighting that, since the submission of the previous ESCs in 2002, we have received and assessed other information that will support any final decision on environmental permitting. This information falls into two main groups: that submitted to us in response to improvement and additional information requirements under Schedule 9 of the current environmental permit (Environment Agency 2010a); and that gained through our ongoing regulation of the site, for example through compliance inspections and assessment of submitted data.

We will address some of this further information in our documentation outlining our decision on environmental permitting before issuing any final decision on the environmental permit variation application. However, some of this information is raised here in the context that it also informs, supports and maps the timeline through to issue of the updated ESC in May 2011.

### 2.18.1. Evidence gained through ongoing regulation of the LLWR

We regulate the site against the environmental permit issued under EPR10. In doing this we ensure ongoing compliance and seek to improve practices at the site through compliance activities. For example, activities we have carried out and continue to do at the site include:

- Inspections and audits carried out periodically to test compliance and to gain confidence in the operations of the LLWR. These inspections and audits are used, for example, to examine systems, test operator competence and examine infrastructure and records. Examples of some

recent audits include those addressing management arrangements (Environment Agency 2013), ESC records (Environment Agency 2011) and environmental monitoring (Clarke 2011).

- Regular meetings with LLW Repository Ltd to review progress, developments, actions and compliance. For example, we hold a joint monthly teleconference with ONR and LLW Repository Ltd to review operational issues and progress against actions and plans. We typically meet monthly to discuss the ESC itself and associated implementation activities. We also periodically meet with local authorities, ONR, NDA and LLW Repository Ltd to discuss common issues. Annually we attend a review of safety and the environment with ONR and LLW Repository Ltd to review progress that year and to look forward to activities in the coming year.
- The review of information we require LLW Repository Ltd to periodically submit to us such as environmental monitoring data, dose assessments, surveys of the sea discharge line and reports on further information requirements.
- Review of LLW Repository Ltd's waste assurance activities. This includes periodic seizure and/or checking of waste destined for the LLWR by us.
- Review of BAT assessments on proposed activities at the site.
- A review of operator competence and management arrangements associated with the transfer of operator in 2008.
- Investigation into any events and breaches of the environmental permit.
- The review of design, construction and verification information, such as that associated with Vault 9.
- Attendance at stakeholder liaison meetings.

Through these activities we gain a far broader insight and understanding of the operations of the LLWR and the management arrangements it applies than solely through review of the submitted 2011 ESC, although the ESC does provide a good summary. These activities have therefore provided important supporting information to us in determining the adequacy of LLW Repository Ltd's management arrangements, safety culture, dialogue with local communities and operations at the site, as discussed within this report. Overall we are satisfied with these areas and where we have concerns we have and will continue to raise these with LLW Repository Ltd and deal with them as necessary to ensure continued compliance and adoption of good practice. Our regulation of the site will continue until the environmental permit is revoked and we will only allow this once we are satisfied a suitable final ESC has been submitted. This ESC must demonstrate the safety of the site in terms of protecting people and the environment at that point and into the future, in accordance with the requirements of the GRA or other relevant extant guidance.

### **2.18.2. Improvement and Additional Information Requirements**

The current environmental permit details 14 'Improvement and Additional Information Requirements' that LLW Repository Ltd was required to deliver to us between 2006 and 2011, with some ongoing annually. A number of these relate closely to the ESC and were included within the environmental permit to ensure adequate and timely progress against a number of issues raised through our earlier review of the previous ESCs and environmental permit review (Environment Agency 2005a and 2006). Some of the requirements were more 'stand alone' and designed to ensure ongoing compliance and effective implementation of the latest ESCs.

In response to some of these requirements we made comments and recommendations which we expected LLW Repository Ltd to take account of within the 2011 ESC. We are satisfied that LLW Repository Ltd has done this. Within our review of the 2011 ESC we have also been able to take account of the evidence provided in response to these requirements, which has given evidence of progress before submission of the 2011 ESC. Our requirements and LLW Repository Ltd's responses are summarised in Table 1 below:



**Table 1 Summary of Improvement and Additional Information Requirements within the current LLWR environmental permit**

Req. No.	Improvement and additional information requirement	Response summary
1	LLW Repository Ltd shall provide the Agency with a full report of a comprehensive review of whether the current disposal practices for waste generated on the site continue to represent the best available techniques, together with a programme for carrying out any necessary changes identified by the review. (Required by 2009)	LLW Repository Ltd provided an adequate response addressing disposal practices for waste generated at the LLWR (LLW Repository Ltd 2009e).
2	LLW Repository Ltd shall 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. (Required 2008)	<p>LLW Repository Ltd delivered its response to Requirement 2 on 1 May 2008 (LLW Repository Ltd 2008b, 2008c, 2008d, 2008e and 2008f). As well as directly addressing Requirement 2, LLW Repository Ltd's submission provided a useful update on its performance assessment and its strategy for optimisation at the LLWR.</p> <p>The response substantially satisfied the Requirement and also made considerable progress towards update of the ESC (Requirement 6). We noted in our response at the time that there remained a substantial amount of work to complete the full ESC, to ensure it would be adequately underpinned by evidence and analysis (Environment Agency 2009a, 2009b, 2009c, 2009d and 2009e). Within our response we indicated areas where we expected to see further improvement within the 2011 ESC.</p>
3	LLW Repository Ltd shall provide the Agency with a full report of a comprehensive review of the means used to assess the activity of radionuclides in disposals and to determine compliance with this environmental permit including consideration of national and international developments in best practice. (Required by 2009)	LLW Repository Ltd provided an adequate response (LLW Repository Ltd 2009f) although we subsequently sought and received further information from LLW Repository Ltd with regards to international developments in best practice which may be relevant to the LLWR.
4	LLW Repository Ltd shall establish and carry out a programme of research and development in support of items 1, 2 and 3 in this Table. The programme and reports on the work carried out shall be provided to the Agency. (Required annually 2006 to 2010)	<p>Each year between 2006 and 2010 LLW Repository Ltd provided a report on its programme of research and development in support of the ESC (e.g. Baker 2010).</p> <p>These reports provided an acceptable response and provided a useful indication of development areas being investigated and progress against these in support of the developing ESC.</p>

Req. No.	Improvement and additional information requirement	Response summary
5	LLW Repository Ltd shall prepare a document that states how it will address the findings of the Environment Agency's review of the 2002 Environmental Safety Cases. (Required 2006)	<p>In 2006 LLW Repository Ltd provided a response (Paulley and Lean 2006), although we raised a number of concerns around the proposed approach to addressing our findings of the 2002 ESCs review. In particular we raised concerns about ownership of the cases and the issues that needed to be addressed, resources at the LLWR to deliver an updated ESC and the robustness of the proposed safety case development process (Fairhurst 2006).</p> <p>In part, as a result of concerns raised here, more regular and ongoing dialogue was established with LLW Repository Ltd with regards to the ESC development. Each of these issues was addressed to our satisfaction in the following years up to delivery of the 2011 ESC.</p>
6	LLW Repository Ltd shall update the Environmental Safety Case(s) for the site covering the period up to withdrawal of control and thereafter. (Required 2011)	The response to this requirement (the 2011 ESC) is the main subject of this report.
7	LLW Repository Ltd shall 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. A report shall be provided to the Agency of the output from that monitoring programme. (Required annually 2007 onwards)	<p>The interim cap covering the trenches and the Bentonite cut-off wall are key safety features of the facility as they help minimise discharges of radioactivity to the environment. These features are both either incomplete or interim with regards to the final site closure engineering and so this requirement sought to understand how the features were performing and may continue to perform through to final site closure.</p> <p>Reports have been provided annually as required (e.g. Jeffries 2011b). The reports identified the cut-off wall was performing well and also attempted to quantify water ingress through the interim trench cap. This evidence suggested the need for a BAT assessment with regards to the suitability of the interim trench cap over the longer term (until final closure engineering was installed) (LLW Repository Ltd 2012b).</p> <p>This work has provided a key input to the 2011 ESC and also led to a range of interim cap improvement works and further, more in depth, investigations into interim cap performance and condition. At the time of writing LLW Repository Ltd are completing further work to establish the BAT for interim protection of the trench waste.</p>
8	LLW Repository Ltd shall establish and	Adequate responses to this Requirement



Req. No.	Improvement and additional information requirement	Response summary
	implement a monitoring programme to determine the extent of groundwater contamination around the site arising from LLW disposals. A report of the programme and how the results have been used to both inform risk management options for the site and build confidence in safety assessment models, shall be provided to the Agency. (Required annually 2007 onwards)	have been provided annually (e.g. LLW Repository Ltd 2011u). LLW Repository Ltd has reported on important data used to underpin and inform the 2011 ESC. Review of this report has enabled us to monitor impacts on groundwater and to advise on expectations with regards to ongoing monitoring of groundwater.
9	LLW Repository Ltd shall develop Conditions for Acceptance (CFA) that are consistent with the assumptions made in the environmental safety cases. (Required 2006)	LLW Repository Ltd provided a response against this Requirement in 2006 indicating a number of proposed changes to the Conditions for Acceptance of Waste to ensure consistency with the ESCs (Dietzold 2006).
10	LLW Repository Ltd shall 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. (Required 2007)	LLW Repository Ltd provided a response against this Requirement in 2007 indicating key actions for the management of records associated with LLW disposal (Dietzold 2007a).
11	LLW Repository Ltd shall carry out appropriate monitoring related to Natura 2000 sites and Sites of Special Scientific Interest in west Cumbria. LLW Repository Ltd shall also carry out a comprehensive assessment of the impact of its radioactive discharges and disposals on ecosystems and wildlife species. The assessment shall use the most up to date assessment framework together with the results of relevant environmental monitoring. LLW Repository Ltd shall submit a written report to the Agency covering the monitoring and assessment. (Required 2007)	LLW Repository Ltd submitted an adequate response to this requirement in 2007 (Eden and Barber 2007). The assessment undertaken was considered an important part of any updated ESC. In responding to the information provided we made a number of detailed recommendations to LLW Repository Ltd for consideration during subsequent updates, which we indicated should be addressed no later than May 2011 when an updated ESC was required according to Requirement 6 (Fairhurst 2007).
12	LLW Repository Ltd shall ensure that all environmental systems and equipment that are required to be maintained/tested in compliance with the environmental permit are categorised, clearly labelled and are clearly identifiable within a written maintenance schedule. (Required 2007)	LLW Repository Ltd submitted an adequate response to this Requirement in 2007 (Dietzold 2007b). Procedures were implemented to identify, label and maintain relevant equipment under a new category of 'Environmental Equipment'.
13	LLW Repository Ltd shall undertake 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	LLW Repository Ltd submitted an adequate response to this Requirement in 2008 (Barber and Henderson 2008). The response was the first requirement for the operators of a radioactive waste disposal site to provide an assessment of the impacts of non-radioactive substances. A requirement for such an

Req. No.	Improvement and additional information requirement	Response summary
	the environment and provide a detailed written report to the Agency. (Required 2008)	<p>assessment became an expectation within our GRA in 2009 (Environment Agency et al. 2009) and was therefore an expectation of the updated ESC required in 2011.</p> <p>In response to the submission we made a number of comments to LLW Repository Ltd (Fairhurst 2008a and 2008b) indicating areas we expected to see improvement against before submission of an updated ESC in May 2011.</p>
14	LLW Repository Ltd shall submit a written report to the Agency that includes a detailed programme of the work that is to be carried out in the existing PCM storage facilities leading up to and including their demolition. The report shall include BPEO/BPM assessments for all waste arising during clean out, decontamination and demolition of the facilities. (Required 2007)	LLW Repository Ltd submitted an adequate response to this requirement in 2007 (LLW Repository Ltd 2007).

## 3. Meeting our requirements

LLW Repository Ltd submitted the 2011 ESC against Schedule 9 Requirement 6 of the current LLWR environmental permit (Environment Agency 2010a). This required LLW Repository Ltd to 'update the Environmental Safety Case(s) for the site covering the period up to withdrawal of control and thereafter'.

We define an ESC as, 'the collection of arguments, provided by the developer or operator of a disposal facility, that seeks to demonstrate that the required standard of environmental safety is achieved' (Environment Agency et al. 2009). In this section we provide a summary of our review of the safety case management sections of the 2011 ESC and assess whether relevant parts of the GRA have been met.

This report specifically covers how the ESC addresses four requirements within the GRA:

- Requirement R1: Process by agreement
- Requirement R2: Dialogue with local communities and others
- Requirement R3: Environmental safety case
- Requirement R4: Environmental Safety Culture and management system

It also addresses other broader areas. Each of these four requirements and other areas are discussed below in relation to the extent to which they meet the expectations of the GRA and also Schedule 9 Requirement 6 of the environmental permit.

### 3.1. Requirement R1: Process by agreement

Requirement R1 of the GRA (Environment Agency et al. 2009) states, 'The developer should follow a process by agreement for developing a disposal facility for solid radioactive waste' (GRA paragraph 5.2.3). The LLWR is not a new facility and so a process by agreement is not required, however, we have noted that elements of the process and expectations detailed within the GRA remain relevant. We welcome the fact that LLW Repository Ltd has taken the guidance into account in formulating its engagement with us and others.

We are satisfied that LLW Repository Ltd has engaged effectively with us throughout the development and review of the 2011 ESC and have enabled agreements to be established on information provision, timescales and requirements. Monthly ESC Liaison meetings with us were a major factor in facilitating this.

LLW Repository Ltd made good use of a number of documents, such as its Approaches document (Baker et al. 2008), to define how the 2011 ESC would be delivered and then implemented. The future development of the ESC has also been adequately recognised, for example within forward programmes of work (LLW Repository Ltd 2011p), an implementation plan (LLW Repository Ltd 2012a) and relevant procedures (LLW Repository Ltd 2013a). We welcome the fact that LLW Repository Ltd recognises the ESC is a 'living' case, which is key to managing the LLWR. Ongoing engagement between LLW Repository Ltd and us will be vital to ensure the continued agreement on the development and application of the ESC.

LLW Repository Ltd has defined how periodic reviews of the ESC will be carried out in agreement with us. We agree these proposals are appropriate and will require reviews as we consider necessary through any environmental permit.

In summary we consider that LLW Repository Ltd has complied consistently with the expectations detailed within Requirement R1 of the GRA. To drive continued improvement of the ESC and to make sure that the ESC continues to meet the requirements of the GRA, we have raised two recommendations associated with Requirement R1 which are summarised in Appendix 2.

### 3.2. Requirement R2: Dialogue with local communities and others

Requirement R2 of the GRA (Environment Agency et al., 2009) states, 'The developer should engage in dialogue with the planning authority, local community, other interested parties and the general public on its developing environmental safety case' (GRA paragraph 5.7.1).

LLW Repository Ltd has provided evidence of significant engagement at a number of levels such as with the NDA, UK Nuclear Waste Management Ltd, the Planning Authority, regulators, local communities, customers and a range of other local, national and international organisations such as NuLeaf<sup>8</sup>, the NDA National Stakeholder Group, government and international technical bodies (LLW Repository Ltd 2011b). We are generally satisfied that LLW Repository Ltd has adequately recognised and identified relevant stakeholders for engagement, along with relevant mechanisms and the scope of engagement (LLW Repository Ltd 2011b). However, we sought clarity on its approach to defining stakeholders through an IRF and received a response which satisfied us that its methods were robust.

Through the 2011 ESC and supporting documents, LLW Repository Ltd demonstrated that, generally, its engagement over the ESC was suitably flexible, early, ongoing, open and inclusive and that it encouraged 'challenge'. Our input to this process was adequately facilitated. We sought engagement from LLW Repository Ltd with wider national stakeholders and NGOs which led to enhancements to engagement programmes.

Overall we welcome LLW Repository Ltd's commitment to dialogue and the priority given to this area of work and consider that adequate engagement has and is being undertaken, in line with expectations detailed within Requirement R2 of the GRA. To drive continued improvement of the ESC and to make sure that the 2011 ESC and its development continues to meet the requirements of the GRA we raised two IRFs related to this requirement and made two recommendations, which are summarised respectively in Appendix 1 and Appendix 2.

### 3.3. Requirement R3: Environmental Safety Case

Requirement R3 of the GRA (Environment Agency et al. 2009) relates to the need for an environmental safety case (ESC) to support the environmental permitting of a facility for the disposal of solid radioactive waste. Our definition of an ESC is given in Section 3 above and is further described in the GRA (Environment Agency et al. 2009).

Within the 2011 ESC LLW Repository Ltd aims to make an integrated and consistent evaluation of the environmental performance of the site over the full lifetime of the LLWR. We welcome this integrated approach, but note that some inconsistencies do remain between the period of authorisation and post-closure assessment models which, although cautious in nature, are based on different assumptions (Environment Agency 2015e).

Requirement R3 of the GRA lays out expectations of what the ESC should address and refers to further chapters of the GRA (primarily chapters 4, 6 and 7) for details. Whether or not these expectations have been addressed is discussed across our ESC technical reviews (Environment Agency 2015b, 2015c, 2015d, and 2015e). However, we are satisfied that there are no significant omissions within the ESC against GRA expectations, or where these did exist they have been addressed by one of the IRFs we raised and LLW Repository Ltd responded to as part of our review.

Overall we conclude that LLW Repository Ltd has taken the expectations of the GRA into account and that the 2011 ESC represents a proportionate response. To drive continued improvement of the ESC we raised one recommendation related to Requirement R3 of the GRA, which is summarised in Appendix 2.

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<sup>8</sup> NuLeaf is the Nuclear Legacy Advisory Forum, a special interest group of the Local Government Association.

### 3.4. Requirement R4: Environmental safety culture and management systems

Requirement R4 of the GRA (Environment Agency et al. 2009) states, 'The developer/operator of a disposal facility for solid radioactive waste should foster and nurture a positive environmental safety culture at all times and should have a management system, organisational structure and resources sufficient to provide the following functions: (a) planning and control of work; (b) the application of sound science and engineering; (c) provision of information; (d) documentation and record keeping; (e) quality management' (GRA paragraph 6.2.5). We have reviewed the diverse areas this requirement covers and how they are addressed within the 2011 ESC, supported by a number of IRFs responded to by LLW Repository Ltd.

Regarding developing a positive environmental safety culture we are satisfied that LLW Repository Ltd has achieved this and that it has been adequately demonstrated through, for example, commitments stated in its EHS&Q Policy, provision of training, communications on environmental matters, events and provision of adequate environmental resource. We sought clarification through an IRF of how the LLW Repository Ltd Board supported such a culture and 'led from the top'. We were re-assured that the LLW Repository Ltd Board were adequately engaged, received and sought relevant information and were independently informed by the independent member of the Board.

We are reassured that LLW Repository Ltd's management system is well established and mature, having developed from systems previously used on the Sellafield site, but having moved on significantly since then into a stand-alone, site-specific system. We also had opportunity to audit and inspect against the system through our ongoing regulation of the site, for example a management arrangements audit carried out during 2013. These activities have provided confidence that the management system is generally effective in achieving its goals, consistent with the GRA's expectations.

We agree with LLW Repository Ltd that the management system is comprehensive and fully integrated. It is clearly documented, with requirements flowing from a top level Management System Manual through to specific site procedures and EHS&Q role and post specifications. Specific to the 2011 ESC we support the fact that specific project management arrangements were put in place during development, including a dedicated Project Team, Project Manager, Project Execution Plan and other quality, peer review and engagement procedures.

We have examined a number of specific areas regarding the management systems, including:

- Organisational structures: These were found to be clear and reasonable, providing an unbroken chain of responsibilities and accountabilities from staff through to the Managing Director and Board. We welcome the fact that the organisation was revised following a significant review in 2008, ensuring it was better aligned with its future mission and responsibilities.
- Management of change processes: These were demonstrated to be in place.
- Resourcing, competency, knowledge management and succession planning: These management processes were demonstrated to be in place, such as organisational baseline documents, succession planning and review processes. We sought re-assurance in this area regarding the maintenance of ongoing ESC knowledge and received a satisfactory response, pointing to measures taken to build strength in the ESC Project Team. However, due to the significance of this area to the ESC we have raised a number of recommendations.
- Processes to ensure learning and continuous improvement: These were in place, such as an operational experience feedback process and LLW Repository Ltd was able to provide examples where learning was applied. We consider that there will be significant learning potential from both the development of the 2002 ESCs and 2011 ESC and we raised an FI on this basis.
- Work supporting the 2011 ESC: We found that this work was suitably controlled by the Integrated Management System which has relevant accreditations to International Standards.



Also, that specific ESC documentation was in place to supplement the wider management system where relevant.

- Compliance with limits and conditions in the environmental permit: We found this area to be suitably controlled by a suite of procedures, supported by WAC and an Environmental Clearance Certificate and supporting documentation.
- Modification and change processes: We support the fact that these change processes are based on established nuclear safety case processes. We identified that relevant procedures were in place to support this, supported by an implementation plan.
- Records management: We found adequate systems to be in place, which was supported by an audit we undertook in 2011. Due to the importance of collating a comprehensive set of ESC records, many of which were generated by contractors, we raised a FI requiring that all relevant records are brought 'in-house' under the direct control of LLW Repository Ltd wherever practicable.
- Quality management: We welcome the fact that LLW Repository Ltd operates a management system accredited to relevant standards (BS EN ISO 9001:2008, BS EN ISO 14001:2004 and OHSAS 18001:2007). A reasonable programme of auditing is operated by LLW Repository Ltd. Following an IRF seeking assurance that the 2011 ESC and its development is adequately audited, further enhancements were made to this programme to make sure the ESC project and other areas, would be suitably quality assured.
- Application of sound science and good engineering practice: We are satisfied that sound science and good engineering practice has generally been employed, with demonstration of good practice in some areas. This was achieved through a number of ways such as use of suitably qualified and experienced staff, use of peer review and involvement in national and international fora. We welcome the fact that LLW Repository Ltd continues to strengthen the ESC Project Team. We do, however, consider that in some areas there has been a tendency to overly rely on model outputs and quantitative arguments in favour of qualitative arguments and have recommended that further emphasis is placed on alternative lines of argument wherever possible and beneficial.
- Passive safety: We are satisfied that LLW Repository Ltd has applied principles of passive safety as far as reasonably practicable.
- Peer review: We welcome the use of both a UK based independent peer review group process and an international peer review group. We consider the outputs of these processes to have been beneficial and support the intent to maintain peer review processes during further development of the ESC. We do, however, consider that a number of improvements could be made to the process and have made recommendations accordingly.

Overall we are satisfied that LLW Repository Ltd operates with a positive environmental safety culture and has a suitable management system in place, in accordance with Requirement R4 of the GRA. However, we noted a number of areas for potential future improvement to the ESC and processes supporting it, such that it continues to meet the requirements of the GRA. We have therefore raised a number of IRFs, recommendations and FIs related to this Requirement, which are summarised in Appendix 1, Appendix 2 and Appendix 3 respectively.

### 3.5. Other areas

This report has addressed a number of other broader areas that are not necessarily directly related to a specific GRA Requirement, but which are all relevant to the production of an ESC. Some of these issues are summarised below.

The GRA details expectations that a clear ESC is made and provides guidance on the content. We consider that the presentation and structure of the 2011 ESC is logical and generally well laid out. Overall the 2011 ESC was sufficient and comprehensive enough to complete our review, subject to the provision of further information in a number of areas, as requested through IRFs (Environment Agency 2015f). However, we did find some shortfalls such as discrepancies, unclear audit trails and the need to trace some evidence back beyond key Level 3 documents. We anticipate that significant learning can be gained for the next major ESC update from the development of the 2011 ESC, its implementation and feedback on it.



We examined the approach LLW Repository took to developing the 2011 ESC. In 2008 an approach to developing the 2011 ESC was documented by the company which we found suitable and consistent with the requirements of the GRA.

The GRA is not prescriptive in terms of specifying how an ESC should describe and substantiate the environmental safety functions provided by each part of the system. We consider that the information presented in the 2011 ESC is sufficient to meet the GRA. However, we believe that a safety function approach would have explained more clearly the roles and performance requirements of the various components of the disposal system and how they contribute to the overall safety of the facility. We recommend that this approach is used in future updates to the ESC.

Managing uncertainties is a necessary and important part of establishing the ESC. During our review we found a number of shortfalls in LLW Repository Ltd's identification and management of uncertainties, although overall we concluded that the requirements of the GRA had been adequately met for this stage in the operating life of LLWR. The prime means of managing uncertainties is a FEP and uncertainty tracking system. To make sure our identified shortfalls are addressed we raised a number of recommendations and a FI. For example, we expect further work to link the forward programme of work to identified uncertainties, development of more systematic processes for the identification of uncertainties and improvements to the reporting of elicitation processes.

We expect an ESC to continue to develop as a live case with ongoing major reviews and to this end we expect a forward programme of work to be developed. A high-level forward programme of work was presented in the 2011 ESC and further detail provided following an IRF seeking this information. Related to this, LLW Repository Ltd also prepared a forward engineering programme to address necessary engineering developments. We consider that the requirements of the GRA have been adequately met; noting that we believe there is scope to refine the level of detail provided and correlation with commitments within the 2011 ESC and other documentation. Furthermore, any forward programme should take account of our recommendations, FIs and requirements we have raised as part of our 2011 ESC review and our environmental permitting process. We raised an FI to this effect.

We have considered how the 2011 ESC has advanced and taken account of learning from the 2002 ESCs. We have concluded that the 2011 ESC presents a more coherent and much improved case for the continued operation of the LLWR. LLW Repository Ltd should continue to ensure that learning from the previous assessments, in particular examples of best practice, are carried through to future ESCs.

The 2011 ESC primarily addresses the reference disposal area (RDA), Vaults 8 to 14 and presents a separate assessment for the extended disposal area (EDA), Vaults 15 to 20. We understand the reasons for this presentation, and the discrepancy between the 2011 ESC and environmental permit variation application, but it has led to some loss of clarity in the safety case overall. We encourage LLW Repository Ltd to make sure that future updates to the ESC are presented in a more integrated manner.

We expect WAC to be managed in line with the latest ESC assessments. LLW Repository Ltd has done this and as a result proposed a number of changes to the WAC. We consider that the proposed changes are consistent with the assumptions made in the 2011 ESC and subsequent updates and will be sufficient to achieve acceptable doses and risks to people and the environment. A 'sum of fractions' approach to managing radiological capacity over the lifetime of the site has been proposed and we believe it has been appropriately implemented within the WAC. We welcome further controls proposed on higher activity particulate materials and discrete items which we believe are appropriate. We have, however, identified a number of areas where recommendations or FIs have been raised to seek ongoing improvements to the robustness and implementation of the WAC.

Where there is a divergence between updates to the WAC proposed in the 2011 ESC and the WAC implemented in March 2014, the latter are more conservative and remain consistent with the environmental permit currently in force. We are satisfied that LLW Repository Ltd has put in place adequate plans to implement the WAC and associated procedures.

Broader aspects of the 2011 ESC must also be effectively implemented on site, such as change control procedures, operational procedures and tools, addressing stored waste and engineering development. We are satisfied that LLW Repository Ltd has demonstrated that these requirements will be met through a broad implementation plan and the implementation of key procedures. We will continue to review the implementation of these measures during our routine regulatory activities.

### 3.6. Summary

An update to the 2011 ESC for the site covering the period up to withdrawal of control and thereafter was submitted to the timescales required by Schedule 9 Requirement 6 of the environmental permit. The 2011 ESC addressed each of the Requirements of the GRA with no major omissions and we therefore consider that the environmental permit requirement was adequately met.

We consider that LLW Repository Ltd has adequately addressed the parts of the GRA of relevance to safety case management.

There are a number of areas, as discussed in Section 2 and summarised in Appendices 2 and 3, where we consider further improvements can be made to make sure the ESC continues to meet the requirements of the GRA.

## 4. Conclusions

LLW Repository Ltd submitted the 2011 ESC against Schedule 9 Requirement 6 of the current LLWR environmental permit. We consider that, in the 2011 ESC, LLW Repository Ltd demonstrates that it has and continues to operate adequate management systems, including: procedural arrangements, approaches to the development of the ESC, ESC implementation arrangements, mechanisms for continued improvement and engagement with local communities and regulators. Additionally, within this report we considered a number of broader areas relevant to the entire 2011 ESC and found demonstration of adequate understanding and approaches. This demonstration is consistent with achieving an appropriate level of environmental safety at the LLWR now and in the future.

The 2011 ESC submission is of good quality and proves clear and concise in the areas addressed by this safety case management report. GRA requirements are generally directly addressed with evidence and further supporting evidence was readily traced. We expect this standard to be maintained and improved on in future iterations of the ESC. However, for some of the broader, cross-topic areas of the ESC, we found the level of detail in Level 1, Level 2 and key Level 3 documents was in some cases insufficient to allow us to trace the ESC arguments between reports. We needed to review other documents, not included in the original 2011 ESC submission, to obtain sufficient information for our assessment.

We consider that LLW Repository Ltd has addressed the requirements of the GRA relating to the safety case management area in sufficient depth for us to complete our assessment of the 2011 ESC. However, to achieve this we needed further information in a number of areas, although LLW Repository Ltd provided this information to our satisfaction. Additionally, we identified a number of areas for potential future improvement of the ESC. These improvement areas are highlighted in our recommendations and FIs and we expect LLW Repository Ltd to demonstrate progress against these.

This safety case management report reviews a broad range of management issues which span the production of the 2011 ESC from start to finish and its implementation, as well as forward programmes of work and procedures aimed at keeping the ESC up to date and to make sure the site is effectively managed in line with it. We were able to gain confidence in this area of work though our engagement with LLW Repository Ltd and routine regulation of the LLWR. This is an ongoing area of work that will require continued attention from LLW Repository Ltd to make sure the ESC remains up-to-date and is effectively implemented and communicated.

It is apparent that LLW Repository Ltd operates a mature and well established management system and that this has been effectively applied to the development of the 2011 ESC. The approach to the development of the ESC has been reasonable and well thought through. Communication with stakeholders and regulators has been generally good throughout. Noting there are many decades yet before proposed final closure engineering is implemented, the expectations of an ESC, as detailed within the GRA, have been met to a reasonable standard. We believe this represents a major step forward from the previous 2002 ESCs. LLW Repository Ltd has demonstrated that the 2011 ESC is supported by a positive environmental safety culture and strong leadership. Resources and succession planning arrangements are adequate to maintain and continue to enhance the ESC, but as noted in the report we believe this is one area of vulnerability that LLW Repository Ltd should actively monitor. We are satisfied that a range of broad issues that affect the whole ESC have been adequately addressed, although we consider there are areas where continued improvements are necessary, for example regarding the structured management of uncertainties identified within the ESC and the use of safety function approaches to support it.

Overall, regarding the topic areas addressed in this report, we consider that LLW Repository Ltd has met the requirements of the GRA and Schedule 9 Requirement 6 of the current LLWR environmental permit through the 2011 ESC and supporting documents. This evidence is of a suitable standard and quality to support an environmental permit decision on future disposals at the site.

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## 6. Appendix 1 - Issue Resolution Forms

### 6.1. Introduction

As outlined in Section 1.3, Issue Resolution Forms (IRFs) are detailed records of concerns and queries raised as part of our review of the ESC. Each IRF includes one or more actions. LLW Repository Ltd was required to provide a substantive response to the action(s) specified on the IRF by the specified date(s). Issues were only closed out when we had determined that the LLW Repository Ltd response adequately addresses the issue.

### 6.2. Safety Case Management Issue Resolution Forms

Summaries of Regulatory Issues (RIs), Regulatory Observations (ROs) and Technical Queries (TQs) raised during our review of the 2011 safety case management work are provided in Table 2, Table 3 and Table 4 respectively. These IRFs are reproduced in full in Environment Agency (2015f). The IRFs are not sequentially numbered. This is because some IRFs were identified as possible queries but not issued, for example, following further detailed review of information provided in support of the 2011 ESC, or following on from clarifications provided by LLW Repository Ltd. All IRFs have now been closed.

**Table 2 Regulatory Issues**

Regulatory Issue number	Title	Summary
<b>ESC-RI-SCM-001</b>	Maintenance of ESC expertise and knowledge	We asked LLW Repository Ltd to provide a robust plan of how it will ensure the continual availability to the Site Licence Company of adequate up-to-date expertise and knowledge to maintain, interpret and periodically update the ESC.
<b>ESC-RI-SCM-001b</b>	Maintenance of ESC expertise and knowledge	We asked LLW Repository Ltd to provide further evidence on: <ul style="list-style-type: none"><li>• Maintenance of live baseline skills understanding.</li><li>• Efforts to maintain access to necessary contractor skills.</li><li>• Recognition of risks associated with the use of PBO reachback resources.</li><li>• The recognition of the importance of ESC skills within management systems</li></ul>
<b>ESC-RI-SCM-002</b>	Engagement with national stakeholders	We asked LLW Repository Ltd to provide a plan of action on how it will engage in dialogue with a broader set of national and local stakeholders. The plan should cover activities up to and during any environmental permit variation consultation and determination.

**Table 3 Regulatory Observations**

Regulatory Observation number	Title	Summary
<b>ESC-RO-SCM-001</b>	Change control for the ESC	We asked LLW Repository Ltd to provide a programme detailing how it will develop and achieve a robust change control process for the ongoing management of the ESC and its relationship to site operations. Then to demonstrate delivery of a robust change control process, captured within written management arrangements, for the ongoing management of the ESC and its relationship to site operations.
<b>ESC-RO-SCM-002</b>	Ensuring continuing consistency between bulk waste properties and ESC assumptions	We asked LLW Repository Ltd to consider establishing quantitative trigger levels to flag changes in bulk properties of waste being disposed of at the LLWR that could potentially lead to waste masses with characteristics inconsistent with ESC assumptions.
<b>ESC-RO-SCM-003</b>	Internal scrutiny of ESC project	We asked LLW Repository Ltd to review ESC audit arrangements and present a plan demonstrating that internal auditing fully takes account of the ESC project.
<b>ESC-RO-SCM-004</b>	Long-term management of ESC related records	We asked LLW Repository Ltd to prepare a plan of how it intends to apply records management procedures to all ESC records so as to comply with LLWR procedures and environmental permit requirements.
<b>ESC-RO-SCM-005</b>	Forward work programme on the ESC	We asked LLW Repository Ltd to provide a future work programme addressing work that will be carried out to support the developing ESC through to site closure.

**Table 4 Technical Queries**

Technical Query number	Title	Summary
<b>ESC-TQ-SCM-001</b>	Board involvement in promoting environmental safety	We asked LLW Repository Ltd to provide further evidence of the LLW Repository Ltd Board actively driving a positive environmental culture, promoting environmental performance and monitoring outcomes.
<b>ESC-TQ-SCM-002</b>	Risk of Tsunami affecting the LLWR	We asked LLW Repository Limited to provide a clear and substantiated statement of its position concerning the possibility and likely scale of any tsunami impacting the LLWR over the site's lifetime.
<b>ESC-TQ-SCM-</b>	Establishing the	We asked LLW Repository Ltd to provide a

Technical Query number	Title	Summary
<b>003</b>	scope of the 'local community'	description of how its stakeholder list was developed and demonstrate that it is appropriate to the scale and scope of the development being proposed.



## 7. Appendix 2 - Recommendations

### 7.1. Introduction

Recommendations raised as a result of our review of the 2011 ESC represent areas where we see scope for possible improvement or development, but which are relatively minor in nature relative to FIs. As a matter of good practice we expect LLW Repository Ltd to address these recommendations and will expect a mechanism to be put in place to track them.

### 7.2. Safety case management recommendations

Table 5 summarises the recommendations made in this report. Further details are provided in Section 2.

**Table 5 Safety case management recommendations**

Recommendation number	Summary of recommendation
<b>SCM1</b>	LLW Repository Ltd should consider continuation of regular ESC Liaison meetings to support development of future updates to the ESC.
<b>SCM2</b>	LLW Repository Ltd should continue to make efforts to maintain engagement with a wide range of potentially interested parties throughout the period of operation of the site.
<b>SCM3</b>	LLW Repository Ltd should provide support to consignors to understand the background to any changes to its WAC, their meaning and appropriate ways to help ensure compliance and adoption of good practice.
<b>SCM4</b>	To ensure transparency, LLW Repository Ltd should make sure that the audit trail of all documentation supporting the current ESC is clearly signposted, dating back to the publication of the 2011 ESC in May 2011.
<b>SCM5</b>	LLW Repository Ltd should aim, as far as possible, to achieve a position in any future ESC submission where all information necessary to 'make the case' is presented within the main tiers of documentation, without the need for us to request further information.
<b>SCM6</b>	Future updates of the ESC should aim to make fuller use of alternative lines of reasoning wherever reasonable to do so.
<b>SCM7</b>	Over the operational period of the site we expect to see elicited data supplemented and supported by empirical data (site and, where appropriate, experimental data) wherever practical and beneficial to do so.
<b>SCM8</b>	LLW Repository Ltd should continue to review the future scenarios that it considers within the ESC, continuing to focus on 'important' areas, but also considering other scenarios such as, for example, delayed coastal erosion, which must be considered proportionately.
<b>SCM9</b>	LLW Repository Ltd should continue to regularly review and update the management system with a view to tailoring it to the specific requirements of the site, to rationalise it where possible, to adapt to new processes such as the implementation of the ESC and to continue to make improvements based on learning.
<b>SCM10</b>	LLW Repository Ltd should be cautious in its reliance on PBO reachback support.

Recommendation number	Summary of recommendation
<b>SCM11</b>	LLW Repository Ltd should pay particular attention to the maintenance of skills and capabilities associated with maintenance and implementation of the ESC, ensuring adequate defence in depth and succession planning is in place.
<b>SCM12</b>	Continuing efforts should be made to ensure access to relevant contractor skills and capabilities which may only be required on a periodic basis.
<b>SCM13</b>	LLW Repository Ltd should define and use strict definitions of relevant terms used for records management of different record types (for example data, information, knowledge, understanding).
<b>SCM14</b>	LLW Repository Ltd should continue to engage with the NDA's Information Management Compliance Programme, but at the same time to make sure an LLWR specific long-term records management strategy is developed, which meets the needs of the LLWR, considering issues such as the need for long-term retention of data local to the LLWR site, how long-term records will be linked to the site and its end-use in the longer-term (post-closure) and how the strategy is made compatible with any wider NDA long-term records storage solution. LLW Repository Ltd will need to engage with NDA to make sure any centralised repository of nuclear site information can meet the possible needs for local information to support the site's end-state.
<b>SCM15</b>	LLW Repository Ltd should maintain a watching brief on improved methods of records management from national and international experience and consider how it can best use these means.
<b>SCM16</b>	LLW Repository Ltd should review records management associated with all ESC records, following completion of the ESC and its initial implementation
<b>SCM17</b>	Within future ESC submissions LLW Repository Ltd should consider inclusion of information on key assessment models and codes used in the ESC, addressing model selection and assurance measures, so as to provide confidence in the quality assurance procedures applied. Also to provide better information on interactions between computer models and the transfer of model output between different models; good practice would include provision of an assessment model flowchart or similar.
<b>SCM18</b>	Within future iterations of the safety assessment, data management forms should record all data used in the assessment calculations to maintain a transparent audit trail.
<b>SCM19</b>	The future peer review process should consider provision of the peer review group's response to LLW Repository Ltd's response to their comments. This would ensure transparency of all findings and demonstrate that all findings have been closed to both LLW Repository Ltd's satisfaction, and ideally also the peer review group.
<b>SCM20</b>	A peer review tracking system should be an addition to the peer review process, to demonstrate that actions resulting from the peer review process have been carried forward and closed.
<b>SCM21</b>	The recommendations of the peer review group should be taken into account in the ESC forward programme.
<b>SCM22</b>	LLW Repository Ltd should consider adoption of a safety function approach within future iterations of the ESC.
<b>SCM23</b>	If LLW Repository Ltd considers that conceptual uncertainty is not important

Recommendation number	Summary of recommendation
	to the ESC, then an argument to this effect should be presented.
<b>SCM24</b>	Consideration should be given to inclusion of a section in the overall register of significant uncertainties devoted to alternative lines of reasoning.
<b>SCM25</b>	The elicitation process only deals with parameter uncertainty. Parallel exercises would be useful to deal with modelling uncertainties, conceptual uncertainties and scenario uncertainties.
<b>SCM26</b>	LLW Repository Ltd should make sure that areas of good practice from the previous assessments (for example, the 2002 ESCs) are carried through to future ESCs.
<b>SCM27</b>	LLW Repository Ltd should make sure that future iterations of the ESC are fully representative of the proposals being made and that the ESC assesses the entirety of the proposals in a consistent manner.
<b>SCM28</b>	LLW Repository Ltd should continue to develop its asbestos assessment in line with national developments in contaminated land and landfill disruption assessment.
<b>SCM29</b>	LLW Repository Ltd should consider use of the definition of 'explosive' in our guidance on definition and classification of hazardous waste of 'substances and preparations which may explode under the effect of flame or which are more sensitive to shocks or friction than dinitrobenzene'.
<b>SCM30</b>	Within its organisation, LLW Repository Ltd should ensure clear ownership of the WAC as well as ESC Project Team input to changes driven by non-ESC considerations (for example, transport requirements).
<b>SCM31</b>	LLW Repository Ltd should make sure it is satisfied that consignor systems are capable of providing an appropriate level of characterisation through provision of instruction, guidance and audit.
<b>SCM32</b>	LLW Repository Ltd should initiate work to enable an informed choice to be made between possible future institutional control strategies.
<b>SCM33</b>	LLW Repository Ltd should clarify and substantiate whether, during the period of active institutional control, it is envisaged that maintenance and remediation will be carried out routinely, or whether remediation will only be carried out in the event that a significant deterioration in performance is detected.
<b>SCM34</b>	LLW Repository Ltd should consider the final land use of the site such that it can be ensured it is compatible with the final cap design, the wider ESC and assessment of habitats.
<b>SCM35</b>	Maintaining detailed knowledge and tools or assessing safety performance, as well as retaining appropriate records must be an active feature of the management of the site through to the end of active institutional control and beyond.
<b>SCM36</b>	Skills maintenance throughout the period of active institutional control will be required; this is a challenging issue and we would expect to see documentation dealing with this topic as part of a future ESC suite.
<b>SCM37</b>	LLW Repository Ltd should continue to look at how its implementation of the ESC can be improved and enhanced. In particular we recommend that, with the implementation of new and revised WAC, LLW Repository Ltd considers the adequacy of the checks it completes on waste transfers to the site to confirm that consignors have adequately interpreted and met the new

Recommendation number	Summary of recommendation
	requirements and have provided all the necessary waste information associated with those transfers.

## 8. Appendix 3 - Forward Issues

### 8.1. Introduction

Forward Issues (FIs) raised as a result of our review of the 2011 ESC represent areas that we believe require, or could benefit from, further work or clarification in the future.

FIs are categorised in terms of the importance of the issue (for example the scope for improvement of the ESC against the GRA) and likely effort required to address the issue (Table 6).

**Table 6 FI categories**

Category	Priority	Explanation
<b>A1</b>	More important, shorter term	<p>An issue that is expected to be important in supporting the delivery of an acceptable update of the ESC in the future and where we believe there is a need to address the issue well in advance of the next major ESC update.</p> <p>LLW Repository Ltd is likely to need to provide substantial additional information, or to significantly change approach. We expect plans to be put in place to address these issues and ongoing reports on progress. Such reporting might, for example, include detailed plans of action, descriptions of proposed approaches, models or data, or results from interim or provisional analyses.</p>
<b>A2</b>	More important, long-term	<p>An issue that is expected to be important in supporting the delivery of an acceptable update of the ESC in the future, but where this improvement can be delivered over relatively long timescales.</p> <p>LLW Repository Ltd is likely to need to provide substantial additional information, or to significantly change approach. We expect ongoing but infrequent reports on progress with these issues. Such reporting might, for example, include detailed plans of action, descriptions of proposed approaches, models or data, or results from interim or provisional analyses.</p>
<b>B1</b>	Important, shorter-term	<p>Issues of less importance than category 'A'. LLW Repository Ltd will need to provide some additional information, evidence or analysis well in advance of the next major ESC update. Plans should be put in place to deliver this information. Generally we estimate the level of effort needed to address this category of issue will be substantially less than for category A. We expect reports on progress with these issues, but with less emphasis than for Category A.</p>
<b>B2</b>	Important, long-term	<p>Issues of less importance than category 'A'. LLW Repository Ltd will need to provide some additional information, evidence or analysis, but over relatively long timescales or as part of the next ESC update. Generally we estimate the level of effort needed to address this category of issue will be substantially less than for category A. We expect only infrequent reports on progress with these issues and with less emphasis than for</p>

Category	Priority	Explanation
		Category A.
<b>C</b>	Additional evidence / improvements in approach	Of lesser importance but of value in improving the ESC. Issues where we require limited reporting or information in advance of any updated ESC.

We will agree with LLW Repository Ltd when and how it intends to address these issues, and will track progress made to resolve them.

## 8.2. Forward Issues

A summary of FIs raised during our review of the 2011 ESC safety case management work is provided in Table 7. FIs are reproduced in full in Environment Agency (2015g).

**Table 7 Safety case management Forward Issues**

Forward Issue number	Title	Categorisation	Summary of issue
<b>ESC-FI-001</b>	Cap settlement issues	A1	LLW Repository Ltd should develop and implement a work programme to identify an optimised cap design and container stack heights.
<b>ESC-FI-004</b>	Forward programme	A1	LLW Repository Ltd should further develop and update its forward programme of work to make sure there is continued improvement of the ESC.
<b>ESC-FI-005</b>	Use of monitoring to reduce uncertainties in the ESC	B1	LLW Repository Ltd to collate and integrate monitoring objectives, strategies and procedures in a single document so as to provide evidence of how the forward monitoring programme will be implemented and developed throughout the period of authorisation and linked to the ESC to reduce uncertainties.
<b>ESC-FI-008</b>	Management of uncertainty	A2	LLW Repository Ltd should further develop the FEPs and uncertainty tracking system (or alternate tools) as a tool to manage uncertainty in the ESC and feed into the forward programme.
<b>ESC-FI-012</b>	Use of probabilistic calculations in derivation of radiological capacity	A2	LLW Repository Ltd should consider update of the probabilistic groundwater pathway assessment model and as appropriate recalculate radiological capacity calculations based on the expectation value of



Forward Issue number	Title	Categorisation	Summary of issue
			the model output.
<b>ESC-FI-017</b>	Radiological capacity calculations	B1	LLW Repository Ltd should explore the relationship between disposed inventory and dose or risk to determine the suitability of the linear relationship assumption. Particular emphasis should be placed on C-14. If required, outputs should be fed into the WAC.
<b>ESC-FI-020</b>	Development of a new Low Level Waste Tracking System	A1	LLW Repository Ltd should develop a new waste tracking system that is fit for purpose for future waste tracking.
<b>ESC-FI-021</b>	Learning from development of the ESC	B1	LLW Repository Ltd should undertake a review of learning from the development of the 2002 and 2011 ESCs, so as to inform future major reviews of the ESC.
<b>ESC-FI-022</b>	Active Management of ESC Records	C	LLW Repository Ltd should make sure all ESC related records are actively managed.
<b>ESC-FI-023</b>	Leachate management strategy	A1	LLW Repository Ltd should produce a leachate management strategy that demonstrates the application of BAT to the management of leachate during the period of authorisation. The company should also investigate long-term leachate drainage performance, degradation and failure mechanisms.
<b>ESC-FI-024</b>	Gas management strategy	A2	LLW Repository Ltd should establish and implement a programme of work to develop a gas management strategy and infrastructure, including collection of necessary monitoring data, for the period of authorisation.
<b>ESC-FI-025</b>	Protection of waste prior to final capping	A1	LLW Repository Ltd should develop and implement a programme of work to develop an optimised container design and restoration sequence that provides adequate protection to waste containers and minimises discharges to the environment.
<b>ESC-FI-026</b>	Engineering	A1	LLW Repository Ltd should develop and implement the

Forward Issue number	Title	Categorisation	Summary of issue
	delivery		<p>engineering forward programme to finalise the as-built design so as to allow further construction to begin. This programme should include:</p> <ul style="list-style-type: none"> <li>• an engineering R&amp;D programme</li> <li>• an engineering performance monitoring programme</li> <li>• the scoping of a proportional Engineering Performance Assessment framework for use in future updates to the ESC</li> </ul>
<b>ESC-FI-027</b>	Cap performance assessment	A1	LLW Repository Ltd should undertake further assessment of the performance of the capping system, including consideration of potential failure scenarios. Where appropriate, the company should incorporate the outcome of the investigations into the repository engineering design and updates to the ESC.
<b>ESC-FI-029</b>	Management of elicited data	C	LLW Repository Ltd should develop documented procedures for the future management of elicited data.

# List of abbreviations

<b>ALARA</b>	As low as reasonably achievable
<b>BAT</b>	Best available techniques
<b>BIOPROTA</b>	An international collaboration in biosphere research for radioactive waste disposal
<b>BNFL</b>	British Nuclear Fuels Limited
<b>BNGSL</b>	British Nuclear Group Sellafield Limited
<b>BPEO</b>	Best practicable environmental option
<b>BPM</b>	Best practicable means
<b>CFA</b>	Conditions for acceptance
<b>COSR</b>	Continued operation safety report
<b>Defra</b>	Department for Environment, Food and Rural Affairs
<b>DISPONET</b>	International Low Level Waste Disposal Network
<b>DRINK</b>	DRlgg Near field Kinetic (model)
<b>EDA</b>	Extended disposal area
<b>EDTA</b>	Ethylene diamine tetra-acetic acid
<b>EH&amp;S</b>	Environment, Health & Safety
<b>EHS&amp;Q</b>	Environment, Health, Safety and Quality
<b>EPR10</b>	Environmental Permitting (England and Wales) Regulations 2010, as amended
<b>ESC</b>	Environmental safety case
<b>FEP</b>	Features, events and processes
<b>FI</b>	Forward issue
<b>GRA</b>	Guidance on requirements for authorisation (of near-surface disposal facilities on land for solid radioactive wastes)
<b>GRM</b>	Generalised Repository Model
<b>HAZOPs</b>	Hazard & operability studies
<b>IAEA</b>	International Atomic Energy Agency
<b>IAF</b>	Issue assessment form
<b>IPRG</b>	International peer review group
<b>IRF</b>	Issue resolution form
<b>ISD</b>	Independent safety director
<b>ISO</b>	International Standards Organization
<b>LLW</b>	Low level waste
<b>LLWR</b>	Low Level Waste Repository near Drigg, Cumbria

<b>LLWTS</b>	Low level waste tracking system
<b>LTP</b>	Lifetime Plan
<b>MEHSC</b>	Management Environment, Health and Safety Committee
<b>NDA</b>	Nuclear Decommissioning Authority
<b>NEA</b>	Nuclear Energy Agency of the OECD
<b>NGO</b>	Non-governmental organisation
<b>NNL</b>	National Nuclear Laboratory
<b>NTA</b>	Nitrilotriacetic acid
<b>NuLeAF</b>	Nuclear Legacy Advisory Forum
<b>NWAT</b>	Nuclear Waste Assessment Team
<b>OEF</b>	Operating experience feedback
<b>OESC</b>	Operational environmental safety case
<b>OHSAS</b>	Occupational Health and Safety Advisory Service (standard)
<b>ONR</b>	Office for Nuclear Regulation
<b>PBO</b>	Parent body organisation
<b>PCM</b>	Plutonium contaminated material
<b>PCSC</b>	Post-closure safety case
<b>PRG</b>	Peer Review Group
<b>QA</b>	Quality Assurance
<b>R&amp;D</b>	Research and development
<b>RI</b>	Regulatory issue
<b>RO</b>	Regulatory observation
<b>RSA 93</b>	Radioactive Substances Act 1993 (as amended)
<b>RSP</b>	Repository site procedure
<b>SCM</b>	Safety case management
<b>SLC</b>	Site Licence Company
<b>SUE</b>	Site understanding and evolution
<b>Sv</b>	Sievert
<b>TQ</b>	Technical query
<b>WAC</b>	Waste acceptance criteria
<b>µSv</b>	Microsievert

# Glossary

Term	Definition
<b>Active institutional control</b>	Control of a disposal site for solid radioactive waste by an authority or institution authorised under EPR10, involving monitoring, surveillance and remedial work as necessary, as well as control of land use.
<b>Activity</b>	In radioactive-decay processes, the number of disintegrations per second, or the number of unstable atomic nuclei that decay per second in a given sample.
<b>Assessment code</b>	A computer code used to assess the performance of some aspect of a system.
<b>Basal drainage layer</b>	A granular drainage layer located below the base of the vault.
<b>Best available techniques (BAT)</b>	The latest stage of development (state of art) of processes, of facilities or of methods of operation which indicate the practical suitability of a particular measure for limiting discharges, emissions and waste.
<b>Calculation case</b>	A calculation case is a specified combination of events, circumstances, conditions or their evolution, including specification of model boundary conditions and data, which represents a particular realisation of the disposal system, its evolutions and radionuclide or contaminant release, migration and exposures. A large number of cases may be required to adequately explore aspects of, or uncertainties within, a scenario. Where the meaning is clear the abbreviated term, 'case', is used.
<b>Cap</b>	Engineered layer covering waste in the trenches and vaults to limit the amount of water entering the disposed waste and minimise the risk of intrusion from human and animal activities.
<b>Chelating agents</b>	A chelating agent is a substance whose molecules can form several bonds to a single metal ion.
<b>Compartment flow model</b>	A compartment-based numerical model of the LLWR near field used to calculate groundwater flows through the near field.
<b>Complexant</b>	'Complexing agents' are chemicals that can bind strongly to metal ions and significantly increase their solubility or decrease their ability to sorb onto solids. They may be an individual atom, molecule or functional group that binds to metal with one or more bonds. The bonding may be ionic or coordinate bonds.
<b>Conceptual model</b>	A set of qualitative assumptions used to describe a system, or part of a system, in the real world.
<b>Conservative (of assumptions and data)</b>	Cautious in the sense that impacts would be overestimated.

<b>Consignor (of waste)</b>	An organisation or person that sends waste to the repository.
<b>Consignment</b>	A consignment is a container or item of waste sent by a waste producer (consignor) to a disposal facility (such as LLWR).
<b>Criticality</b>	A condition in which a sufficient quantity of fissile material is assembled in the right arrangement for a self-sustaining neutron chain reaction to take place.
<b>Differential settlement</b>	Different settlement between two adjacent stacks in the vaults or between adjacent locations of waste in the trenches.
<b>Discrete items</b>	Discrete items are distinct items of waste that may in future be recognisable as unusual or not of natural origin and so could be a focus of curiosity or interest and potentially recovered, recycled or re-used by persons.
<b>Disposal</b>	Disposal is the emplacement of waste in a specialised land disposal facility without intent to retrieve it at a later time; retrieval may be possible but, if intended, the appropriate term is storage.
<b>Dose guidance level (for human intrusion)</b>	In the context of near-surface disposal facilities, the dose standard against which the radiological consequences of human intrusion are assessed. It indicates the standard of environmental safety expected but does not suggest that there is an absolute requirement for this level to be met.
<b>Dose rates</b>	The radiation dose (dosage) absorbed per unit of time.
<b>Effective dose</b>	The sum of the equivalent doses from internal and external radiation in all tissue and organs of the body, having been weighted by their tissue weighting factors. The unit of effective dose is the sievert (Sv).
<b>Elicitation</b>	A structured process in which a group of experts are brought together to derive logical theoretical outcomes or to solve problems.
<b>Emplacement</b>	The placement of a waste package in a designated location for disposal, with no intent to reposition or retrieve it subsequently.
<b>Emplacement strategy</b>	A strategy to control the locations in which certain waste streams and waste consignments are emplaced in the vaults. For example, not placing certain waste in the upper levels of stacks in the vaults in order to reduce the probability of inadvertent human intrusion into such waste. An emplacement strategy may be necessary to meet dose constraints and dose guidance levels, or it might be an optimisation measure to minimise the environmental impact of disposals to the LLWR.
<b>Engineered barrier</b>	A barrier that is designed to protect from human intrusion into disposed waste and minimise the release of contaminants, both radiological and non-radiological, from the disposal facility, consequently minimising the dose to humans and non-human biota.



<b>Engineering performance assessment (EPA)</b>	An evaluation of engineered system degradation and associated failure mechanisms.
<b>Environmental permit</b>	A permit issued under the Environmental Permitting (England and Wales) Regulations 2010.
<b>Environmental safety</b>	The safety of people and the environment both at the time of disposal and in the future.
<b>Environmental safety case (ESC)</b>	The collection of arguments, provided by the developer or operator of a disposal facility, that seeks to demonstrate that the required standard of safety for people and the environment, both at the time of disposal and in the future, will be achieved.
<b>Environmental safety functions</b>	The various ways in which the components of the disposal system may contribute towards environmental safety.
<b>Environmental safety strategy</b>	An approach or course of action designed to achieve and demonstrate environmental safety.
<b>Extended disposal area (EDA)</b>	An extended area of the repository, beyond but including the Reference Disposal Area, which is considered in the 2011 ESC to be sufficient to dispose of all waste requiring vault disposal in the United Kingdom Radioactive Waste Inventory.
<b>Features, events and processes (FEPs)</b>	Any factors that may influence the disposal system.
<b>Fissile</b>	Fissile material is material capable of sustaining a nuclear fission chain reaction. By definition, fissile material can sustain a chain reaction with neutrons of any energy (as opposed to 'fissionable' material requiring high-energy neutrons).
<b>Forward issue (FI)</b>	Areas of work that we believe it is important for LLW Repository Ltd to progress as part of its forward improvement plan. Areas where we see scope for continued improvement in the ESC and its implementation.
<b>Geological strata</b>	A geological stratum is a layer of sedimentary rock that has characteristics that distinguish it from other layers.
<b>Geosphere</b>	The geological formations and subsurface environment through which radionuclides may migrate.
<b>Groundwater</b>	Water which is below the surface of the ground in the saturated zone and in direct contact with the ground or subsoil.
<b>Human intrusion</b>	Any human action that accesses the waste or that damages a barrier providing an environmental safety function after the period of authorisation.
<b>Infiltration</b>	The process in which a fluid passes into the pores of a solid.
<b>ISO freight container</b>	A steel container built to standard dimensions defined by the International Standards Organization (ISO), which can be loaded and unloaded, stacked and transported efficiently over long distances without being opened. Currently, most wastes intended for disposal in the vaults at LLWR are placed in half-height ISO containers licensed for LLW

transport. The 2011 ESC assumes that this will continue to be the case.

**Issue assessment form (IAF)**

Issues raised during our review of the 2002 ESCs, which the operators of the LLWR were required to address as part of the development of the 2011 ESC.

**Issue resolution form (IRF)**

A template form used to record and track issues raised as part of the 2011 ESC review, along with their resolution. Each form provides a record of concerns or questions along with one or more actions for LLW Repository Ltd. LLW Repository Ltd recorded or summarised its response on the form, which was then reviewed by the Environment Agency and closed when a satisfactory response was received.

**Leachate**

Any liquid which has been in contact with wastes. Leachate is collected in the base of vaults and trenches and arises as a result of the infiltration of rainwater or groundwater.

**Lifetime Plan**

NDA requires each Site Licence Company to produce a Lifetime Plan for the site. The Lifetime Plan is usually updated every five years. The Lifetime Plan describes all the activities in terms of scope, schedule and cost to be undertaken on the site in the remaining period of its lifecycle until it is closed.

**Low level waste (LLW)**

In government policy, low level waste is defined as 'radioactive waste having a radioactive content not exceeding four gigabecquerels per tonne ( $\text{GBq te}^{-1}$ ) of alpha or  $12 \text{ GBq te}^{-1}$  of beta/gamma activity'. It consists largely of paper, plastics and scrap metal items that have been used in the nuclear industry, hospitals and research establishments. In future, there will also be large volumes of LLW in the form of soil, concrete and steel, as existing nuclear facilities are decommissioned.

**Monitoring**

Taking measurements so as to be aware of the state of the disposal system and any changes to that state. This may include measuring levels of radioactivity in samples taken from the environment, and also measuring geological, physical and chemical parameters that are relevant to environmental safety and which might change as a result of construction of the disposal facility, waste emplacement or closure.

**Near field**

In the context of the assessments in support of the LLWR ESC, the near field consists of the waste and engineered barriers.

**Operational environmental safety case**

The 2002 ESC submitted by LLW Repository Ltd was split into two parts, the first being the operational environmental safety case, which addressed matters of environmental safety during the period of authorisation.

**Optimisation**

Optimisation is the principle of ensuring that radiation exposures are as low as reasonably achievable (ALARA) in the given circumstances. It is a key principle of radiation protection recommended by the International Commission on Radiological Protection (ICRP) and incorporated into UK legislation.

**Organic**

A class of chemical compounds that include carbon within their structure.

<b>Pathway</b>	A route or means by which a receptor could be, or is exposed to, or affected by a contaminant. Four pathways are considered in the 2011 LLWR ESC: groundwater, gas, natural disruption (coastal erosion) and human intrusion.
<b>Peer review</b>	A formally documented examination of a technical programme or specific aspect of work by a suitably qualified expert or group of experts who have not been directly involved in the programme or aspect of work.
<b>Period of authorisation</b>	The period of time during which disposals are taking place and any period afterwards while the site is under active institutional control.
<b>Post-closure safety case</b>	The safety case presented as part of the ESC that covers the time after the end of the period of authorisation.
<b>Radioactivity</b>	The emission of alpha particles, beta particles, neutrons and gamma or x-radiation from the transformation of an atomic nucleus.
<b>Radiological capacity</b>	An inventory of radioactive material that the facility is capable of accepting based on the ESC.
<b>Radionuclide</b>	An unstable form of an element that undergoes radioactive decay.
<b>Receptor</b>	Something that could be adversely affected by a contaminant, such as people, an ecological system, property or water body.
<b>Reference design</b>	The engineering design arrived at through optimisation studies within the 2011 ESC. It is used as the basis for detailed assessments of facility performance and radiological and non-radiological impacts within the 2011 ESC.
<b>Reference disposal area (RDA)</b>	The disposal area including the trenches and Vaults 8 to 14.
<b>Regulatory issue (RI)</b>	An issue raised in an issue resolution form during our review of the 2011 ESC where deficiencies in the case were identified. An RI is a deficiency sufficiently serious that, unless or until it is resolved, we will either: (a) not grant a permit; or (b) grant a permit constrained by major limiting conditions (as distinct from information or improvement conditions) defined by us to mitigate the consequences of the RI.
<b>Regulatory observation (RO)</b>	An issue raised in an issue resolution form during our review of the 2011 ESC where deficiencies in the case were identified. An RO is a deficiency not sufficiently serious to prevent us issuing a permit but sufficiently serious that, unless or until it is resolved, we will include an improvement or information condition in the permit requiring defined actions on defined timescales to resolve it (or to demonstrate suitable and sufficient progress towards resolving it).
<b>Retardation</b>	A measure of the reduction in solute velocity relative to the velocity of the flowing groundwater caused by processes such as adsorption.

<b>Risk guidance level</b>	A level of radiological risk from a disposal facility that provides a numerical standard for assessing the environmental safety of the facility after the period of authorisation.
<b>Scenario</b>	One of several possible descriptions of the evolution of the disposal facility and its surroundings from the time of site closure as a result of natural and human-induced, events and processes.
<b>Sievert (Sv)</b>	The International System of Units (SI) unit of effective dose, obtained by weighting the equivalent dose in each tissue in the body with ICRP-recommended tissue-weighting factors, and summing over all tissues. Because the Sievert is a large unit, effective dose is commonly expressed in milli-Sieverts (mSv) – that is, one thousandth of one Sievert, and micro-Sievert (µSv) – that is, one thousandth of one milli-Sievert.
<b>Site Licence Company</b>	The legal entity (LLW Repository Ltd) that operates the LLWR on behalf of the Nuclear Decommissioning Authority (NDA).
<b>Sum of fractions</b>	An approach to setting limits on the total quantities and specific activity of radionuclides that may be disposed of at a radioactive waste repository. The approach is based on derivation of values of radiological capacity for each assessment case and for each radionuclide. A key characteristic of the approach is that it addresses the additive contributions of different radionuclides to overall impacts.
<b>Technical query (TQ)</b>	An issue raised in an issue resolution form during our review of the 2011 ESC where deficiencies in the case were identified. TQs are the least significant of the issues raised and represent a deficiency not sufficiently serious for us to require defined action by LLW Repository Ltd but sufficiently significant that we would request action.
<b>Trench</b>	A trench is an excavation in the ground into which loose waste was tumble tipped.
<b>Uncertainty</b>	Lack of certainty. A state of limited knowledge that precludes an exact or complete description of past, present or future.
<b>Variant cases</b>	Alternative calculation cases that are defined to investigate the effect of uncertainty in FEPs on the risk and dose calculations.
<b>Vault</b>	A space constructed of reinforced concrete base slabs and walls where wastes are emplaced.
<b>Waste acceptance criteria (WAC)</b>	Quantitative and qualitative criteria, specified by the operator of a disposal facility, for solid radioactive waste to be accepted for disposal. WAC form part of the set of waste acceptance arrangements that ensure the safety of waste disposal at the site.
<b>Waste Consignment Variation Form</b>	A form that customers complete when seeking agreement to vary a condition within LLW Repository Ltd's Waste Acceptance Criteria.

**Waste form**

The waste and its immediate packaging (for example grout and container) that is disposed of at the LLWR.

**Waste stream**

Waste streams are designated in the UKRWI to summarise waste or a collection of waste items at a particular site, usually in a particular facility or from particular processes or operations. A waste stream is often distinguishable by its radioactive content and, in many cases, also by its physical and chemical characteristics.

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