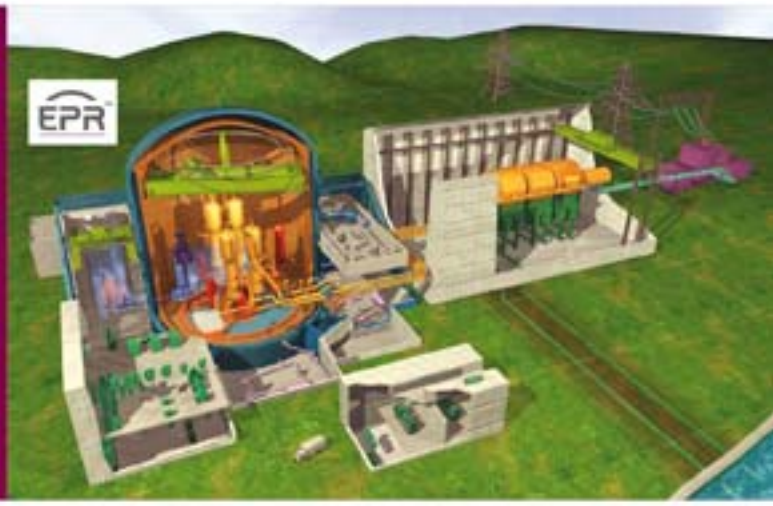
Generic design assessment

UK EPR™ nuclear power plant design
AREVA NP SAS and Electricité de France SA

Final assessment report

Radiological impacts on non-human species



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Generic design assessment

UK EPR™ nuclear power plant design by Electricité de France SA and AREVA NP SAS

Final assessment report:

Radiological impact on non-human species

Protective status	This document contains no sensitive nuclear information or commercially confidential information.
Process and Information Document[1]	The following sections of Table 1 in our Process and Information document are relevant to this assessment: Section 2.10 the requesting party should provide an assessment of the likely impact of the radioactive discharges on non-human species.
Radioactive Substances Regulation Environmental Principles[2]	The following principles are relevant to this assessment: SEDP1 General RSR Principle for siting new facilities - When evaluating sites for a new facility, account shall be taken of the factors that might affect the protection of people and the environment from radiological hazards and the generation of radioactive waste. SEDP2 Movement of radioactive material in the environment - Data shall be provided to allow the assessment of rates and patterns of movement of radioactive materials in the air and the aquatic and terrestrial environments around sites. SEDP4 Multi-facility sites - In the case of nuclear and other sites on which there are already one or more facilities, the radiological impact of the whole site on people and the environment shall be assessed when considering the suitability of the site for any new facility. RPDP3 Protection of non-human species - Non-human species shall be adequately protected from exposure to ionising radiation. RPDP4 Prospective dose assessments for radioactive discharges to the environment - Assessments of potential doses to people and to non-human species shall be made prior to granting any new or revised authorisation for the discharge of radioactive wastes into the environment.
Report author	Original report by: Tooley, E. J. Final report updated by: Green, R.

1. Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Environment Agency, Jan 2007.

   http://publications.environment-agency.gov.uk/pdf/GEHO0107BLTN-e-e.pdf

2. Regulatory Guidance Series, No RSR 1: Radioactive Substances Regulation - Environmental Principles (REPs), 2010.

   http://publications.environment-agency.gov.uk/pdf/GEHO0709BQSB-e-e.pdf

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1 Summary

1 This assessment considers the information provided by Electricité de France SA and AREVA NP SAS (EDF and AREVA) for their UK EPR design.

2 This report summarises the outcomes of our assessment of the information provided and the assessment carried out by EDF and AREVA with respect to prospective doses to non-human species as a result of the disposal of liquid and gaseous radioactive waste from the UK EPR™ to the environment.

3 Our assessment concluded that the maximum predicted gaseous releases and liquid discharges for a UK EPR at the generic site are unlikely pose a risk to non-human species. We consider that our assessment is suitably conservative.

4 We consider the assessment carried out by EDF and AREVA to be conservative and reasonable. We consider that EDF and AREVA have used an appropriate approach to the assessment of the radiological impact of the UK EPR on non-human biota.

5 Our assessment of EDF and AREVA's submission concluded that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 μGy h^{-1} is less than 1%. The maximum predicted dose rate for a terrestrial organism was calculated by EDF and AREVA to be 0.003 μGy h^{-1} (for a mammal) and for a marine organism to be 0.01 μGy h^{-1} (for a polychaete worm) which do not exceed the dose rate threshold of 40 μGy h^{-1} that the Environment Agency have agreed with Natural England to be protective of Natura 2000 sites (NDAWG, 2008).

6 We also assessed radiation dose rates to plants and animals near an operating UK EPR using the independently calculated activity concentrations (which are more realistic). We predict the highest dose rates to be:

a) 0.1 μGy h^{-1} for a terrestrial organism (a bird egg); and

b) 0.02 μGy h^{-1} for a marine organism (a mammal and reptile).

7 These dose-rates are well below 40 μGy h^{-1}, the value below which we consider that there will be no adverse effect on the integrity of a conservation site.

8 This assessment relates to predictions of impact based on a generic site and we recognise that a detailed impact assessment will be required at site-specific permitting. We will require a detailed radiological impact assessment to be carried out at site-specific permitting based on the actual environmental characteristics of the proposed site to demonstrate that dose rates to non-human species from the UK EPR at the proposed site will be as low as reasonably practicable (ALARP) and below relevant dose constraints and dose limits.

9 Our findings on the wider environmental impacts and waste management arrangements for the UK EPR reactor may be found in our Decision Document (Environment Agency, 2011a).

2 Introduction

10 We originally published this report in June 2010 to support our GDA consultation on the UK EPR design. The consultation was on our preliminary conclusions. It began on 28 June 2010 and closed on 18 October 2010.

11 We reviewed this report after considering relevant responses to our consultation. We did not receive any additional information from EDF and AREVA on this topic after their March 2010 update of their submission. Where any paragraph has been added or substantially revised it is in a blue font.

12 We do not specifically deal with all consultation responses in this report, they are covered in detail in the Decision Document (Environment Agency, 2011a). However, where a response prompted additional assessment by us this is referenced, the key to GDA reference numbers is in Annex 7 of the Decision Document. The conclusions in this report have been made after consideration of all relevant responses to our consultation.

13 This assessment considers the impact of the UK EPR on non-human species arising from discharges into the environment.

14 The assessment considers the information provided by Electricité de France SA and AREVA NP SAS (EDF and AREVA) for their UK EPR design.

15 We appointed contactors (Enviros Consulting Ltd) to make an independent assessment of environmental activity concentrations from the UK EPR at the generic site (Environment Agency, 2011b).

16 This assessment does not cover radioactive waste arising from decommissioning at the end of the reactor lifecycle.

17 The assessment aims to establish whether the design could be operated in the UK in line with UK Statute, policy and guidance on radioactive waste as currently written but it is recognised that the assessment should be kept under review to reflect changes in statute, policy and guidance that may occur between now and plant commissioning.

3 Assessment

18 This assessment considers the radiological impact of discharges from a UK EPR on non-human species. We have taken into account Statutory guidance to the Environment Agency concerning the regulation of radioactive discharges into the environment (DECC, 2009) which sets out the principle that:

a) regulatory justification of practices should be carried out by the Government;

b) optimisation of protection on the basis that radiological doses and risks to workers and members of the public from a source of exposure should be kept as low as reasonably achievable (the ALARA principle);

c) application of limits and conditions to control discharges from justified activities;

d) sustainable development;

e) the use of Best Available Techniques (BAT);

f) the precautionary principle;

g) the polluter pays principle;

h) the preferred use of 'concentrate and contain' in the management of radioactive waste over 'dilute and disperse' in cases where there would be a definite benefit in reducing environmental pollution, provided that BAT is being applied and worker dose is taken into account.

3.1 Assessment Methodology

19 The basis of our assessment was to:

a) consider the submission made by EDF and AREVA in particular the Pre-Construction Environmental Report (PCER) and its supporting documents;

b) hold technical meetings with EDF and AREVA to clarify our understanding of the information presented and explain any concerns we had with that information;

c) raise Regulatory Observations and Technical Queries where we believed information provided by EDF and AREVA was insufficient;

d) assess the radiological impact of discharges from a UK EPR on non-human species to demonstrate that doses to non-human species from the UK EPR at the proposed site will be ALARP and not exceed the dose rate threshold that the Environment Agency have agreed with Natural England to be protective of Natura 2000 sites;

e) consider consultation responses and comments from our July 2010 stakeholder seminar relevant to this topic;

f) decide on any GDA Issues;

g) identify assessment findings to carry forward from GDA.

20 EDF and AREVA provided their submission to GDA in August 2007. We carried out our initial assessment and concluded we needed additional information. We raised a Regulatory Issue on EDF and AREVA in February 2008 setting out the further information that we needed. EDF and AREVA completely revised their submission during 2008 and provided a Pre-Construction Environmental Report (PCER) with supporting documents.

21 We assessed information contained in the PCER but found that while much improved from the original submission there were some areas where we required further information.

22 We raised 31 Technical Queries (TQs) on EDF and AREVA during our assessment. One was relevant to this report:

a) TQ-EPR-237 - Non-human species impact assessment. 1 July 2009

23 EDF and AREVA responded to the TQ. They reviewed and updated the PCER in March 2010 to include all the relevant information provided by the TQ. This report only uses and refers to the information contained in the updated PCER and its supporting documents.

24 There was another revision to the PCER in March 2011 but the main chapter relevant to this report – chapter 11 '*Radiological impact assessment*' – was unchanged.

3.2 Assessment Objectives

25 Key areas of the submission made under the GDA arrangements by EDF and AREVA for the UK EPR design that have been considered are:

a) Is the radiological impact assessment carried out by EDF and AREVA reasonable and justified?

b) Can the radiological impact assessment carried out by EDF and AREVA be independently validated?

c) Are predicted dose rates below our agreed dose rate threshold?

3.3 EDF and AREVA Documentation

26 The Pre-Construction Environmental Report is divided into chapters and sub-chapters (provided as separate documents) and has supporting documents. We referred to the following documents to produce this report:

Document reference	Title	Version number
UKEPR-0003-011	PCER-Sub-chapter 1.1 - Introduction	04
UKEPR-0003-012	PCER – Sub-chapter 1.2 – General description of the unit	02
UKEPR-0003-090	PCER – Chapter 9 – Principles and methods used for environmental approach at the design stage	02
UKEPR-0003-100	PCER – Chapter 10 – Site environmental characteristics	04
UKEPR-0003-110	PCER – Chapter 11 – Radiological impact assessment	02

27 We use short references in this report, for example:

a) PCER sub-chapter 6.2 section 1.2.1 = PCERsc6.2s1.2.1;

b) BAT Demonstration section 3.2 = EPRBs3.2.

3.4 Assessment Findings

28 This report summarises the outcomes of our assessment of the information provided and the assessment carried out by EDF and AREVA with respect to prospective doses to non-human species as a result of the disposal of aqueous and gaseous radioactive waste from the UK EPR to the environment.

29 In order to assess potential impacts we required EDF and AREVA to carry out dose assessments as set out in section 2.9 of our Process and Information Document. In order to assess doses we also required EDF and AREVA to describe a generic site on which the dose assessment was based and which represented likely sites where a UK EPR might be located. A separate assessment report EAGDAR UK EPR-10 has been prepared setting out our assessment of the generic site parameters provided by EDF and AREVA (Environment Agency, 2011b). For consistency the generic site description was also used in the assessment of potential impact on members of the public (Environment Agency, 2011c).

30 In order to assess doses to non-human species, in addition to the description of the environmental features of the generic site, we required EDF and AREVA to provide information about discharges of aqueous and gaseous radioactive waste from the UK EPR and these are set out in our assessment reports (Environment Agency, 2011d, 2011e).

31 We appointed contactors to make an independent assessment of environmental activity concentrations from the UK EPR at the generic site.

32 During the assessment of doses to non-human species certain matters were identified and dealt with using the Regulatory Observation and Technical Query system.

33 Technical Query TQ-EPR-237 was raised on 1 July 2009 which required EDF and AREVA to provide further information on aspects of their assessment of impact on non-human species. In particular:

a) to justify why the freshwater eco-system has not be considered;

b) to assess the impact of noble gases using the R&D128 approach;

c) to confirm the type of sediment concentration data;

d) to explain the source of transfer parameter data for the polychaete worm reference organism used in the ERICA model.

34 EDF and AREVA responded on 28 August 2009 and confirmed that:

a) a freshwater eco-system has not been considered at the generic stage because all liquid discharges are made into the marine environment, but will be assessed at the site-specific stage if appropriate;

b) assessment of doses to non-human species from the noble gases argon-41 and krypton-85 will be carried out using the R&D128 approach at the site-specific stage;

c) sediment concentrations were derived using the PC-CREAM DORIS model as wet weight;

d) cephalopod data was used as a surrogate for the polychaete worm.

35 We informed Natural England of our GDA process at the outset.

36 We carried out two evaluations of the assessment carried out by EDF and AREVA using the Environmental Risk from Ionising Contaminants: Assessment and Management ERICA Tool (Beresford, 2007) and the R&D128 approach (Copplestone, 2001):

a) A validation exercise using the ERICA Tool to satisfy ourselves that the results of the EDF and AREVA assessment were reproducible.

b) An independent assessment using the ERICA Tool and R&D128 approach to determine the dose rates using discharge data provided by EDF and AREVA and predicted activity concentrations modelled for us by an independent contractor.

37 The results of our assessments are summarised in Table 1 (page 14 of this report).

3.5 The assessment models

38 A number of systems have been developed to assess the risk to non-human species from ionising radiation. The PROTECT Consortium (Beresford, 2008) has recommended the ERICA (Environmental Risk from Ionising Contaminants: Assessment and Management) Integrated Approach for use within the European Union.

39 The purpose of the ERICA Integrated Approach is to ensure that decisions on environmental matters give appropriate weight to the environmental exposure, effects and risks from ionising radiation with emphasis on ensuring the structure and function of ecosystems. The ERICA Integrated Approach is supported by the ERICA Tool, a software programme with supporting databases which can be used to assess environmental risks from ionising radiation.

40 The ERICA Tool calculates the radiation dose rate that a reference organism is likely to receive from a defined activity concentration of a radionuclide. Reference organisms are used because given the variation between species, it is not generally possible to develop species-specific assessment systems (as has been done for human radiation protection). The reference organisms have been selected to be typical or representative of a contaminated environment, and include terrestrial, freshwater and marine ecosystems.

41 The default screening value in the ERICA Integrated Approach is an incremental dose rate of 10 µGy h^{-1}, to be used for all ecosystems and organisms. The criterion of 10 µGy h^{-1} is a proposed generic screening value that below which 95% of all species should be protected from ionising radiation (Anderson, 2009). The 10 µGy h^{-1} criterion is a screening value which should be used to screen out sites of low concern. It is not intended that this screening value be used as a dose rate limit. The Environment Agency, Natural England and the Countryside Council for Wales have agreed a dose rate threshold of 40 µGy h^{-1} (Environment Agency, 2009, and our regulatory guidance note (Environment Agency, 2010)), below which it has been concluded that there will be no adverse effect on the integrity of a Natura 2000 site (a protected area for birds, species or habitats).

42 The ERICA Integrated Approach is organised into three separate tiers. If the effects are predicted to be low or negligible then the user can exit the assessment with confidence, if not then they are to progress to the next tier.

a) Tier 1 is simple and conservative – it requires a minimal amount of input data, the user can select radionuclides from a default list, and the results are for the most sensitive combination of reference organisms.

b) Tier 2 is more specific and less conservative – the user can enter input data such as radionuclides that are not on the default list and edit transfer parameters[1]. The results are calculated for each reference organism individually.

c) The situations requiring a Tier 3 assessment are likely to be complex and unique. Tier 3 is a probabilistic risk assessment in which uncertainties within the results may be determined using sensitivity analysis. A Tier 3 assessment requires consideration of biological effects data.

43 The ERICA Tool does not allow the assessor to consider the impact of radioactive noble gases. One approach that does allow this is the R&D128 method. The R&D128 method was developed as an interim methodology while waiting for ERICA to be developed; it contains fewer radionuclides and was designed to be conservative. R&D128 has since been superseded by ERICA, but is used here as it is the only approach that allows radioactive noble gases to be assessed.

[1] Transfer parameters are K_d and Concentration Ratio

3.6 Results of the assessment carried out by EDF and AREVA

44 EDF and AREVA predicted the maximum discharges of radionuclides likely to occur from their UK EPR design, and used this data to assess the potential impact to non-human species.

45 They used the ERICA Tool for their assessment, and started at Tier 2 as Tier 1 does not contain all the radionuclides that they predict will be discharged to the environment from their EPR design. They assessed the risk to terrestrial reference organisms from the predicted gaseous releases and to marine reference organisms from the predicted liquid discharges.

46 EDF and AREVA used the following parameters in the ERICA Tool at Tier 2:

a) The maximum predicted activity concentrations of the radionuclides discharged to air and water. These were used to derive activity concentrations in sea water, sea bed sediments, air and soil using a modelling package called PC CREAM.

b) Default ERICA values for transfer parameters where available. Where this was not possible, values from IAEA TRS 422 (IAEA, 2004) or the most conservative value for a reference organism were used.

47 The results of their assessment identified that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than 1%. The maximum predicted dose rate for a terrestrial organism was calculated to be 0.003 µGy h^{-1} (for a mammal) and for a marine organism to be 0.01 µGy h^{-1} (for a polychaete worm).

48 We consider the input parameters to be reasonable at this stage, because EDF and AREVA have used the maximum predicted activity concentrations, (which is a conservative approach) and they have followed the ERICA guidelines (or used more conservative parameters).

49 EDF and AREVA did not consider the impact that discharges of radionuclides might have on freshwater organisms, or the impact of the release of noble gases to the atmosphere. We raised a Technical Query (TQ-EPR-237) to address these matters. In response EDF and AREVA stated that their generic UK EPR design makes discharges to the marine environment and atmosphere only. As part of the site-specific study they would consider freshwater bodies if present and relevant. They will use R&D128 to assess the impact of noble gases on the terrestrial ecosystem as part of the site-specific assessment.

3.7 Our Assessment of the EDF and AREVA design

50 To evaluate the findings of EDF and AREVA we completed our own ERICA and R&D128 assessments using the EDF and AREVA parameters and also using predicted activity concentrations modelled by an independent contractor.

51 We were able to reproduce the results of the EDF and AREVA assessment when we used their input parameters. However we did note that EDF and AREVA had not assessed the impact of noble gases on non-human species and we carried out an assessment for noble gases using the R&D128 approach. For this we used the EDF and AREVA maximum predicted activity concentrations and conservatively assumed that the reference organism was at the point of release. The maximum predicted dose rate was calculated to be 0.2 µGy h^{-1} for fungi which does not exceed the screening dose rate of 10 µGy h^{-1}.

52 The results of our assessments are summarised below and in Table 1.

3.8 Environment Agency ERICA assessment

53 We used the independently calculated activity concentrations in the ERICA assessment, and the results showed that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than 1%. The highest predicted dose rate for a terrestrial organism was calculated to be 0.1 µGy h^{-1} (for a bird egg) and for a marine organism to be 0.02 µGy h^{-1} (for a mammal and a reptile).

3.9 Environment Agency R&D128 assessment

54 To assess the risks to terrestrial organisms from radioactive noble gases we used the R&D128 approach. We used EDF and AREVA's maximum predicted activity concentrations and conservatively assumed that the reference organism was present at the point of release. We calculated the maximum predicted dose rate to be 0.2 µGy h^{-1} (for fungi), which does not exceed the screening dose rate of 10 µGy h^{-1}.

55 We also completed the assessment using the independently calculated activity concentrations, and calculated the maximum predicted dose rate to be 0.00009 µGy h^{-1} (for fungi).

4 Variability

56 Some variation does exist between the results we obtained using the predicted activity concentrations provided by EDF and AREVA and those by an independent contractor.

57 Using the ERICA approach, the values of the maximum predicted dose rates that we calculated using the independent data are different to those calculated by EDF and AREVA. However, as each set of results are two or more orders of magnitude lower than the generic screening value and the outcomes of the assessments are the same, the variation is not considered significant enough to warrant further discussion.

58 We obtained significantly different results using the R&D128 approach using the EDF and AREVA activity concentrations and those derived by the independent contractor. This is because when we completed the EDF and AREVA assessment we conservatively assumed the receptor was at the point of release, as it is the simplest (and most pessimistic) screening technique given in IAEA SRS 19. The independent assessment used predicted activity concentrations calculated at the receptor, which is a more realistic scenario and involves more complex calculations. As our results from the pessimistic scenario calculations did not exceed the screening dose rate we did not consider it necessary to undertake the complex calculations to make the results more realistic.

Table 1 - EDF and AREVA Assessment Summary Table

Assessment Type	Data Source	EDF and AREVA Results	Our Results
Terrestrial			
ERICA Tier 2	EDF and AREVA	No risk for any individual reference organism. Maximum predicted dose rate is 0.003 µGy h^{-1} for a mammal	No risk for any individual reference organism. Maximum predicted dose rate is 0.003 µGy h^{-1} for a mammal
	Independent	-	No risk for any individual reference organism. Maximum predicted dose rate is 0.1 µGy h^{-1} for a bird egg
R&D 128	EDF and AREVA	Not assessed	Maximum predicted dose rate is 0.2 µGy h^{-1} for fungi
	Independent	-	Maximum predicted dose rate is 0.00009 µGy h^{-1} for fungi
Marine			
ERICA Tier 2	EDF and AREVA	No risk for any individual reference organism. Maximum predicted dose rate is 0.01 µGy h^{-1} for a polychaete worm	No risk for any individual reference organism. Maximum predicted dose rate is 0.01 µGy h^{-1} for a polychaete worm
	Independent	-	No risk for any individual reference organism. Maximum predicted dose rate is 0.02 µGy h^{-1} for a mammal and a reptile

"No risk" means the probability of the predicted discharges exceeding the screening dose rate of 10 µGy h^{-1} is less than 1%

5 Compliance with Environment Agency requirements

P&I Table 1 section or REP	Compliance comments
P&I Table 1 Section 2.10 to provide an assessment of the likely impact of the radioactive discharges on non-human species.	An assessment of impact on non-human species was made by EDF and AREVA.
SEDP1 General RSR Principle for siting new facilities - When evaluating sites for a new facility, account shall be taken of the factors that might affect the protection of people and the environment from radiological hazards and the generation of radioactive waste.	The generic site proposed by EDF and AREVA considered factors that might affect the protection of people and the environment. The information about the generic site used in the assessment of impact on non-human species seemed reasonable.
SEDP2 Movement of radioactive material in the environment - Data shall be provided to allow the assessment of rates and patterns of movement of radioactive materials in the air and the aquatic and terrestrial environments around sites.	Information on the potential movement of radioactive material in the environment was provided by EDF and AREVA.
SEDP4 Multi-facility sites - In the case of nuclear and other sites on which there are already one or more facilities, the radiological impact of the whole site on people and the environment shall be assessed when considering the suitability of the site for any new facility.	This will be dealt with at the site-specific stage if the UK EPR is located on a multi-facility site.
RPDP3 Protection of non-human species - Non-human species shall be adequately protected from exposure to ionising radiation.	A prior assessment has been made based on the generic site. The outcome of the assessment shows that the maximum predicted gaseous releases and liquid discharges for a UK EPR at the generic site are unlikely pose a risk to non-human species.
RPDP4 Prospective dose assessments for radioactive discharges to the environment - Assessments of potential doses to people and to non-human species shall be made prior to granting any new or revised authorisation for the discharge of radioactive wastes into the environment.	A prior assessment has been made based on the generic site. We will require that prospective dose assessments are carried out at the site-specific stage as part of the permitting process and using information specific to the site in question.
Doses to non-human species do not exceed the dose rate threshold of 40 µGy h^{-1} agreed between the Environment Agency, Natural England and the Countryside Council for Wales.	Estimated dose rates to non-human species do not exceed the dose rate threshold of 40 µGy h^{-1}.

6 Public comments

59 The public involvement process remained open during our assessment see http://www.hse.gov.uk/newreactors/publicinvolvement.htm

60 We did not receive any public comments by this route during this assessment relating to the assessment of the radiological impact of discharges from the UK EPR on non-human species.

61 One response to the consultation was relevant to this topic. The Committee on Medical Aspects of Radiation in the Environment (GDA129[2]) commented:
'*The evidence base and the assessment methodology is more advanced for humans than it is for non-humans (or wildlife). Therefore, whilst the conclusions of low predicted doses for non humans appear reasonable, the confidence in the assessments is probably lower. For instance, the maximum predicted dose rates are, in some cases, for reference organism groups for which few, if any, transfer or effects data exist at present. Also, there is some potential confusion for the reader from the use of both the Erica screening value of 10µSv/h and the EA value of 40µSv/h. The use of a consistent methodology and criteria for the assessments for both designs is desirable for the future, and confidence in the assessment methodology and its underpinning science should be considered during detailed site specific assessments*'
We provide some additional explanation of our methodology below:

Dose rate comparison

62 As part of non-human assessments we compare predicted dose rates to a screening value of 10 µGy h^{-1} (different to µSv h^{-1}used for human dose rate) which is protective of 95% of non-human species. This value is used to screen out sites of low regulatory concern, therefore if the dose rates to wildlife are calculated to be less than 10 µGy h^{-1} we do not require further assessments to be made. It was proposed by an European consortium of experts called PROTECT (Anderson, 2009). The value was derived using internationally agreed approaches for setting environmental thresholds (for example, species sensitivity distributions), therefore it was derived using the same methods as the criteria used in chemicals risk assessments (Copplestone, 2009).

63 We use an action level of 40 µGy $h^{-1}$when we determine permits. It is the level below which we consider that there will be no adverse effect on the integrity of a conservation site and was agreed with Natural England (Environment Agency, 2009). This value was derived from:

a) a comprehensive review of the available radiation effects data (Real, 2004) which found that in general, the dose rate threshold for significant adverse effects in non-human species was about 100 µGy h^{-1}; and

b) a review paper (Brown, 2004) which indicated that wildlife might receive up to 60 µGy $h^{-1}$from natural sources in European ecosystems.

64 Both values have been used in the generic design assessments in the way they are intended. In the first instance we compared the predicted dose rates to the 10 µG y^{-1} screening value to see if the sites could be screened out from further assessment. This gives us a high level of confidence due to the conservative nature of the screening value. If they could not, we compared the predicted dose rates to the 40 µGy h^{-1} action level to see if they were below the level which is considered to have no adverse effects on the integrity of a conservation site.

[2] We list the names of all the organisations that responded to the consultation in Annex 7 of the Decision Document (Environment Agency, 2011a). We have not given names of individuals or members of the public. The list gives a GDA number to each response (for example, GDA76 is for the Health & Safety Executive (now the Office for Nuclear Regulation)), so that the documents can be searched to allow all respondents to see where their responses have been considered. Where we quote consultation responses in this document, we have not corrected spelling or grammar.

65 The predicted dose rates for the UK EPR generic design did not exceed the screening level of 10 µGy h^{-1}, therefore were screened out and not considered for more detailed assessment against the 40 µGy h^{-1}action level.

66 We will conduct more refined assessments for the site-specific applications.

Confidence in the assessment methodology

67 The assessment methodology for non-humans is less advanced than for humans and therefore it is inevitable that dose assessments for non-humans are subject to greater uncertainty. There are no species-specific models for wildlife, nor detailed assessments of doses to different organs as there are for humans.

68 The ERICA Tool was recommended for completing chronic exposure assessments for non-human species by the PROTECT consortium (Howard, 2010). The tool has been maintained and improved since this recommendation was made, and we have continued to be involved in this process. Therefore we are happy that it was adequate to use for the prospective assessment for the generic designs and remains fit for our purposes.

69 We are participating in model inter-comparison exercises as part of a working group of the International Atomic Energy Agency. ERICA performs reasonably well against other available tools, and where it has been possible to test model predictions (e.g. Beresford, 2009). ERICA has also performed reasonably well predicting dose rates to biota (e.g. Beresford, 2010).

70 In the event of gaps in the data needed to complete assessments, conservative assumptions were made (both in the ERICA Tool development and in our generic design assessments) to ensure the final result was likely to be an over-prediction of dose. This gives confidence at this generic assessment level in the overall results.

Transfer factors

71 Where possible most of the default transfer factor values in the ERICA database were derived from a review of original publications. However, for many of the organism-radionuclide combinations there were no reported data from which to derive values. These data gaps were dealt with in a conservative manner, for example, by using values for organisms of similar taxonomy, or the highest available value for elements of similar biogeochemistry.

72 We are working to improve this by actively participating in the working group responsible for the International Atomic Energy Agency's handbook of parameter values for the prediction of radionuclide transfer to wildlife, which is due to be published in 2011. This provides an up-to-date review of all available transfer parameters. We will take the parameter values into account when completing the site-specific assessments.

Effects data

73 The effects dataset available for reference organism groups is by no means complete. It would be very expensive and time consuming to conduct experiments to assess the effects of chronic radiation exposure to each reference organism.

74 A database of data on radiation effects for all species has been developed, called FREDERICA. This is the most comprehensive source of radiation effects data available, and was used to derive the 10 µGy h^{-1}screening value within the PROTECT project. By comparing the predicted dose rates to this screening value, we are considering the best available dataset on radiation effects data for all species, including sensitive species. Note that the limiting reference organisms are those that are predicted to receive the highest dose rate from the radioactivity discharged, not necessarily the most sensitive organisms to radiation.

75 Furthermore, the ICRP Committee 5 on Environmental Protection has defined Derived Consideration Reference Levels (ICRP, 2008); these are consistent with

our dose rate predictions for different wildlife species. While the ICRP is continuing its work in this area, our generic design assessments have been conducted in line with the current knowledge and application of a radiological protection of the environment approach.

76 Protected species may be identified to be present near the locations for the site-specific assessments. At the moment, our generic design assessment has assessed the likely dose rates to them using the reference organisms given in the ERICA Tool. We will however conduct more refined assessments as appropriate for the sites identified for potential new build. In these more refined assessments, specific efforts will be made to predict dose rates to protected species for comparison to the screening value and, if necessary, to the action level.

7 Conclusion

77 We consider the assessment carried out by EDF and AREVA to be conservative and reasonable. We consider that EDF and AREVA have used an appropriate approach to the assessment of the radiological impact of the UK EPR on non-human biota.

78 Our assessment concluded that the maximum predicted gaseous releases and aqueous discharges for a UK EPR at the generic site are unlikely to pose a risk to non-human species. We consider that the assessment is suitably conservative.

79 Our assessment of EDF and AREVA's submission concluded that for each reference organism the probability of the predicted discharges exceeding the screening dose rate of 10 μGy h^{-1} is less than 1%. The maximum predicted dose rate for a terrestrial organism was calculated by EDF and AREVA to be 0.003 μGy h^{-1} (for a mammal) and for a marine organism to be 0.01 μGy h^{-1} (for a polychaete worm) which do not exceed the dose rate threshold of 40 μGy h^{-1} that the Environment Agency have agreed with Natural England to be protective of Natura 2000 sites.

80 We also assessed radiation dose rates to plants and animals near an operating UK EPR using the independently calculated activity concentrations (which are more realistic). We predict the highest dose rates to be:

a) 0.1 μGy h^{-1} for a terrestrial organism (a bird egg); and

b) 0.02 μGy h^{-1} for a marine organism (a mammal and reptile).

81 These dose-rates are well below 40 μGy h^{-1}, the value below which we consider that there will be no adverse effect on the integrity of a conservation site.

82 This assessment relates to predictions of impact based on a generic site and we recognise that a detailed impact assessment will be required at site-specific permitting. We will require a detailed radiological impact assessment to be carried out at site-specific permitting based on the actual environmental characteristics of the proposed site to demonstrate that doses to members of the public and non-human species from the UK EPR at the proposed site will be ALARP and below relevant dose constraints and dose limits.

Glossary

Activity concentration – the amount of radioactivity per unit mass or volume of a substance expressed in units of Becquerels per kilogram (Bq kg^{-1}) or Becquerels per litre (Bq l^{-1})

Discharges – disposal of aqueous and gaseous radioactive waste by discharging it to the environment

Dose – amount of energy deposited per unit mass of tissue from an exposure to ionising radiation expressed in units of Gray (Gy)

Dose assessment – calculation of the impact of a source of radioactivity on a receptor in terms of dose taking into account exposure pathways

Dose rate – dose received per unit time expressed in units of microGray per hour (µGy h^{-1})

Dose rate threshold – a value above which there may be an adverse effect

Non-human species – all species (wild and domestic) with the exception of humans

Radionuclide – radioactive isotope that emits ionising radiation

Reference organism – a range of organisms that are typical, or representative, of a contaminated environment

Screening value – a value which is used to screen out sites of low concern

Transfer parameters – values that are used to calculate where an element concentrates in the environment, in this report they are K_d (ratio between concentration in water and sediment) and Concentration Ratio (ratio between concentration in the environmental medium and a living organism)

References

(Anderson, 2009) Andersson, P., Beaugelin-Seiller, K., Beresford, N. A., Copplestone, D., Della Vedova, C, Garnier-Laplace, J., Howard, B. J., Howe, P., Oughton, D.H., Wells, C., and Whitehouse, P., Numerical Ranges for Protecting Species from Radiation in the Environment: Proposed Levels, Underlying Reasoning and Recommendations (2009). https://wiki.ceh.ac.uk/download/attachments/115016283/PROTECT_D5_final.pdf?version=1&modificationDate=1263808944000

(Beresford, 2007) Beresford, N., Brown, J., Copplestone, D., Garnier-Laplace, J., Howard, B., Larsson, C., Oughton, D., Prohl, G. and Zinger, I., An Integrated Approach to the Assessment and Management of Environmental Risks from Ionising Radiation (2007). https://wiki.ceh.ac.uk/download/attachments/115017395/D-Erica.pdf?version=1

Beresford, 2008) Beresford, N. A., Hosseini, A., Brown, J. E., Cailes, C., Copplestone, D., Barnett, C. L., Beaugelin-Seiller, K., Evaluation of Approaches for Protecting the Environment from Ionising Radiation in a Regulatory Context (2008). https://wiki.ceh.ac.uk/download/attachments/115016283/PROTECTWP2deliverableFinal.pdf?version=1&modificationDate=1263808930000

(Beresford, 2009) Beresford, N.A., Barnett, C.L., Beaugelin-Seiller, K., Brown, J.E., Cheng, J-J., Copplestone, D., Gaschak, S., Hingston, J.L., Horyna, J., Hosseini, A., Howard, B.J., Kamboj, S., Kryshev, A., Nedveckaite, T., Olyslaegers, G., Sazykina, T., Smith, J.T., Telleria, D., Vives i Batlle, J., Yankovich, T.L., Heling, R., Wood, M.D., Yu, C. 2009. Findings and recommendations from an international comparison of models and approaches for the estimation of radiological exposure to non-human biota. *Radioprotection*, 44, 5, 565-570.

(Beresford, 2010 Beresford, N.A., Barnett, C.L., Brown, J.E., Cheng, J-J., Copplestone, D., Gaschak, S., Hosseini, A., Howard, B.J., Kamboj, S., Nedveckaite, T., Olyslaegers, G., Smith, J.T., Vives I Batlle, J., Vives-Lynch, S., Yu, C. 2010. Predicting the radiation exposure of terrestrial wildlife in the Chernobyl exclusion zone: an international comparison of approaches. *J. Radiol. Prot.*, 30, 341-373.

(Brown, 2004) Brown, J.E., Jones, S.R., Saxén, R., Thørring, H., Vives i Batlle, J. 2004. Radiation doses to aquatic organisms from natural radionuclides. J. *Radiol. Prot.,* 24, A63-A77.

(Brown et al, 2008) Brown, J.E., Alfonso, B., Avila, R., Beresford, N.A., Copplestone, D., Pröhl, G., Ulanovsky A. 2008. The ERICA Tool. *J. Environ. Radioact*., 99, 1371-1383

(Copplestone, 2001) Copplestone, D., Bielby, S., Jones, S. R., Patton, D., Daniel, P and Gize, I., Impact Assessment of Ionising Radiation on Wildlife. Environment Agency R&D Publication 128 (2001). http://publications.environment-agency.gov.uk/pdf/SR-DPUB-128-E-E.pdf

(Copplestone, 2009 Copplestone, D., Andersson, P., Beresford, N.A., Brown, J., Dysvik, S., Garnier-Laplace, J., Hingston, J., Howard, B.J., Oughton, D., Whitehouse, P. 2009. Protection of the environment from ionising radiation in a regulatory context (PROTECT): review of current regulatory approaches to both chemicals and radioactive substances. *Radioprotection*, 44, 5, 881-886.

(DECC 2009a) Statutory Guidance to the Environment Agency concerning the regulation of radioactive discharges into the environment, Department of Energy and Climate Change and Welsh Assembly Government, 2009. http://www.decc.gov.uk/media/viewfile.ashx?filepath=what%20we%20do/uk%20energy%20supply/energy%20mix/nuclear/radioactivity/dischargesofradioactivity/1_20091202160019_e_@@_guidanceearadioactivedischarges.pdf&filetype=4

(Environment Agency, 2005) Development of Guidance on Setting Limits on Radioactive Discharges to the Environment from Nuclear Sites, (Science Report: SC010034/SR, Environment Agency, December 05) http://publications.environment-agency.gov.uk/pdf/SCHO1205BIVK-e-e.pdf

(Environment Agency, 2007) Process and Information Document for Generic Assessment of Candidate Nuclear Power Plant Designs, Environment Agency, Jan 2007. http://publications.environment-agency.gov.uk/pdf/GEHO0107BLTN-e-e.pdf

(Environment Agency, 2009) Environment Agency, Habitats Assessments for Radioactive Substances (2009) http://publications.environment-agency.gov.uk/pdf/SCHO0309BPML-e-e.pdf

(Environment Agency, 2010) Regulatory Guidance Series, No RSR 2: The regulation of radioactive substance activities on nuclear licensed sites, 2010 http://www.environment-agency.gov.uk/static/documents/Business/GEHO0310BSGF-E-E.pdf

(Environment Agency, 2011a) Generic design assessment. UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS. Decision Document. http://publications.environment-agency.gov.uk/pdf/GEHO1211BTNO-e-e.pdf

(Environment Agency, 2011b) Generic design assessment. UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS. Final assessment report: Generic site http://publications.environment-agency.gov.uk/pdf/GEHO1211BTNI-e-e.pdf

(Environment Agency, 2011c) Generic design assessment. UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS. Final assessment report: Radiological impact on members of the public http://publications.environment-agency.gov.uk/pdf/GEHO1211BTNJ-e-e.pdf

(Environment Agency, 2011d) Generic design assessment. UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS. Final assessment report: Gaseous radioactive waste disposal and limits http://publications.environment-agency.gov.uk/pdf/GEHO1211BTNC-e-e.pdf

(Environment Agency, 2011e) Generic design assessment. UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS. Final assessment report: Aqueous radioactive waste disposal and limits http://publications.environment-agency.gov.uk/pdf/GEHO1211BTND-e-e.pdf

(Howard, 2010) Howard, B. J., Beresford, N. A., Andersson, P., Brown, J. E., Copplestone, D., Beaugelin-Seiller, K., Garnier-Laplace, J., Howe, P. Oughton, D., Whitehouse, P. 2010. Protection of the environment from ionising radiation in a regulatory context - an overview of the PROTECT coordinated action. *J. Radiol Prot.,* 30, 195-214.

(IAEA, 2001) Safety Reports Series No.19. Generic Models for Use in Assessing the Impact of Discharges of Radioactive Substances to the Environment International Atomic Energy Agency, Vienna, 2001 http://www-pub.iaea.org/MTCD/publications/PDF/Pub1103_scr.pdf

(IAEA 2004) International Atomic Energy Agency Technical Report Series 422 – Sediment Distribution Co-efficients and Concentration Factors for Biota in the Marine Environment (2004). http://www-pub.iaea.org/MTCD/publications/PDF/TRS422_web.pdf

(ICRP, 2008) International Commission on Radiological Protection, 2008. Environmental Protection - the Concept and Use of Reference Animals and Plants. ICRP Publication 108. *Ann. ICRP*, 38 (4-6).

(NDAWG, 2008) Paper 13-04: Update on Habitats Assessments for England and Wales http://www.ndawg.org/documents/Paper13-04.pdf

(NRPB, 2003) Smith, K R and Jones A L, Generalised Habit Data for Radiological Assessments, NRPB-W41, NRPB, Chilton (2003) http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1194947308013

(Real, 2004) Real, A., Sundell-Bergman, S., Knowles, J.F., Woodhead, D.S., Zinger, I., 2004. Effects of ionising radiation exposure on plants, fish and mammals: relevant data for environmental radiation protection. *J. Radiol. Prot*., 24, A123-A137.

While every effort has been made to ensure the accuracy of the references listed in this report, their future availability cannot be guaranteed.

Abbreviations

ALARA	As low as reasonably achievable
ALARP	As low as reasonable practicable
BAT	Best available techniques
EPR 10	Environmental Permitting (England and Wales) Regulations 2010
EPRB	GDA UK EPR – BAT demonstration, document UKEPR-0011-001
EPRB 3.5s1.2	EPRB form 3.3 section 1.2 (example reference)
FSA	Food Standards Agency
GDA	Generic design assessment
HPA	Health Protection Agency
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
IWS	GDA UK EPR – Integrated Waste Strategy Document UKEPR-0010-001 Issue 00
JPO	Joint Programme Office
NDAWG	UK National Dose Assessment Working Group
P&ID	Process and information document
PCER	Pre-Construction Environmental Report
PCERsc3.3s4.1	PCER sub-chapter 3.3 section 4.1 (example reference)
PCSR	Pre-Construction Safety Report
REPs	Radioactive substances environmental principles
RGN	Regulatory Guidance Note
RGS	Regulatory Guidance Series
RI	Regulatory Issue
RO	Regulatory Observation
RSA 93	Radioactive Substances Act 1993
RWMD	Radioactive Waste Management Directorate (of NDA)
TQ	Technical Query

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