



Low Level Waste Repository

LLWR Environmental Safety Case

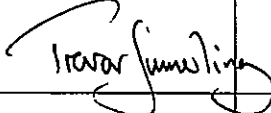
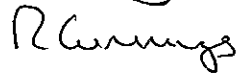

Status of the Environment Agency's "Issue Assessment Forms" (IAFs) February 2009

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LLWR/ESC/R(09)10012

Issue 1

Date: March 2009

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LLWR Environmental Safety Case

Status of the Environment Agency's “Issue Assessment Forms” (IAFs) – February 2009

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LLWR/ESC/R(09)10012

Issue 1 – 4th March 2009

EXECUTIVE SUMMARY

Background

The current Authorisation for disposal of radioactive waste at Low Level Waste Repository (LLWR) was issued to the then site licence company (BNG Sellafield Ltd.) by the Environment Agency with an effective date of 1st May 2006. This followed a review of the previous Authorisations and was informed by a review of BNFL's 2002 Operational Environmental Safety Case (OESC) and the Post-Closure Safety Case (PCSC).

During the review of the 2002 OESC and PCSC, the Agency's technical review teams produced "Issue Assessment Forms" (IAFs) that provide detailed comments on aspects of the PCSC and OESC and recommendations for actions and work by BNFL and also by the Agency. A report issued in October 2006 described the programme of work developed by the SLC to address the issues associated with the 2002 safety cases and the resulting Authorisation, and the assessment of the issues was updated in reports of March 2007 and December 2007.

Aim of this report

The aim of this report is to make a comprehensive re-assessment of the IAFs and corresponding technical recommendations, and how they have been addressed or will be addressed in the programme of work leading to the Environmental Safety Case (ESC) that the SLC will present to the Agency by 01 May 2011 – the 2011 ESC.

The assessment is timely in view of

- significant progress on supporting work within the ESC Project;
- experience gained during the development of submissions to the Environment Agency; and
- the development of a detailed programme of work leading to the 2011 ESC.

In particular, the re-assessment points to the direction of future work that is expected to satisfy many of the issues, as summarised in our recent report "*Technical Approach to the 2011 Environmental Safety Case*" (Baker et al., 2008a).

Method and recording of the re-assessment

The re-assessment has been made returning to the original comments and recommendations compiled by the Agency's technical review teams and taking account of our current understanding, experience and forward programme.

The Appendix to this report presents tables containing recommendations to the SLC extracted from the IAFs compiled by each of the Agency's twelve technical review groups.

In the appendix tables, responses are made against each of the recommendations. The responses:

- consider the foundation and/or current applicability of each recommendation and state any disagreement with the review team recommendations;
- identify work already completed that satisfies the recommendation, or identify work planned in support of the 2011 ESC that we consider will satisfy the recommendation;
- refer to documents that outline our approach to the topic in the 2011 ESC.

An evaluation of the status of each recommendation is then stated based on the above comments and responses.

Section 2 of this report gives a summary evaluation of the issues within each of the Agency's technical review group areas, based on the more detailed responses given in the appendix tables.

Final remarks

We consider that our re-assessment of the IAF recommendations shows that actions to satisfy the recommendations to the extent that we consider appropriate are already complete or in hand within the planned work leading to the 2011 ESC.

Our aim is to establish a common understanding and confidence with the Agency on the sufficiency of the 2011 ESC and its underpinning. We therefore value feedback especially as to where the Agency feels that we have satisfactorily addressed the issues and where not. Thus, through dialogue with the Agency, we can identify the further work that may be required to produce an ESC that is acceptable and fit for purpose.

This report and our recent report "*Technical Approach to the 2011 Environmental Safety Case*" (Baker et al., 2008a) are complementary. Both reports are submitted to the Agency as a basis for dialogue.

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1 INTRODUCTION

1.1 Background

The Low Level Waste Repository (LLWR) is the UK's principal facility for the disposal of solid low-level radioactive waste (LLW). The site is owned by the Nuclear Decommissioning Authority (NDA) and operated on behalf of the NDA by a Site Licence Company (SLC), the LLW Repository Ltd., which is owned by United Kingdom Nuclear Waste Management (UKNWM) Ltd.

The LLWR operates under the terms of Authorisations issued by the Environment Agency for England and Wales (the Agency).

The current Authorisation (Environment Agency, 2006a) was issued to the then SLC (BNG Sellafield Ltd.) with an effective date of 1st May 2006. This followed a review of the previous Authorisations for the site and was informed by a review of BNFL's 2002 Operational Environmental Safety Case (OESC) and the Post-Closure Safety Case (PCSC) (BNFL, 2002a & 2002b).

The Agency's review findings are summarised in the Agency's Authorisation review Explanatory Document (Environment Agency, 2005) and Decision Document (Environment Agency, 2006b), and are described in detail in a separate technical report (Environment Agency, 2005b). During the review of the 2002 OESC and PCSC, the Agency's technical review teams produced "Issue Assessment Forms" (IAFs) that provide detailed comments on aspects of the PCSC and OESC and recommendations for actions and work by BNFL and also by the Agency.

The Agency's findings led to specific requirements placed upon the LLWR SLC, as given in Schedule 9 of the current Authorisation. In particular, Requirement 5 states that within six months of the effective date of the Authorisation:

"The Operator shall prepare a document that states how it will address the findings of the Environment Agency's review of the 2002 Environmental Safety Cases."

This requirement was fulfilled by report issued by BNFL in October 2006 (Paulley and Lean, 2006). This described the programme of work developed by the SLC to address the issues associated with the 2002 environmental safety cases and the resulting Authorisation. The programme of work was termed the 'Lifetime Project' (now called the Environmental Safety Case Project) and supports the LLWR Lifetime Plan. The report showed how the Lifetime Project would address the findings of the Agency's review, and also a number of wider site and Nuclear Decommissioning Authority (NDA) requirements. The report also presented an assessment of the status of each IAF based on the understanding and information available at the time.

Subsequently, the status of IAFs has been updated taking account of progress within the Project in reports issued in March 2007 (Grimwood, 2007) and December 2007 (Lean, 2007). These updates provide an incremental assessment of status based on the evaluation methodology set out in the first status report.

1.2 Aim of this report

The aim of this report is to make a comprehensive re-assessment of the IAFs and corresponding technical recommendations, and how they have been addressed or will be addressed in the programme of work leading to the Environmental Safety Case (ESC) that the SLC will present to the Agency by 01 May 2011 – the 2011 ESC.

The assessment is timely in view of

- significant progress on supporting work within the ESC Project;
- experience gained during the development of recent submissions to the Environment Agency; and
- the recent development of a detailed programme of work leading to the 2011 ESC.

In particular, the assessment points to the direction of future work that is expected to satisfy many of the issues, as summarised in our recent report “*Technical Approach to the 2011 Environmental Safety Case*” (Baker et al., 2008a). Thus, this report and the “*Technical Approach*” report are complementary.

1.3 Method for the current assessment

The re-assessment has been made returning to the original comments and recommendations compiled by the Agency’s technical review teams and taking account of our current understanding, experience and forward programme. We have re-examined the comments and evaluations made under each IAF, focussing on the “Recommendations to BNFL”.

We recognise that the recommendations relate primarily to actions that the Agency’s technical review teams considered necessary to complete or develop the 2002 OESC and PCSC or underpinning work and methods. In undertaking the current assessment of issues, we are most concerned with ensuring that equivalent comments will not apply to the 2011 ESC. That is, although the immediate comment may no longer be directly applicable, we seek to draw out any more general issue that should be addressed in the 2011 ESC. On the other hand, some of the recommendations can be considered superseded, either because of changes in our technical understanding or approach (e.g. the focus on shorter timescales due to expected erosion of the LLWR within a period of a few thousand years), or because of changes in the applicable regulatory guidance (e.g. changes in the requirements set in the environment agencies new Guidance on Requirements for Authorisation (GRA) (environment agencies, 2008 & 2009)).

The Appendix to this report presents tables containing recommendations extracted from the IAFs compiled by each of the Agency's twelve technical review groups, see Table 1.

Table 1: Agency's technical review groups	
Core Group	Geosphere
Biosphere	Near-field
Cap	OESC
Assessment Codes	Parameters
Disruptive Events	Radiological Capacity
Gas	Site Development and Engineering

In the appendix tables, responses are made against each of the recommendations. The responses:

- consider the foundation and/or current applicability of each recommendation and state any disagreement with the review team recommendations;
- identify work already completed that satisfies the recommendation, or identify work planned in support of the 2011 ESC that we consider will satisfy the recommendation;
- refer to documents that describes our approach to the topic in the 2011 ESC. In particular, we refer to sections of the *“Technical Approach to the 2011 Environmental Safety Case”* (Baker et al., 2008a).

An evaluation of the status of each recommendation is then stated based on the above comments and responses. The evaluations describe the issue status in terms such as:

- accepted, partly accepted or rejected.

Then, if accepted or partly accepted:

- satisfied by work completed since 2002, or
- work in hand or planned leading to 2011 ESC.

In some cases issues are considered to be:

- no longer relevant.

The basis for the evaluations are given in the tabulated responses or further comments as needed.

In the first pass through the issues, a few issues were identified as “outstanding issues”, meaning that it was not clear whether the issue had been fully addressed, or was being addressed in the forward work programme. This led to focus on these issues and, in a few cases, recognition that additional attention or emphases needed to be placed on the issues in work leading to the 2011 ESC or presentation of the ESC.

2 SUMMARY EVALUATION OF THE ISSUES

This section gives a summary evaluation of the issues within each of the Agency’s technical review group areas, based on the more detailed responses given in the corresponding appendix sections.

2.1 Core Group

Since 2002, key developments with respect to the issues examined by the Core Group have included:

- formation of the NDA as owner of the UK’s civil nuclear sites and associated liabilities on behalf of the Government;
- formation of the LLW Repository Ltd as SLC for the low-level waste repository near Drigg and subsequent competitive tendering and award of the management of the site on behalf of the NDA;
- issue and consultations on the environment agencies’ draft GRA for near-surface disposal facilities (environment agencies, 2008) and also on the Health Protection Agency advice on radiological protection objectives (HPA, 2008) and issue of the new GRA for near-surface disposal facilities (environment agencies, 2009);
- LLWR submissions under Schedule 9 of our Authorisation, especially under Requirement 2, which indicate our current level of understanding of the facility and site, management options and updated view on post-closure impacts (Baker, 2008; Baker et al., 2008b; Randall, 2008; Shevelan, 2008; Sumerling, 2008).
- development of a lifetime plan setting out the work plan leading to the 2011 ESC and issue of a report indicating our approach to the 2011 ESC (Baker et al., 2008a).

We appreciate many of the Core Group review comments and to a large degree they have already been incorporated into our work already completed and work leading to the 2011 ESC. In particular:

- We agree the importance of coastal erosion as a scenario for the LLWR. Disruption by coastal erosion will form part of our expected evolution of the site in the 2011 ESC with consequently greater focus on the impacts of erosion.

- We are developing an improved method for estimating radiological capacity taking account of all wastes at the site and the scale over which disposals can give rise to doses and risk via different scenarios.
- We have already examined a broader range of risk management options for the site and are planning a further exercise to further define and examine the options for the future management of the site. One input to this will be a detailed study of the benefits, practicalities and costs of selective retrievals from the trenches.
- We agree the importance of making a presentation of risk from all pathways or cases, but consider it informative and practical to keep the evaluation of different pathways separate. We will provide overall risk estimates for pathways to which the risk target applies.
- We are planning to make improvements in our demonstration of a multiple factor safety case taking account of guidance in Chapter 8 of the revised GRA, for example considering safety functions.
- We will be proposing an alternative, simpler approach to FEP management more directly linked to models and the treatment of uncertainty.
- We accept that probabilistic calculations have an important role, especially to explore uncertainty, and we are planning to undertake probabilistic calculations of risk as part of the 2011 ESC for key pathways. We consider, however, that deterministic calculations of consequence, and estimates of probability, can yield estimates of risk suitable for comparison with the GRA guidance level and may be appropriate in some cases.
- We will undertake a balanced mix of deterministic and probabilistic calculations, which will both be needed to explore the repository performance and illustrate the effect of uncertainties.
- We have appointed an independent peer review panel and implemented an improved approach to peer review of the safety cases and supporting work such that peer review will be an ongoing activity during the development of the 2011 ESC.
- We will support the NDA and the National Strategy team within the LLWR in their development of the NDA LLW National Strategy and Plans that will identify a future role for the LLWR.

We disagree, however, on one key point. We do not agree that disruption of the facility by erosion or any other mechanism constitutes “unacceptable loss of containment” and we reject the comments that the threat to due coastal erosion is incompatible with the principles of sustainability or precaution. Rather, we consider that the nature of near-surface disposal at any site is that the disposed material will at some time in the future be exposed and distributed in the biosphere by natural processes, human actions or both. Hence, the waste disposed must be such that at times when this could happen and taking account of possibilities for how it might happen, doses and risk are acceptably low, i.e. comparable to the risk and dose guidance levels specified in the GRA.

We therefore assess the Core Group issues and recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
COR_027	COR_001, COR_009	COR_002, COR_003 COR_004/5/6 COR_008, COR_010 COR_011, COR_013 COR_014, COR_015 COR_016, COR_018 COR_019, COR_020 COR_021, COR_022 COR_024, COR_025 COR_026, COR_028	

There are no issues COR_007, 012, 017, 023.

2.2 Biosphere

Since 2002, key developments with respect to assessment of the biosphere have included:

- a firmer understanding of coastal processes and the potential for erosion of the Cumbrian coast (Halcrow, 2008);
- consideration of alternative global CO₂ production scenarios and consequent sea level rise to define a range of scenarios for coastal development and erosion at the LLWR site (Thorne and Kane, 2007).

This work leads to the conclusion that the site will be eroded within a period a few thousands of years and therefore our assessment of the biosphere for the 2011 ESC will focus (although not exclusively) on the period up to 5000 years AP. The underpinning work has addressed several issues. The conclusion that attention should be focussed on a shorter timescale reduces the impact of other issues. We are undertaking some further work on coastal erosion in view that this now forms the expected evolution for the site, see section 5.9 in the “Technical Approach” report (Baker et al. 2008a).

We have carried out work to define potentially exposed groups (PEGs) giving consideration to the environments into which contaminants may emerge, and assign habits taking account of local and regional habit data and more general data compilations (Thorne, 2007), which addresses several issues. For the 2011 ESC, we will be taking an alternative simplified approach to issues of FEP management, see section 5.3.3 in (Baker et al. 2008a).

We disagree with the Biosphere review group on the level of detail required for biosphere assessment and the connection to present-day local land use and habits. We agree with the NS-GRA position that a cautiously stylised representation is more appropriate to take account of uncertainties in future natural conditions and human behaviour. Hence, we reject or partially reject a number of recommendations.

We also disagree with the Biosphere review group's interpretation of the Requirement 4 on environmental radioactivity in the previous GRA (environment agencies, 1997), and hence reject some recommendations. We note that the equivalent requirement in the new NS-GRA (Environment agencies, 2009), Requirement R10, calls for assessment of the impact on non-human species; we have carried out such an assessment (Eden and Barber, 2007).

We therefore assess the Biosphere review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
BIO_001.1 / 1.2 / 1.3	BIO_006.4 / 6.5	BIO_002.1	
BIO_002.2 / 2.3	BIO_007.1	BIO_003.3 / 3.4	
BIO_003.1 / 3.2	BIO_008.1	BIO_004.1 / 4.2	
BIO_007.2	BIO_009.1	BIO_005.1 / 5.2	
BIO_011.2 / 11.3 / 11.5	BIO_011.1 / 11.4	BIO_006.1 / 6.2 / 6.3	
BIO_012.1 / 12. 2			
BIO_013.1 / 13.2			

There was no recommendation under BIO_010.

2.3 Cap

Since 2002, the cap design has been updated (Belton, 2007) and calculations of infiltration and erosion have been reconsidered. Thorne (2008) provides more detail on predicted cap erosion rates over the lifetime of the site taking into account settlement. Paksy (2008) provides an update of the engineering performance assessment and the expert elicited values taking into account the work on predicted cap erosion rates and the updated cap design. The design of the cap will be optimised and expert elicited values will be reviewed and updated as part of the 2011 ESC.

The site-scale groundwater model uses the predicted infiltration rate over the area of the cap and is designed to allow the sensitivity of the model results to variations in cap performance to be assessed as part of the 2011 ESC.

Gas migration through the cap has been addressed as part of the Schedule 9 Requirement 2 submission (Sumerling, 2008) and is considered in more detail as part of our response to the Gas review group recommendations.

The reduced time to expected disruption of the site by coastal erosion means there is no longer a significant influence of assumed natural erosion rates on human intrusion scenarios, although the potential vulnerability of the cap margins will need to be considered in the 2011 ESC.

We therefore assess the Cap review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
CAP_004.1	CAP_001.1	CAP_001.2 CAP_002.1 / 2.2 CAP_003.1 / 3.2 CAP_005.1 / 5.2	

2.4 Assessment Codes

There has been a significant change in approach since the 2002 PCSC. We no longer propose to use GRM and GEO for assessment calculations (although we may use DRINK, based on GRM, for certain supporting calculations), but rather to base our case on the use of relatively simpler and more easily understood and justified assessment models.

We therefore assess the Assessment Codes review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
COD_007		COD_004	

No recommendations arose from the other COD IAFs.

2.5 Disruptive Events

Several of the disruptive events review group recommendations call for further work on risk management in view of the relatively high, calculated doses and conditional risks from human intrusion, coastal erosion and non-human biotic intrusion. Since 2002, a general consideration of risk management options is reported in Edwards and Alexander (2005), and this has been extended by more detailed work on each of the more promising options as summarised in our submission against Schedule 9 Requirement 2, Volume 2 (Baker et al., 2008b).

Largely as a result of the former study a re-design of the cap was undertaken (Belton, 2007). As well as reducing infiltration, the re-designed cap provides more robust protection against natural processes, including biotic intrusion, and provides a thicker protective cover over the wastes to lower the likelihood of inadvertent human intrusion into the waste. Options for

protection of the site against coastal erosion have been considered (Towler, 2008), but we believe that effective coastal defences would require periodic re-building as sea level rises, and continuing maintenance, and this cannot be presumed.

Based on the work on coastal processes (Halcrow, 2008) and scenarios for future climate change, sea-level rise and land form development (Thorne and Kane, 2007), we now consider disruption by coastal erosion within a period of a few thousand of years to be the most likely evolution and the reference assessment end point for the site. Hence, for the 2011 ESC we will put increased attention on the assessment of coastal erosion, and we are planning further work to examine the relevant processes and their specific impacts on the LLWR, see section 5.9 in (Baker et al., 2008a).

We consider that the thicker cap and shorter assessment timeframe reduces the likelihood of inadvertent human intrusion into the waste, relative to the assessed situation in 2002, but accept that scenarios of intrusion into the waste must still be assessed in the 2011 ESC, consistent with the NS-GRA.

Prior to 2002, a formal expert elicitation study identified possible developments and events at the site taking account of patterns of land use on the West Cumbrian Coastal Plain (Thorne, 1996). This was followed by a report (Halcrow, 1998) that considered how each of the common site uses would be implemented if the presence of a repository at the LLWR site were to be forgotten. We are revisiting these studies and will include a list of human activities and events that could affect the site in the 2011 ESC, and set out screening arguments for those that are not taken forward. Thus, a more balanced discussion and presentation will be developed of the uncertainties around the impacts of possible human actions at the site, see section 5.10 in (Baker et al., 2008a).

Work has been done on the heterogeneity of disposals to the Trenches (Lennon, 2008), which provides a basis for an assessment of the influence of heterogeneity of disposals on impacts from coastal erosion and from human intrusion of the Trenches. Such an assessment will be made as part of a detailed consideration of selective retrievals, see section 4.3 in (Baker et al., 2008a).

We therefore assess the Disruptive Events review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
DIS_002.2	DIS_002.1	DIS_001.1 / 1.2	
DIS_005.2	DIS_004.2	DIS_003.1 / 3.2	
	DIS_005.1	DIS_004.1	
	DIS_006.1	DIS_006.2 / 6.3	
		DIS_007.1	

2.6 Gas

Since 2002, key developments with respect to assessment of the gas pathway have included:

- a review of gas pathway taking account of Trench monitoring data, the origin of C-14 bearing waste and potential for association with degradable organics (Ball et al., 2008);
- a re-consideration of the calculation of exposure due to radon in a dwelling constructed on excavated waste/spoil and adoption of an empirical model relating radon levels to radium levels in the underlying ground (Sumerling, 2008).

The former (Ball et al., 2008) has increased our confidence in the assessment of C-14 and demonstrated the importance of understanding the physico-chemical form of the C-14 in disposed waste. Further work is planned on both the form of the C-14 in disposed waste and the modelling of its release from Trench and Vault conditions including the effect of waste innovations, see sections 3.1, 4.2 and 5.8.1 in “Approach to 2011 ESC” (Baker et al. 2008a).

The latter (Sumerling, 2008) has set out a better founded and more robust approach to assessing the potential levels of radon from Ra-226 disposals. Further work is planned to improve the empirical model utilising the extensive data sets held by the HPA concerning radon in UK dwellings. The situation of a building development that pierces the cap but does not disturb the waste is also being evaluated, as described in section 5.8.2 in “Approach to 2011 ESC” (Baker et al. 2008a).

We will be considering the merits of probabilistic calculations for assessment of both C-14 labelled gases and radon. We note, however, that a probabilistic approach is only warranted if justified probability density functions can be defined for the key parameters, see section 5.4 in “Approach to 2011 ESC” (Baker et al. 2008a).

We therefore assess the Gas review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
GAS_001.2	GAS_003.1 / 3.2	GAS_001.1 GAS_002.1 / 2.2 / 2.3 GAS_003.3 to 3.9	

2.7 Geosphere

A substantial programme of work has been carried out since 2002 to provide a better understanding and representation of the geosphere. The current site understanding is summarised in Shevelan (2008).

The programme has included the re-evaluation of the geological understanding and the development of a 3D geological model for the site (Hunter et al., 2007; Smith, 2007). The

Vault 9 excavation works have provided a valuable opportunity to be able to observe the structure of the drift deposits and compare it with the geology predicted from borehole data.

Work has also continued to provide a better definition of the uncertainty in the geological and hydrogeological system (Serco 2008a) and investigate the possibility of implementing a stochastic representation of the hydrogeological properties.

The hydrogeological conceptual model (Henderson 2008) for the site has been updated in light of both continued monitoring and the development of a site-scale 3D hydrogeological model for the site (Henderson et al 2008). Further work to refine the hydrogeological model is planned to provide the information on potential groundwater pathways for the 2011 ESC.

The environmental monitoring programme for the site has been designed to provide the hydrogeological data required for the 2011 ESC. Additional geological and hydrogeological data would also be obtained from the proposed off-site boreholes.

All the work is seen as contributing to the understanding of the site and forms the basis for further development and planned work to address the issues raised by the review group.

We assess the Geosphere review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
GEO_003.6	GEO_001.1 to 1.3	GEO_001.4	
GEO_004.1 / 4.2	GEO_002.1	GEO_002.2 /2.3	
GEO_009.1	GEO_003.3 / 3.5 / 3.9	GEO_003.1/ 3.2/ 3.7/ 3.8	
GEO_016.2	GEO_006.1 / 6.2 / 6.4	GEO_005, GEO_006.3	
GEO_021	GEO_016.1	GEO_007, GEO_008,	
	GEO_019	GEO_009.2 / 9.3	
	GEO_022	GEO_010, GEO_011	
		GEO_013, GEO_015	
		GEO_016.3 / 16.4	
		GEO_017, GEO_018,	
		GEO_023, GEO_024	

No additional recommendations arose from GEO_012, 014 and 020.

2.8 Near-field

Since the 2002 PCSC, the following areas of work have been taken forward:

- Work to understand the impact of spatial variability in the near field, which continues;

- Developing a model for the release of uranium from the key trench wasteform, based on the dissolution rate of magnesium fluoride;
- Review of near field and gas assessment models and the development of updated approaches. This work continues;
- Reviews of the impacts of colloids and superplasticisers and a recent review of the colloids work programme;
- Updating our understanding of the evolution of the near-field barriers based on argument and recorded judgment.

Of particular importance is the changed approach to assessment calculations. We intend to use relatively simple approaches based on the use of the program GoldSim, supported by more detailed underlying models. DRINK (based on GRM) will no longer be used as an assessment model, but as a tool to understand the impacts of chemical and physical processes at a more detailed level. We envisage that estimates of the impact of carbon-14 will be based on a better understanding of the distribution and form of the inventory, on assumptions concerning the timescale of gas evolution and monitoring data, rather than on uncertain microbiological models. In our view, this change in approach requires a re-evaluation of some of the recommendations of the Near-field review group.

There have also been a number of general developments in assessment methodology, which are relevant to consideration of the Near-field review group recommendations (see section 2.1); these include the planned review of FEPs and the implementation of probabilistic calculations for certain pathways.

We assess the near-field review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
NRF_007.6, NRF_010.1, NRF_011, NRF_012.2 / 12.3 NRF_013.3 / 13.4 / 13.5 NRF_016, NRF_017.2 NRF_018.2, NRF_019	NRF_010.2;	NRF_001, NRF_002 NRF_003, NRF_004 NRF_005, NRF_006 NRF_007.1 to 7.5 NRF_008, NRF_009, NRF_012.1; NRF_013.1 / 13.2 NRF_014, NRF_015 NRF_017.1, NRF_018.1	

2.9 OESC

In 2002, the OESC and PCSC were presented as two separate cases. The aim of the 2011 ESC is to make an integrated and consistent evaluation of the environmental performance over the full lifetime of the LLWR (see Section 5.2, Baker et al. 2008). However, the emphasis of the safety arguments during the period of authorisation (construction, operation and closure) and period thereafter (post-closure) will be different.

During the period of authorisation, a key safety case argument will be that the site is monitored and managed so that releases will be acceptably low. This will include the following considerations and arguments:

- Good practice is used to limit the releases from the facility by limiting the inflows to the repository and collecting, managing and treating the leachate arising.
- A suite of boreholes is regularly monitored for the release of chemotoxic and radioactive contaminants to groundwater.
- The generation of gas is also monitored and arrangements are in place to ensure that this gas is vented to atmosphere.
- Cautious models will be developed of the release of contaminants from the facility consistent over the periods of operation, closure and post-closure.

Although we appreciate the comments made by the OESC review group, some of the recommendations were at a relatively detailed level and are not relevant in light of our planned integration of the OESC and PCSC. Others are either satisfied by work completed since 2002 or planned for the 2011 ESC. The issue of quality and data management is an area in which we are currently working to define a suitable system for both OESC and PCSC requirements.

We assess the OESC review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
OESC_007.1 / 7.2	OESC_001.1	OESC_003.1 / 3.2	
OESC_009.2	OESC_005.3	OESC_004.1	
OESC_010.1 / 10.2	OESC_008.1	OESC_005.1 / 5.2 / 5.4	
OESC_011.1 / 11.2	OESC_009.1	OESC_006, OESC_007.3	
OESC_012.2 / 12.3 / 12.4		OESC_009.3	
		OESC_011.3	
		OESC_012.1 / 12.5 to 12.8	

No recommendations were made under OESC_002.

2.10 Parameters

Since the 2002 PCSC, several changes have occurred which will be reflected in the 2011 ESC:

- the increased emphasis on coastal erosion and reduced importance of the discharge to 'emergent land' case;
- increased emphasis on the well scenario for which geosphere paths are short allowing less influence of geosphere sorption and dispersivity;
- adoption of an empirical model for radon in a dwelling, avoiding the need for some parameters.

This leads to many of the Parameters review group recommendations being judged as no longer relevant or rejected.

We assess the Parameters review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
PAR_002, PAR_003 PAR_004.2, PAR_006 PAR_007.1 / 7.3 PAR_008.1 / 8.3	PAR_001, PAR_004.1 PAR_008.2	PAR_005 PAR_007.2 PAR_009	

2.11 Radiological Capacity

One IAF (RAD_001) addressed radiological capacity issues. We have totally revised the approach that to radiological capacity. In this sense, many of the comments have been superseded. However, the key points that are raised by the Environment Agency review will be addressed in our revised methodology (see Baker et al. 2008a).

We assess the Radiological Capacity review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
RAD_001.1 c		RAD_001.1 a, b, d to h	

2.12 Site Development and Engineering

In the 2002 PCSC the assessment had to consider the performance of the site engineering over 60,000 years. A conclusion from the expert elicitation process, however, was that the engineering could not be relied on beyond 10,000 years. Under the updated climate and landform change scenarios, the site will be destroyed by coastal erosion within a few thousands of years. In this shorter period the engineering is considered to still have a significant influence on the movement of water through the site.

The work by Thorne (2008) illustrates that the engineered cap design will maintain its core integrity over the lifetime of the facility, even taking into account the effects of erosion and settlement, limiting infiltration into the waste. Paksy (2008) presents the updated engineering performance assessment model and details of the expert elicitation process that has been undertaken to derive property values over the lifetime of the repository. Further work is planned to underpin the parameter selection and ensure that they are justifiable, consistent with each other and the predicted evolution of the site.

The role of the engineering in the performance of the site will be assessed as part of the 2011 ESC. The assessment will consider the overall performance of the engineering components and consider whether the design can be further optimised.

A study of the inventory by Wareing et al. (2008) has delivered a significant improvement in the understanding of the distribution of radionuclides in the trench disposal from the disposal records, the nature of the waste streams and National Inventory. The work is considered sufficient to mean that intrusive investigations are not considered to be necessary. Further work is underway to interview current and past employees about disposal practices to add confidence to the derived inventory.

A study of the feasibility and cost of selective retrievals that contribute most to assessed post-closure impacts is currently underway.

We assess the Site Development and Engineering review group recommendations as follows:

No longer relevant or rejected	Satisfied by work completed since 2002	In hand or planned for the 2011 ESC	Outstanding issues
SDE_005.2 SDE_007.2 / 7.3	SDE_001.2 SDE_006.1 SDE_008.5	SDE_001.1, SDE_002 SDE_003, SDE_004 SDE_005.1 / 5.3 / 5.4 SDE_006.2 /6.3 SDE_007.1 / 7.4 / 7.5 SDE_008.1 / 8.2 / 8.3 / 8.4 / 8.6	

3 FINAL REMARKS

We consider that our assessment of the IAF recommendations shows that actions to satisfy the recommendations to the extent that we consider appropriate are already complete or in hand within the planned work leading to the 2011 ESC. Our position in each of the twelve technical areas is summarised in Section 2 and detailed responses are given in the Appendix to this report.

Our aim is to establish a common understanding and confidence with the Agency on the sufficiency of the 2011 ESC and its underpinning. We believe that the present document is important in demonstrating our commitment to consider each of the issues, judge their importance and relevance to the ESC, and deal with them appropriately. We value feedback, however, especially as to where the Agency feels that we have satisfactorily addressed the issues and where not. Thus, through dialogue with the Agency, we can identify the further work that may be required to produce an ESC that is acceptable and fit for purpose.

This report and our recent report "*Technical Approach to the 2011 Environmental Safety Case*" (Baker et al., 2008a) are complementary. Both reports are submitted to the Agency as a basis for discussion.

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APPENDIX 1: REVIEW GROUP RECOMMENDATIONS AND LLWR RESPONSES
Core Group issues

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
COR_001	Independence of Safety from Control	<p>No recommendations, <i>however</i>:</p> <p>The Core Group (CG) was concerned over the possibility of disruption of the site by coastal erosion, related uncertainties, and statements in the 2002 PCSC indicating that credit might be taken for coastal defences. This would be inconsistent with GRA Principle 1.</p>	<p>More recent work on climate change and coastal erosion (Thorne and Kane 2007) has confirmed the likelihood of disruption of the site by coastal erosion.</p> <p>We agree that coastal defences are unlikely to be effective in the long term and cannot be relied on in the ESC, and this was stated in our submission against Requirement 2 of Schedule 9, see (Baker et al. 2008b).</p> <p>The 2011 ESC will assess the expected progression of coastal erosion leading to disruption of the site, uncertainties in the progression and consequent impacts to humans and the environment. A case in which the site is not disrupted by coastal will be treated as an illustrative “what if” case.</p>	<p>COR_001</p> <p>Accepted / incorporated in our R2S9¹ submission</p>
COR_002	Effects in the Future	<p>No recommendations, <i>however</i>:</p> <p>The CG considered that:</p> <ul style="list-style-type: none"> - some of the arguments relating to the use of radiological capacity may not be consistent with GRA Principle 2 since they attempt to discount impacts that could arise beyond 10,000 years. - the 2002 PCSC does not demonstrate that impacts on the health of future generations from 	<p>An alternative approach to calculation of radiological capacity was presented in Volume 2 of R2S9 submission (Baker 2008), and will be further developed, taking account of EA comments..</p> <p>We consider that radiological capacity should be based on those scenarios that are broadly expected, which includes human intrusion, but may exclude impacts at very long times when uncertainties make the results of doubtful</p>	<p>COR_002</p> <p>Mainly accepted.</p> <p>We have revised our approach to radiological capacity.</p> <p>Improved modelling</p>

¹ R2S9 = Requirement 2 of Schedule 9 of the Authorisation.

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>the Drigg disposal facility will be less than relevant levels of impact that are acceptable today.</p> <p>More detailed criticisms refer to:</p> <ul style="list-style-type: none"> - to treatment of uncertainties in the groundwater pathway; - high risks from intrusion (especially due radon); - non-evaluation of non-radiological impacts. 	<p>significance.</p> <p>We acknowledge that the 2002 PCSC did not demonstrate that impacts below the 10^{-6} risk target.</p> <p>More realistic models of the groundwater pathway and of radon exposures related to human intrusion are liable to bring down the calculated risks and doses below those presented in 2002 PCSC.</p> <p>We believe, as stated in the GRA, that assessed risks above the 10^{-6} risk target may be acceptable provided that it is shown that the disposal solution is optimised.</p> <p>A preliminary assessment of non-radiological impacts has now been presented in (Barber and Henderson, 2008). An improved approach to assessment of non-radiological impacts is currently being developed (Kelly and Applegate, 2008), and will be discussed with the Agency, and thereafter included in the 2011 ESC.</p>	<p>approaches will be employed in support of the 2011 ESC.</p> <p>An improved assessment of non-radiological impacts will be included in the 2011 ESC.</p> <p>Hence, in summary, will be incorporated into the 2011 ESC.</p>
COR_003	Optimisation and Best Practicable Means (BPM)	<p>The CG commented:</p> <p>The entire disposal facility is a single source in the context of dose and risk calculations. Hence, the risk target of 10^{-6} y^{-1} applies to all parts of the disposal facility.</p> <p>BNFL must provide a justification for any risks that exceed the risk target, in accordance with Principle 3 of the GRA.</p> <p>The erosion of the waste into the sea might be regarded as an unacceptable loss of containment</p>	<p>We accept that the entire disposal facility is a single source and the risk target applies to the site as whole.</p> <p>We accept that we must provide a justification for any risks that exceed the risk target, in accordance with Principle 3 of the GRA.</p> <p>We do not agree that disruption of the facility by erosion or any other mechanism constitutes "unacceptable loss of containment". The GRA places requirements related to protection of humans and the environment; containment is not a</p>	<p>COR_003</p> <p>Mainly accepted.</p> <p>Work ongoing that will be incorporated into the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>and, therefore, of effective management control over the waste.</p> <p>The CG concluded that:</p> <ul style="list-style-type: none"> - the 2002 PCSC presents useful information on the possible performance of a range of risk management measures but that reservations remain regarding the range of options considered and the provision of information on social and economic factors; - results should be provided for a broader range of risk management options; - the 2002 PCSC does not demonstrate that the disposal facility has been optimised or that the radiological detriment is ALARA; - hence, the 2002 PCSC does not show compliance with GRA Principle 3. <p><i>Recommendation COR_003.1:</i></p> <p>Provide results from consideration of a broader range of risk management options than was considered in the 2002 PCSC. The risk management options to be considered should include one that involves future disposal of only short-lived radioactive waste, and another that combines future disposal of only short-lived radioactive waste with selective removal of those long-lived wastes in the trenches that contribute most significantly to site risk. As part of its optimisation work, BNFL should ensure an appropriate level of stakeholder involvement and</p>	<p>requirement. Management control is exercised during operations and up to the end of operator control. Beyond this time protection relies on the nature of the waste and engineered barriers.</p> <p>We accept that the 2002 PCSC did not present a sufficient exploration of facility design and risk management options and work is ongoing to correct this, e.g. see (Baker et al., 2008a).</p> <p><i>Response to recommendation COR_003.1;</i></p> <p>Work leading to the R2S9 submission considered a broader range of risk management options (Baker et al. 2008b). Planned work will make more specific evaluation of options, see (Baker et al., 2008a).</p> <p>Consideration of options for future disposals will include assessment of acceptability (or not) of waste streams that contribute most to overall impacts. The future use of LLWR will be addressed by National Strategy and Plans.</p> <p>We are currently considering options for selective retrieval of waste from the trenches and consequent detriments and benefits.</p> <p>We do not consider social factors per se since the distinction between options does not generate social differences. Costs and conventional environmental impacts will be considered in the evaluation of options. Results will be presented and discussed with stakeholders as appropriate.</p>	

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		should document an assessment of the relevant social and economic factors associated with the options considered.		
COR_004, COR_005, COR_006	Radiological Protection Standards: Dose Constraint and Risk Target	<p>No recommendations, however, the CG commented:</p> <p><i>Dose constraint - before withdrawal of control:</i></p> <p>The 2002 OESC suggests that before site closure, a potentially exposed member of the public consuming contaminated groundwater adjacent to the site could receive a dose in excess of the dose constraint.</p> <p>The CG considers that the OESC and PCSC analyses should be consistent, and suggests that the two analyses could be merged into a single ESC.</p> <p><i>Risk target - after withdrawal of control</i></p> <p>The CG is critical of the lack of an approach to integrating the results from the 2002 PCRSA in order to produce a risk estimate for comparison with the GRA. Even allowing for conservatism, long-term site risks are likely to be significantly above the risk target.</p>	<p>Work is in hand to develop an improved modelling approach and assessment for the evaluation of wells.</p> <p>The 2011 ESC will present an integrated and consistent evaluation of impacts up to and beyond withdrawal of control.</p> <p>The 2002 PCRSA did not present an integrated evaluation of risk from all pathways or cases. We consider it informative and practical to keep the evaluation of different pathways separate. Risks should only be aggregated if they are risks to the same potentially exposed group. In the 2011 ESC we will provide overall risk estimates for pathways to which the risk target applies.</p> <p>We believe the 2002 PCRSA presented a pessimistic view of the long-term impacts as illustrated by results from the 2008 PA update (Sumerling, 2008). We acknowledge, however, that even with improved modelling and assessment some pathways may pose risks close to or above the risk guidance level.</p>	<p>COR_004/5/6</p> <p>Accepted.</p> <p>Incorporated in the 2011 ESC.</p>
COR_007	No issue	-	-	-
COR_008	Multiple Factor Safety Case	<p>No recommendations, however, the CG commented:</p> <p>BNFL has made a reasonable interpretation of GRA Requirement R5, and have considered and</p>	<p>Illustration of the multiple factors that contribute to safety is an area in which we are planning to make improvements taking account of guidance in Chapter 8 of the revised GRA, for example considering safety functions. An approach is</p>	<p>COR_008</p> <p>Mainly accepted.</p> <p>Our approach is</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>documented information on a wide range of factors. However, because the 2002 PCSC suggests that impacts exceed the relevant dose constraints and risk targets by a significant margin, the CG considers that the safety case as a whole is not sufficiently robust, or optimised.</p> <p>The 2002 PCSC suggests that the Drigg disposal facility could exhibit 'cliff edge' effects, e.g. performance would deteriorate rapidly if oxidising conditions are re-established in the trenches, or if the site is destroyed by coastal erosion.</p> <p>These characteristics of the safety case and the disposal system at Drigg provide further support to the recommendation that consideration be given to a range of possible risk management measures for the repository, see IAF COR_003.</p>	<p>outlined in the ESC approach report (Baker et al., 2008a).</p> <p>Our assessments will consider changes in conditions, e.g. related to chemical changes and disruption by coastal erosion. It is the nature of a near-surface facility that it will be subject to changes, much more so that a deep geological repository. However, it is also a spatially extensive and heterogeneous system, so that different parts of the facility may be affected differently at different times. We consider "cliff-edge effects" an inappropriate term and concept in this context.</p>	<p>set out in the ESC approach report.</p>
COR_009	Waste Form and Characterization: Consistency with the PCSC	<p>The CG commented that the existing controls are based on previous safety assessments and other factors, their basis is not sufficiently transparent, and they may not be consistent with, the 2002 safety cases. The controls, including the CFA, need to be reviewed and updated.</p> <p><i>Recommendation COR_009.1:</i></p> <p>Document the basis for the derivation of the Conditions For Acceptance (CFA) of waste at Drigg and update the CFA so that they are consistent with assumptions, models and parameter values in the most recent operational and post-closure safety cases.</p>	<p>Subsequent to the 2002 OESC and PCSC, a review was undertaken to determine whether the CFA were consistent with the assumptions and results of the 2002 PCSC (Barber et al., 2006). The extent to which current inventory limits are appropriate was discussed in the May 2008 submission to the EA (Baker, 2008).</p> <p>An approach for the 2011 ESC with respect to post-closure impacts is outlined in the ESC approach report (Baker et al., 2008a).</p> <p>The determination of Conditions for Acceptance is considered to be a major objective of the 2011 ESC, and CFA will be revised to reflect the outcome of the 2011 ESC, consistent with our Authorisation.</p>	<p>COR_009</p> <p>Completed in respect of the 2002 safety cases.</p> <p>The determination of CFA is a major objective of the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
COR_010	Records	<p>The CG commented on:</p> <ul style="list-style-type: none"> - lack of evidence of a comprehensive system of records in the upper-level 2002 PCSC documents (although, a series of audits of BNFL's lower-level PCSC documents found the level and detail of checking by BNFL was comprehensive). - BNFL's proposal to retain records for up to 37 years is insufficient because BNFL argues that the site should remain under active management control until ~2150. - Lack of steps to ensure that duplicates of the records are kept in "diverse" locations and in durable form. <p><i>Recommendations:</i></p> <p>COR_010.1 Implement improved arrangements for records management to ensure retention of appropriately detailed information on all aspects of the safety case until the withdrawal of institutional controls.</p> <p>COR_010.2 Transfer the Drigg disposal records onto durable media.</p> <p>COR_010.3 Provide formally documented records of the work of Clearing Houses and other groups involved in developing the safety case.</p>	<p>COR_010.1 / 10.2</p> <p>The response to Schedule 9, Requirement 10 outlines the records management strategy (Dietzold 2007). The arrangements for all Records Management at LLWR are contained in the Repository Site Procedures (RSPs). Specifically, RSP 5.01 (Records Management) contains the LLWR requirements and is fully implemented.</p> <p>A system of long-term records management will be proposed as part of the overall development of the 2011 ESC. The issue of record keeping beyond the period of authorisation and tenure of the SLC will be referred to the NDA.</p> <p>COR_010.3</p> <p>The system of "clearing houses" is not being carried forward in the 2011 ESC. Rather a simpler but comprehensive database system is being initiated to record reference data values, uncertainties and source of all assessment data.</p>	<p>COR_010</p> <p>In summary:</p> <p>Accepted / will be incorporated in the 2011 ESC</p> <p>Issue of record keeping beyond the tenure of the SLC will be referred to the NDA.</p>
COR_011	Quality Assurance	<p>The CG commented that although the 2002 PCSC appears to have been developed under an appropriate QA regime, it is difficult and sometimes</p>	<p>QA documentation relating to the 2002 Safety Cases could be provided if requested by the Agency.</p>	<p>COR_011</p> <p>Specific</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>not possible to determine what QA measures were in place for individual pieces of supporting work.</p> <p><i>Recommendations:</i></p> <p>COR_011.1 Provide access to the RIMS and DTP Manuals for Agency review and audit.</p> <p>COR_011.2 Provide copies of procedures, instructions, and associated forms from the RIMS, R&T and DTP manuals, and any relevant internal and/or external audit reports, particularly for those areas covered by: DTP/WI/012 DTP Conceptual Model Uncertainty Form; DTP/WI/013 DTP Parameter Input Form; DTP/WI/008 Clearing houses.</p> <p>COR_011.3 Provide procedure(s) for the use of expert judgement, or indicate which procedures and instructions from the RIMS and the DTP manuals cover the use of expert judgement, see also COR_024.3.</p> <p>COR_011.4 Provide evidence of independent checking of quantitative data (i.e., provide documents showing what exactly was checked, how the checking was done and controlled, what proportion of the work was sampled, and what the results of the checking were).</p>	<p>Development of the ESC is carried out under the LLWR's QA system, which meets the requirements of ISO 9001. Appropriate subsidiary procedures, specific to the ESC Project, are being put in place.</p> <p>For the 2001 ESC, the LLWR will be documenting an assessment process and writing some overarching QA procedures that it will require contractors to work to when undertaking the assessment. This is an area in which we are currently working.</p>	<p>recommendations are no longer relevant / QA principles of defined procedures and traceability will be incorporated in the 2011 ESC</p>
COR_012	No issue	-	-	-
COR_013	Completion of Disposal	<p>The CG considers that disposal of the wastes in the trenches and in Vault 8 will not be complete until the final site closure engineering is emplaced and, for example, the final site cap is constructed.</p>	<p>We agree that disposal of wastes is not complete until the final site closure engineering is emplaced. We consider, however, that emplacement of waste at its intended disposal position is a significant step</p>	<p>COR_013</p> <p>Mainly accepted.</p> <p>A preliminary</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>BNFL has taken account of the need to seal and close the disposal facility in its design. The CG infers that BNFL accepts that the process of optimisation applies to all parts of the Drigg disposal facility, including the trenches and the vaults.</p> <p>The CG considers that suitable techniques are available for construction of the closure components described by BNFL in the 2002 PCSC, but has not been able to find a demonstration of this in the documents of the 2002 PCSC.</p> <p>The CG is concerned that the vertical drain represents a proposal to intentionally contaminate groundwater at the site. BNFL will have to provide further justification for this design feature.</p> <p>Recommendation COR_013.1:</p> <p>To present additional information on the techniques to be used for constructing the site closure engineering.</p>	<p>that is carried out under regulatory supervision and according to disposal standards of the time. Such disposal may not necessarily meet revised standards that are imposed later. In this case, decisions on the possible modification of an existing disposal or retrieval of waste should be taken in the context of optimisation and risk management considering the impacts from the site as a whole.</p> <p>The 2011 ESC will include consideration of options related to past disposals and will include information on site engineering closure methods and their practicality. The vertical drain is an option that is still under consideration.</p> <p>A preliminary assessment of site management options was presented in Edwards and Alexander (2005) and a further assessment of the status of options was presented in Baker et al. (2008b). A formal identification and evaluation of options leading to a BPEO study is planned for 2009, which will guide the site development plan for the 2011 ESC.</p>	<p>assessment of options is completed and a further study is planned leading into the 2011 ESC.</p>
COR_014	Funding of Liabilities	<p>The CG commented there was inconsistency between BNFL's policy to ensure that funds are available to meet long-term liabilities and the statement that "...a long term PCSC forward programme cannot be regarded as a commitment by BNFL nor the LMA [Liabilities Management Authority].</p> <p>The CG considers that the 2002 PCSC provides insufficient information on the level of resources required for the forward programme to develop</p>	<p>The current Lifetime Plan assumes that the site will be managed by LLWR Ltd. until the site is closed. The site will then revert to direct NDA control. Ultimately, the Government is responsible for providing funding and the LLWR cannot provide guarantees.</p> <p>We will provide estimates of the costs for operating, closing and post-operational control of the LLWR site, including costs for the safety case, as part of the 2011 ESC.</p>	<p>COR_014</p> <p>Accepted.</p> <p>Cost information will be included in the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		future iterations of the safety cases, and provides inadequate assurance that the required resources will be available. Recommendation COR_014.1: Provide justified estimates of the costs for operating, closing and post-operational control of the Drigg site, including costs for the safety case.		
COR_015	Overview of BNFL's FEP List and FEP Screening Information	<p>The CG raised a number of comments and concerns about BNFL's analysis of FEPs, particularly lack of information concerning FEPs categorised as "subsumed", some unclear or poorly justified arguments for excluding FEP and EFEPs from the assessment, and the absence of a clear link between the FEPs categorised as "included" and the equations implemented in the codes used for assessment calculations.</p> <p>The series of audits conducted concluded that although most assumptions were traceable, there was a lack of clear justification for some decisions and judgements, and the process of FEP identification and categorisation was complex.</p> <p><i>Recommendation COR_015.1:</i></p> <p>Specific suggestions for FEPs analysis including:</p> <ul style="list-style-type: none"> - a comprehensive site-specific list of FEPs. - clearly-defined screening criteria to determine which FEPs to include in the PCRSA. - clear and logically-justified reasons for all FEP 	<p>We believe that formal FEP methodologies are helpful in expanding phenomenological consideration and checking completeness. We agree that the FEP methodology used in support of the 2002 PCSC was complex, and that this complexity may have tended to obscure traceability.</p> <p>We believe that given the experience from the 2002 PCSC and 2008 PA update, plus experience from other radiological safety assessments, we are now able to focus better on those FEPS that are most relevant to safety or that have the capacity to undermine safety. Hence, for the 2011 ESC we will be proposing an alternative, simpler approach to FEP management based on repository safety functions and more directly linked to models and the treatment of uncertainty. The methodology is outlined in Baker et al. (2008a).</p>	COR_015 Accepted. For the 2011 ESC a revised, simpler approach to FEP management will be adopted.

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>screening decisions.</p> <ul style="list-style-type: none"> - Document FEPs and models in a way that reduces uncertainty in the inclusion or exclusion of FEPs in PCRSA models - Ensure consistency between PCRSA models and codes, and the results of the FEP screening analysis, and identify biases due to inconsistencies or model/code limitations. 		
COR_016	Scenarios, Pathways and Event Probabilities	<p>The CG considers that BNFL has assessed the consequences of the scenarios most likely to affect the LLW repository at Drigg.</p> <p>The CG criticised the presentation of scenarios that were not certain to occur in terms of conditional risk, noting that BNFL has made some qualitative statements regarding scenario probability, but has not presented values of risk as defined in the GRA.</p> <p><i>Recommendations:</i></p> <p>COR_016.1 Clearly document and justify the selection of scenarios to be assessed in the PCRSA, including that a sufficiently representative set of scenarios has been assessed.</p> <p>COR_016.2 Provide information on the likelihood or probability of scenarios sufficient to support an understanding of radiological risk as defined in the GRA.</p> <p>COR_016.3 Assess potential exposures, doses and risks for all credible exposure pathways, including:</p> <ul style="list-style-type: none"> - A PEG living in housing constructed at the site 	<p>The strategy for addressing the four pathways – groundwater, gas, natural disruption and human intrusion – was outlined in the safety assessment approach document (Lean & Fowler, 2007) and illustrated in the 2008 PA update (Sumerling, 2008).</p> <p>The new GRA (environment agencies, 2009) also makes statements regarding probabilities and assessment, especially of human intrusion that alter the position from that in 2002.</p> <p>We have outlined our approach to the classification of scenarios and to the treatment of natural events of uncertain occurrence or timing, and of human intrusion scenarios in the ESC approach report (Baker et al., 2008a). We will set out the scenarios that we plan to assess in advance of the 2011 ESC for EA comment. Detailed work has already been undertaken to define the characteristics of potentially exposed groups (Thorne 2007).</p>	<p>COR_016</p> <p>Shortcomings of the 2002 PCSC are accepted.</p> <p>Related regulatory guidance has changed.</p> <p>We have outlined our approach for the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>near the waste after the cap has eroded.</p> <ul style="list-style-type: none"> - Use of contaminated well water by future site occupiers. - Abstraction from a well, focusing flow of contaminated waters from the near-field. - Upward flow and transport of radionuclides as a result of drain clogging and/or changing hydrogeological conditions. - Radionuclide diffusion through the cut-off walls into streams. 		
COR_017	No issue	-	-	-
COR_018	Modelling and Model Validation	<p>The CG commented that BNFL has suitable arrangements governing software quality assurance, but that not all of the assessment models have been peer reviewed.</p> <p>BNFL has taken some steps towards "validating" its models (i.e., showing that they are "fit-for-purpose"), but the CG considers that further work will be necessary to enhance confidence in the models. The CG made specific comments on each model being most critical of the model of groundwater flow and suggested alternative cases to be considered, e.g. related to erosion of the final site cap, repository flooding ("bathtubbing"), advection of gas via cracks in the site cap. Other IAFs were referred to.</p> <p><i>Recommendation COR_018.1:</i></p> <p>Adopt a strategic approach to, and implement a</p>	<p>We have embarked on systematic programme of work leading to the 2011 ESC in which the models in use are being reviewed and developed as needed and alternative models considered. An evaluation of the confidence in each model and its "fitness-for-purpose" will be central to decisions on the models to be used in the 2011 ESC.</p> <p>A thorough review of cases to be considered will also be carried out, and justification of omitted (non-credible or unimportant) cases provided.</p>	<p>COR_018 Accepted.</p> <p>Incorporated in the work leading to the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>long-term programme for, building confidence in safety assessment and supporting models.</p>		
COR_019	Presentation of PCRSA Results	<p>The CG was critical of the lack of an approach for integrating the results from the 2002 PCRSA in order to produce a risk assessment for comparison with the GRA, and also the lack of probabilistic calculations.</p> <p>The CG commented that PRA techniques can provide a better understanding of disposal system behaviour, a better means of focusing further research and assessment work on key uncertainties, and a more efficient path to demonstrating optimisation.</p> <p>The Core Group considers that BNFL should be more consistent throughout the safety case in presenting results for different performance measures (e.g. the same assessment timescale should be used for assessments of risk, collective dose, and impacts to non-human species).</p> <p>No recommendation under this IAF.</p>	<p>We accept that probabilistic calculations have an important role, especially to explore uncertainty, and we are planning to undertake probabilistic calculations of risk as part of the 2011 ESC for key pathways. We consider, however, that deterministic calculations of consequence, and estimates of probability, can yield estimates of risk suitable for comparison with the GRA guidance level and may be appropriate in some cases.</p> <p>Moreover, undue focus on probabilistic simulations can place emphasis on those uncertainties that are amenable to incorporation and consequent comparative neglect of other uncertainties.</p> <p>A balanced mix of deterministic and probabilistic calculations will be needed to explore repository performance and illustrate the effect of uncertainties.</p> <p>We disagree that PRA techniques provide a better understanding of disposal system behaviour, or a better means of focusing further work, or optimisation.</p>	<p>COR_019</p> <p>We disagree with the CG comments on the importance of PRA vs deterministic calculations.</p> <p>The 2011 ESC will include probabilistic calculations for key pathways and cases and coherent presentation of results from both.</p>
COR_020	Treatment of Uncertainty	<p>The CG commented that assessments need to address three key sources of uncertainty related to scenarios, conceptual models, and parameters. BNFL has taken a systematic approach to identify uncertainties in each of these areas, and has evaluated some of the uncertainties. Overall, the CG considers that BNFL has not presented a</p>	<p>We acknowledge that the 2002 safety cases present an incomplete evaluation of uncertainty.</p> <p>For the 2011 ESC, we will seek to comprehensively identify significant uncertainties and investigate those that are amenable to treatment, discuss those that are not, and thus present a balanced evaluation of uncertainties and their importance to</p>	<p>COR_020</p> <p>Accepted.</p> <p>Will be taken into account in analyses for the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>sufficiently comprehensive or systematic evaluation of uncertainty. Nor has BNFL adopted a methodology that allows for the systematic propagation of uncertainties through the PCRSA calculations.</p> <p>More specific criticism were also given including related to:</p> <ul style="list-style-type: none"> - not quantifying scenario probabilities; - the model of groundwater flow; - justifications for conceptual models and lack of consideration of alternative models; - selection of parameter values (both ranges and best estimate values). - Lack of probabilistic analysis. <p><i>Recommendation COR_020.1:</i></p> <p>Undertake an improved assessment of the expectation value of risk associated with the Drigg disposal facility, including a probabilistic treatment of uncertainty, and taking due account of the review comments and suggestions for further improvements contained in Environment Agency (2004), supporting reviews and the associated IAFs.</p>	<p>performance.</p> <p>We acknowledge the 2002 safety cases present an incomplete evaluation of model sensitivities. We understand sensitivity analysis as a quantitative examination of how the behaviour of a system varies with parameter change. For the 2011 ESC, we will undertake focussed sensitivity studies to understand behaviour and check the veracity of key models.</p> <p>We agree that probabilistic analysis has an important role and will seek to analyse key pathways though probabilistic calculations.</p> <p>Our approach in these areas is set out in the ESC approach report (Baker et al., 2008a).</p>	
COR_021	Structured Risk Assessment and the Forward Programme	<p>The CG commented that BNFL has applied a structured risk assessment to identify issues that may be included in the forward programme, and has used results from PCRSA to prioritise the forward programme. This is appropriate, but the CG notes</p>	<p>Risk assessments and supporting work are ongoing and an iterative approach can be used to continuously inform and refine the forward programme. We consider, however, that 10 years is an appropriate interval between major PCSC/OESC or ESC iterations, on which formal regulatory review</p>	<p>COR_021</p> <p>Partly accepted.</p> <p>A detailed plan of work leading to</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>and considers that:</p> <ul style="list-style-type: none"> - the Forward Programme Report only covers the period up to the next iteration of the PCSC, which BNFL suggests should be in around 10 years time, which the CG consider is an unacceptably long interval; - BNFL should document a commitment to a plan for a longer-term programme of work until withdrawal of active institutional control over the site and should put in place arrangements to ensure that this commitment is fully transferred to any successor organisation, such as the NDA; - the forward programme described by BNFL is not sufficiently specific or detailed; - the justification for some of the items proposed by BNFL as possible components of the forward programme is not clear; - BNFL has not indicated the costs of the forward programmes or demonstrated that adequate funds will be available. <p><i>Recommendation COR_021.1</i></p> <p>Present a more detailed and costed forward programme for further development of the Drigg environmental safety cases during the period until withdrawal of controls. Use risk-informed approaches to determine the priority for particular improvements to the safety case, and the priority for studies to be incorporated within the research and</p>	<p>and amendment of the Authorisation may be based.</p> <p>The LLWR SLC will prepare and execute a forward programme of assessment and supporting work that relates to the duties of the SLC as determined by its contract with the NDA. The SLC will also advise the NDA with regard to longer-term site management needs and costs.</p> <p>The LLWR SLC has recently developed an ESC Lifetime Plan (LTP) that sets out our programme. This is more detailed than hitherto and provides the detailed basis for justification of LLWR budget applications to the NDA.</p> <p>Assessed risk is important in deciding where effort is needed in improve to the ESC, but is not the only criterion. We take a rounded approach considering also scientific and stakeholder confidence in various aspects of the ESC and especially the potential for effective remedial actions and improvement of practice and design that could lead to reduction of impacts or increased efficiency of disposals.</p>	<p>the 2011 ESC is in place.</p> <p>The LLWR will advise the NDA on longer term needs but these must be judged by and remain the responsibility of the NDA.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		development programme supporting the safety case.		
COR_022	Radiological Capacity	<p>The CG commented that BNFL provides a description of their approach to calculating the radiological capacity of the future vaults, but this takes no account of the wastes disposed of in the trenches, which may dominate long-term risk.</p> <p>The CG also criticised that the calculations did not include all scenarios (esp. site termination events), do not adequately take into account the additive effects of disposed radionuclides, are not necessarily conservative and do not provide an expectation value of the risk associated with the entire site.</p> <p><i>Recommendation COR_022.1:</i></p> <p>Provide results from calculations of site radiological capacity that take full account of all of the wastes at the site, that account for the effects of site destruction events (coastal erosion, glaciation) and other potential exposure pathways, that account for the additive effects of the radionuclides present, and that are based on the expectation value of risk.</p>	<p>We accept that the calculation of radiological capacity should include appropriate consideration of past and future disposals and any scenario that is limiting on potential disposal capacity. In general, however, because of the characteristics of the system, total impacts are not estimated by adding the impacts for the trenches to those of the vaults.</p> <p>We illustrated a revised approach to calculation of radiological capacity in the R2S9 submission Volume 1 (Baker, 2008). Our approach has been further developed taking account of EA comments on the R2S9 submission and an approach is set out in our "Approach to ESC" report (Baker et al., 2008a) that takes account of both the CG's comments and the EA's more recent comments.</p>	<p>COR_022</p> <p>Accepted.</p> <p>A revised method has been developed and will be applied in the 2011 ESC.</p>
COR_023	No issue	-	-	-
COR_024	Supply of Information	<p>The CG commented that</p> <ul style="list-style-type: none"> - BNFL should adopt an iterative approach to future updates of the safety case, and demonstrate and communicate an understanding of the behaviour of the disposal system at an early stage. 	<p>We appreciate the review comments and are taking account of them in the planning of documentation of the 2011 ESC. In particular, we agree that addressing the regulatory requirements is the primary objective of the ESC and these requirements should impact on the design and</p>	<p>COR_024</p> <p>Accepted.</p> <p>Comments taken into account in the planning of</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<ul style="list-style-type: none"> - the Level I and II reports did not provide sufficient information to make the safety case or to enable a thorough assessment of their basis, and that underlying documents were delayed which protracted the review process. - The relationships between the 2002 PCSC documentation and the regulatory requirements and guidance are not always apparent. - There are many instances where the level of cross-referencing is either too sparse or insufficiently precise to follow lines of evidence easily. - BNFL classified some of the information supporting the 2002 PCSC as "commercial-in-confidence"; the Agency considers that the justifications given for classifying these documents were not always clear or sufficient. <p><i>Recommendations:</i></p> <p>COR_024.1 Provide information in a timelier manner and that BNFL should strive to achieve the highest levels of openness.</p> <p>COR_024.2 Adopt a more strategic approach when planning the production of safety case and associated documentation, such that conformance with regulatory requirements is more directly addressed, and regulatory review and stakeholder dialogue are made easier.</p> <p>COR_024.3 Clearly identify and record the use of expert judgement in developing the safety cases.</p>	<p>presentation of the ESC.</p> <p>To make documentation comprehensive and fully traceable is a demanding task. By making documents on issues of concern to the EA available at an early stage, we aim to allow iteration and refinement to best meet EA requirements.</p> <p>We also have a work plan by which the underlying documents should be produced mainly in advance of the top-level submission, not in arrears.</p>	<p>documentation for the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>[see also COR_011.3]</p> <p>COR_024.4 Adopt an iterative approach when developing future updates of the safety case, and demonstrate and communicate an understanding of the behaviour of the disposal system at an early stage.</p>		
COR_025	Peer Review	<p>The CG commented that the BNFL peer review (Hill and Irvine 2002) was commissioned at far too late a stage, hence, not all of the peer review comments had been addressed when the PCSC was submitted. The CG considers that peer review should begin at an early stage and should be an active and continuous part of work leading to revision of the safety case.</p> <p>The CG also criticised BNFL description of the contribution of peer review to the safety case, and the lack of clear resolution to the peer review comments, which are rather critical. Reports containing the detailed findings of BNFL's peer review team were not provided to the Agency.</p> <p>BNFL's rejection of the main conclusion of its independent review team (BNFL 2003) reflects a lack of understanding by BNFL of peer review.</p> <p><i>Recommendation COR_011.1</i></p> <p>Implement an improved approach to peer review of the Drigg safety cases. The improved approach should include peer review beginning at an early stage in each iteration of the safety case, and BNFL should demonstrate that peer review comments</p>	<p>We accept the shortcomings of the peer review process around the 2002 safety cases.</p> <p>We have appointed an independent peer review panel and implemented an improved approach to peer review of the safety cases and supporting work. This has been applied to the review of the recent R2S9 submissions.</p> <p>We value independent peer review as an important test and input to the development of the ESC. We note, however, that on occasions we may disagree with views from the peer review panel. We will identify and seek to resolve any such disagreement but ultimately responsibility for decisions on the direction and scope of the ESC lie with the LLWR.</p>	<p>COR_025</p> <p>Accepted.</p> <p>An improved approach to peer review has been tested and is being applied during the development of the 2011 ESC.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		have been adequately addressed.		
COR_026	Minimising Radionuclide Releases via the Contaminant Plumes	<p>BNFL has observed two plumes of tritium contamination leading away from the Drigg trenches.</p> <p>The CG considers that the tritium plumes are more significant to the OESC than the PCSC because of the short half-life of tritium. BNFL acknowledges that it has not yet addressed the Agency's expectation that it should present an assessment of the best practicable means for minimising radionuclide releases via the contaminant plumes in either the OESC or the PCSC</p>	<p>The Agency concern arises from the old GRA Requirement R3 (§ 6.23), that BPM "shall be employed to ensure that any radioactivity coming from a facility will be such that doses to members of the public and risks to future populations are as low as reasonably achievable".</p> <p>This was a general requirement. Any posited future doses arising from the existing tritium plume are within the dose guidance level for the period of authorisation. At the time of withdrawal of the authorisation any potential risk should be compared with the risk guidance level. Optimisation studies are planned as part of developing the ESC to ensure that doses and risks are ALARA.</p>	<p>COR_026</p> <p>Superseded</p> <p>No equivalent requirement in the new NS-GRA.</p>
COR_027	Supporting Arguments	<p>No recommendations, however, the CG commented:</p> <p>On multiple lines of reasoning, many of BNFL's arguments are irrelevant, misleading or inaccurate, e.g. related to the national interest, HSE's Tolerability of Risk, stakeholder engagement, insufficient analysis of the uncertainties, optimisation.</p> <p>With regard to sustainable development, the CG has concerns that the potential for destruction of the Drigg site by coastal erosion in the relative near-term means that, it may create undue burdens on future generations. In addition, erosion of the waste into the sea might be regarded as an unacceptable loss of containment and management control over</p>	<p>We accept that the presentation of arguments may have been weak in the 2002 OESC/PCSC, we consider that the ESC <i>should</i> present a full range of arguments and evidence as required by the new GRA.</p> <p>In the 2011 ESC we will focus on technical multiple and supplementary lines of reasoning to support confidence in the ESC and compliance with the new NS-GRA, as outlined in Baker et al. (2008a).</p> <p>We reject the comments that the threat due to coastal erosion is incompatible with the principles of sustainability or precaution.</p> <p>The nature of near-surface disposal at any site is that the disposed material will at some time in the future be exposed and distributed in the biosphere</p>	<p>COR_027</p> <p>Largely rejected or superseded.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		<p>the waste.</p> <p>With regard to the Precautionary Principle the CG considers that the key issue centres on the potential for site destruction by coastal erosion and the question "is it sensible to dispose of radioactive wastes where they might be eroded into the sea?"</p> <p>The Core Group notes that even though it was not the aim of the 2002 PCSC to demonstrate that disposal at Drigg represents the BPEO for the management of the UK's low-level radioactive waste, this demonstration remains to be made.</p> <p>BNFL's arguments regarding background radiation are discussed in IAF BIO_004.</p>	<p>by natural processes, human actions or both. Hence, the waste disposed must be such that at times when this could happen (and taking account of possibilities for how it might happen), doses and risk are acceptably low, i.e. comparable to the risk and dose guidance level specified in the GRA.</p>	
COR_028	Waste Retrieval	<p>No recommendations, however, the CG commented:</p> <p>Once the PCM currently on the Drigg site has been removed, it will have no effect on the long-term safety of the repository.</p> <p>BNFL has not provided information to support its assertions regarding the difficulty and costs of waste retrieval.</p> <p>The safety case should be used to help determine the appropriate response to the threat of coastal erosion at Drigg.</p> <p>The CG has reservations regarding BNFL's argument for deferring consideration of waste retrieval.</p> <p>BNFL should consider a range of risk management</p>	<p>Since 2002, we have made an initial study of retrieval of waste from the trenches considering three broad options – retrieve all waste, partial disturbance and leave undisturbed. The main conclusion is that complete retrieval would entail grossly disproportionate cost and is not appropriate (Baker et al., 2008b).</p> <p>A study is now underway that is looking at the post-closure amelioration, detailed operational requirements / practicalities and cost of specific options for focussed and selective retrieval from the trenches. Results from these studies will inform an optimisation study considering a wide range of options.</p>	<p>COR_028</p> <p>Accepted.</p> <p>Preliminary study accomplished and detailed work in hand to address the question of selective waste retrievals.</p>

IAF no.	Title	Review group key comments and recommendations	Our response to comments and recommendations	Issue status
		options, including one that involves selective removal of those long-lived wastes in the trenches.		
END				

Biosphere issues

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
BIO_001	Biosphere adequacy of information / referencing	<p>BIO_001.1</p> <p>Provide a more detailed description of the current biosphere in support of the development of the biosphere model.</p> <p>BIO_001.2</p> <p>Include an evaluation of the biosphere data for agro-climatic analogues and use such data to illustrate the range of parameter values that may be employed in the PCRSA.</p> <p>BIO_001.3</p> <p>Map the FEPs to the Parameter Input Forms in order to provide traceability through the PCRSA.</p>	<p>BIO_001.1</p> <p>More detailed description of the biosphere would be relevant mainly in relation to present day exposures. We do not, however, consider additional data are needed in order to assess doses to currently exposed groups. In the longer term and especially in the period after authorisation, more stylised representations are appropriate as suggested in the draft NS-GRA. An exception is that we are seeking information on the use of wells locally in order to assess the likelihood of future agricultural or domestic wells.</p> <p>BIO_001.2</p> <p>The BIOMASS reference biosphere approach implies using appropriate local and analogue data. The data for this have been reviewed, and reference parameters set out by Thorne (2007). The focus is now on the period up to 5000 years making alternative agro-climatic analogues less relevant. We do not consider that it is appropriate to sample across consumption data or other human-habit related factors.</p> <p>BIO_001.3</p> <p>We are proposing a more direct approach to demonstrating inclusion of FEPs in scenarios and models for the 2011 ESC, see section 5.3.3 on FEPs in (Baker et al. 2008).</p>	<p>BIO_001.2</p> <p>Rejected / not needed</p> <p>BIO_001.2</p> <p>Not needed / no longer relevant</p> <p>BIO_001.3</p> <p>No longer relevant</p>
BIO_002	Biosphere screening, model development and	<p>BIO_002.1</p> <p>Justify the modelling of compartments and the</p>	<p>BIO_002.1</p> <p>Accepted. Additional attention will be paid especially in</p>	<p>BIO_002.1</p> <p>Accepted / Work</p>

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
	assumptions	<p>compartment sizes used in the Biosphere Model during each system state. In particular, the compartments for Drigg coastal land, beach, foreshore and local coastal waters need to be justified and explained.</p> <p>BIO_002.2</p> <p>Provide documentation on the decisions and assumptions used in identification and categorisation of the FEPs by the Biosphere Clearing House, including those FEPs which were eliminated from consideration in the PCRSA.</p> <p>BIO_002.3</p> <p>Provide thorough documentation on the treatment of FEPs. In particular, BNFL should map the FEPs listed in the appendices to the process system report to the appropriate CMU form.</p>	<p>the context of impacts through coastal erosion. Work is planned in this area, see section 5.9 on coastal erosion in (Baker et al., 2008).</p> <p>BIO_002.2</p> <p>We are proposing a more direct approach to demonstrating inclusion of FEPs in scenarios and models for the 2011 ESC, see section 5.3.3 on FEPs in (Baker et al., 2008).</p> <p>BIO_002.3</p> <p>As above.</p>	<p>planned.</p> <p>BIO_002.2</p> <p>No longer relevant</p> <p>BIO_002.3</p> <p>No longer relevant</p>
BIO_003	Biosphere Treatment of Uncertainty	<p>BIO_003.1</p> <p>Undertake an evaluation of the results of the PCRSA to understand how the key uncertainties relate to the most significant pathways and to focus the uncertainty analysis on the conceptualisation of the process system during the states when the most significant doses occur.</p> <p>BIO_003.2</p> <p>Undertake a more thorough uncertainty analysis</p>	<p>BIO_003.1 and BIO_003.2</p> <p>We consider that investigation of uncertainties should focus on those cases that are both realistic and potentially challenge regulatory guidance levels. Cases that have low credibility, i.e. the key uncertainty concerns their occurrence, may be examined as “what-if”s in a less exhaustive fashion even if high conditional doses are implied.</p> <p>In addition, we consider that details of human habits and food-chain uptake parameters should be excluded from uncertainty analysis since this information relates to the</p>	<p>BIO_003.1 / 3.2</p> <p>Largely rejected / disproportionate</p> <p>BIO_003.3 / 3.4</p> <p>General issues / to be addressed in 2011 ESC</p>

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
		<p>of currently omitted CMU topics, or provide a more rigorous justification for omitting uncertainties in heterogeneities within the biosphere, accumulation of contaminants, livestock husbandry and agricultural practices, and native/wild animal and plant populations.</p> <p>BIO_003.3</p> <p>Develop a clear presentation and audit trail of their uncertainty analysis.</p> <p>BIO_003.4</p> <p>Map modelled FEPs (including subsumed FEPs) to terms in the mathematical equations used in the BIOS, DEGAS and AMBER models.</p>	<p>uncertainties that are irreducible and cannot contribute to decisions on facility design or disposal practice</p> <p>Our approach to the treatment of uncertainty in general and also to biosphere uncertainties is out in the sections 5.4 and 5.6 in (Baker et al., 2008).</p> <p>BIO_003.3 and BIO_003.4</p> <p>These are general issues. Our approach to the treatment of uncertainty in general and to FEP audit is contained sections 5.4 and 5.3.3 in (Baker et al., 2008).</p>	
BIO_004	Environmental radioactivity	<p>BIO_004.1</p> <p>Undertake a sampling and monitoring campaign to establish background levels of radioactivity in and around the Drigg site.</p> <p>BIO_004.2</p> <p>Make a full assessment of the potential increases in environmental radionuclide concentrations that includes all of the radionuclides considered in the PCRSA.</p>	<p>BIO_004.1</p> <p>We consider that we have an understanding of background levels of radioactivity based on extensive surveys carried out in relation to Sellafield and to LLWR. This information is useful to provide general context and in relation to understanding a baseline for monitoring.</p> <p>BIO_004.2</p> <p>This is part of the calculations needed to assess dose to human and to non-human biota. An assessment against base-line levels could be informative for some, e.g. natural, radionuclides and will be considered in the 2011 ESC.</p> <p><i>General comment</i></p> <p>The new NS-GRA sets a different requirement in the</p>	<p>BIO_004.1 / 4.2</p> <p>Partly accepted.</p> <p>To be considered in the 2011 ESC.</p>

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
			area of environmental activity area, focusing on potential for doses to non-human biota. An assessment is presented in Eden and Barber (2007).	
BIO_005	Geosphere-biosphere interface	BIO_005.1 Evaluate the effect of further alternative geosphere-biosphere interfaces with respect to the most significant pathways and PEGs. BIO_005.2 Demonstrate that there is mass conservation between the geosphere and biosphere models.	BIO_005.1 All relevant geosphere-biosphere interfaces will be investigated will be investigated for pathways and scenarios within the 2011 ESC. The emphasis will, however, be on possible interfaces in the period up to 5,000 AP. Beyond this time more generic stylised scenarios are appropriate. BIO_005.2 Should be an automatic and necessary check within any model. However, cautious treatment of each pathway may imply some mass creation overall.	BIO_005.1 Accepted / included in the 2011 ESC BIO_005.2 Accepted
BIO_006	Selection and characterisation of exposed groups	BIO_006.1 Account explicitly for uncertainties in the properties and characteristics of transport pathways (e.g. using probabilistic techniques) in order to calculate the expectation values of dose and risk to PEGs for comparison with the design target. BIO_006.2 Calculate doses to PEGs exposed to individual pathways, to clarify the key routes for radionuclides to reach the accessible environment and give rise to doses. BIO_006.3	BIO_006.1 Not a biosphere issue. Probabilistic calculations will be carried out for selected cases in the 2011 ESC, see (Baker et al., 2008a). BIO_006.2 We agree it is necessary to understand both the route of migration to the biosphere and the modes of exposure. Such presentations will be included in the 2011 ESC. BIO_006.3 The assumptions regarding human intrusion in the 2002 PCSC are cautiously representative, i.e. they involve representative amounts of excavated waste and cap materials distributed on land that is used in such a way	BIO_006.1 Not a biosphere issue, but accepted BIO_006.2 Accepted BIO_006.3 Partly accepted but intrinsically problematic

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
		<p>Justify the assumptions made concerning the fate of material excavated during human intrusion and subsequent land use, or provide dose calculations for a broader set of intrusion scenarios.</p> <p>BIO_006.4</p> <p>Use the same assumptions on the habits and characteristics of PEGs in calculations of doses arising from both the groundwater and gas pathways.</p> <p>BIO_006.5</p> <p>Base its safety case on calculated risks to reasonable PEGs and not on arguments concerning inappropriate and undemonstrated conservatism.</p>	<p>that doses are reasonably maximised. A broader set of intrusion cases will be addressed in the 2011 ESC, see section 5.9 of (Baker et al., 2008a), but choice of assumptions must remain largely be matter of expert opinion and/or consensus with stakeholders, especially the EA.</p> <p>BIO_006.4</p> <p>Definition of PEGs by Thorne (2007) means consistent PEG characteristics can be used where the PEG is “the same”. On the other hand, different pathways may lead to exposure of different PEGs.</p> <p>BIO_006.5</p> <p>Definition of PEGs has been reviewed and characteristics defined by Thorne (2007). This is based on generalised descriptions of observed behaviours in the region.</p>	<p>BIO_006.4</p> <p>Partly accepted / necessary work complete</p> <p>BIO_006.5</p> <p>Accepted / necessary work complete</p>
BIO_007	Selection and use of climate analogues	<p>BIO_007.1</p> <p>Provide a critical assessment of the issues relating to the up-scaling of short-term observations from individual meteorological stations to represent temporal and spatial variability within system states, and justify, using scoping calculations or sensitivity studies, the assumptions made in the 2002 PCRSA calculations.</p> <p>BIO_007.2</p> <p>Justify why the full range of climate analogue sites identified has not been used as the basis</p>	<p>BIO_007.1</p> <p>Consideration of climate analogues is given in Thorne and Kane (2007). The level of detail implied in this comment is disproportionate given the stylised nature of future biosphere assessment.</p> <p>BIO_007.2</p> <p>See above. Focus of assessment on timescale up to 5,000 years reduces the relevance of such detail.</p>	<p>BIO_007.1</p> <p>Partly accepted / work complete</p> <p>BIO_007.2</p> <p>No longer relevant</p>

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
		for deriving patterns of land-use change and human activities at Drigg.		
BIO_008	Treatment of current climate conditions	BIO_008.1 Undertake sensitivity analyses to determine whether variability in climatic conditions could have a significant effect on derived parameters such as cap infiltration.	BIO_008.1 Variability in climatic conditions has been considered in calculation of cap infiltration and erosion (Thorne, 2008).	BIO_008.1 Accepted / work complete
BIO_009	Non-human receptors	BIO_009.1 Calculate doses to non-human biota for the entire assessment period using the same environmental concentrations for radionuclides as used for the calculation of doses to humans.	BIO_009.1 An assessment of impacts to non-human biota, including doses at times of peak concentrations in a 4,000 year and 50,000 year time frame is presented in Eden and Barber (2007).	BIO_009.1 Accepted / work complete
BIO_010	Use of dose - risk conversion factor	No recommendation. The Review Group considers BNFL used the ICRP-recommended dose-risk conversion factor appropriately.	No recommendation.	-
BIO_011	Treatment of environmental change	BIO_011.1 Provide a more detailed assessment of the relative likelihood of different site evolutions. BIO_011.2 Provide a more thorough uncertainty analysis for the treatment of environmental change, including the duration of system states, sea-level and changes in emergent land and the location of the GBI, and the behaviour of radionuclides in evolving and non-evolving compartments. BIO_011.3	BIO_011.1 Climatic and landscape scenarios that bound future evolutions have been developed in Thorne and Kane (2007). Likelihood cannot be reliably assessed and the likely alternative evolutions lead to broadly similar conditions for radiological assessment. BIO_011.2 Emergent land scenarios are no longer considered as realistic, and will be considered only as a "what-if" case. BIO_011.3 No longer relevant.	BIO_011.1 Not needed / underpinning work complete BIO_011.2 No longer relevant BIO_011.3 No longer relevant

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
		<p>Assess the implications of using time-steps of up to 47,000 years to model an evolving biosphere and the use of initial rather than representative conditions to characterise system states.</p> <p>BIO_011.4</p> <p>Augment the extrapolation of historical coastal erosion rates with appropriate erosion calculations, and relate estimates of erosion to assumed patterns of sea-level change.</p> <p>BIO_011.5</p> <p>Assess its commitment to consider coastal defence measures in relation to the Shoreline Management Plan's conclusion that defences along the Drigg coast would restrict sediment supply to a significant section of coast.</p>	<p>BIO_011.4</p> <p>Studies of coastal dynamics have been carried out (Halcrow, 2008) and estimates of long-term erosion made based on these studies plus possible climate and sea-level change (Thorne and Kane, 2007).</p> <p>BIO_011.5</p> <p>The LLWR no longer considers sea defences an appropriate or viable option to protect the site in the long term.</p>	<p>BIO_011.4</p> <p>Accepted / work complete</p> <p>BIO_011.5</p> <p>No longer relevant</p>
BIO_012	Derivation of biosphere sorption database	<p>BIO_012.1</p> <p>Document the primary data sources (i.e., the actual measurements) used to derive Kd values for biosphere modelling, document the expert judgement applied in evaluating the suitability of the data, and document the methodology used to derive the Kd database for the biosphere.</p> <p>BIO_012.2</p> <p>Assess the variability and uncertainty associated with biosphere Kds, and use these rather than arbitrary "two orders of magnitude" ranges in sensitivity studies.</p>	<p>BIO_012.1</p> <p>The biosphere Kd values come from international tabulations and sources that have been recommended for use in biosphere studies, e.g. BIOMASS, and have been extensively reviewed. Further detailed review is not needed and would be disproportionate.</p> <p>BIO_012.2</p> <p>We consider it is appropriate to use orders of magnitude ranges in sensitivity studies where the aim is to test the importance of a parameter. If a risk or dose via a pathway was found to be crucially dependent on a Kd value, then greater effort would be focused on the</p>	<p>BIO_012.1</p> <p>Rejected</p> <p>BIO_012.2</p> <p>Rejected</p>

IAF no.	Title	Review group recommendations	Our response to the recommendations	Issue status
			particular radionuclide and soil/sediment/waste form conditions and case-specific justification may be derived.	
BIO_013	Collective radiological impact	BIO_013.1 Extend the calculations of collective dose to include release of radionuclides to the accessible environment after 4,000 years post-closure. BIO_013.2 Present the results of its collective dose calculations in a series of 100-year periods from closure so as to demonstrate that the calculations pass the time of maximum collective dose.	BIO_013.1 The ICRP advises that doses into the future should not be considered as measures of health detriment (ICRP, 2000) and hence collective dose is not a useful measure in the long term. We do not propose to present estimates of collective dose for the period after authorisation in the 2011 ESC. BIO_013.2 See above.	BIO_013.1 Rejected BIO_013.2 Rejected
END				

Cap issues

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
CAP_001	FEP Analysis and Engineering Performance Assessment	<p>CAP_001.1</p> <p>Elicit directly the parameters used in modelling, or seek endorsement from the experts for values derived from their elicited views.</p> <p>CAP_001.2</p> <p>Provide more detailed justification for the assumptions that some FEPs are considered to be "subsumed" within the effects of other FEPs or interactions.</p>	<p>CAP_001.1</p> <p>Thorne (2008) provides a methodology for determining cap performance without the need for elicitation taking into account cap erosion rates and the updated cap design (Belton 2007).</p> <p>CAP_001.2</p> <p>A simplified approach to FEP management is proposed for the 2011 ESC, see section 5.3.3 of the "Approach to 2011 ESC" (Baker et al. 2008b).</p>	<p>CAP_001.1</p> <p>Accepted / work complete</p> <p>CAP_001.2</p> <p>In hand or planned for the 2011 ESC</p>
CAP_002	Cap Integrity and Performance – Groundwater Pathway	<p>CAP_002.1</p> <p>Assess the importance of cap infiltration to calculations of dose via the groundwater pathway, and consequently adopt either a simplified approach to defining infiltration or adopt a more detailed cap profile in future hydrogeological modelling.</p> <p>CAP_002.2</p> <p>Adopt a set of assumptions regarding the settlement and erosion of the cap that are consistent throughout all parts of the PCSC or that are demonstrably cautious for each pathway considered. Provide better justification for assumptions regarding changes in the cap topography in response to settlement (see also SDE_007.5). Justify the rate of cap erosion assumed.</p>	<p>CAP_002.1</p> <p>The influence of cap design on the safety assessment will be considered as part of the 2011 ESC. Thorne (2008) defines how infiltration rates are calculated for the proposed cap design, It is not proposed to model the cap in detail within the site-scale model.</p> <p>CAP_002.2</p> <p>Thorne (2008) addresses the issue of cap settlement. It the intention to ensure that any assumptions made in the determining performance of the cap will be consistent with the performance of other engineered components in the 2011 ESC.</p>	<p>CAP_002.1 / 2.2</p> <p>Accepted / in hand or planned for the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
CAP_003	Cap Integrity and Performance – Gas Pathway	<p>CAP_003.1</p> <p>Consider calculations to scope the effect of a house constructed over a gas vent, or over a fissure. Justify why Rn-220 is never assessed (even when the cap is thin).</p> <p>CAP_003.2</p> <p>Assess the implications of the migration of bulk gas (including entrainment of radon).</p>	<p>CAP_003.1</p> <p>Consideration of gas migration was considered as part of the Schedule 9 Requirement 2 submission (Sumerling 2008), which has increased our confidence in the assessment of radon from Ra-226 disposals. Further calculations are currently being undertaken and will be will be considered as part of the 2011 ESC.</p> <p>CAP_003.2</p> <p>Gas bulk migration was considered by Ball et al. (2007). Calculations in (Sumerling 2008) show the effect is to be small. More recent work has confirmed this and identified atmospheric pressure variations probably the main driver for gas migration in the wastes and cap.</p>	<p>CAP_003.1</p> <p>In hand or planned for the 2011 ESC</p> <p>CAP_003.2</p> <p>Accepted / work complete or in hand and to be presented in the 2011 ESC</p>
CAP_004	Cap Integrity and Performance – Intrusion Pathway	<p>CAP_004.1</p> <p>Justify the selected erosion rates and erosion model used to determine consequences of intrusion.</p>	<p>CAP_004.1</p> <p>As noted under CAP_001, further work has been carried to assess the erosion rates of the cap (Thorne, 2008).</p> <p>Human intrusion scenarios for the 2011 ESC are being reconsidered, (see section 2.5, Disruptive events). The reduced time to expected disruption of the site by coastal erosion means there is no longer a significant influence of assumed natural erosion rates on human intrusion scenarios.</p>	<p>CAP_004.1</p> <p>Work undertaken / No longer relevant</p>
CAP_005	HELP Modelling	<p>CAP_005.1</p> <p>Undertake a more comprehensive set of sensitivity / uncertainty analyses for the cap to</p>	<p>CAP_005.1</p> <p>The sensitivity of the safety assessment to cap design will be considered as part of the 2011 ESC using the</p>	<p>CAP_005.1 / 5.2</p> <p>Accepted / In hand or planned</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		explore more fully the potential range of infiltration through the cap and the effect of changing infiltration on the source term for radionuclide transport via all pathways. CAP_005.2 Explain the apparent differences between water balance and infiltration through the cap calculated using different approaches, and justify the selected approach.	potential range of infiltration through the cap. CAP_005.2 Infiltration through the interim cap is being assessed as part of the response to Schedule 9 Requirement 7. Different approaches are being used to provide checks that the values selected are justifiable.	for the 2011 ESC
END				

Assessment Codes issues

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
COD_001	Supply of information	No recommendation for actions by BNFL.	No recommendation.	-
COD_002	Recording of modelling assumptions	No recommendations for actions by BNFL or the Agency.	No recommendation.	-
COD_003	GRWOLF usage and verification	No recommendations for actions by BNFL or the Agency.	No recommendation.	-
COD_004	GEO usage and verification	<p>COD_004.1</p> <p>Compare GEO with the MASCOT transport model, using the example reported in the GRWOLF PUG for flow comparisons.</p> <p>COD_004.2</p> <p>Verify the assumption that transverse dispersion can be represented by widening of legs with distance along major plume paths.</p> <p>COD_004.3</p> <p>Demonstrate the functionality of GEO in combination with TIMEDEP for an evolving hydrogeological system.</p>	<p>COD_004.1</p> <p>This recommendation has been superseded, since GEO is no longer a tool that will be used.</p> <p>COD_004.2</p> <p>This is a detailed modelling issue that would be considered if necessary in future assessments.</p> <p>COD_004.3</p> <p>This recommendation has been superseded, since GEO is no longer a tool that will be used.</p>	<p>COD_004</p> <p>No longer relevant</p>
COD_005	BIOS usage and verification	No recommendations for actions by BNFL or the Agency.	No recommendation.	-
COD_006	DEGAS usage and verification	No recommendations for actions by BNFL or the Agency.	No recommendation.	-
COD_007	GRM usage and	COD_007.1	We agree that QA needs to be appropriately recorded.	COD_007

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
	verification	Include QA forms for test cases in all PVRs.		In hand or planned for the 2011 ESC
END				

Disruptive Events issues

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
DIS_001	FEP screening - future human actions and disruptive events	<p>DIS_001.1</p> <p>Assemble and screen a single list of EFEPs, including the range of possible site development activities, and compare its EFEP list with FEP lists derived for other LLW disposal facilities.</p> <p>DIS_001.2</p> <p>Improve the traceability of FEP screening arguments by providing sufficient information within the catalogue of FEP screening decisions for an independent reviewer to evaluate the basis for BNFL's decisions, including provision of adequate and specific references to supporting literature. BNFL should include adequate documentation for the elimination of FEPs from PCRSA calculations on the basis of well-defined screening criteria (screened-out FEPs), and adequate/traceable documentation of the treatment in the PCRSA of FEPs accounted for in the calculations (screened-in FEPs).</p>	<p>DIS_001.1 & DIS_001.2</p> <p>A formal expert elicitation study has identified possible developments and events at the site taking account of patterns of land use on the West Cumbrian Coastal Plain (Thorne, 1996). This was followed by a report (Halcrow, 1998) that considered how each of the common site uses would be implemented if the presence of a repository at the LLWR site were to be forgotten.</p> <p>We are revisiting these studies and will include a list of human activities and events that could affect the site in the 2011 ESC, and set out screening arguments for those that are not taken forward. Thus, a more balanced discussion and presentation will be developed of the uncertainties around the impacts of possible human actions at the site.</p>	<p>DIS_001.1 / 1.2</p> <p>Accepted / underpinning work complete / to be addressed in the 2011 ESC</p>
DIS_002	Human intrusion assessment	<p>DIS_002.1</p> <p>Undertake further work on risk management in view of the relatively high calculated doses and risks from human intrusion. BNFL should undertake a study to identify and document a thorough list of options that could reduce the likelihood and/or consequences of human intrusion into the trenches. BNFL should consider the benefits and detriments of each of the identified options at the appropriate level of detail, including their environmental impacts, technical</p>	<p>DIS_002.1</p> <p>Extensive work has been undertaken on risk management options and has guided our current proposals for the site development (Baker et al., 2008a).</p>	<p>DIS_002.1</p> <p>Accepted / work complete</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		<p>viability, public and worker health and safety, and social, political and cost implications.</p> <p>DIS_002.2</p> <p>Link necessary work on risk management to further work on human intrusion assessment to respond to the comments raised in this IAF - on code verification, site development and occupation subsequent to cap erosion, the characteristics of a site occupier PEG, exposure likelihood, and risk assessment - to produce a more defensible consideration of the potential impacts associated with future human actions. In particular, BNFL should:</p> <ul style="list-style-type: none"> - Provide evidence that the implementation of the human intrusion model in AMBER is correct. - Re-consider the likelihood of cap erosion, and the need for CPS calculations to consider a PEG that resides near the cap at times when the cap may have eroded and knowledge of the site lost. - Re-consider the model implementation for an agricultural site occupier PEG, and the potential additive impact on doses of "non-intrusive" pathways considered in the CPS, such as the possible use of locally derived contaminated groundwater. - Re-evaluate its presentation of arguments on the likelihood of various kinds of future human action. 	<p>DIS_002.2</p> <p>Detailed comments, largely superseded.</p> <p>In particular the proposed thicker cap reduces likelihood of intrusion into, or excavation of, the waste at times up to 5000 years, which is now the main period of interest.</p> <p>Our proposed approach to assessing human intrusion is set out in section 5.10 of Baker et al., 2008a.</p>	<p>DIS_002.2</p> <p>Largely superseded</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		<ul style="list-style-type: none"> Consider the potential risks associated with future human actions, until such time as ICRP 81 is accepted as the basis for regulation in the UK. 		
DIS_003	Waste inhomogeneity	<p>DIS_003.1</p> <p>Link necessary work on risk management to further inspection of historical disposal records in an attempt to better define the nature and extent of any unusual disposals having particularly high concentrations of specific radionuclides in the trenches.</p> <p>DIS_003.2</p> <p>Undertake a study to identify and document a thorough list of options that could reduce the likelihood and/or consequences associated with exposures to unusual disposals having particularly high concentrations of specific radionuclides (e.g., Th-232, Ra-226). This will entail consideration of the benefits and detriments of each of the options, including their environmental impacts, technical viability, public and worker health and safety, and social, political and cost implications.</p>	<p>DIS_003.1</p> <p>The heterogeneity of disposals has now been mapped (Lennon et al., 2008), and this information will be used to estimate variability of doses from human intrusion scenarios related to the heterogeneity. We note, however, that most exposure scenarios lead to exposure to significant volumes of waste.</p> <p>DIS_003.2</p> <p>General options have been considered (Edwards and Alexander, 2005).</p> <p>Detailed work related to the impacts of selective retrieval of higher activity waste is in hand, see section 4.3 of the "Approach to 2011 ESC" (Baker et al. 2008a).</p>	<p>DIS_003.1</p> <p>Accepted / underpinning work complete / will be addressed in the 2011 ESC</p> <p>DIS_003.2</p> <p>Accepted / detailed work in hand / will be addressed in the 2011 ESC</p>
DIS_004	Site destruction scenarios	<p>DIS_004.1</p> <p>Conduct further work on risk management in view of the relatively high calculated conditional doses / risks from coastal erosion. BNFL should undertake a study to identify and document a thorough list of options that could reduce the likelihood and/or</p>	<p>DIS_004.1</p> <p>A general consideration of risk management options is reported in Edwards and Alexander, 2005). This has been extended by more detailed work on each of the most promising options as summarised in R2S9, Volume 2 (Baker et al., 2008b).</p>	<p>DIS_004.1</p> <p>Accepted / detailed work largely complete / with some additional work to</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		<p>consequences of coastal erosion, and should consider each identified option at the appropriate level of detail. This will entail consideration of the benefits and detriments of each of the options, including their environmental impacts, technical viability, public and worker health and safety, and social, political and cost implications.</p> <p>DIS_004.2</p> <p>Better justify assumptions underlying its consideration of potentially exposed groups for site termination events.</p>	<p>Detailed work related to the impacts of selective retrieval of higher activity waste is in hand, see section 4.3 of the "Approach to 2011 ESC" (Baker et al. 2008a).</p> <p>DIS_004.2</p> <p>The work on definition of PEGs (Thorne, 2007) provides the traceable basis to local and regional habit data. The use of this basis for assessment of PEGs most exposed during coastal erosion is set out in R2S9, Volume 5 (Sumerling, 2008).</p>	<p>be done before 2011 ESC</p> <p>DIS_004.2</p> <p>Accepted / work complete</p>
DIS_005	Treatment of potentially disruptive, intermittent, natural events and processes	<p>DIS_005.1</p> <p>Undertake further work on risk management in view of the relatively high calculated doses and risks from non-human biotic intrusion. BNFL should undertake a study to identify and document a thorough list of options that could reduce the likelihood and/or consequences of non-human biotic intrusion into the trenches, and should consider each identified option at the appropriate level of detail. This will entail consideration of the benefits and detriments of each of the options, including their environmental impacts, technical viability, public and worker health and safety, and social, political and cost implications.</p> <p>DIS_005.2</p> <p>Re-assess its calculations of doses to non-human biota in the light of the criticisms (see IAF DIS_002) that cap erosion has not been properly accounted for in "undisturbed performance", by considering in</p>	<p>DIS_005.1</p> <p>The cap has been re-designed since 2002 (Belton, 2007) and is designed to exclude intrusion by non-human biota. It is expected to be effective in this regard at least up to 5000 Years, see (Thorne, 2008).</p> <p>DIS_005.2</p> <p>The timescale for consideration of undisturbed performance is now reduced to ca. 5000 years, considering the site is likely be destroyed by coastal within this time period.</p>	<p>DIS_005.1</p> <p>Accepted / work complete</p> <p>DIS_005.2</p> <p>No longer relevant</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		<p>more detail the possible doses to animals and plants that are active around the site as the cap degrades and erodes (see also BIO_009.1).</p>	<p>The cap will prevent is expected to resist natural erosion and remain largely intact over the period up to at least 5000 years AP (Thorne, 2008).</p>	
DIS_006	<p>Treatment of uncertainty - future human actions and disruptive events</p>	<p>DIS_006.1</p> <p>Undertake further work on risk management in view of the relatively high and uncertain calculated doses and risks from human intrusion. BNFL should undertake a study to identify and document a thorough list of options that could reduce uncertainty associated with human intrusion calculations, the likelihood of human intrusion, and/or the consequences of human intrusion, particularly into the trenches. BNFL should consider the benefits and detriments of each of the identified options at the appropriate level of detail, including their environmental impacts, technical viability, public and worker health and safety, and social, political and cost implications.</p> <p>DIS_006.2</p> <p>Link necessary work on risk management to further work on human intrusion assessment to produce a more defensible consideration of the impact of uncertainties associated with future human actions. Key assessment assumptions and uncertainties associated with BNFL's calculated conditional doses include: dilution of waste in soil, amount of waste excavated, identification of PEGs and exposure pathways, and processes considered in the stylised human intrusion assessment calculations - in</p>	<p>DIS_006.1</p> <p>A general consideration of risk management options is reported in Edwards and Alexander (2005). This has been extended by more detailed work on each of the most promising options as summarised in R2S9, Volume 2 (Baker et al., 2008b).</p> <p>Detailed work related to the impacts of selective retrieval of higher activity waste is in hand, see section 4.3 of the "Approach to 2011 ESC" (Baker et al. 2008a).</p> <p>DIS_006.2</p> <p>Characteristics of human intrusion scenarios will be revisited for the 2011 ESC, see section 5.10 of the "Approach to 2011 ESC" (Baker et al. 2008a). Assumptions regarding human intrusion are always uncertain and scenarios can only be illustrative. We will present the scenarios we propose to assess to the EA before the 2011 ESC.</p> <p>An empirically-based approach has been adopted to estimate exposures from radon following intrusion (Sumerling 2008).</p>	<p>DIS_006.1</p> <p>Accepted / work largely complete</p> <p>DIS_006.2</p> <p>Accepted / basis in place / some further consideration in the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		<p>particular, the treatment of the radon emanation factor.</p> <p>DIS_006.3</p> <p>Re-consider the screening of resource exploration/exploitation and, if necessary, evaluate the potential implications of resource exploration/exploitation occurring in the future on the Drigg site.</p>	<p>DIS_006.3</p> <p>Characteristics of human intrusion scenarios will be revisited for the 2011 ESC, see above.</p>	<p>DIS_006.3</p> <p>Accepted / basis in place / further consideration in the 2011 ESC</p>
DIS_007	Supply of information - future human actions and disruptive events	<p>DIS_007.1</p> <p>Improve presentation of the PCSC so that key lines of reasoning and evidence are readily traceable, apparent and internally consistent.</p>	<p>DIS_007.1</p> <p>Our overall approach is set out in section 5.10 of the "Approach to 2011 ESC" (Baker et al. 2008a). We accept the need for clear documentation of assumptions and their basis in this area.</p>	<p>DIS_007.1</p> <p>Accepted / to be addressed in the 2011 ESC</p>
END				

Gas issues

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
GAS_001	Supply of information on gas generation and transport	<p>GAS_001.1</p> <p>Consider taking a probabilistic approach to addressing uncertainty in gas-related issues to provide a clearer indication of the likelihood of the situations that result in high calculated risk occurring (e.g, short Rn-222 diffusion path).</p> <p>GAS_001.2</p> <p>Provide information linking the screened-in gas-related FEPs to modelled parameters on the Parameter Input Forms, and provide information on the relationship between the terms in the DEGAS mathematical equations and parameters and the gas-related FEPs.</p>	<p>GAS_001.1</p> <p>We will be considering a probabilistic approach to addressing uncertainty in the gas pathway, for both C-14 and radon, but note that a probabilistic approach is only warranted if justified pdfs can be defined for the key parameters.</p> <p>GAS_001.2</p> <p>A simplified approach to FEP management is proposed for the 2011 ESC, see section 5.3.3 of the "Approach to 2011 ESC" (Baker et al. 2008a).</p>	<p>GAS_001.1</p> <p>Accepted / to be addressed in the 2011 ESC</p> <p>GAS_001.2</p> <p>No longer relevant</p>
GAS_002	Treatment of gas generation processes	<p>GAS_002.1</p> <p>Explain why the gas vent model is appropriate for assessment of the gas pathway in the long term when degradation of the vent system might occur.</p> <p>GAS_002.2</p> <p>Evaluate the possible contribution of aluminium and copper corrosion to gas generation and justify the values of mass fraction of metals as plates and as spheres in the different disposal regions, the values of metal plate thickness, and the values of metallic sphere radii.</p> <p>GAS_002.3</p> <p>Assess the sensitivity of PCRSA results to</p>	<p>GAS_002.1</p> <p>Work is in hand to consider the migration of gases in the waste and profiling and release through the cap.</p> <p>GAS_002.2</p> <p>The contribution of aluminium and copper to gas generation is considered to be insignificant compared to gas generation from steel. However, as part of our review and update to DRINK, we will consider this bias further. The geometry of disposed metal items is likely to remain an issue for judgment, although this is another area where we will consider sensitivities to the assumptions made.</p>	<p>GAS_002.1</p> <p>Accepted / work in hand</p> <p>GAS_002.2</p> <p>Accepted work / work in hand</p> <p>GAS_002.3</p> <p>Accepted / to be included in the</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		uncertainty associated with variations in cellulose degradation rates.	GAS_002.3 Accepted, see also GAS_001.1.	2011 ESC
GAS_003	Treatment of radionuclides in the gas phase	<p>GAS_003.1 Provide a cross-reference to information that supports the screening-out of methylated Se-79, Sn-126 and Pb-210 on the basis of their low probability of occurrence.</p> <p>GAS_003.2 Provide an explanation of what the emanation factor represents and justify its value.</p> <p>GAS_003.3 Clarify the results of the calculations on gas release fractions in order to confirm a release fraction of 10% C-14.</p> <p>GAS_003.4 Provide information to support the assumption that the mass of cellulosic waste will decay as an exponential function of time.</p> <p>GAS_003.5 Provide more information about the derivation of the DEGAS atmospheric dispersion model and the selection of atmospheric stability categories.</p> <p>GAS_003.6 Provide guidance as to when inhalation dose factors need to be augmented to allow for external</p>	<p>GAS_003.1 Minor. There are several possible references, e.g. see Rodwell et al., 2003.</p> <p>GAS_003.2 Minor. The factor comes from Appendix B in UNSCEAR 2000.</p> <p>GAS_003.3 The association of C-14 bearing waste with organic degradable waste has been scoped (Ball et al., 2007). Further work is planned before the 2011 ESC</p> <p>GAS_003.4 The assumption is the simplest option based on linear rate process. It also yields the highest rate of gas generation at early times and is thus cautious.</p> <p>GAS_003.5 This is not relevant to the post-closure assessment; other exposure pathways dominate. Assessment of gaseous releases prior closure will be considered in the 2011 ESC.</p> <p>GAS_003.6 External irradiation is not relevant to the key radionuclides H-3, C-14, Rn-222. Absorption</p>	<p>GAS_003.1 / 3.2 Minor see opposite</p> <p>GAS_003.3 to 3.9 Mainly detailed queries all of which can be answered or will be dealt with in the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to the recommendations	Issue status
		<p>irradiation and absorption through intact skin.</p> <p>GAS_003.7</p> <p>Provide information on the potential for tritium to contaminate foodstuffs and contribute to doses by ingestion.</p> <p>GAS_003.8</p> <p>Provide an explanation as to why one of the six evaluation points for the gas pathway is a home located on the northern wall of vault 8, rather than any other location on the cap, and clarify why gases from all parts of the disposal site are assumed to be released to the dwelling on the cap.</p> <p>GAS_003.9</p> <p>Consider the likelihood of a dwelling existing on a 3-m thick cap after 250 years, and undertake analyses aimed at improving confidence in the cap evolution after closure and reducing uncertainty in cap thickness. This analysis should include a discussion as to why significant cracking would not occur in the cap, and in general why advection is not significant.</p>	<p>through intact skin is minor and effectively included in the ICRP dose per unit inhalation factors for H-3 and C-14.</p> <p>GAS_003.7</p> <p>Airborne tritium gas is of no importance. Tritiated water will be diluted in water vapour. The airborne releases are in any case very small.</p> <p>GAS_003.8</p> <p>We will revisit the gaseous exposure assumptions for the 2011 ESC in line with the defined PEGs (Thorne, 2007).</p> <p>GAS_003.9</p> <p>We will revisit the gaseous migration assumptions for the 2011 ESC. Work is in hand to consider the migration of gases in the waste and profiling and release through the cap.</p>	
END				

Geosphere issues

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
GEO_001	Planning and adequacy of site characterisation programme – geology and hydrogeology	<p>GEO_001.1</p> <p>Document and justify more precisely how data and conclusions from BNFL investigations have been selected for inclusion in the Interpretation Reports (BNFL, 2002h, 2002i). In particular, explain why data and conclusions offered in lower-level reports concerning palaeo-depressions within the drift have been omitted from the Level II Interpretation Reports.</p> <p>GEO_001.2</p> <p>Demonstrate the reliability and representative nature of the hydrogeological information obtained from the (unweathered) Ormskirk Sandstone in and around the Drigg site, and specify how new information will be collected.</p> <p>GEO_001.3</p> <p>Provide explicit information concerning the effects of glacio-tectonic features on groundwater flow at the Drigg site.</p> <p>GEO_001.4</p> <p>Augment the good quality, but sparse, hydraulic data from both the shallow and the deeper drift formations in the region between the site and the coast.</p>	<p>Work on the geological and hydrogeological conceptualisations has progressed considerably since 2002. Site investigation work as part of the Modular Vaults project along combined with the Phase 1 and 2 geological conceptualisations (Hunter et al., 2007; Smith, 2007) provided an updated interpretation of the geological setting and the development of a 3D geological model of both the Quaternary drift deposits and the Ormskirk sandstone. This work will be continued with the investigations of the large exposures of drift deposits seen as part of the Vault 9 excavation work. Additional boreholes are also planned to provide further data on both the shallow and deep deposits between the site and the coast.</p> <p>A 3D hydrogeological model (Henderson et al., 2008) has been developed for the site which has been used to investigate and subsequently update the hydrogeological conceptual model (Henderson, 2008). Further work to refine the hydrogeological model is planned to provide the information on potential groundwater pathways for the 2011 safety assessment.</p> <p>On the specific recommendations:</p> <p>GEO_001.1 is concerned with the documentation structure of the 2002 PCSC and is superseded as new documentation will be prepared for the 2011 ESC.</p> <p>GEO_001.2 has been addressed as part of the site</p>	<p>GEO_001.1 to 1.3</p> <p>Accepted.</p> <p>Satisfied by work completed since 2002</p> <p>GEO_001.4</p> <p>Accepted.</p> <p>Satisfied by work planned in support of the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
			<p>investigation work carried out since 2002 and by the planned boreholes between the site and the coast</p> <p>The effect of glacio-tectonic features (GEO_001.3) will have some impact on the distribution of lithologies at the site. A programme of work will consider the implications of our broad understanding of spatial variation.</p> <p>GEO_001.4 will be addressed by the planned boreholes between the site and the coast.</p>	
GEO_002	Planning and adequacy of site characterisation programme – hydrogeological modelling	<p>GEO_002.1</p> <p>Develop a 3-D geological model to present / interpret the site geology.</p> <p>GEO_002.2</p> <p>Determine the appropriateness of the "layered cake" hydrogeological model and explore its associated uncertainty by using 3-D stochastic facies models to represent alternative conceptual models of the hydrogeology of the site.</p> <p>GEO_002.3</p> <p>Justify why, in BNFL's suggestions for the forward programme, the determination of permeability values is based on measurement of samples while, in the PCRSA, mostly the in situ measurements were considered valid.</p>	<p>A 3D geological model of the site has been developed (Smith, 2007), which addresses GEO_002.1. The model has been updated with new data as it has become available and has also been used to predict the geology of the proposed boreholes between the site and the coast.</p> <p>Work has been carried out recently on alternative geological conceptual models (Serco, 2008a) and to determine whether a stochastic representation (Serco, 2008b) of the system can be developed. This work is specifically considering the connectivity of individual layers and the validity or otherwise of the 'layer-cake' model.</p> <p>We are considering all sources of permeability data, but note that the two sorts of measurement identified in GEO_002.3 address different lengthscales. We will justify our approach to parameterisation in presenting the hydrogeological model for the 2011 ESC.</p>	<p>GEO_002.1</p> <p>Accepted / Work completed since 2002</p> <p>GEO_002.2 /2.3</p> <p>Accepted / In hand or planned for the 2011 ESC</p>
GEO_003	Planning and adequacy of site	GEO_003.1	GEO_003.1	GEO_003.1 / 3.2 /

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	characterisation programme – geochemistry	<p>Continue to monitor for tritium in groundwater, and use the data to improve understanding of flow paths.</p> <p>GEO_003.2</p> <p>Regularly monitor between the site and the coast to evaluate discharges from the Upper Groundwater and Regional Groundwater to the coastal area and to the north-west of the site.</p> <p>GEO_003.3</p> <p>Establish the reason for similar tritium concentrations in the under- and over-slab components of the Vault 8 drain (e.g., discharge of contaminated groundwater into the over-slab drain, or mixing of over-slab and under-slab waters at the measurement point).</p> <p>GEO_003.4</p> <p>Consider an investigation of man-made contaminant concentrations along flow paths (e.g., CFCs) to help a more detailed analysis of preferential flow paths and flow rates.</p> <p>GEO_003.5</p> <p>Consider undertaking a spatial analysis of hydrochemistry, considering both depth and location with regard to flow-defining features, to help a more detailed analysis of flow paths and rates.</p> <p>GEO_003.6</p> <p>Undertake reaction path modelling between water</p>	<p>Monitoring of tritium concentrations in groundwater has continued and is an input to our understanding of flow paths.</p> <p>GEO_003.2</p> <p>Monitoring is undertaken to identify potential discharges of radioactive contamination to surface receptors.</p> <p>GEO_003.3</p> <p>The tritium contamination in the Vault 8 drain is considered to derive from the trenches and mixing at the measurement point is considered to be the reason for the similar concentrations in the under and overslab components.</p> <p>GEO_003.4</p> <p>The monitoring of non-radiological contaminants has been incorporated into the site environmental monitoring programme. This will provide an opportunity to assess whether such contaminant concentrations can be used to assess flow paths.</p> <p>GEO_003.5</p> <p>Spatial analysis of hydrochemistry has been incorporated into the development of the hydrogeological conceptual model. In particular the analysis of tritium concentration have been used to assess flow paths and rates.</p> <p>GEO_003.6</p> <p>We consider that the likely benefits of a spatial</p>	<p>3.7 / 3.8</p> <p>Accepted / In hand or planned for the 2011 ESC</p> <p>GEO_003.3 / 3.5 / 3.9</p> <p>Accepted / work complete</p> <p>GEO_003.6</p> <p>Rejected / disproportionate</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>samples along flow paths to build confidence in the geochemical interpretation and the PCRSA assumptions.</p> <p>GEO_003.7</p> <p>Present the basis for selecting sample K114 as the representative groundwater composition, both for the near-field modelling and the sorption modelling.</p> <p>GEO_003.8</p> <p>Consider the potential for sealing of porosity and generation of colloids in further work on the processes occurring at the near-field / far-field interface.</p> <p>GEO_003.9</p> <p>Present a more detailed forward plan.</p>	<p>analysis of the hydrochemistry and reaction path modelling do not justify the cost and have prioritised other areas of work.</p> <p>GEO_003.7</p> <p>Review of data quality will be carried out as part of the groundwater monitoring.</p> <p>GEO_003.8</p> <p>Colloid generation at the near field / far field interface would not increase the source term, which we consider to be the potential effect of colloids that would be of most concern. Such colloids if they were transported could decrease radionuclide transport times in the geosphere, but this would have little impact as environmental receptors (such as the well) are already very close to the source of contamination. Sealing of the porosity would have a low impact since relevant bentonite and concrete barriers are already associated with a low permeability. We will discuss and present arguments in relation to a range of colloid FEPs (including these) in the 2011 ESC.</p> <p>GEO_003.9</p> <p>We have developed a forward plan as the basis of the LTP and have set out approach in the Safety Case Approach Document.</p>	
GEO_004	Planning and adequacy of site characterisation programme -	<p>GEO_004.1</p> <p>Consider undertaking colloid mobility studies using column and field experiments similar to those</p>	<p>GEO_004.1 & 2</p> <p>Colloid concentrations sampled in trench leachate and far-field groundwater are low. Colloid</p>	<p>GEO_004.1 / 4.2</p> <p>Rejected / disproportionate</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	colloids / organics / retardation (sorption)	<p>carried out by the BGS (see references 15 and 16 in DTP/048), since these have the potential to provide definitive answers regarding the potential for colloid transport. The studies should focus on humic and fulvic (organic) acids, as these probably have greater potential than inorganic colloids to transport radionuclides.</p> <p>GEO_004.2</p> <p>Conduct further research into radionuclide-fulvic acid stability constants, dissociation kinetics, and models (including PA) incorporating these parameters.</p>	<p>concentrations in the vaults would also be expected to be low (owing to the presence of cements). In comparison with other uncertainties, the role of colloids is likely to be low. Further, we consider that enhancements to the source term are likely to be more significant than any impact on geosphere transport. Therefore, the LLWR does not consider that these areas of research are a priority. The potential influence of colloidal processes will be addressed in the 2011 ESC and relevant arguments and data will be presented.</p>	
GEO_005	Adequacy of information / referencing – overall PCSC document structure	<p>GEO_005.1</p> <p>Improve the structure and clarity of reporting in a future PCRSA.</p>	<p>GEO_005.1</p> <p>The Structure of the ESC was discussed in the Safety Case Approach Document (Baker et al. 2008). There will be an improvement relative to the 2002 PCSC.</p>	<p>GEO_005.1</p> <p>In hand or planned for the 2011 ESC</p>
GEO_006	Adequacy of information / referencing - geological and hydrogeological characterisation	<p>GEO_006.1</p> <p>Ensure uniformity of stratigraphic and geological nomenclature in all relevant top-level reports.</p> <p>GEO_006.2</p> <p>Provide necessary data or references to justify statements in the Geological Interpretation on source-diagnostic clast compositions of various drift deposits.</p> <p>GEO_006.3</p> <p>Provide information on the sampling, analytical and</p>	<p>GEO_006.1</p> <p>It is recognised that presentation of the geology needs to be consistent on both a site and regional scale and this will be addressed in the presentation of the geological understanding in the 2011 ESC. Actions are incorporated into geological model report.</p> <p>GEO_006.2</p> <p>Clast composition has been considered as part of the geological re-interpretation (Smith 2007)</p>	<p>GEO_006.1 / 6.2</p> <p>Accepted / Satisfied by work completed since 2002</p> <p>GEO_006.3</p> <p>Accepted / to be include in the</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>presentational techniques used in constructing the ternary and summary particle size distribution (PSD) pie-diagrams for all drift formations.</p> <p>GEO_006.4</p> <p>Provide an account within the context of Geological Interpretation, of existing knowledge of Late Quaternary sea-level change in the Drigg region, including an assessment of the Drigg Quaternary sequence in relation to the regional framework.</p>	<p>GEO_006.3</p> <p>Supporting information for constructing diagrams will be clearly referenced in the 2011 ESC.</p> <p>GEO_006.4</p> <p>Smith (2007) presents the geological reinterpretation of the LLWR site and its setting with respect to the Regional geology as described by the BGS.</p>	<p>2002 ESC</p> <p>GEO_006.4</p> <p>Accepted / Satisfied by work completed since 2002</p>
GEO_007	Adequacy of information / referencing – geochemical characterisation	<p>GEO_007.1</p> <p>Ensure that the tritium data derived from monitoring results are referenced back to their source, and assessed for quality in the same manner as the other BNFL site characterisation data and Nirex data.</p> <p>GEO_007.2</p> <p>Reference the source of thermodynamic data used in speciation and mineral saturation calculations in the Geochemical Interpretation.</p> <p>GEO_007.3</p> <p>Document the procedures for entering all historical and future site characterisation data used to support the PCSC into the BNFL site characterisation database.</p>	<p>GEO_007.1 all parts</p> <p>Referencing and quality of data used in the 2011 ESC will addressed as described in the ESC approach document (Baker et al., 2008a).</p>	<p>GEO_007</p> <p>In hand or planned for the 2011 ESC</p>
GEO_008	Adequacy of information / referencing – retardation	<p>GEO_008.1</p> <p>Provide the series of BNFL Internal Reports that support the derivation of the Drigg sorption</p>	<p>GEO_008.1 & GEO_008.2</p> <p>Randall et al (2008) provides a recent justification of the sorption parameters used in the Requirement 2</p>	<p>GEO_008</p> <p>Accepted / work done plus planned</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	characterisation	<p>database for the geosphere. The information to be provided should include the sorption data used, should allow the quality of the data to be evaluated, and should include a list of excluded data.</p> <p>GEO_008.2</p> <p>Justify the selection of the data used for modelling sorption in the Ormskirk sandstone.</p>	<p>assessment calculations. We will consider the need for further review, referencing or data compilation prior to the 2011 ESC.</p>	for the 2011 ESC
GEO_009	Screening, model development and assumptions - geological issues	<p>GEO_009.1</p> <p>Provide further quantified justification for the use of the MODFLOW model to describe flow within the Regional Groundwater, in the light of the more recent conceptual model for groundwater flow.</p> <p>GEO_009.2</p> <p>Further justify the use of "appropriate parameters" within the network model to account for groundwater flow in the sandstone below the north-western part of the site in certain future scenarios.</p> <p>GEO_009.3</p> <p>Provide evidence that the effects on future groundwater flow paths of migrating coastal dune fields (in the area between the site and the coast, and further inland) have been adequately accounted for in the risk assessment models.</p>	<p>GEO_009.1</p> <p>These comments relate to the approach pursued in the 2002 PCSC and have been superseded.</p> <p>GEO_009.2</p> <p>Henderson et al. (2008) describes the development of the 3D site-scale groundwater model using FEFLOW. The FEFLOW model has been used to derive the groundwater fluxes and associated pathway geometry required by the ESC Project safety assessment model.</p> <p>GEO_009.3</p> <p>Further development of the site-scale groundwater flow model is planned to ensure that potential effects on the groundwater pathway due to climatic changes or coastal erosion are considered.</p>	<p>GEO_009.1</p> <p>Superseded</p> <p>GEO_009.2 / 9.3</p> <p>Accepted / in hand or planned for the 2011 ESC</p>
GEO_010	Screening, model development and assumptions - hydrogeology	<p>GEO_010.1</p> <p>Develop a realistic continuum hydrogeological model, based on the stochastic descriptions of the geology and hydrogeology (see also GEO_002.2).</p>	<p>GEO_010.1</p> <p>As mentioned under GEO_002 work has been carried out recently on alternative geological conceptual models (Serco, 2008a) and further work</p>	<p>GEO_010</p> <p>Accepted / in hand or planned for the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	issues	Calibrate the model in both steady and transient states, for each stochastic realisation, and assess the effect of structural (i.e., facies distribution) and parameter uncertainty. Use this model directly for the PCRSA, producing a set of alternative results (stochastic approach) and, if a network model is desired, develop the network model so that its results are consistent with each of the continuum model results.	is planned to determine whether a stochastic representation of the system can be developed.. We would then determine how this model should be used to support the safety case. However, we consider the details of this recommendation to be disproportionate and question whether the proposed approach is the best way of enhancing confidence in the safety case.	
GEO_011	Screening, model development and assumptions - geochemical issues	<p>GEO_011.1</p> <p>Introduce a stronger linkage between FEP screening, modelling assumptions, and derivation of parameter values, so that it is clear where and how FEPs are accounted for in models and parameter values.</p> <p>GEO_011.2</p> <p>Clarify how the derivation of "best-estimate" parameter values accounts for all of the FEPs that the parameter is purported to represent.</p>	<p>GEO_011.1</p> <p>We will review the list of FEPs prior to or as part of the 2011 ESC in order to ensure that they are treated appropriately or ruled out using appropriate arguments. This will result in an auditable trail.</p> <p>GEO_011.2</p> <p>No general justification can be provided. Where parameter choices in the 2011 ESC are intended to allow for some specific process, we will present the parameter-specific arguments.</p>	<p>GEO_011</p> <p>Accepted / in hand or planned for the 2011 ESC</p>
GEO_012	Screening, model development and assumptions - retardation / organics / colloid issues	<p>Sorption issues: See IAF GEO_011.</p> <p>Colloids and humics: No action need be taken at present.</p>	No additional recommendation.	-
GEO_013	Treatment of uncertainty - site characterisation, geology and	<p>GEO_013.1</p> <p>Discuss the effects of major (laterally restricted) high-permeability fast hydraulic pathways on the conceptual and numerical models for groundwater</p>	<p>GEO_013.1 & GEO_013.3</p> <p>The development of a 3D hydrogeological model for the site as described in Henderson et al (2008) and the update of the conceptual model (Henderson,</p>	<p>GEO_013</p> <p>Accepted / in hand or planned for the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	hydrogeology	<p>flow, and consider whether the measures adopted to accommodate smaller features of this type in the PCRSA models are adequate to describe and quantify larger-scale effects.</p> <p>GEO_013.2</p> <p>Provide explicit justification for the use of geometric mean values for hydraulic conductivities as the basis for "best-estimate" measures for the hydrogeological behaviour of all drift formations.</p> <p>GEO_013.3</p> <p>Clarify, and address discrepancies in, its hydrogeological pathway analysis.</p>	<p>2008) has enabled further investigation of the potential groundwater pathways. Such preferential pathways are not considered to be the dominant mechanism for the release of contaminants from the site. Further consideration will be part of future work and relevant arguments will be set out as part of the 2011 ESC.</p> <p>GEO_013.2</p> <p>Justification and the linkage between modelling assumptions and data will be revised for the 2011 ESC.</p>	
GEO_014	Treatment of uncertainty - hydrogeological modelling	See GEO_010.1.	No additional recommendation.	-
GEO_015	Treatment of uncertainty - geochemical issues	<p>GEO_015.1</p> <p>Present the analytical errors associated with the geochemical data, and document an assessment of whether these errors are significant to the hydrogeochemical interpretation.</p> <p>GEO_015.2</p> <p>Further constrain the variation in rainwater composition at the Drigg site in order to reduce uncertainty in detailed aspects of the hydrochemical interpretation.</p> <p>GEO_015.3</p>	<p>GEO_015.1</p> <p>Interpretation of the hydrogeochemical data in the 2011 ESC will take into account the range of errors associated with analytical testing and assess whether they are significant in terms of any interpretation derived from the use of the data.</p> <p>The environmental monitoring programme is designed to provide analytical data from accredited laboratories in which there can be a high degree of confidence. However, where analytical data are used in support of the 2011 ESC any uncertainty in the data will be presented.</p>	<p>GEO_015</p> <p>Accepted / In hand or planned for the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>Review the dichotomy between averaging experimental data to obtain a "best-estimate" and the assumption that the range in the experimental data captures uncertainty over the geochemical environment.</p> <p>GEO_015.4</p> <p>Present the assessment of the uncertainty associated with selection of a single groundwater composition for near-field performance.</p>	<p>GEO_015.2, 15.3 & 15.4</p> <p>Treatment of uncertainty in the safety assessment is detailed in the safety assessment approach document. Our intent is to focus on those uncertainties that are most important in determining performance. We do not believe that the uncertainties identified in this IAF fall into this category.</p>	
GEO_016	Geosphere sorption database derivation and treatment of uncertainty	<p>GEO_016.1</p> <p>Carry out a new systematic experimental study of uranium sorption in the Drigg sediment/groundwater system. Such a study should be guided by speciation and sorption modelling, and should concentrate on the effects on sorption of groundwater composition and fulvic acids. Note that the sediment contains sorbed organics which may desorb if organic-free groundwater is used. It is also important that colloids should remain with the solid phase when the phases are separated (some of the older data sources in DTP/104 used 0.2 or 0.45 micron filters or short centrifugation times at slow speeds - this can result in "low" Rd values). Groundwater composition should be measured before, during and after sorption (probably in radionuclide-free experiments), and the sediment used should be fresh, i.e., stored for a minimum time under in situ conditions and not dried.</p> <p>GEO_016.2</p>	<p>GEO_016.1</p> <p>The LLWR has carried out an experimental study of uranium sorption, which reported this year (Dutton and Trivedi, 2008).</p> <p>GEO_016.2</p>	<p>GEO_016.1</p> <p>Accepted / Satisfied by work completed since 2002</p> <p>GEO_016.2</p> <p>Rejected /</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>Radionuclides other than uranium should be included in the above study where their sorption properties (Kd values) could significantly affect the safety case. In particular, elements in the U-234 decay chain could usefully be included in the above experimental programme. The limited data for Th, Ra and Pb means that the experimental variation is not observed to the same extent as for uranium; this gives a false sense of confidence in the Kd value, based on data scarcity rather than real sensitivity.</p> <p>GEO_016.3</p> <p>Develop an improved treatment of upscaling of sorption measurements, either by including the effects of organics and colloids when modelling column experiments and/or by more realistic field studies.</p> <p>GEO_016.4</p> <p>Show clearly where and how expert judgement has been used and on what basis chemical analogues have been selected for the sorption database.</p>	<p>Sorption in the geosphere is not likely to be a significant control on the radiological impacts arising for the water abstraction well and therefore such studies are not considered a priority.</p> <p>GEO_016.3</p> <p>As noted above, we have recently re-assessed available far-field sorption data. We will consider the need for further review, referencing or compilation of far-field sorption data prior to the 2011 ESC. This will include consideration of the use of data from different sorts of experiment and their application to longer lengthscales.</p> <p>GEO_016.4</p> <p>We will record where and how expert judgement has been used as part of the data management process in the 2011 ESC.</p>	<p>disproportionate</p> <p>GEO_016.3</p> <p>Accepted / In hand or planned for the 2011 ESC</p> <p>GEO_016.4</p> <p>Accepted / In hand or planned for the 2011 ESC</p>
GEO_017	Climate change effects on hydrogeology	<p>GEO_017.1</p> <p>Analyse an increase in recharge scenario for the regional groundwaters, and a low recharge scenario for a totally forested site.</p> <p>GEO_017.2</p> <p>Link the narrative descriptions of site evolution with continuum hydrogeological modelling of the responses to climate change in order to calibrate</p>	<p>GEO_017.1</p> <p>The 2011 ESC will use recharge values that reflect the range of possible climate evolution scenarios for the site.</p> <p>GEO_017.2</p> <p>The 2011 ESC will provide a clear link between the scenarios selected and the narrative descriptions of site evolution.</p>	<p>GEO_017.1 / 17.2</p> <p>In hand or planned for the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		the PCRSA modelling over time.		
GEO_018	Planning and adequacy of site monitoring programme – hydrology and hydrogeology	<p>GEO_018.1</p> <p>Ensure, as a priority, the systematic collection of further time-series hydro-data (water flow parameters, water quality and contaminant analyses) from both the site and off-site area. See also GEO_022.2.</p> <p>GEO_018.2</p> <p>Specify the principles and practices adopted in defining the baseline hydrogeological and geological conditions for comparison with future situations.</p>	<p>GEO_018</p> <p>The environmental monitoring programme for the site has been designed to provide the data required for 2011 ESC including time series data sets.</p> <p>Baseline hydrogeological conditions are defined taking into account the range of values observed as part of the site monitoring programme taking into account seasonal fluctuations and any definable trends.</p> <p>Geological conditions are defined from borehole, trial pits and field exposures. A 3D geological model of the site has been developed which will be updated as new data become available.</p>	GEO_018 Accepted / In hand or planned for the 2011 ESC
GEO_019	Characterisation for construction and minimisation of geological disturbance during construction	<p>GEO_019.1</p> <p>In advance of construction of Vault 9, provide detail of what ground conditions are specified in the design envelope for Vault 9, how these conditions assure that the geology and hydrogeology assumed in the PCRSA are met, and how alternative designs might be assessed for implementation in the case of conditions not being met. Also provide detail of the investigations that will be conducted in advance of, or during, construction to assess the conditions.</p> <p>GEO_019.2</p> <p>Provide an improved FEP analysis of potential disturbance by site investigation, excavation/construction, and repository sealing</p>	<p>GEO_019.1 & GEO_019.2</p> <p>A detailed site investigation programme was implemented to provide ground condition data to support the Vault 9 design. Further observations have been made during the construction of Vault 9 to provide further confirmation of the predicted conditions.</p>	GEO_019 Satisfied by work completed since 2002

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		activities.		
GEO_020	Demonstration of multi-barrier concept	There are no recommendations.	No response required.	-
GEO_021	Implications of data freeze	<p>GEO_021.1</p> <p>Document the data freeze points applied in the 2002 PCSC, identify and present data that have been collected since the data freeze, and present an evaluation of the potential significance of these data to PCRSA results.</p> <p>GEO_021.2</p> <p>Present the procedures in place to regularly review site characterisation data arising after data freeze points and to deal with new data that affect or contradict PCRSA modelling approaches or parameter values.</p>	<p>GEO_021</p> <p>A datafreeze is essential as a starting point for an assessment or Environmental Safety Case. All data sets to be used in the 2011 ESC will be frozen in advance of the assessment. If new data that become available after the datafreeze, are significantly different or cast doubt on the ESC, then this would be considered and appropriate action identified. The LLWR has no specific procedure of the sort identified, but we will provide appropriate comment in the 2011 ESC, indicating any significance of data collected subsequent to the datafreeze. We do not however propose to present those data systematically in the 2011 ESC.</p>	<p>GEO_021</p> <p>No longer relevant or rejected</p>
GEO_022	Documentation of the site characterisation programme	<p>GEO_022.1</p> <p>Provide detailed information on the following:</p> <p>(1) core-recovery data for all boreholes penetrating drift formations used in the risk assessment, together with an account of the geological and hydrogeological significance of such data;</p> <p>(2) the sampling methods used, and the distribution of samples obtained, from boreholes and other exposures for use in hydraulic conductivity testing; and</p>	<p>GEO_022.1</p> <p>Smith (2007) provides a summary of the site investigation works that have been carried out since 2002 that have targeted both the Ormskirk Sandstone and the drift deposits. Where geological data are used to support the 2011 ESC the source of the data will be fully referenced and the limitations of core recovery and sampling methods used will be considered.</p> <p>GEO_022.2</p> <p>Systematic collection of time series hydrological and</p>	<p>GEO_022</p> <p>Accepted / satisfied by work completed since 2002</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>(3) the techniques used to calibrate, process and filter signals obtained during studies using ground-penetrating radar, MRT and down-hole geophysical logging.</p> <p>GEO_022.2</p> <p>Ensure, as a priority, the systematic collection of further time-series hydrological and hydrogeological data, with special reference to:</p> <p>(1) site water balance calculations; and</p> <p>(2) hydraulic properties of the Ormskirk Sandstone (including fractures) and deeper drift formations in on-site and off-site areas.</p>	<p>hydrogeological data has been instigated since 2002 to aid the understanding of the site water balance. These data have been used to update the site water balance (Towler et al 2007) and identify areas where further monitoring will be undertaken to support the 2011 ESC.</p> <p>Boreholes into the Ormskirk sandstone and deeper drift deposits have been constructed since 2002 and have been used to assess hydraulic properties of the strata. Further boreholes are planned off-site, which are designed to provide further information on the hydraulic properties of both the Ormskirk sandstone and the drift deposits as described in the updated conceptual model report (Henderson 2008).</p>	
GEO_023	Characterisation of contaminant plumes	<p>GEO_023.1</p> <p>Monitor for contamination entering the sandstone beneath the site, and determine if the flow in the sandstone is dominated by fracture flow or by matrix properties.</p>	<p>GEO_023.1</p> <p>Contaminant levels in the sandstone have been monitored as part of the site investigation work since 2002. Flow in the sandstone has been investigated as part of the site scale modelling work (Henderson et al 2008). The hydraulic gradients in the deeper drift deposit and the Ormskirk Sandstone indicate that flow is predominantly horizontal with vertical gradient reducing with depth as such contaminant transport from the site is considered to be predominantly within the drift deposits. New off-site boreholes are planned to provide more information on the contaminant movement within the sandstone with both analysis of the groundwater for contamination and hydraulic testing.</p>	<p>GEO_023</p> <p>Accepted / In hand or planned for the 2011 ESC</p>
GEO_024	Specific	GEO_024.1	GEO_024.1	GEO_024

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	modelling issues	<p>Further justify or revise the modelling approach to representation of a well for water extraction.</p> <p>GEO_024.2</p> <p>Further justify or revise the screening-out of diffusion through the cut-off wall.</p> <p>GEO_024.3</p> <p>Re-estimate the hydrologically effective recharge (HER) in the forested areas of Drigg, and improve the calibration of the water balance model.</p>	<p>Further work on the representation of water abstraction wells has been carried out (Serco, 2008c) and will be continue to be developed in conjunction with the refinement of the site-scale groundwater model.</p> <p>GEO_024.2</p> <p>Further work is planned to consider the representation of the engineering structures as part of the 2011 ESC. We would be able to confirm for suitable choices of parameters that advective fluxes dominant over diffusive fluxes.</p> <p>GEO_024.3</p> <p>Further work has been carried out on both the site water balance (Towler et al., 2007) and the calculation of HER using the WATBAL model (Henderson and Whitaker 2008). Henderson and Whitaker (2008) take into account the land use of different areas of the site including the effects of trees on effective rainfall. Since 2002 a significant area of the site has been cleared of the trees and this has been incorporated into the HER calculations.</p>	Accepted / In hand or planned for the 2011 ESC
END				

Near-field issues

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
NRF_001	Nuclear criticality	<p>NRF_001.1</p> <p>Account in the Drigg post-closure criticality safety case for the uncertainty in the inventory of fissile isotopes.</p> <p>NRF_001.2</p> <p>Demonstrate how criticality safety arguments will apply in the event of changes to the limit on the uranium content of waste containers.</p>	<p>NRF_001.1 / 1.2</p> <p>We will include a short re-evaluation of the potential for nuclear criticality as part of the 2011 ESC. In the re-evaluation, we will discuss uncertainties and the implications of waste acceptance criteria and container limits. We do not propose a major activity since the content of fissile material is so low that the chance of a criticality is remote.</p>	<p>NRF_001</p> <p>Accepted</p> <p>In hand or planned for the 2011 ESC.</p>
NRF_002	Supply of near-field information	<p>NRF_002.1</p> <p>Adopt a more inclusive approach when developing future updates of the PCSC that allows the regulator to comment on actual drafts of the safety case documents, including results from performance assessment calculations, as they are developed during the conduct of successive iterations of safety assessment.</p> <p>NRF_002.2</p> <p>Provide information readily and in a timely manner and strive to achieve the highest levels of openness and transparency.</p> <p>NRF_002.3</p> <p>Plan the production of the safety case documentation in a strategic manner such that it facilitates regulatory review and stakeholder dialogue.</p>	<p>NRF_002 all parts</p> <p>The LLWR wishes to adopt an open approach and to make documents available for regulatory comment in a regular and timely manner. For example, we have recently provided the Safety Case Approach Document to the Environment Agency and will provide other interim documents before the 2011 ESC. However, we do not wish to commit to produce early drafts of Safety Case documentation for review as project timescales might make this difficult. We suggest that such opportunities for review and exchange of information should continue to be discussed at the regular liaison meetings between the LLWR and the EA.</p> <p>We have previously responded to the IAFs provided by the Environment Agency. This document provides a further review.</p>	<p>NRF_002</p> <p>Accepted</p> <p>In hand or planned for the 2011 ESC.</p> <p>We are committed to as much exchange of information and review as possible, consistent with project timescales.</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		NRF_002.4 Respond to each of the issues raised by the Agency following the Agency's Issue Resolution Procedure.		
NRF_003	Near-field disaggregation	NRF_003.1 Re-assess the structure of the Drigg PCSC documentation and aim for greater levels of transparency in future revisions to the Drigg PCSC.	NRF_003.1 The structure of the 2011 ESC documentation will be improved from that in the 2002 PCSC and is discussed in the Safety Case Approach Document (Baker et al., 2008a).	NRF_003 Accepted In hand or planned for the 2011 ESC.
NRF_004	Near-field FEP screening	NRF_004.1 Provide traceable documentation demonstrating a systematic analysis of the FEPs that may influence the site, including the use of reasoned arguments and scoping calculations for extreme events and for processes not otherwise considered in the PCRSA. NRF_004.2 Provide traceable documentation of the reasoning for the elimination of FEPs from the assessment calculations on the basis of well-defined elimination (screening) criteria. NRF_004.3 Provide traceable documentation of the treatment of FEPs in the assessment calculations. NRF_004.4 Document FEPs and models in a way that reduces uncertainty in the inclusion or exclusion of FEPs in PCRSA models. Where possible, relate FEPs	NRF_004 all parts As part of the 2011 ESC, we propose to review the list of relevant FEPs and to provide an audit of their treatment or exclusion. Such treatment might involve addressing a FEP within an assessment model or conducting some side calculation to justify a view that further consideration of the FEP is not required.	NRF_004 Accepted, although our proposed review and re-analysis will be more limited in scope than undertaken for the 2002 PCSC. In hand or planned for the 2011 ESC.

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>directly to the terms in the mathematical equations solved by the assessment codes. Where FEPs are incorporated in the PCRSA calculations through parameter values, document the relationship between the parameter values and the FEPs contributing to the selected values of those parameters. Where FEPs are included in the PCRSA through the way in which the PCRSA models are used to simulate particular scenarios, explain clearly how such FEPs are incorporated in the PCRSA analysis.</p> <p>NRF_004.5</p> <p>Demonstrate consistency between assessment models and computer codes, and the results of the systematic analysis of FEPs.</p> <p>NRF_004.6</p> <p>Provide traceable documentation of any situations in which the limitations of the assessment codes, or inconsistencies between the assessment codes and the results of systematic analysis of FEPs, may bias assessment results.</p>		
NRF_005	Near-field model description, assumptions and justification	<p>NRF_005.1</p> <p>Review the assumptions that underlie the DRINK model (particularly those associated with the range of metals considered, the corrosion model, and the sorption model for the trenches) and modify the model so that it is more closely representative of the actual wastes at the disposal facility, and can be used on a more routine basis to consider the post-closure impacts of site operations and the</p>	<p>NRF_005.1</p> <p>This comment is in part superseded since the LLWR does not intend DRINK to fulfil the same role in the assessment modelling as was the case in the 2002 PCSC. In the 2011 ESC, DRINK will be used as a supporting tool to support a simpler assessment model. We will consider modifications and updates to the model prior to its use in the 2011 ESC. However, we do not see DRINK as the regular</p>	<p>NRF_005</p> <p>Partially accepted</p> <p>In hand or planned for the 2011 ESC.</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		acceptability of specific waste consignments.	choice of software tool to address the issues identified in the recommendation.	
NRF_006	Near-Field Model Implementation	<p>NRF_006.1 Provide results from calculations to evaluate the uncertainty introduced to the near-field modelling results by the scale of spatial discretisation of the waste in the DRINK model.</p> <p>NRF_006.2 Provide results from calculations to evaluate the uncertainty introduced to the near-field modelling results by the selection of time steps in DRINK calculations.</p>	<p>NRF_006.1 / 6.2 We will consider the need to evaluate such numerical effects when reviewing the further use of DRINK. This is a task that will begin shortly.</p>	<p>NRF_006 Partially accepted In hand or planned for the 2011 ESC.</p>
NRF_007	Near-field parameters	<p>NRF_007.1 Document and justify the parameter values used in the PCSC.</p> <p>NRF_007.2 Document the primary sources of data used in establishing the parameter values used in the PCSC.</p> <p>NRF_007.3 Document the calculations and techniques used to derive parameter values from primary data.</p> <p>NRF_007.4 Document the range of uncertainty associated with the parameter values used in the PCSC.</p>	<p>NRF_007.1 / 7.2 / 7.3 / 7.5 The LLWR will implement a data control procedure that require the documentation of parameter values, the sources of data and any related assumptions.</p> <p>NRF_007.4 In characterising uncertainty we propose to focus on those parameters that are significant in terms of performance. We will justify which parameters are important as part of the analysis.</p>	<p>NRF_007.1 to 7.5 Accepted / in hand or planned for the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>NRF_007.5</p> <p>Document which features, events and processes are represented within each range of parameter values.</p> <p>NRF_007.6</p> <p>Demonstrate that the thermodynamic database used in the PCRSA calculations is internally-consistent and has been compiled using appropriate procedures.</p>	<p>NRF_007.6</p> <p>We propose to use the best available thermodynamic data. However, it needs to be recognised that available thermodynamic databases are not fully consistent internally.</p>	<p>NRF_007.6</p> <p>Rejected</p>
NRF_008	Near-field Performance and uncertainties	<p>NRF_008.1</p> <p>Revise its approach to the treatment of uncertainty in the Drigg PCSC, and base future PCSCs for Drigg on probabilistic safety assessment calculations.</p> <p>NRF_008.2</p> <p>Conduct a thorough quantitative uncertainty analysis to evaluate uncertainties associated with the selection of conceptual models, modelling assumptions and parameter values, and present a justification for the adopted approach.</p> <p>NRF_008.3</p> <p>Conduct multi-parameter sensitivity analyses to help prioritise work aimed at reducing uncertainties, and present a justification for the adopted approach.</p>	<p>NRF_008.1</p> <p>We propose to undertake a probabilistic safety assessment for the groundwater pathway.</p> <p>NRF_008.2</p> <p>Our overall approach to dealing with uncertainty is set out in the Safety Case Approach Document (Baker et al., 2008a). We will put the available effort into characterising the uncertainty in key parameters.</p> <p>NRF_008.3</p> <p>Sensitivity analyses for key parameters will be an important part of our approach.</p>	<p>NRF_008 all parts</p> <p>Accepted / In hand or planned for the 2011 ESC.</p>
NRF_009	Near-field flow	<p>NRF_009.1</p> <p>Demonstrate clearly that the post-closure risk</p>	<p>NRF_009.1</p> <p>We do not think it is feasible that the repository as a</p>	<p>NRF_009</p> <p>Mainly accepted</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>assessment adequately accounts for the potential effects of gas flow and pressurisation on repository components (e.g., the cap).</p> <p>NRF_009.2 Provide evidence to build confidence in the hydraulic conductivities selected for the below-ground structures.</p> <p>NRF_009.3 Conduct a sensitivity analysis to evaluate the effect of the timescale over which the near-field is assumed to degrade.</p> <p>NRF_009.4 Document a quantitative assessment of the potential consequences of repository flooding.</p>	<p>whole could become pressurised to any significant extent. Gas vents will be present which will prevent pressurisation, noting that gas is dominantly generated during the period of management control. The effects of gas flow on radiological impacts, from radon and C-14-labelled species will be evaluated.</p> <p>NRF_009.2 Where possible, we will provide evidence and arguments in support of the properties assigned to degraded engineered barriers. However, it should be recognised that there is an element of judgment in such assignment.</p> <p>NRF_009.3 The variation of groundwater flow through the repository is an important control on performance and the implications of uncertainty will therefore be evaluated by the proposed probabilistic calculations.</p> <p>NRF_009.4 The consequences of bathtubbing leading to localised discharges will be assessed in the 2011 ESC.</p>	<p>Work is in hand or planned for the 2011 ESC</p>
NRF_010	Near-Field Colloids and Organic Complexation	<p>NRF_010.1 Undertake further applied research to reduce uncertainties related to colloids, including kinetically-controlled radionuclide sorption on colloids, and colloid stability; and develop a scientifically justified assessment of the potential influence of colloids on radionuclide mobility, dose and risk.</p>	<p>NRF_010.1 Our view of colloids is addressed under GEO_004. We propose to address the issues in the ESC, but do not regard the area as a priority for further research. We do not feel that the areas identified by NRF-010.1 are the most significant potential impacts as far as colloids are concerned.</p>	<p>NRF_010.1 Rejected / disproportionate</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		NRF_010.2 Evaluate the potential significance of organic complexation to radionuclide mobility, dose and risk in the Drigg disposal system.	NRF_010.2 We will present arguments in the 2011 ESC in relation to the significance of organic complexation, which we consider to be of low impact, as demonstrated by work subsequent to the 2002 PCSC (Trivedi et al., 2008).	NRF_010.2 Accepted / work completed
NRF_011	Near-Field Microbes	NRF_011.1 Provide further justification for the selected value of the initial microbe concentration parameter, or document evidence to support the assertion that the value of the parameter is of low significance to the performance of the disposal system. NRF_011.2 Provide further information on the sensitivity analyses conducted to assess the significance of the microbiological parameters and modelling assumptions, fully document the rationale behind the decisions to perform the sensitivity analyses, and document in a clear and transparent manner the links between the significance indices on the microbiological Parameter Input Forms and the results from the sensitivity analyses.	NRF_011.1 / 11.2 Our approach to modelling gas release in the 2011 ESC is under development. We will examine the implications of relevant uncertainties. We agree that it would be unsatisfactory if the safety case were to be based on an unsupported assumption concerning a key parameter. Our focus is on a better understanding of the inventory that could give rise to C-14-labelled gas and the adoption of relatively simple assumptions concerning the time period for the evolution of gas. We wish to avoid undue reliance on uncertain microbiological models.	NRF_011 No longer relevant or rejected
NRF_012	Near-Field Interactions	NRF_012.1 Provide detailed information regarding the chemical and physical composition, and properties of the superplasticiser used in the Drigg grout backfill, document an assessment of the potential effects of the superplasticiser on radionuclide migration and overall disposal system performance, and	NRF_012.1 Subsequent to the 2002 PCSC, a review of the potential impact of superplasticiser has been undertaken and concluded that impacts are likely to be small (Trivedi et al., 2008). Further consideration of the wasteform is planned	NRF_012.1 Work completed in relation to superplasticiser and work on the wasteform in hand or planned for the

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>demonstrate that the formulation of the Drigg grout backfill and the nature of the Vault wasteform represent BPM (Best Practicable Means) for ensuring that doses and risks are As Low As Reasonably Achievable (ALARA), economic and social factors being taken into account.</p> <p>NRF_012.2</p> <p>Provide detailed information on the materials of the "over vault drainage blanket", the "inter-ISO container drainage" and the "vertical drain", document an assessment of the compatibility of these materials with the waste and the host rock, and demonstrate that the design of these engineering features and the nature of the chosen materials represent BPM (Best Practicable Means) for ensuring that doses and risks are As Low As Reasonably Achievable (ALARA), economic and social factors being taken into account.</p> <p>NRF_012.3</p> <p>Document clearly the potential significance to site risks of trench-to-vault uranium transfers. Provide further information that allows clear understanding of the amounts and spatial distribution of possible uranium transfers between the trenches and vaults as a result of cross-flow (e.g., two-dimensional plan views of the disposal facility, representing the spatial distribution and evolution of chemical conditions over time). Document more fully the uncertainties associated with the 2002 PCSC modelling of trench-vault interactions. If trench-vault uranium transfers are significant to site risks, take</p>	<p>as part of preparatory work for the 2011 ESC.</p> <p>NRF_012.2</p> <p>Optimisation studies will be completed before the 2011 ESC in relation to the design of the facility. We would not propose to undertake a specific optimisation study for each individual sub-component of the facility unless it were clear that there is a major link between that sub-component and overall performance.</p> <p>NRF_012.3</p> <p>We will discuss such interactions and any related bias. However, we consider that a detailed evaluation and modelling of such effects is disproportionate. We consider that there are other near-field FEPs that are more important to prioritise for further study. Our proposed approach is not to represent every near-field FEP in an assessment model, but to conduct a systematic evaluation, supported by appropriate arguments and models.</p>	<p>2011 ESC</p> <p>NRF_012.2</p> <p>Rejected / not relevant</p> <p>NRF_012.3</p> <p>Rejected / disproportionate</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		account of the potential effects of spatial heterogeneity in near-field water flows and of physico chemical processes (e.g., grout hydration, passivation of fracture surfaces) that may influence the retention of uranium in the vaults.		
NRF_013	Near-Field Sorption	<p>NRF_013.1</p> <p>Provide further information on the treatment of sorption in the near-field in the 2002 PCRSA, including a clear statement of the ranges of chemical conditions for which the best estimate Kd values are considered valid.</p> <p>NRF_013.2</p> <p>Undertake a broader and technically-justified set of sensitivity and uncertainty analyses.</p> <p>NRF_013.3</p> <p>Revise the approach to modelling near-field sorption so that the evolution of chemical conditions is taken into account.</p> <p>NRF_013.4</p> <p>Consider investigating further the effects on radionuclide sorption of additional near-field solid phases (e.g., iron corrosion products).</p> <p>NRF_013.5</p> <p>Commit to conducting work under the forward programme aimed at developing a defensible approach to the treatment of sorption in the near-field.</p>	<p>NRF_013.1</p> <p>We envisage a simple treatment involving linear equilibrium distribution coefficients. We will discuss the applicability of these distribution coefficients to the chemical conditions of interest.</p> <p>NRF_013.2</p> <p>As part of our analysis of uncertainty, we will undertake sensitivity studies.</p> <p>NRF_013.3</p> <p>We will consider the relevant FEPs and discuss and evaluate any potential effects. We consider, however, that it would be disproportionate to develop an assessment model with such a complex representation of chemistry.</p> <p>NRF_013.4</p> <p>There will be beneficial effects from sorption to such phases, but the safety case would be cautious in ignoring such effects.</p> <p>NRF_013.5</p> <p>We consider that the treatment of sorption in the 2002 PCSC is appropriate for assessment purposes, although arguments could be improved in</p>	<p>NRF_013.1 / 13.2</p> <p>Accepted / planned for the 2011 ESC.</p> <p>NRF_013.3 / 13.4 / 13.5</p> <p>Rejected / disproportionate</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
			<p>relation to parameter choices. We note that the equilibrium sorption model produces very conservative estimates of contaminant concentrations in trench leachate compared to observation.</p>	
NRF_014	Near-field mineralogy	<p>NRF_014.1 Document the justification for the inclusion/exclusion of solid mineral and radionuclide phases in the DRINK database by reference to observations and/or the results of thermodynamic speciation calculations for relevant chemical/geochemical systems.</p> <p>NRF_014.2 Document further evidence for the adequacy of the cement dissolution model adopted in DRINK.</p> <p>NRF_014.3 Provide further information to demonstrate that the automatic reaction path model used in the GRM code for resolving mineral oversaturations and undersaturations adequately addresses uncertainties such as temporary disequilibrium of multiple-mineral systems, dominant undersaturation of an absent phase, and the possibility of inappropriate phases in a system with a range of chemical environments.</p>	<p>NRF_014 all parts These are comments related to the use of DRINK. DRINK will not have such a central role in future assessments so the recommendations are less pressing than would have been the case.</p> <p>We will consider the comments as part of a review and update of DRINK, which is to commence shortly.</p>	<p>NRF_014 Partly reduced relevance but the comments will be considered ongoing work</p>
NRF_015	Radionuclide screening	<p>NRF_015.1 Demonstrate that the PCRSA includes all radionuclides of potential significance and improve</p>	<p>NRF_015.1 As a preparation for the 2011 ESC, we will review the radionuclide screening calculations. However,</p>	<p>NRF_015 Accepted / In hand or planned</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		the screening presented in the 2002 PCRSA by: <ul style="list-style-type: none"> a) documenting the justification for the exclusion of the seafood exposure pathway from the calculations used to screen radionuclides for the groundwater pathway, b) documenting the justification for the exclusion of the external irradiation pathway from the calculations used to screen radionuclides for human intrusion, c) documenting which radionuclides were modelled for the natural termination events (glaciation and coastal erosion), d) documenting the justification for the exclusion of radionuclides from the PCRSA calculations for the groundwater pathway on the basis of a small calculated dose compared to tritium (H-3), or documenting results from further assessment calculations for radionuclides excluded from the 2002 PCRSA. 	screening calculations must necessarily make approximations and simplifications or they would not be screening calculations. The following specific observations are noted. <ul style="list-style-type: none"> a) The impacts via the seafood exposure pathway pathway are very low and key radionuclides expected to be the largest contributors are screened in. b) It would seem reasonable to include rather than exclude external irradiation, since this exposure pathway is a dominant contributor in some cases. c) We agree that this is necessary. d) The screening calculations will need to be reconsidered in the light of the importance of the water abstraction well. 	for the 2011 ESC
NRF_016	Near-field microbiological model description, assumptions and justification	NRF_016.1 Provide more detailed information on the chemical composition of materials in the Drigg disposal facility to demonstrate that all potentially significant sources of nutrients and energy for microbial activity have been taken into account. NRF_016.2 – no recommendation NRF_016.3 Provide information that records clearly how and	NRF_016.1 DRINK will be reviewed. However, microbiological models of the sort under discussion are inherently uncertain. We therefore intend that the assessment should be based as far as possible on simpler arguments e.g. an analysis of the form of C-14 within the inventory, sensible assumptions about the timescale over which it might be released and monitoring data. It is noted that a small fraction of the inventory of C-14 is associated with cellulose (currently the subject of investigation) so that such	NRF_016.1 / 16.2 Mainly rejected / disproportionate

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>why each individual microbiological near-field FEP has been considered in the PCRSA.</p> <p>NRF_016.4</p> <p>Document the logical links between the near-field Conceptual Model Uncertainty (CMU) forms and the geosphere-near-field interactions CMU forms.</p>	<p>microbiological effects are less important.</p> <p>NRF_016.3</p> <p>The simplified approach envisaged would not require such a detailed analysis of microbiological FEPs. Nevertheless, a review of FEPs and their documentation are important. This is planned.</p> <p>NRF_016.4</p> <p>This recommendation is superseded as we do not propose such a complex approach in the 2011 ESC.</p>	<p>NRF_016.3 / 16.4</p> <p>No longer relevant / superseded</p>
NRF_017	Near-Field Microbiological Parameters and Significance	<p>NRF_017.1</p> <p>Provide clear documentation of the links between FEPs and parameter values to show which FEPs are captured within each parameter.</p> <p>NRF_017.2</p> <p>Document the rationale for sensitivity analyses to address uncertainty in microbiological parameter values and conceptual models, and demonstrate that all relevant microbiological uncertainties have been adequately assessed.</p>	<p>NRF_017.1</p> <p>If any FEPs are treated by adjusting parameter values, then clear documentation of this will be required. This will be achieved by appropriate records in data entry forms.</p> <p>NRF_017.2</p> <p>The simplified approach noted under NRF_016 would not require such a detailed analysis.</p> <p>We are proposing an assessment based primarily on simple assumptions rather than complex microbiological models, so the importance of the recommendations is reduced in the LLWR's view.</p>	<p>NRF_017.1</p> <p>Accepted / in hand or planned for the 2011 ESC</p> <p>NRF_017.2</p> <p>No longer relevant</p>
NRF_018	Near-Field Performance and Microbiological Uncertainties	<p>NRF_018.1</p> <p>Document an assessment of the effects of spatial heterogeneity of waste on biogeochemical evolution and radionuclide solubilities within the repository.</p>	<p>NRF_018.1</p> <p>We have undertaken work and will undertake future work to investigate the effects of spatial variation in the near field. We will focus on those effects that we judge to be the most significant and document</p>	<p>NRF_018</p> <p>Accepted / In hand or planned for the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		NRF_018.2 Document a clear evaluation of the significance of microbiological and other assumptions in the aqueous source-term model to dose and risk estimates in the PCRSA calculations.	the arguments. NRF_018.2 Our overall approach will be to base the assessment calculations on relatively simple models. We consider that an in-depth analysis of every related FEP would be disproportionate.	NRF_018.2 No longer relevant / disproportionate
NRF_019	Isotopic Fractionation	NRF_019.1 Present an analysis of the potential effects of isotopic fractionation among hydrogen isotopes.	NRF_019.1 Isotopic fractionations are very small compared to the other effects under consideration and would provide only a very small contribution to uncertainty. We do not see a need for further analysis, although the topic can be mentioned in the ESC.	NRF_019 Rejected / disproportionate
END				

OESC issues

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
OESC_001	Optimisation and Best Practicable Means	<p>OESC_001.1</p> <p>The Agency expects BNFL to provide a clear commitment to consideration and evaluation of potential mitigation or remedial measures in support of risk management and optimisation at the Drigg Facility, including the trench disposals. The presence of uncertainties and the absence of fully quantified data do not justify a decision to delay this exercise.</p>	<p>OESC_001.1</p> <p>A general consideration of risk management options is reported in Edwards and Alexander (2005). This has been extended by more detailed work on each of the most promising options as summarised in R2S9, Volume 2 (Baker et al., 2008b).</p> <p>Detailed work related to the impacts of selective retrieval of higher activity waste is in hand, see section 4.3 of the "Approach to 2011 ESC" (Baker et al. 2008a).</p>	<p>OESC_001.1</p> <p>Accepted / work mainly complete</p>
OESC_002	Radiological protection and dose constraint	No recommendations made for this IAF.	No recommendation.	-
OESC_003	Definition of exposed groups	<p>OESC_003.1</p> <p>The dose assessment for the Drigg stream considers doses to infants from consumption of milk from cows drinking Drigg stream water and a limited consumption of Drigg stream water by children. This limited assessment is not sufficient and the Agency expects the inclusion of more pathways (in particular animal products) and consideration of a wider range of age groups where appropriate. The Agency expects BNFL to document a comprehensive assessment of potential exposure routes and to ensure that the results of this assessment are applied consistently in the dose assessments for each of the pathways.</p>	<p>OESC_003.1</p> <p>The only realistic pathway at the present day is consumption of milk and meat from cattle drinking from the Drigg stream. The consideration of drinking water is precautionary. For the 2011 ESC we will undertake of an assessment of all pathways that can reasonably be conceived at the present day. Irrigation is not a sustainable use for the stream.</p>	<p>OESC_003.1</p> <p>To be re-examined in the 2011 ESC.</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		OESC_003.2 For the airborne release pathway, it is not unreasonable that Properties 1 and 2 could grow their own vegetables and therefore their ingestion dose could have been considered, in addition to assessing the dose to Property 3 (the nearest farm). It is recommended that BNFL evaluate the significance of including Properties 1 and 2 as the critical group.	OESC_003.2 To be examined in 2011 ESC.	OESC_003.2 Partly accepted / to be re-examined in the 2011 ESC.
OESC_004	Scope, purpose and objectives of the OESC	OESC_004.1 The Agency expects BNFL to define the objectives for the OESC clearly, and to address the following: <ul style="list-style-type: none"> - the questions that the OESC is attempting to answer; - how and where the GRA Principles and Requirements are addressed; - the broad methodological approach adopted for the dose assessments; - whether the empirical data are of sufficient quality to justify the modelling approach; - bias, uncertainty and variability in the choice of assumptions and data; - how the OESC output influences site strategy and operations. 	OESC_004.1 We accept the 2002 OESC was not clear in its presentation and completeness of argument. In the 2011 ESC the OESC and PCSC will be blended to form a continuous assessment from the present day (when protection is assured though compliance with authorised discharges and confirmed by monitoring) to the post-authorisation conditions (when protection is estimated through modelling). Our approach is outlined in section 5.2 of the "Approach to 2011 ESC" (Baker et al. 2008a).	OESC_004.1 Accepted / to be addressed in the 2011 ESC
OESC_005	Quality assurance and supply of	OESC_005.1 The Agency requires demonstration of the suitability	OESC_005.1 Development of the ESC is carried out under the	OESC_005.1 Accepted / to be

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	information	<p>of the QA system and evidence of its implementation in order to gain confidence in the quality of the OESC. Therefore the Agency requires BNFL to provide further information on the overall quality system and project specific procedures and instructions.</p> <p>OESC_005.2</p> <p>The cross-linking between the OESC and PCSC needs significant improvement and BNFL should consider the benefits of combining the OESC and PCSC assessments in future.</p> <p>OESC_005.3</p> <p>The information supplied on the waste inventory gives a misleading impression of the characteristics for the disposed wastes. It is recommended that the variety/heterogeneity of historic disposed wastes is qualitatively described in the OESC.</p> <p>OESC_005.4</p> <p>If the OESC is meant to read as a stand-alone document then a good set of drawings and figures should accompany the text to aid understanding.</p>	<p>LLWR's QA system, which meets the requirements of ISO 9001. Appropriate subsidiary procedures, specific to the ESC Project are being put in place.</p> <p>See also response to COR_011.</p> <p>OESC_005.2</p> <p>We accept this, see response to OESC_004.1.</p> <p>OESC_005.3</p> <p>The variety/heterogeneity of historic disposed wastes will be qualitatively described in the 2011 ESC. The necessary underpinning work has been undertaken (Lennon et al., 2008). However, the connection of variety/heterogeneity of historic disposed wastes to the OESC is not clear.</p> <p>OESC_005.4</p> <p>Details of the presentation of the OESC within the 2011 ESC are not fixed at this time but we accept the underlying criticism.</p>	<p>included in the 2011 ESC</p> <p>OESC_005.2</p> <p>Accepted / to be addressed in the 2011 ESC</p> <p>OESC_005.3</p> <p>Accepted / underpinning work is in place</p> <p>OESC_005.4</p> <p>Accepted / to be addressed in the 2011 ESC</p>
OESC_006	Minimising radionuclide releases via the contaminant plumes	<p>OESC_006.1</p> <p>There is a need for a better presentation and fuller analysis of the evolution of groundwater concentrations versus time. If a model is to be used to support the safety argument that no intervention or mitigation measures are necessary, then</p>	<p>OESC_006.1</p> <p>We do not agree that detailed modelling of the contaminant plume will impact on decisions related intervention and mitigation, as such decisions are based on more general and robust arguments.</p>	<p>OESC_006</p> <p>Several connected points here that are partly accepted and will be</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>agreement needs to be demonstrated between the time variations of concentrations in the plume and the model. In developing the arguments, due account should be taken of the localisation of the contamination (as a result of variability in the Quaternary sediments).</p> <p>OESC_006.2</p> <p>In the absence of a convincing argument that doses from tritium and other soluble radionuclides would be less than 20 µSv per year, a demonstration of Optimisation is required. This should include (but not be limited to) consideration of the following:</p> <ul style="list-style-type: none"> - should the repository cap be constructed earlier than envisaged? - should additional engineered barriers be installed to prevent discharge into the sea? <p>OESC_006.3</p> <p>The Agency expects BNFL to explain and resolve the apparent discrepancy between the date of the main disposals of tritium phone dials in Trench 6 (~1983/84) and the date of the modelled peak tritium dose (~1980).</p> <p>OESC_006.4</p> <p>Present an assessment of the best practicable means for minimising radionuclide releases via the contaminant plumes.</p>	<p>However, the activities of tritium in groundwater are a marker of the potential for migration from the Trenches; as such we accept that further work to reconcile observed tritium concentration and groundwater modelling could be helpful and will form part of the 2011 ESC.</p> <p>OESC_006.2</p> <p>The appropriate guidance level for the period of authorisation is 0.3 mSv/a; we do not agree that levels above 20 µSv/a imply a specific requirement for optimisation. Rather it must be shown that the levels will reduce to 20 µSv/a or below at a time such as withdrawal of controls is planned.</p> <p>OESC_006.3</p> <p>See response to OESC_006.1.</p> <p>OESC_006.4</p> <p>See response to OESC_006.2.</p>	<p>addressed in the 2011 ESC.</p>
OESC_007	Site investigations,	OESC_007.1	OESC_007.1	OESC_007.1

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	facility design and construction	<p>The Agency expects BNFL to document an evaluation of mitigation measures to minimise the impact of potential releases from the ‘uncapped’ bays to the environment in support of Condition 4 of the Authorisation and as part of an overall risk management programme.</p> <p>OESC_007.2</p> <p>The Agency expects BNFL to document an indication of what ground conditions would be considered unsuitable for Vault 9 and what alternative designs might be implemented in the case of expected conditions not being met.</p> <p>OESC_007.3</p> <p>The Agency expects BNFL to document more technical detail on the site development plans or otherwise present a clear correlation with the PCSC Site Development Plan.</p>	<p>(We assume that the recommendation refers to “Schedule 4” of the Authorisation?)</p> <p>The drainage from Vault 8 (currently “uncapped”) is primarily rainwater with very low concentrations of nuclides and is collected in the holding tanks for discharge to sea compliant with Schedule 4 of the authorisation. No further mitigation is currently envisaged.</p> <p>OESC_007.2</p> <p>No longer relevant in that Vault 9 has been built.</p> <p>OESC_007.3</p> <p>We agree that a more detailed description is required of site management and closure plans, and this will form part of the 2011 ESC.</p>	<p>Rejected.</p> <p>OESC_007.2</p> <p>No longer relevant.</p> <p>OESC_007.3</p> <p>Accepted / to be addressed in the 2011 ESC</p>
OESC_008	Waste form and characterisation	<p>OESC_008.1</p> <p>The Agency requires an acknowledgement that BNFL will periodically update the Conditions for Acceptance.</p>	<p>OESC_008.1</p> <p>The CFA will be updated as needed based on results of safety cases and operational experience. A comprehensive review of the consistency of the CFA with the 2002 OESC and PCSC was undertaken (Barber et al., 2006). This led to recommendations for future changes to the CFA and Guidance Note (Barber, 2006).</p>	<p>OESC_008.1</p> <p>Accepted / work carried out and acknowledgement so given</p>
OESC_009	Monitoring	<p>OESC_009.1</p> <p>BNFL need to develop and justify an overall monitoring strategy. A monitoring programme is an</p>	<p>OESC_009.1</p> <p>We agree the importance of presenting and following an overall monitoring strategy. A review</p>	<p>OESC_009.1</p> <p>Accepted / work is in place</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>important element in ensuring that a disposal facility provides the required level of containment, isolation and protection. See for example, Monitoring of Near Surface Disposal Facilities for Radioactive Waste, Safety Report Series No. 35 (IAEA June 2004) and Near Surface Disposal of Radioactive Waste, Safety Standards Series No. WS-R-1 (IAEA 1999).</p> <p>OESC_009.2</p> <p>The decision-making criteria for interim cap refurbishment should be made transparent in the OESC to increase confidence in the monitoring of cap performance. The results of cap performance to date should also be presented.</p> <p>OESC_009.3</p> <p>BNFL should acknowledge the possibility of model uncertainty as a contributing reason for the divergence between model output and environmental monitoring data.</p> <p>(See also OESC_006 Minimising radionuclide releases via the contaminant plumes).</p>	<p>of monitoring requirements has been undertaken leading to the definition of a monitoring programme (Hillary 2008), which has been incorporated into the ESC Lifetime Plan.</p> <p>OESC_009.2</p> <p>We consider that it would not be efficient to provide precise criteria. We will present the results of cap performance as part of the 2011 ESC and indicate the implications with respect to any need for refurbishment.</p> <p>OESC_009.3</p> <p>Accepted and will be addressed in the 2011 ESC.</p>	<p>OESC_009.2</p> <p>Rejected / inappropriate</p> <p>OESC_009.3</p> <p>Accepted / to be addressed in the 2011 ESC</p>
OESC_010	Management of uncertainty	<p>OESC_010.1</p> <p>The Agency recommends that BNFL undertake an uncertainty analysis for the quantitative modelling calculations presented in the OESC. This analysis should take account of good practice in the management of uncertainties (see references below).</p> <p>OESC_010.2</p>	<p>OESC_010.1</p> <p>During the operational period the case rests mostly on management controls, monitoring and taking action if required. For the 2011 ESC we intend to strengthen the OESC based on these principles. Any quantitative modelling will mainly relate to interpretation of monitoring results.</p> <p>OESC_010.2</p>	<p>OESC_010.1</p> <p>Rejected / not relevant.</p> <p>OESC_010.2</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>The Agency recommends that BNFL presents a qualitative discussion of uncertainties surrounding the following issues and to assess the level of confidence that can be attached to the results of the dose assessments in view of these:</p> <ul style="list-style-type: none"> - coastal erosion (though generally considered unlikely over the next 150 years, it is not an incredible scenario); - tritium plumes migrating off-site; - inventory records for disposed waste; and - site (hydro)geology. 	<p>These issues are relevant to post-closure performance and will be considered in the 2011 ESC but are not central to the OESC.</p>	<p>Low relevance.</p>
OESC_011	Management of bias	<p>OESC_011.1</p> <p>The Agency recommends that uncertainties and potential sources of bias in the data and the modelling assumptions are clearly identified and the extent of this bias explicitly identified wherever possible throughout the OESC. This can be achieved by making the implicit and unstated assumptions more transparent to the reader.</p> <p>OESC_011.2</p> <p>When presenting summary statements, the Agency recommends they are qualified to reflect the basis on which the conclusions are drawn and the problem-framing assumptions on which they depend.</p> <p>OESC_011.3</p> <p>Information in Section 5 of the OESC on</p>	<p>OESC_011.1</p> <p>See response to OESC_010.1</p> <p>OESC_011.2</p> <p>Agreed but unspecific as an issue.</p> <p>OESC_011.3</p> <p>This section "Radiological protection principles"</p>	<p>OESC_011.1</p> <p>Low relevance.</p> <p>OESC_011.2</p> <p>Low relevance.</p> <p>OESC_011.3</p> <p>Partly accepted / to be addressed in the 2011 ESC</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		international policy, principles and practice should be evaluated for its relevance and significance to Drigg operations.	will be updated to the extent needed. However, the new HPA guidance and NS-GRA provide more direct guidance.	
OESC_012	Assessment of prospective public doses	<p>OESC_012.1</p> <p>BNFL should justify whether any critical group could be exposed to more than one exposure pathway.</p> <p>OESC_012.2</p> <p>BNFL should provide evidence to support the assertion that there will be no further migration of radioactivity into the Drigg stream over the next 150 years. (Appendix B notes that in heavy rain, the run off from Vault 8 will enter the Drigg Stream. The basic assumption that concentrations in the Drigg Stream in 2050, 2100 and 2150 will be the same as in 2005 (after radioactive decay) may not therefore be valid)</p> <p>OESC_012.3</p> <p>BNFL should assess the possibility of flooding of land either side of the Drigg stream and the consequences for radionuclides in foods to the critical group.</p> <p>OESC_012.4</p> <p>BNFL should consider whether irrigation (using water from the Drigg stream) is reasonable for green veg, root veg and fruit and evaluate the significance of radionuclide ingestion by the critical group from foodstuffs irrigated using water from the Drigg stream.</p>	<p>OESC_012.1</p> <p>Critical groups are defined with characteristics such as to represent the groups that could be most exposed to a given exposure pathway or set of connected pathways. Where the same group can be exposed to multiple pathways the total dose will be will be assessed.</p> <p>OESC_012.2</p> <p>Any contaminated flow to the Drigg stream will be very small. The stream will be monitored. The assumption of no additional flow is adequate for prospective assessment during the period of authorisation.</p> <p>OESC_012.3</p> <p>Flooding to the extent it occurs is due to high tide conditions and involves flooding by a mix of marine and freshwater from the River Irt. This is considered in the estuary modelling.</p> <p>OESC_012.4</p> <p>We have done so. The flow is insufficient and seasonal and therefore unsuitable for irrigation</p>	<p>OESC_012.1</p> <p>Accepted / to be addressed in the 2011 ESC.</p> <p>OESC_012.2</p> <p>Not relevant</p> <p>OESC_012.3</p> <p>Not relevant.</p> <p>OESC_012.4</p> <p>Rejected</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>OESC_012.5</p> <p>It would be better to calculate the total effective dose to a child using reasonable inadvertent ingestion rates of water and a bank occupancy rather than the volume of water needed to be consumed to reach the dose constraint.</p> <p>OESC_012.6</p> <p>BNFL should evaluate whether external dose from the stream bank also needs to be allowed for in the Drigg stream critical group. The total dose from the Drigg stream to children can then be calculated for comparison with the appropriate criteria.</p> <p>OESC_012.7</p> <p>BNFL should justify why the PCSC dietary intake assumptions are not consistent with equivalent data published in BNFL's monitoring reports or the Radioactivity in Food and the Environment (RIFE) monitoring reports.</p> <p>OESC_012.8</p> <p>BNFL should justify why it believes the highest atmospheric emissions are expected to occur over the next 50 years followed by a decline up until closure in 2150 (atmospheric releases may increase after 2050).</p>	<p>OESC_012.5</p> <p>Accepted. We will present the calculation in this way in the 2011 ESC.</p> <p>OESC_012.6</p> <p>Accepted. We will include the external exposure in the 2011 ESC.</p> <p>OESC_012.7</p> <p>We will review the dietary intake assumptions for CGs in the 2011 ESC.</p> <p>OESC_012.8</p> <p>Emissions of dust to atmosphere relate to operations and will cease when operations cease. For the 2011 ESC we will reassess emissions of tritium, carbon-14 and radon.</p>	<p>OESC_012.5</p> <p>Accepted / to be included in the 2011 ESC.</p> <p>OESC_012.6</p> <p>Accepted / to be included in the 2011 ESC.</p> <p>OESC_012.7</p> <p>Accepted / to be included in the 2011 ESC.</p> <p>OESC_012.8</p> <p>Accepted / to be included in the 2011 ESC.</p>
END				

Parameter issues

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
PAR_001	Uranium solubility and the timing of key changes in near-field chemistry	PAR_001.1 Present an analysis of the significance of calcium uranate control on solubility in the vaults that excludes the influence of the trenches.	PAR_001.1 We have undertaken a review, reported in Fowler et al. (2003), which addresses among other issues the likely solubility controls for uranium at the LLWR and addresses the issue raised in the recommendation.	PAR_001 Accepted / work complete
PAR_002	Key sorption parameters	PAR_002.1 (geosphere sorption) Building on recommendation GEO_016.1, obtain better sorption parameters for uranium in the geosphere by: (i) Undertaking migration experiments (column and/or diffusion experiments) because these have the advantage that they more nearly simulate in situ conditions, although they do introduce new experimental difficulties. (ii) Developing improved speciation and surface complexation models together with good site characterisation data, which might provide more credible sorption values than geometric means of greatly differing batch sorption results. Such an approach could provide sorption values that reflect changes in pH and carbonate contents of the aqueous phase as the migration plume develops. (The Parameters Review Group made no recommendations regarding the near-field and biosphere Kds beyond those presented at NRF_013.1, NRF_013.4 and BIO_012.)	PAR_002.1 Geosphere sorption is not a major control on the maximum calculated impacts (from the water abstraction well) and therefore we do not regard it as a priority for further work. We have undertaken further sorption experiments on uranium sorption in the geosphere. There are pros and cons of undertaking column and diffusion experiments versus batch experiments. If detailed study was considered appropriate, then it is likely that both techniques would be used. However, we do not consider this to be proportionate because of the limited influence of geosphere sorption in the current assessment. We suggest that similar arguments are appropriate in relation to the use of better chemical models of speciation and surface complexation.	PAR_002 Rejected / not needed

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
PAR_003	Treatment of dilution and dispersion in the geosphere	<p>PAR_003.1</p> <p>Provide details and justification of the process by which the topology of the regional groundwater flow pathways was determined from the MODFLOW particle track results, and clarify why a thickness of 15 m has been chosen for the flow paths through the sandstone under colder climate conditions.</p> <p>PAR_003.2</p> <p>Undertake a detailed analysis of radionuclide migration from the Drigg disposal facility using appropriate groundwater flow and radionuclide transport models in order to demonstrate that the one-dimensional PCSC model provides an appropriate approximation of radionuclide transport in the geosphere. (See also recommendation GEO_010.1.)</p> <p>PAR_003.3</p> <p>Demonstrate that, for a Peclet number of 10, the effects of the variability in dispersivity over the network on the results of the risk assessment are insignificant, especially for radionuclides such as Sr-90 which are sensitive to dispersion, and verify that numerical dispersion is insignificant if the Peclet number is 10 with $NX = 20$.</p>	<p>PAR_003.1 / 2 / 3</p> <p>These are detailed technical comments relevant to the approach used in the 2002 PCSC. As the approach is now different, we consider that these comments are no longer relevant.</p>	<p>PAR_003</p> <p>No longer relevant</p>
PAR_004	Emergent land dimensions	<p>PAR_004.1</p> <p>Provide the rationale for the choice of the values of sea level in the different altered states, and explain how values have been determined for the extent to which changes in sea level alter the geographical extent of the biosphere, especially the dimensions of</p>	<p>PAR_004.1</p> <p>We have undertaken further work in relation to changes in sea level as a consequence of climate evolution and other effects (Thorne and Kane, 2007).</p>	<p>PAR_004.1</p> <p>Accepted / addressed by work since 2002</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		<p>emergent land, for each altered state. (See also recommendation B_BIO_002.1.)</p> <p>PAR_004.2</p> <p>Determine bounds on emergent land dimensions and undertake sensitivity analyses based on these bounds to determine the significance of emergent land dimensions to risk.</p>	<p>PAR_004.2</p> <p>Impacts to future occupiers of emergent land are not now a main concern because of the expected erosion of the facility. Therefore, the case will be considered as a “what if”, which must be largely hypothetical. Detailed underpinning of the assumptions is neither practicable nor necessary.</p>	<p>PAR_004.2</p> <p>Rejected / not needed</p>
PAR_005	Hydrologically effective rainfall (HER) and recharge	<p>PAR_005.1</p> <p>Assess the effects of uncertainty in HER for future climate states, and the uncertainties in the proportion of HER assumed to enter the groundwater systems and the surface waters.</p>	<p>PAR_005.1</p> <p>We agree that this is an important consideration, which will be considered in modelling for the 2011 ESC.</p>	<p>PAR_005</p> <p>Accepted / to be addressed in the 2011 ESC</p>
PAR_006	Groundwater discharge zones	<p>PAR_006.1</p> <p>Present the rationale for the subjective judgments made in selecting the best-estimate coastal discharge distributions and present the uncertainty in these distributions. The sensitivity of risk to assumptions about discharge distributions should be investigated.</p> <p>PAR_006.2</p> <p>Explain in detail the method for decreasing plume cross-sectional area at discharge nodes, and test and support or, if necessary, replace the approach with a more detailed contaminant plume migration analysis. (See also recommendation GEO_010.1.)</p>	<p>PAR_006.1 and 006.2</p> <p>These are detailed technical comments relevant to the approach used in the 2002 PCSC. We consider that the recommendations have been superseded because new approaches will be used in the ESC.</p>	<p>PAR_006</p> <p>No longer relevant.</p>
PAR_007	Radon accumulation in building following	<p>PAR_007.1</p> <p>Build on comments in DIS-006. Present a firmer basis for the 10% waste material in soil explaining why this</p>	<p>PAR_007.1</p> <p>We agree this factor is arbitrary and was related to an assumption that growing of crops on a</p>	<p>PAR_007.1</p> <p>No longer relevant</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
	intrusion	<p>is applicable to buildings and why waste materials could not be considered to be applied as soil improvers.</p> <p>PAR_007.2</p> <p>Build on GAS_003.9 and DP094b.2, but with a focus on transport through 'soil' rather than cap. Explain why radon transport is always diffusion controlled, and for example why advective transport within bulk gas flow from underlying bulk waste is not considered.</p> <p>PAR_007.3</p> <p>Justify the 'three minute' radon travel time from the source into the house more robustly.</p>	<p>waste-soil would be important. In the 2008 update (Sumerling, 2008), we dispensed with this dilution allowing a dwelling to be constructed on waste-cap spoil.</p> <p>PAR_007.2</p> <p>Work is currently in hand to assess the migration of radon from disposed waste through cap materials including the soil fill.</p> <p>PAR_007.3</p> <p>The empirical model illustrated in Sumerling (2008) avoids the need for this parameter.</p>	<p>PAR_007.2</p> <p>Accepted / Including in more recent work and to be included in the 2011 ESC</p> <p>PAR_007.3</p> <p>No longer relevant.</p>
PAR_008	Coastal erosion, exposure of individuals, and residence time of waste on beach	<p>PAR_008.1</p> <p>Underpin the basis for the residence time and justify why a homogeneous distribution of waste material in sand is reasonable. This is related to BIO_002.1, which recommends that BNFL should justify the modelling of compartments and the compartment sizes used in the Biosphere Model during each system state.</p> <p>PAR_008.2</p> <p>Justify the basis for the dust loading (3.5 10⁻⁸ kg/m³), inadvertent ingestion of contaminated sand (10⁻⁴ kg/m³), and assumed distance from source (1-10m) in an absolute and/or relative sense compared with the land-based scenarios.</p> <p>PAR_008.3</p>	<p>PAR_008.1</p> <p>Homogeneous distribution is reasonable assuming exposure is to a PEG using the beach area beneath the repository.</p> <p>We are planning to improve our models of exposure that may occur during erosion of the facility taking account of heterogeneity in the waste and differential dispersion of waste materials according to more detailed study of coastal erosion processes.</p> <p>PAR_008.2</p> <p>PEG parameters have been reviewed and basis established, see Thorne (2007).</p> <p>PAR_008.3</p>	<p>PAR_008.1</p> <p>Accepted / Including in more recent work and to be included in the 2011 ESC</p> <p>PAR_008.2</p> <p>Accepted / work completed</p> <p>PAR_008.3</p> <p>No longer relevant</p>

IAF no.	Title	Review Group recommendations	Our response to recommendations	Issue status
		Based on PAR_007.3. Justify the 'three minute' radon travel time from the source into the beach dwelling more robustly, and the choice of the same diffusion coefficient as for the soil applied in the equivalent land-based scenario (especially relevant for Rn-220).	The empirical mode illustrated in Sumerling (2008) avoids the need for the 'three minute' parameter. Other factors mitigate against radon exposure for the beach hut case.	
PAR_009	Doses received by future site occupants	PAR_009.1 Justify the basis for the assumption that the concentration of contaminants in bulk soil is a reasonable approximation for the concentration in suspendable solids.	PAR_009.1 We consider that the assumption is a reasonable one for the purposes of assessment. Further evaluation of the assumption would require a detailed understanding of the distribution of radionuclides within the waste or soil at future times. We will reconsider this for any cases in which particulate inhalation is the dominant exposure mode.	PAR_009 Partly accepted / to be reconsidered in the 2011 ESC
END				

Radiological Capacity issues

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
RAD_001	Radiological capacity	<p>RAD_001.1</p> <p>Revise the radiological capacity calculations for the repository, having particular regard to the following:</p> <ul style="list-style-type: none"> a) Provide adequate justification for the selected performance measure(s) and assumed performance requirements. This should include the use of calculated risk as defined in the GRA to measure performance, consideration of the application of the GRA risk target to existing waste disposals, and the basis for using any performance measures that have not been adopted in UK legislation (e.g., the ICRP intervention level for FHA). b) Provide clear proposals as to how the Environment Agency should derive conclusions concerning radiological capacity from the results of calculations. This concerns the existing presentation of a range of results for different scenarios and calculation cases. The potential benefits of a probabilistic treatment of uncertainty might be considered. c) Base capacities on the highest values of calculated risk over the PCSC assessment timescale. d) Consider need to derive specific activity limits for key radionuclides based on exposure scenarios where the risk is related to the specific activity (activity per unit mass) over a volume appropriate to the nature of the exposure, rather than to the average activity of the entire volume of waste in the repository, trench or vault. 	<p>RAD_001.1</p> <p>Our approach to addressing radiological capacity issues has been substantially changed from that pursued previously. An outline of our approach is provided in the Safety Case Approach document. In many respects the recommendations in the IAFs have therefore been superseded. Some further commentary is provided below.</p> <ul style="list-style-type: none"> a) The provision of such justification is clearly important. b) We will provide suggestions and recommendations in the 2011 ESC. c) We suggest that capacities should be reasonable cases rather than the worst case that can be identified. We recognise that the choice of cases is subjective and is a subject that we would like to discuss with the Environment Agency. d) We agree that many scenarios constrain the average specific activity on a scale smaller than that of the whole repository. 	<p>RAD_001.1 c)</p> <p>Rejected</p> <p>RAD_001.1 other parts</p> <p>Accepted / to be addressed in the 2011 ESC</p>

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
		<p>e) Define PEGs on the basis of reasonable behaviour, and calculate capacities using these PEGs.</p> <p>f) Implement strict change control procedures for input data. Parameter values used in the 2002 PCSC should only be updated and changed where there is a clear basis for doing so. The rationale/justification for all changes must be clearly documented. This includes updates to assumptions about the future inventory.</p> <p>g) Link the radiological capacity calculation results to a comprehensive and holistic risk management/optimisation exercise, particularly for radionuclides that contribute to calculated risks above the GRA risk target.</p> <p>h) On the basis of the revised capacity calculations, BNGS should propose appropriate disposal limits, radionuclide groupings, and associated management arrangements to ensure that waste disposals conform with the proposed limits and groupings.</p>	<p>e) Agreed</p> <p>f) We agree that the basis for all parameters needs to be adequately documented.</p> <p>g) Consideration of the appropriate disposal inventory and optimisation studies need to be appropriately linked in our view.</p> <p>h) Agreed</p>	
END				

Site Development and Engineering issues

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
SDE_001	Site Development and Engineering Adequacy of Information / Referencing	<p>SDE_001.1</p> <p>Provide quantitative evidence to demonstrate that the performance of the engineered clay layer under Vault 8 will be sufficient such that the Pebbly Clay Formation can be regarded solely as an assurance measure for the control of leachate and is not needed for compliance .</p> <p>SDE_001.2</p> <p>Provide appropriate performance data for a range of compositions for the surrounding cut-off wall to demonstrate that the properties assumed in PCRSA calculations will be achievable.</p>	<p>SDE_001.1:</p> <p>The sensitivity of the safety assessment to the performance of the engineering components, including the Vault 8 engineered clay layer will be assessed as part of the 2011 ESC.</p> <p>SDE_001.2</p> <p>The Engineering Performance Assessment for the 2002 PCSC has been revisited (Paksy 2008) to provide performance data for the engineering components including the proposed cut-off wall design (Carpenter and Proctor, 2007). The Institution of Civil Engineers (ICE) specification for bentonite slurry walls (ICE, 1999) suggests a hydraulic conductivity of $1E-09 \text{ m s}^{-1}$. This is taken to be the best estimate for the initial 'as placed' performance.</p>	<p>SDE_001.1</p> <p>Accepted / in hand or planned for the 2011 ESC</p> <p>SDE_001.2</p> <p>Accepted / work complete</p>
SDE_002	Site Development and Engineering Screening, Model Development and Assumptions	<p>SDE_002.1</p> <p>Present more information on the effect of key assumptions in the Level II documents. Specifically, provide justification for the assumption that the properties of all engineered features converge to a single value at a specific time.</p> <p>SDE_002.2</p> <p>Assess the effect of alternative conceptual models regarding the evolution of engineered features, specifically the inclusion of assumptions regarding component behaviour that could lead to "over-topping" .</p>	<p>SDE_002.1</p> <p>The assumption of the engineering components becoming 'hydrogeologically indistinguishable' is no longer considered to be justifiable given the reduced timescales being considered due to the effects of coastal erosion.</p> <p>SDE_002.2 & SDE_002.3</p> <p>Paksy (2008) presents the updated engineering performance assessment model and details of the expert elicitation process that has been undertaken to derive property values over the</p>	<p>SDE_002 all parts</p> <p>Accepted / in hand or planned for the 2011 ESC</p>

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
		<p>SDE_002.3</p> <p>Conduct integrated uncertainty analyses that link uncertainties in near-field evolution to uncertainties in the properties of the geosphere.</p> <p>SDE_002.4</p> <p>Use the results of modelling studies of the engineered features to assess the cost-effectiveness of the proposed components (e.g. the over-waste drainage blanket).</p>	<p>lifetime of the repository. The behaviour of the engineered system as a whole will be considered using both the site-scale model and a GoldSim model as part of the 2011 ESC taking into account both the uncertainty in the evolution of the engineering features and uncertainties in the properties of the geosphere.</p> <p>SDE_002.4</p> <p>The 2011 ESC safety assessment will consider the cost effectiveness of the proposed components and optimisation of the design.</p>	
SDE_003	Site Development and Engineering Treatment of Uncertainty	<p>SDE_003.1</p> <p>Provide quantitative results from PCRSA calculations to demonstrate the effect on overall system performance of a range of overall designs and sub-system options .</p> <p>SDE_003.2</p> <p>Provide more detailed uncertainty analyses (e.g., probabilistic calculations) to provide a better understanding of system behaviour and to ensure that the full range of potential system behaviour has been examined.</p> <p>SDE_003.3</p> <p>Integrate the treatment of uncertainty in the near-field with the treatment of uncertainty in the geosphere to avoid making unrealistic assumptions about the evolution of the engineered features.</p>	<p>SDE_003.1</p> <p>Demonstrating the link between the behaviour of the engineering components, water movement within the wastes and the movement of water into the geosphere is recognised as being important in the development of the 2011 ESC.</p> <p>SDE_003.2</p> <p>The system behaviour will be assessed using a combination of the a GoldSim model of the near field taking into account the Engineering Performance Assessment (EPA) work by Paksy (2008) and the site-scale model (Henderson et al 2008). Probabilistic calculations will be undertaken to ensure that the full range of potential system behaviour is considered.</p> <p>SDE_003.3</p>	<p>SDE_003 all parts</p> <p>Accepted / in hand or planned for the 2011 ESC</p>

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
			The 2011 ESC will ensure that a consistent approach to the treatment of uncertainty and the assumptions made about the evolution of the engineered features.	
SDE_004	Design Justification	<p>SDE_004.1</p> <p>Assess the effect of any proposed design options on overall system performance and not restrict optimisation studies to the performance of individual components.</p> <p>SDE_004.2</p> <p>Demonstrate either that the bath-tubbing drainage system is likely to function as intended at the appropriate time or, if not, that the failure of the system is represented in the scenarios considered in the PCRSA modelling.</p> <p>SDE_004.3</p> <p>Demonstrate that the joints between the existing Vault 8 walls and the vertical extensions will have an appropriately low permeability to prevent lateral migration of leachate and so not compromise the intended function of the over-waste drainage blankets.</p> <p>SDE_004.4</p> <p>Justify the selection of the proposed composition for bentonite enhanced soils.</p>	<p>SDE_004.1 & SDE_004.3</p> <p>As discussed in SDE_003 & SDE_004 the overall performance of the design options will be considered as part of the 2011 ESC.</p> <p>SDE_004.2</p> <p>The behaviour of the drainage system will be considered as part of the assessment of the overall performance of the engineering components.</p> <p>SDE_004.4</p> <p>Carpenter and Proctor (2007) provide details used in the selection of the engineered properties required for the Single Design Option. The 2011 ESC will consider how the proposed engineering affects the overall performance of the site.</p>	<p>SDE_004 all parts</p> <p>Accepted / in hand or planned for the 2011 ESC</p>
SDE_005	Engineering Performance Assessment - Methodology	<p>SDE_005.1</p> <p>Modify the complexity and/or resolution of the EPA approach to better reflect its overall purpose.</p>	<p>SDE_005.1</p> <p>The EPA has been updated since the 2002 PCSC (Paksy 2008) and selection of parameter values for the 2011 ESC will be revisited to</p>	<p>SDE_005.1</p> <p>Accepted / in hand or planned for the</p>

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
		<p>SDE_005.2</p> <p>Either justify why elicited uncertainties on the time required for the properties of engineering features to become indistinguishable from those of the surrounding geology were not propagated through the 2002 EPA and PCRSA calculations, or provide PCRSA results that account explicitly for the uncertainties in the degradation rates of the engineered features.</p> <p>SDE_005.3</p> <p>Either justify why all the scenarios of near-field evolution considered in the EPA have not been carried forward to the PCSC, or provide PCRSA results for the scenarios omitted from the 2002 analyses.</p> <p>SDE_005.4</p> <p>Improve the transparency and traceability of the EPA by providing additional information and explanations for topics including:</p> <ul style="list-style-type: none"> - The terminology used for the potential gaseous pathways - The descriptive categories used to define the consequence, likelihood and risk ratings for different fault sequences. - The selection criteria used to identify appropriate subject and normative experts. - Where expert judgement has been used rather than a formal process of expert elicitation. 	<p>ensure that any changes over time are consistent with the evolution of the site.</p> <p>SDE_005.2</p> <p>Paksy (2008) provides more detail on the justification of each parameter value. As noted in SDE_002.1, the assumption of the engineering components becoming 'hydrogeologically indistinguishable' is no longer considered to be justifiable given the reduced timescales being considered due the effects of coastal erosion.</p> <p>SDE_005.3</p> <p>The 2011 ESC will ensure that a consistent approach is maintained between the scenarios considered in the EPA and those in the ESC safety assessment.</p> <p>SDE_005,4</p> <p>Referencing and quality of data used in the EPA for the 2011 ESC will be addressed as described in the ESC approach document (Baker et al 2008a).</p>	<p>2011 ESC</p> <p>SDE_005.2</p> <p>Some work undertaken / superseded</p> <p>SDE_005.3 / 5.4</p> <p>Accepted / in hand or planned for the 2011 ESC</p>

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
SDE_006	Engineering Performance Assessment - Derivation of Parameters	<p>SDE_006.1</p> <p>Provide references to the sources of information used by the experts as the basis for the values elicited for use in the 2002 EPA, and information on how elicited values compare with other information available.</p> <p>SDE_006.2</p> <p>Conduct systematic sensitivity studies to show the extent to which the hydrological behaviour of the engineered features is sensitive to elicited values for the rate of property changes and the assumptions used for interpolating data between the elicited values.</p> <p>SDE_006.3</p> <p>Clarify the extent to which the selection of options for engineered features has been based on system-wide assessments rather than on the performance of individual components (see also SDE_002.4).</p>	<p>SDE_006.1</p> <p>References for the sources of information are included in the updated EPA (Paksy 2008).</p> <p>SDE_006.2 & SDE_006.3</p> <p>As noted above, the overall performance of the engineering components will be assessed as part of the 2011 ESC and appropriate sensitivity studies will be undertaken.</p>	<p>SDE_006.1</p> <p>Accepted / work complete</p> <p>SDE_006.2 / 6.3</p> <p>Accepted / in hand or planned for the 2011 ESC</p>
SDE_007	Cap Properties and Behaviour	<p>SDE_007.1</p> <p>Include an assessment of the implications of not removing the interim cap prior to final cap emplacement in optimisation and risk management studies.</p> <p>SDE_007.2</p> <p>Instigate field trials of the cap layering system as proposed in DTP/006.</p> <p>SDE_007.3</p> <p>Provide a justification for the assertion that the layer of cobbles in the proposed final cap design will provide an</p>	<p>SDE_007.1</p> <p>The timing of emplacement of the final cap will be considered as part of the optimisation studies on the engineering design.</p> <p>SDE_007.2 & SDE_007.3</p> <p>It is considered that no additional R&D is required for assessment of the final cap performance beyond the work carried out by Thorne (2008) on cap performance which has indicated that the cap is of robust design and will maintain its core integrity over the lifetime of</p>	<p>SDE_007.1</p> <p>Accepted / in hand or planned for the 2011 ESC</p> <p>SDE_007.2 / 7.3</p> <p>Rejected / disproportionate</p>

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
		<p>obstruction barrier to burrowing animals and deter roots from penetrating into deeper layers.</p> <p>SDE_007.4</p> <p>Document more clearly the justification for the waste reduction factors used in estimating waste settlement, and instigate a programme of monitoring waste degradation as proposed in DTP/020.</p> <p>SDE_007.5</p> <p>Update the estimates of waste settlement used in the 2002 PCSC to use the latest available information on the inventory, and consider explicitly the potential effects of localised differential settlement.</p>	<p>the facility, even taking into account the effects of erosion and settlement, limiting infiltration into the waste.</p> <p>SDE_007.4 & SDE_007.5:</p> <p>Thorne (2008) provides details on the estimated settlement of the cap. Justification of the factors used in the calculations will be clarified as part of the 2011 ESC.</p>	<p>SDE_007.4 / 7.5</p> <p>Accepted / some work done and more planned for the 2011 ESC</p>
SDE_008	Derivation and Justification of Radiological Inventory	<p>SDE_008.1</p> <p>Improve the traceability of the reports recording the inventory derivation work by including detailed cross-references and citations throughout all levels of the PCSC documentation.</p> <p>SDE_008.2</p> <p>Provide access to the Drigg Inventory database, and related Level IV reports and spreadsheets, and include these in future submissions of the PCSC.</p> <p>SDE_008.3</p> <p>Undertake a comprehensive examination of all of the disposal records to extract the maximum possible amount of information on the trench inventory and thereby minimise, and if possible eliminate, the need for backfitting trench inventory estimates from more recent</p>	<p>SDE_008.1, SDE_008.2, SDE_008.3 & SDE_008.4</p> <p>The work carried out by Wareing et al. (2008) provides a better understanding of the inventory and its derivation taking into account past disposal records, the nature of waste streams and the distribution of radionuclides across the repository. These data will be clearly referenced and available in the 2011 ESC. Further work to interview current and past employees about disposal practices has also been instigated to add confidence to the derived inventory.</p> <p>SDE_008.5</p> <p>Intrusive investigations are not considered to be feasible due to the large number of boreholes</p>	<p>SDE_008.1 / 8.2 / 8.3 / 8.4</p> <p>Accepted / substantial work complete and more planned for the 2011 ESC</p> <p>SDE_008.5</p> <p>Accepted / work complete</p>

IAF no.	Title	Review group recommendations	Our response to recommendations	Issue status
		<p>National Inventory estimates.</p> <p>SDE_008.4</p> <p>Modify the Drigg Inventory database to record the activity of each individual radionuclide in the same form as the UK National Inventory.</p> <p>SDE_008.5</p> <p>Provide an assessment of the best practicable means for physical characterisation of the nature and location of trench wastes (e.g., geophysical techniques, physical sampling).</p> <p>SDE_008.6</p> <p>Provide an assessment of the feasibility of selective removal from the trenches of wastes that contribute most significantly to risk.</p>	<p>that would be required to have confidence in the predicted inventory as well as the safety issues and cost implications. Ross (2007) considered the potential use of geophysical techniques to characterise the trench waste. The report concluded that Ground Penetrating Radar (GPR), Electromagnetic and Microgravity methods could be used to identifying the volume and shape of the buried materials but that no geophysical method available would provide an accurate depiction of the distribution of Uranium contaminated waste within the trenches. The shielding effect of the trench cap precludes the use of radiometric surveying.</p> <p>SDE_008.6</p> <p>A study of the feasibility and cost of selective retrievals that contribute most to assessed post-closure impacts is currently underway. This and will feed into a management options study and thence to the 2011 ESC.</p>	<p>SDE_008.6</p> <p>Accepted / work in hand</p>
END				