Generic design assessment

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

Final assessment report

Radiological impact on members of the public

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Environment Agency
Horizon house, Deanery Road,
Bristol BS1 5AH
Email: enquiries@environment-agency.gov.uk
www.environment-agency.gov.uk

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

Final assessment report:

Assessment of radiological impact on members of the public

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 2.7 Prospective dose assessment for the generic site at the proposed limits for levels of discharge.

Section 2.8 Collective dose assessments for discharges from the facility truncated at 500 years to the UK, European and World populations. Assumptions made in carrying out these assessments should be set out.

Section 2.9 Sufficient assumed data for others to be able to carry out all dose assessments including as relevant

Radioactive Substances Regulation Environmental Principles[2]

The following principles are relevant to this assessment:

Fundamental Principle E – Protecting Human Health and the Environment

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.

SEDP3 Ambient radioactivity - Levels of ambient radioactivity around the sites of new facilities shall be assessed.

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.

RPDP1 Optimisation of protection - All exposures to ionising radiation of any member of the public and of the population as a whole shall be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account.

RPDP2 Dose limits and constraints - Radiation doses to individual people shall be below the relevant dose limits and constraints.

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:: Tooley, E. J.
Final report updated: 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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Summary

1 We have assessed information in the generic design assessment (GDA) submission made by EDF and AREVA for the UK EPR™ with respect to prospective doses to members of the public as a result of the disposal of liquid and gaseous radioactive waste from the UK EPR to the environment.

2 We appointed contactors to undertake the verification and validation of assessments made by EDF and AREVA for the UK EPR at the generic site and to make an independent assessment of doses to members of the public from the UK EPR at the generic site.

3 EDF and AREVA's estimate of dose is well below the UK constraint for any single new source of 300 μSv y^{-1}. The assessment of dose is also below the dose constraint proposed by the Health Protection Agency (HPA 2009) from new nuclear power stations of 150 μSv y^{-1}.

4 Our independent assessment concluded that the sum of doses to the representative person at our proposed limits is below the source dose constraint.

5 A number of the sites listed in the Nuclear National Policy Statement as potentially suitable for a new nuclear power station are adjacent to existing nuclear power stations. In GDA the specific site at which a UK EPR might be located is not known but we consider in the light of our assessment that the highest total dose is estimated to be 31 μSv y^{-1} it is very unlikely that doses at the site will exceed the site dose constraint of 500 μSv y^{-1}. We consider that site dose should be assessed at the site-specific stage.

6 Comparison against the dose limit can only be done at site-specific permitting when contributions from all sources of radiation can be included.

7 In line with our usual procedures we will require a detailed site-specific 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 constraint and dose limits.

8 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).

1 Introduction

9 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.

10 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.

11 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.

12 This assessment considers the radiological impact of the UK EPR on members of the public arising from discharges into the environment.

13 Regulation of public radiation exposure is shared between the Environment Agency (in England and Wales) and the Office for Nuclear Regulation[1] (ONR). The Environment Agency regulates doses to the public resulting from discharges of radioactive waste into the environment during normal operation. ONR regulates doses to the public resulting from direct radiation (i.e. direct radiation originating from within the site boundary) during normal operation. ONR require site operators to measure direct radiation at the site perimeter and estimate exposure to a reference person on an annual basis. Direct radiation is radiation received directly from a source such as a nuclear power station, instead of indirectly as a result of radioactive discharges.

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 contractors (Enviros Consulting Ltd) to make an independent assessment of environmental activity concentrations and radiological impact to members of the public from the UK EPR at the generic site (Environment Agency, 2010a). We have produced a separate assessment report on the generic site proposed by EDF and AREVA (Environment Agency 2011b).

16 This assessment does not cover radioactive discharges 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.

2 Assessment

18 This assessment considers the radiological impact of discharges from a UK EPR on members of the public. 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 principles for:

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

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1 The Office for Nuclear Regulation (ONR) was created on 1st April 2011 as an Agency of the Health and Safety Executive (HSE). It was formed from HSE's Nuclear Directorate and has the same role. In this report we therefore generally use the term “ONR”, except where we refer back to documents or actions that originated when it was still HSE’s Nuclear Directorate.

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.

2.1 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) appoint contractors (Enviros Consulting Ltd) to make an independent assessment of environmental activity concentrations and radiological impact to members of the public from the UK EPR at the generic site;

e) assess the radiological impact of discharges from a UK EPR on members of the public to demonstrate that doses to members of the public from the UK EPR at the proposed site will be as low as reasonably practicable (ALARP) and not exceed dose constraints and limits;

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

g) decide on any GDA Issues;

h) 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 with supporting documents.

21 We assessed information contained in the Pre-Construction Environmental Report 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. Two were relevant to this report:

a) TQ-EPR-180 – Dose assessment assumptions – short -term releases. 27 May 2009.

b) TQ-EPR-186 – Marine dispersion parameters for dose assessment. 27 May 2009.

23 EDF and AREVA responded to the TQs. They reviewed and updated the PCER in March 2010 to include all the relevant information provided by the RO and TQs. 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.

2.2 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 doses to members of the public below dose constraints and limits?

2.3 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.

2.4 Summary of assessment

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 members of the public 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 2.7 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 (Environment Agency, 2011b)

has been prepared setting out our assessment of the generic site parameters provided by EDF and AREVA. For consistency the generic site description was also used in the assessment of potential impact on non-human species, see our assessment report (Environment Agency, 2011c).

30 In order to assess doses to members of the public, 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 EPR and these are set out in our respective assessment reports (Environment Agency 2011d, e).

31 In order to verify and validate the dose assessment carried out by EDF and AREVA we appointed a contractor to comment on the assumptions made by EDF and AREVA with respect to dose assessment parameters, to repeat EDF and AREVA's dose assessment and provide a methodology by which we could calculate doses to members of the public at our proposed discharge limits (Environment Agency, 2010a).

32 During the dose assessments certain matters were identified and dealt with using the Regulatory Observation and Technical Query system.

33 Technical Query TQ-EPR-180 was raised on 27 May 2009 and required EDF and AREVA to provide information on certain parameters they had used in their short-term dose assessment. EDF and AREVA responded on 29 July 2009 and their response was taken into account by the contractor undertaking the validation and verification of EDF and AREVA's dose assessment.

34 Technical Query TQ-EPR-186 was raised on 27 May 2009 which required EDF and AREVA to justify certain marine dispersion parameters they had used in their dose assessment, in particular volumetric flow rate used in individual and collective dose assessments. EDF and AREVA responded on 14 July 2009 and their response was taken into account by the contractor undertaking the validation and verification of EDF and AREVA's dose assessment.

35 The outcomes of the dose assessment were compared with limits and constraints set out in Council Directive 96/29/Euratom, laying down basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation and enacted in England and Wales by the SI 2010 No. 675 The Environmental Permitting (England and Wales) Regulations 2010. The limits and constraints are:

a) UK dose limit for members of the public: 1 mSv (1000 μSv) per annum individual effective dose.

b) UK dose constraints:

   i) 300 μSv per year individual effective dose from a single new source, (in their 2009 publication '*Application of the 2007 Recommendations of the ICRP to the UK*' (HPA, 2009) the Health Protection Agency (HPA) has advised the UK Government to select a constraint value for members of the public for new power station that is less than 0.15 mSv (150 μSv) per year);

   ii) 500 μSv per year individual effective dose from a single site not including exposures arising from direct radiation.

36 There are no regulatory limits and constraints for collective dose. Collective dose information is normally used for comparisons across sites or facilities. The International Atomic Energy Agency (IAEA) suggest that practices which give rise to collective doses less than 1 personSv (personSv is intended to be equivalent to manSv) in a year of operation may be exempted from regulatory control.

37 In their submission EDF and AREVA described a generic site and discharge data and using these they undertook a dose assessment to meet the requirements of our Process and Information Document. The dose assessment was provided to us in PCER Chapter 11 Radiological impact assessment.

38 In early 2009 we invited tenders from contractors using our framework contract to carry out a validation and verification exercise on EDF and AREVA's dose assessment and undertake an independent dose assessment of the UK EPR. The contract was let to Enviros Consulting Ltd. We consulted with HPA, Food Standards Agency (FSA) and the UK National Dose Assessment Working Group (NDAWG) on the contract specification prior to the tendering exercise and incorporated their comments in the final technical specification for the contract.

39 The aim of the independent assessment was to:

a) Validate and verify the assumptions made by EDF and AREVA in their dose assessments.

b) Validate and verify the outcomes of the dose assessments carried out by EDF and AREVA.

c) Carry out independent dose assessments to demonstrate that the dose assessments carried out by EDF and AREVA were realistic.

40 We required the contractor to use PC CREAM-98 to model dispersion and calculate doses to the reference group and collective doses for all exposure pathways including any unusual pathways. PC CREAM-98 is a long recognised system for dose assessment developed for the EC.

41 We considered that:

a) Site-specific habits data should be used where available however we recognised that at the generic stage the dose assessment would be carried out using parameters relating to the generic site provided by the EDF and AREVA.

b) In the absence of site-specific habits data generalised habits data from NRPB W41 should be used (NRPB, 2003). NRPB W41 gives generalised food intake rates, generalised inhalation and water intake rates, inadvertent ingestion rates, critical group ingestion rates of aquatic food, coastal, lakeside and river bank occupancy factors and indoor occupancy.

c) For site-specific dose assessments at sites where new facilities are close to existing nuclear facilities consideration needs to be given to doses which may arise as a result of discharges from the existing facilities bearing in mind the dose constraint of 500 μSv per year individual effective dose from a single site not including exposures arising from direct radiation.

d) In order to compare to the dose limit, significant future doses from historic discharges at the site or nearby sites and future direct radiation from other sites need to be added to future doses due to discharges and direct radiation from the site being assessed.

e) For assessments of individual dose, it is appropriate to take account of accumulation of radionuclides in the environment, usually by undertaking the assessment for the year in which the highest critical group dose is likely to occur. This ensures that future generations are afforded the same level of protection as the current generation. Assuming no change in discharge limits, the highest critical group dose is generally predicted to occur during the last few years of discharges from a plant / site. Once discharges cease or are reduced significantly, the highest environmental activity concentrations near the discharge point generally start to decline. An accumulation time-scale of 50 years is usually selected for new plants and for plants / sites where it is difficult to specify a closure date. Where radionuclides build-up to an equilibrium level more quickly in the environment, then a shorter time-scale may also be adopted. Generally, the highest radionuclide concentrations in the environment, from a given site, tend to decline following a reduction in discharges. A key exception is where there is in-growth of a daughter radionuclide from its parent (e.g. americium-241).

f) We noted that in their 2009 publication '*Application of the 2007 Recommendations of the ICRP to the UK*' (HPA, 2009) the HPA advised that the term 'representative person' should be gradually adopted to replace the term 'critical group' in order to ensure consistency with ICRP advice and terminology. In line with their advice we consider the terms 'critical group' and 'representative person' to be equivalent and to refer those individuals in the population of interest who receive or are expected to receive the highest dose.

42 We required the contractor to undertake:

a) Prospective assessment of doses from potential gaseous and aqueous discharges from the UK EPR design for the members of the public using information on potentially exposed members of the public set out by the EDF and AREVA for their generic site and taking account of direct radiation for comparison with the source dose constraint. Where applicable assessments should be carried out for 'normal discharges', 'worst case discharges' and at any discharge limits proposed by the requesting party.

b) Prospective assessments of:

i) annual dose to most exposed members of the public for liquid discharges;

ii) annual dose to most exposed members of the public for gaseous discharges;

iii) annual dose to the most exposed members of the public for all discharges from the facility;

iv) annual dose from direct shine radiation to the most exposed member of the public;

v) annual dose to the critical group for the facility;

vi) potential short-term doses based on the maximum anticipated short-term discharges from the facility in normal operation.

c) Assessment of the collective doses from gaseous and aqueous discharges from the UK EPR design for the populations identified by EDF and AREVA for their generic site. Where applicable assessments should be carried out for 'normal discharges', 'worst case discharges' and at any discharge limits proposed by the requesting party (RP).

43 In order to carry out the assessments we assessed the submission made by EDF and AREVA to ensure it provided the following data for their generic site:

a) For atmospheric dispersion modelling and dose assessment:

i) Effective release height

ii) Volumetric flow rate

iii) Activity of each radionuclide in annual foreseeable discharges

iv) Location of receptors such as nearby residents, local food production sites, persons most exposed via inhalation of the plume, any free food sources

v) Meteorological data

vi) Surface roughness length

vii) Stability category

viii) Deposition velocity

ix) Washout coefficient

x) Terrestrial food consumption habits

b) For marine dispersion modelling and dose assessment:

i) Activity of each radionuclide in annual foreseeable discharges

ii) Volumetric exchange rate for receiving water

iii) Location of discharge

iv) Consumption rates of locally caught seafood

v) Inhalation rates

vi) Beach occupancy rates

vii) Location of any receptors

44 The methodology and outcome of the work carried out by the contractor is set out in the report 'Generic design assessment, UK EPR nuclear power plant design by Electricité de France SA and AREVA NP SAS, Assessment report - Independent Dose assessment' (IMAS/TR/2010/05) (Environment Agency, 2010a). Its outcome is summarised in the section below.

2.5 EDF and AREVA's dose assessment

45 In the EDF and AREVA submission, it is assumed that the UK EPR would be located on the coast. The annual maximum radioactive liquid and atmospheric discharges were used as the basis for assessing doses to the local population and collective doses. It should be noted that in their assessment EDF and AREVA used a value of 340 MBq for 'other radionuclides' discharged to the air despite proposing a discharge limit of 120 MBq. This was because they claimed they did not have time to repeat their dose assessment to reflect their revised proposed annual limits. For the same reason EDF and AREVA used a value of 900 GBq for carbon-14 to air despite proposing a discharge limit of 700 GBq. EDF and AREVA state the following in PCERsc11.1s1.1.1.e: '*Since gaseous carbon-14 is the main contributor to the overall gaseous dose received from gaseous discharges, it is expected that the overall dose from gaseous discharge will be lower than discussed. Considering the low impact of fission and activation products on the total dose received, it is expected that the reduction of the annual limit for fission and activation products will not have a major impact on the overall dose calculation.*'

46 A tiered assessment approach was applied by EDF and AREVA to estimate doses to the local population. The requesting party's initial assessment was based on the methodology in the Environment Agency system (Environment Agency 2006). Their more detailed assessment of exposure of people used the methodology described in EC publication RP-72 (Simmonds et al 1995) and as implemented in PC CREAM-98 by the HPA. EDF and AREVA also provided estimates of the collective doses to the UK, European and World populations (truncated at 500 years), estimated using PC CREAM. They also predicted doses from expected short-term releases.

47 As part of the validation and verification activity the approaches applied by EDF and AREVA were reviewed and repeated.

48 **Doses from gaseous discharges** - Using the Stage 3 approach EDF and AREVA estimated the annual effective doses to the most exposed members of the local population, arising from the predicted annual maximum radioactive discharge to atmosphere, to be 7.8 μSv y^{-1} (to infants). It was possible to repeat the EDF and AREVA assessment outcome.

49 **Doses from aqueous discharges** - EDF and AREVA estimated doses from the maximum annual liquid radioactive discharges to the marine candidate critical group to be 17 μSv y^{-1} (to adult). It was possible to repeat the EDF and AREVA assessment outcome.

50 **Doses from direct radiation** - Exposure of the public from direct radiation from nuclear sites in the UK is the responsibility of the ONR. ONR require site operators to measure direct radiation at the site perimeter and estimate exposure to a reference group on an annual basis. EDF and AREVA have used direct radiation measurements

for Sizewell B as a basis for their estimated direct radiation doses. Direct radiation doses were assessed as likely to be between 1.7 – 4.8 μSv y^{-1}, depending on the outdoor occupancy of the age of the group considered.

51 **Doses from short-term releases –** From time to time, processes on site may result in additional discharges to atmosphere. These include de-fuelling and coolant purges. The discharges can range from 30 minutes to several hours. EDF and AREVA have made an assessment of a short duration release – assuming one month's discharge is released over 24 hours. This is a conservative assumption in that it is likely to be an overestimate of the discharge made over such a short timescale. These modelling assumptions resulted in estimated doses from a UK EPR to the representative person of the public of 1.5 μSv to an infant. Doses to adults and children are estimated to be 0.9 μSv. It was possible to reproduce the majority of the assessment with the exception of ingestion from terrestrial foods. Our assessment gave a slightly higher dose of 5 μSv, due to the less complex but more conservative food chain model that we used.

52 **Doses to the representative person** – Doses to the representative person were estimated by adding the doses to the most exposed group (adult) from atmospheric discharges to the dose to the most exposed group (adult) from liquid discharges to the marine environment and the dose from direct radiation. This gives the dose to a hypothetical person who is a member of the local fishing community and who also simultaneously is a farmer living 500 m from the sites who is exposed to atmospheric releases and consumes locally produced food, two food types at high rates and all other food types at average rates. This person also spends time close enough to the site to receive a dose from direct radiation. The dose arising from this combined person is 25.8 μSv y^{-1} - which is taken to be the dose to the representative person.

53 EDF and AREVA's estimate of dose is well below the UK constraint for any single new source of 300 μSv y^{-1}. The assessment of dose is also below the dose constraint proposed by the Health Protection Agency (HPA 2009) from new nuclear power stations of 150 μSv y^{-1}.

54 Collective dose – EDF and AREVA estimated the collective doses to the world population (truncated at 500 years) from representative atmospheric discharges to be of the order of 16 personSv per year of discharge to atmosphere and 1.1 personSv per year from representative liquid discharges. The highest dose per person was estimated to be 2 nSv y^{-1} to the UK population. Calculated average annual individual doses for a population group in the nanosievert (nSv/y) range or below can be ignored in the decision making process as the associated risks are minuscule and the contribution to total doses to individuals will be insignificant. Higher annual doses, up to say a few microsievert (μSv/y) can be considered trivial but may require some consideration particularly if at the higher end of the range.

55 Other aspects of the submission, related to the assessment of the build up of material in the environment, were reviewed but not repeated.

56 The results of EDF and AREVA's dose assessment are summarised below:

Dose to public from EDF and AREVA's maximum discharges μSv y^{-1}					
Candidate for representative person	**Age Group**	**EPR Discharges**			
		Stack 1	**Marine**	**Direct Radiation**	**Total**
CRP1 - local resident (high rate terrestrial food consumer)	Adult	4.0	1.9	4.8	10.7
	Child	4.4	1.2	2.5	8.1
	Infant	7.8	1.1	1.7	10.6
CRP2 - local fisherman (high marine exposure)	Adult	1.4	17	0	18.4
	Child	1.6	4.7	0	6.3
	Infant	2.3	1.5	0	3.8

2.6 Our independent assessment of doses from maximum expected discharges

57 An independent assessment of doses from discharges from the UK EPR design was also undertaken on our behalf by a contractor, Enviros Consulting Ltd. The assessment was based on information provided by EDF and AREVA and generic assumptions agreed with us. The following were assessed for gaseous and aqueous discharges:

a) the annual dose to the critical group for the facility;

b) the potential short-term doses from the maximum anticipated short-term discharges from normal operation;

c) collective doses to the UK, European and World populations truncated at 500 years;

d) doses from direct radiation.

58 **Doses from gaseous discharges** - The independent assessment predicted doses to members of the public from atmospheric discharges as 8.5 μSv y^{-1} to an infant in the local resident family who consume locally produced terrestrial foods. The ingestion of carbon-14 in milk accounts for the majority of the dose predicted from aerial discharges.

59 **Doses from aqueous discharges -** At the maximum liquid discharges, the highest dose to members of the public from marine discharges has been predicted to be around 28 μSv y^{-1} to an adult fisherman. The dose arises primarily from carbon-14 in fish.

60 **Doses from direct radiation -** The dose from direct radiation was independently assessed by basing it on values measured for Sizewell B. The direct radiation dose to members of the public was estimated to be 4 μSv y^{-1}. For the purposes of this assessment, this value has been assumed to apply to the UK EPR.

61 **Doses from short-term releases –** The estimated doses from short-term releases in the independent assessment (of the order of 5 μSv from a single occurrence) were higher than those in the EDF and AREVA assessment (of 1.5 μSv from a single occurrence) but still very low. This difference is a reflection of the greater level of simplification and conservatism implicit in the independent assessment of the contribution from terrestrial foods than in that undertaken by EDF and AREVA.

62 **Doses to the representative person -** The dose to the representative person from a UK EPR located at a generic coastal site taking account of contributions from gaseous and aqueous discharges and direct radiation, was estimated to be around 31 μSv y^{-1} to local adult fishermen, of which 28 μSv y^{-1} was due to aqueous discharges and

3 μSv y^{-1} was from gaseous discharges from the consumption of locally produced terrestrial foods and no contribution from direct radiation (as the representative person belongs to the group that is most exposed to liquid discharges and receives no dose from direct radiation).

63 **Collective dose -** The outcome of the independent assessment of collective doses was essentially equivalent to that presented in the EDF and AREVA submission.

64 The results of the independent assessment at EDF and AREVA's maximum discharges are summarised below:

Dose to public from EDF and AREVA's maximum discharges μSv y^{-1}					
Candidate for representative person	**Age Group**	**EPR Discharges**			
		Stack 1	**Marine**	**Direct Radiation**	**Total**
CRP1 - local resident (high rate terrestrial food consumer)	Adult	5.3	2.0	4	11.3
	Child	5.7	1.1	4	10.9
	Infant	8.5	1.1	4	13.6
CRP2 - local fisherman (high marine exposure)	Adult	3.2	27.9	0	31.1
	Child	3.8	8.3	0	12.0
	Infant	4.1	2.7	0	6.9

65 The results from the independent assessment were slightly higher than those found by EDF and AREVA because, in the independent assessment, different assumptions about the characteristics of the local marine environment were applied and local residents were assumed to live closer to the site and to produce some vegetables and fruit closer to the site than in the EDF and AREVA assessment.

2.7 Our independent assessment of doses from discharges at our proposed limits

66 We used the spreadsheet prepared by Enviros Consulting Ltd to estimate doses at our proposed discharge limits. The discharges at the proposed limits are set out below:

Gaseous discharges at Environment Agency proposed limits		
Radionuclide	**Atmospheric Discharges per Stack (TBq y^{-1})**	
	Stack 1	**Composition from PCER c11.1 table 2**
Ar-41	6.53E-01	2.9% of noble gases limit of 22.5 TBq
C-14	7.00E-01	
Co-58	1.28E-05	25.5% of 'other radionuclide' limit of 50 MBq
Co-60	1.51E-05	30.1% of 'other radionuclide' limit of 50 MBq
Cs-134	1.17E-05	23.4% of 'other radionuclide' limit of 50 MBq
Cs-137	1.05E-05	21.0% of 'other radionuclide' limit of 50 MBq
H-3	3.00E+00	
I-131	1.82E-04	45.6% of 'iodine radionuclides' maximum predicted discharge of 400 MBq
I-133	2.18E-04	54.4% of 'iodine radionuclides' maximum predicted discharge of 400 MBq
Kr-85	3.13E+00	13.9% of noble gases limit of 22.5 TBq
Xe-131m	6.75E-02	0.3% of noble gases limit of 22.5 TBq
Xe-133	1.42E+01	63.1% of noble gases limit of 22.5 TBq
Xe-135	4.46E+00	19.8% of noble gases limit of 22.5 TBq

Aqueous Discharges at Environment Agency proposed limits		
Radionuclide	**Aqueous Discharges (TBq y^{-1})**	
	Discharge point 1	**Composition from PCER c11.1 table 2**
Ag-110m	2.85E-04	5.7% of 'other radionuclide' limit of 5 GBq
C-14	9.50E-02	
Co-58	1.04E-03	20.7% of 'other radionuclide' limit of 5 GBq
Co-60	1.50E-03	30% of 'other radionuclide' limit of 5 GBq
Cr-51	3.00E-05	0.6% of 'other radionuclide' limit of 5 GBq
Cs-134	2.80E-04	5.6% of 'other radionuclide' limit of 5 GBq
Cs-137	4.70E-04	9.45% of 'other radionuclide' limit of 5 GBq
H-3	7.50E+01	
I-131	5.00E-05	Not limited – value as maximum predicted discharge
Mn-54	1.35E-04	2.7% of 'other radionuclide' limit of 5 GBq
Ni-63	4.80E-04	9.6% of 'other radionuclide' limit of 5 GBq
Sb-124	2.45E-04	4.9% of 'other radionuclide' limit of 5 GBq
Sb-125	4.07E-04	8.15% of 'other radionuclide' limit of 5 GBq
Te-123m	1.30E-04	2.6% of 'other radionuclide' limit of 5 GBq

67 **Doses from gaseous discharges –** The highest doses from gaseous discharges was 8.5 µSv to an infant and the highest contribution was from carbon-14 in milk.

68 **Doses from aqueous discharges –** The highest doses from aqueous discharges was 28 µSv to an adult. The dose arises primarily from carbon-14 in fish.

69 **Doses from direct radiation –** The assessment of direct radiation was based on measured values for Sizewell B for 2007, for which a value of 4 µSv y^{-1} has been published in Radioactivity in Food and the Environment 2007 (Environment Agency, 2008).

70 **Doses to the representative person –** Our Stage 3 assessment resulted in the highest estimated doses from an UK EPR is to the representative person of 30 µSv y^{-1}. This assessment outcome is for our proposed annual limits on discharges for the UK EPR.

71 The results of the dose assessment at our proposed limits are summarised below:

Dose to the public at Environment Agency proposed limits µSv y^{-1}					
Candidate for representative person	**Age Group**	**UK EPR Discharges**			
		Stack 1	**Marine**	**Direct Radiation**	**Total**
CRP1 - local resident (high rate terrestrial food consumer)	Adult	4.2	2.0	4	10.2
	Child	4.5	1.1	4	9.6
	Infant	6.7	1.1	4	11.8
CRP2 - local fisherman (high marine exposure)	Adult	2.6	27.8	0	30.4
	Child	3.0	8.2	0	11.2
	Infant	3.3	2.7	0	6.0

2.8 Comparison to dose constraints and dose limits

72 Source dose constraint (Defra, 2000) - The dose constraint for the maximum dose to people that may result from discharges from a new single source (for example, a new power station) is 300 µSv y^{-1} which applies to the dose from proposed discharges and direct radiation.

73 We conclude that sum of doses to the representative person at our proposed limits is below the source dose constraint, and below the dose constraint recommended by the HPA for new build of 150 µSv y^{-1}.

74 Site dose constraint - The dose constraint for the maximum dose to people that may result from discharges from a site as a whole is 500 µSv y^{-1} and it applies to the total dose from the discharges (direct radiation is not included) from all sources at a single location, including discharges from immediately adjacent sites.

75 All the sites listed in the Nuclear National Policy Statement (DECC, 2011) as potentially suitable for a new nuclear power station are adjacent to existing nuclear power stations. In GDA the specific site at which a UK EPR might be located is not known but we consider, in the light of our assessment that the highest total dose is estimated to be 31 µSv y^{-1}, it is very unlikely that doses at the site will exceed the site dose constraint of 500 µSv y^{-1}. We consider that site dose should be assessed at the site-specific stage.

76 Dose limit - There is also a dose limit for the maximum dose to any member of the public from ionising radiation. The dose limit is 1 mSv y^{-1}

(1000 μSv y^{-1}) and it applies to the total dose from all artificial sources including past discharges but excluding medical and accidental exposure.

77 Comparison against the dose limit can only be done at site-specific permitting when contributions from all sources of radiation can be included.

3 Detailed findings

78 The assessment findings are set out in more detail in the independent dose assessment report prepared on our behalf by Enviros Consulting Ltd (Environment Agency, 2010a).

79 We consulted the Health Protection Agency and the Food Standards Agency on the draft and their comments, which were minor in nature, were incorporated into the final report.

4 Public comments

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

81 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 members of the public.

82 We did receive comments from several respondents to our consultation about two recent studies and reports on health risks near nuclear sites and from tritium and whether these have been considered.

83 Our dose assessments take into account health risks arising from exposure to radiation using UK dose to risk factors that have been recommended by the Health Protection Agency (HPA). The UK factors are based on those recommended by the International Commission on Radiation Protection (ICRP) and form part of a wider radiation protection framework (ICRP-60 and ICRP-103) and enacted into legislation through the Basic Safety Standards Directive (96/29/EURATOM) and in the UK through the Ionizing Radiations Regulations- 1999, and the Environmental Permitting Regulations 2010. The risks from doses are reflected in the dose limits and dose constraints set in this legislation.

84 In 2007 a study had been published of leukaemia near nuclear sites in Germany – the so called KiKK study (Spix et al 2008, Kaatsch et al 2008). A separate study was also undertaken into risk factors specifically related to tritium (AGIR 2007).

85 The HPA (Mobbs et al 2010) have stated that the KiKK study was reviewed by the German Commission on radiation protection who concluded that the design of the KiKK study was unsuitable for establishing relationships between leukaemia and exposure to radiation from nuclear power plants. This is because the natural radiation exposure within the study area and its fluctuations are greater by several orders of magnitude than the radiation exposure from the nuclear power plants themselves. Similar UK and French data have subsequently been analysed for any trend with distance and do not show higher levels of leukaemia close to power stations.

86 We formally sought advice from the HPA to confirm if our dose factors or methodology should as a result of the Advisory Group on Ionizing Radiation (AGIR, 2007) report on tritium. HPA have advised us that the current radiation protection system remains appropriate, the current risk factors are valid and that we should continue to use the dose coefficients published by ICRP in our regulatory decision. HPA restated this position with respect to tritium and the AGIR in their response to the 2007 recommendations of ICRP.

87 For our regulation we continue to apply the dose factors published by ICRP (ICRP, 1996) and compare the calculated doses with the legal dose limits and dose constraints (EPR 10) and have taken into account the revised dose constraint recommended by the HPA.

5 Conclusion

88 EDF and AREVA's estimate of dose is well below the UK constraint for any single new source of 300 μSv y^{-1}. The assessment of dose is also below the dose constraint proposed by the Health Protection Agency (HPA 2009) from new nuclear power stations of 150 μSv y^{-1}.

89 Our independent assessment concluded that the sum of doses to the representative person at our proposed limits is below the source dose constraint.

90 A number of the sites listed in the Nuclear National Policy Statement as potentially suitable for a new nuclear power station are adjacent to existing nuclear power stations. In GDA the specific site at which a UK EPR might be located is not known but we consider in the light of our assessment that the highest total dose is estimated to be 31 μSv y^{-1} it is very unlikely that doses at the site will exceed the site dose constraint of 500 μSv y^{-1}. We consider that site dose should be assessed at the site-specific stage.

91 Comparison against the dose limit can only be done at site-specific permitting when contributions from all sources of radiation can be included.

92 In line with our usual procedures we will require a detailed site-specific 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 constraint and dose limits.

6 Compliance with Environment Agency requirements

P&I Table 1 section or REP	Compliance comments
Section 2.7 Prospective dose assessment for the generic site at the proposed limits for levels of discharge.	An assessment was carried out by EDF and AREVA which included an assessment of • annual dose to most exposed members of the public for liquid discharges; • annual dose to most exposed members of the public for gaseous discharges (identifying separately the dose associated with on site incineration where applicable); • annual dose to the most exposed members of the public for all discharges from the facility; • annual dose from direct radiation to the most exposed member of the public; • annual dose to the critical group for the facility; • potential short-term doses, including via the food chain, based on the maximum anticipated short-term discharges from the facility in normal operation; • a comparison of the calculated doses with the relevant dose constraints; • an assessment of whether the build-up of radionuclides in the local environment of the facility, based on the anticipated lifetime discharges, might have the potential to prejudice legitimate users or uses of the land or sea.
Section 2.8 Collective dose assessments for discharges from the facility truncated at 500 years to the UK, European and World populations.	An assessment of collective dose was made by EDF and AREVA.
Section 2.9 Sufficient assumed data for others to be able to carry out all dose assessments.	Sufficient data was provided by EDF and AREVA and this allowed the independent validation and verification of their dose assessments.
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 dose assessments seemed reasonable.

P&I Table 1 section or REP	Compliance comments
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.
SEDP3 Ambient radioactivity - Levels of ambient radioactivity around the sites of new facilities shall be assessed.	An assessment of potential doses from direct radiation from the EPR were made.
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 EPR is located on a multi-facility site.
RPDP1 Optimisation of protection - All exposures to ionising radiation of any member of the public and of the population as a whole shall be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account	ALARP has been demonstrated at this stage however we require EDF and AREVA to keep ALARP matters under review.
RPDP2 Dose limits and constraints - Radiation doses to individual people shall be below the relevant dose limits and constraints.	Predicted doses to members of the public from the UK EPR at the generic site are less than the relevant dose limits and constraints.
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.

P&I Table 1 section or REP	Compliance comments
UK dose limit for members of the public - 1 mSv per annum individual effective dose.	Individual doses predicted from the EDF and AREVA assessment and from the independent assessment were below the UK dose limit for members of the public. 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.
UK dose constraints -300 µSv per annum individual effective dose from a single new source, (in their 2009 publication Application of the 2007 Recommendations of the ICRP to the UK (HPA, 2009) the Health Protection Agency has advised the UK Government to select a constraint value for members of the public for new power station that is less than 0.15 mSv per year).	Individual doses predicted from the EDF and AREVA assessment and from the independent assessment were below the dose constraint of 300 µSv y^{-1} and the proposed constraint for new power stations of 150 µSv y^{-1}. 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.
UK dose constraints -500 µSv per annum individual effective dose from a single site not including exposures arising from direct radiation.	Individual doses predicted from the EDF and AREVA assessment and from the independent assessment were below the dose constraint of 500 µSv y^{-1} from a single site assuming the EPR is not on a multi-facility 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.
IAEA suggest that practices which give rise to collective doses less than 1 man Sv per year of operation may be exempted from regulatory control.	Collective doses predicted from the independent assessment are greater than 1 man Sv per year of operation. The practice will not be exempted from regulatory control.

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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 3.5 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
JPO	Joint Programme Office
NDAWG	UK National Dose Assessment Working Group
NRPB	National Radiological Protection Board (now part of Health Protection Agency)
ONR	Office for Nuclear Regulation (an Agency of the Health & Safety Executive, formerly HSE's Nuclear Directorate)
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
RP	Requesting Party
RSA 93	Radioactive Substances Act 1993
RWMD	Radioactive Waste Management Directorate (of NDA)
TQ	Technical Query

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