Generic design assessment

AP1000® nuclear power plant design by Westinghouse Electric Company LLC

Final assessment report

Radiological impact on non-human species

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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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AP1000® nuclear power plant design by Westinghouse Electric Company LLC

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	Tooley, E.J., as amended by Grundy, Dr C. L.

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

Table of contents

1 Summary

1 This assessment considers the impact of the AP1000® on non-human species arising from discharges into the environment. This assessment considers the information provided by Westinghouse Electric Company LLC for its AP1000 design.

2 This report summarises the outcomes of our assessment of the information provided and the assessment carried out by Westinghouse with respect to prospective doses to non-human species as a result of the disposal of liquid and gaseous radioactive waste from the AP1000 to the environment.

3 We consider the assessment carried out by Westinghouse to be conservative and reasonable at the GDA stage and we consider that Westinghouse has used an appropriate approach to the assessment of the radiological impact of the AP1000 on non-human biota.

4 From our assessment of Westinghouse's submission we conclude that the expected predicted gaseous releases and aqueous discharges from the AP1000 for the generic site are unlikely to pose a risk to non-human species. Although the marine Tier 2 dose rates calculated by Westinghouse exceed the screening dose rate of 10 μGy h^{-1}, they 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 (National Dose Assessment Working Group, 2008).

5 We have also made an assessment of radiation dose rates to plants and animals near an operating AP1000 using the independently calculated activity concentrations (these were made by Enviros on our behalf and are considered 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) 0.04 μGy h^{-1} for a marine organism (a mammal).

6 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

7 We conclude that at the GDA stage we consider that the maximum predicted gaseous releases and aqueous discharges for an AP1000 at the generic site are unlikely to pose a risk to non-human species. We consider that the assessment is suitably conservative at this stage of the GDA process.

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 doses to members of the public and non-human species from the AP1000 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 AP1000 reactor may be found in our Decision Document (Environment Agency, 2011).

2 Introduction

10 We originally published this report in June 2010 to support our GDA consultation on the AP1000 design. On 28 June 2010, our consultation began on our preliminary conclusions following our detailed assessment of this submission. The consultation closed on 18 October 2010.

11 This report is an update of our original report covering assessment undertaken between June 2010 and the end of March 2011 when Westinghouse published an update of its submission. Where any paragraph has been added or substantially revised it is in a blue font.

12 This assessment considers the impact of the AP1000 on non-human species arising from discharges into the environment.

13 The assessment considers the information provided by Westinghouse Electric Company (WEC) for its AP1000 design.

14 We appointed contractors (Enviros Consulting Ltd) to make an independent assessment of environmental activity concentrations from the AP1000 at the generic site.

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

16 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.

17 Our assessment of Westinghouse's generic site is documented within this assessment report. This is essentially the same as that provided in the first issue of this assessment report but updated, where appropriate, to reflect:

a) Our assessment of any further information provided by Westinghouse since the consultation date.

b) Any further work that we said, in the consultation document, that we intended to do.

c) Any matters arising from the Office for Nuclear Regulation's[1] (ONR's) GDA Step 4 work that are relevant to our assessment.

d) Our consideration of any consultation responses relevant to this topic.

e) Our consideration of any comments from our 6 July GDA stakeholder seminar relevant to this topic.

18 We have published the consultation responses submitted in regard to our preliminary conclusions for the AP1000 design on our website (see: https://consult.environment-agency.gov.uk/portal/ho/nuclear/gda).

19 The questions raised at our stakeholder seminar have also been published (see: http://www.hse.gov.uk/newreactors/seminar-060710.pdf).

[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.

3 Assessment

20 This assessment considers the radiological impact of discharges from an AP1000 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, 2009a) 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

21 The basis of our assessment was to:

a) consider the submission made by Westinghouse in particular the Environment Report and its supporting documents;

b) hold technical meetings with Westinghouse 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 Westinghouse was insufficient;

d) assess the radiological impact of discharges from an AP1000 on non-human species to demonstrate that doses to non-human species from the AP1000 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 stakeholder seminar relevant to this topic;

f) decide on any GDA Issues;

g) identify assessment findings to carry forward from GDA.

22 Westinghouse provided its submission for GDA in August 2007. We carried out our initial assessment and concluded we needed additional information. We raised a Regulatory Issue on Westinghouse in February 2008 setting out the further information that we needed. Westinghouse completely revised its submission during 2008 and provided an Environment Report with supporting documents.

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

24 We raised 42 Technical Queries (TQs) on Westinghouse during our assessment. Four were relevant to this report:

a) TQ-AP1000-150 – Dose assessment assumptions – effective release height. 1 June 2009.

b) TQ-AP1000-178 – Non-human species impact assessment - general issues. 2 July 2009.

c) TQ-AP1000-179 – Non-human species impact assessment - coastal assessment. 2 July 2009.

d) TQ-AP1000-180 – Non-human species impact assessment - terrestrial assessment. 2 July 2009.

25 Westinghouse responded to the TQ's. They reviewed and updated the Environment Report in April 2010 to include all the relevant information provided by the TQs.

26 In March 2011, Westinghouse provided an updated ER (rev. 4).

3.2 Assessment objectives

27 Key areas of the submission made under the GDA arrangements by Westinghouse for the AP1000 design that have been considered are:

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

b) Can the radiological impact assessment carried out by Westinghouse be independently validated?

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

3.3 Westinghouse documentation

28 We referred to the following documents to produce this report:

Document reference	Title	Version number
UKP-GW-GL-790	UK AP1000 Environment Report	4
UKP-GW-GL-025	Generic Site Report	1
UKP-GW-GL-033	Assessment of Radioactive Discharges on Non-Human species	2

3.4 Assessment Findings

29 This report summarises the outcomes of our assessment of the information provided and the assessment carried out by Westinghouse with respect to prospective doses to non-human species as a result of the disposal of aqueous and gaseous radioactive waste from the AP1000 to the environment.

30 In order to assess potential impacts we required Westinghouse 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 Westinghouse to describe a generic site on which the dose assessment was based and which represented likely sites where an AP1000 might be located. A separate assessment report has been prepared setting out our assessment of the generic site parameters provided by Westinghouse (Environment Agency, 2011d). For consistency the generic site description was also used in the independent assessment of potential impact on members of the public (Environment Agency, 2010c).

31 In order to assess doses to non-human species, in addition to the description of the environmental features of the generic site, we required Westinghouse to provide information about discharges of aqueous and gaseous radioactive waste from the AP1000 and this information is considered in our assessment reports (Environment Agency, 2011b,c).

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-AP1000-178 was raised on 2 July 2009 which required Westinghouse to provide further general information in order that we could carry out an independent assessment of the impact on non-human species. We required Westinghouse to clarify certain data used in its non-human species assessment and to set out its approach to assessment of the impact on the freshwater eco-system. Westinghouse responded on 20 August 2009 by providing the information requested and they repeated the assessment and revised the Environment Report s5.3.1. to reflect the new assessment. Westinghouse confirmed that they did not foresee any discharges to the freshwater eco-system.

34 Technical Query TQ-AP1000-179 was raised on 2 July 2009 which required Westinghouse to provide further information relating to its coastal assessment. Westinghouse responded on 20 August 2009 by providing the information requested and they repeated the assessment and revised the Environment Report s5.3.1. to reflect the new assessment.

35 Technical Query TQ-AP1000-180 was raised on 2 July 2009 which required Westinghouse to provide further information relating to its terrestrial assessment. Westinghouse responded on 24 August 2009 by providing the information requested and they repeated the assessment and revised the Environment Report s5.3.1. to reflect the new assessment.

36 We appointed contactors to make an independent assessment of environmental activity concentrations from the AP1000 at the generic site.

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

38 We carried out two evaluations of the assessment carried out by Westinghouse using the Environmental Risk from Ionising Contaminants: Assessment and Management "ERICA" Tool (Beresford, 2007) and the R&D128 (Copplestone, 2001);

a) A validation exercise to satisfy ourselves that the results of the Westinghouse assessment were reproducible.

b) An independent assessment at Tier 2 to determine the dose rates using discharge data provided by Westinghouse and predicted activity concentrations modelled for us by an independent contractor.

39 The results of our assessments are summarised in Table 1.

3.5 The assessment models

40 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.

41 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.

42 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.

43 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), 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).

44 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[2]. 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.

45 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&D 128 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.

3.6 Results of the assessment carried out by Westinghouse

46 Westinghouse calculated the expected annual discharge of radionuclides that is likely to occur from its new AP1000 design. They used this data to assess the potential impact of the discharges to non-human species.

47 For its terrestrial assessment, Westinghouse used the ERICA Tool at Tier 1 and the R&D128 approach for noble gases, using the expected gaseous releases and assuming the organisms were present at the site boundary. Westinghouse completed its assessment for marine organisms using the ERICA Tool at Tier 1 and Tier 2, using the expected liquid discharges and assuming the organism was located 150 m away from the discharge point. Westinghouse used the IAEA SRS 19 models for dispersion (IAEA, 2001); these are an inbuilt feature of the ERICA Tool which use the discharge rate and other site data to calculate activity concentrations in air and water. They also used the IAEA SRS 19 methodology for its R&D128 assessment, to calculate the

[2] Transfer parameters are K_d and Concentration Ratio

activity concentrations of noble gases at the site boundary. For the site data, Westinghouse has generally used average values for its generic site.

48 The results of the terrestrial assessment showed that for the most sensitive combination of reference organisms, the probability of the predicted discharges exceeding the screening dose rate of 10 μGy h^{-1} is very low, and therefore the situation is of negligible radiological concern. The results of the R&D128 assessment calculated the highest predicted dose rate to be 0.00027 μGy h^{-1} (for fungi), which does not exceed the screening dose rate of 10 μGy h^{-1}.

49 The results of the marine assessment at Tier 1 showed that the dose rate for the most sensitive combination of reference organisms exceeded the screening dose rate and therefore a Tier 2 assessment was necessary. The Tier 2 marine results showed that the predicted dose rates exceeded the screening dose rate of 10 μGy h^{-1} for the reference organisms polychaete worm, macroalgae, sea anemone / true coral polyp and colony, benthic mollusc, vascular plant, benthic fish and crustacean. The highest predicted dose rate was 25.2 μGy h^{-1} for the polychaete worm. Westinghouse noted that iron-55 and iron-59 contributed the majority of the dose, and as iron partitions into the sediment phase it is the organisms that live in or on the sediment which are predicted to receive the highest dose rate.

50 Westinghouse carried out a sensitivity analysis to examine the effect on the dose rates to terrestrial reference organisms if:

a) All emissions were made from the turbine vent stack which is lower than the main plant vent.

b) Wind speeds were varied between 1 m s^{-1} and 10 m s^{-1}.

c) The distance between the release point and the receptor was varied in the range from 50 m to 300 m.

d) The worst case of each of these parameters, i.e. all discharges from the turbine stack, the lowest wind speed and the nearest receptor distance.

51 The results of the worst case terrestrial scenario showed that for the most sensitive combination of reference organisms, the probability of the predicted discharges exceeding the screening dose rate of 10 μGy h^{-1} is very low, and therefore the situation is of negligible radiological concern.

52 Westinghouse carried out a sensitivity analysis to examine the effect on the dose rates to marine reference organisms if:

a) Water depth was varied between 2 m to 13 m.

b) The distance between the release point and the shore was varied between 50 m and 200 m.

c) The distance between the release point and the receptor was varied in the range from 50 m to 560 m.

d) Coastal currents were varied in the range 0.05 to 0.5 m s^{-1}.

e) The worst case for each of these parameters, i.e. a water depth of 2 m, the distance to the shore to be 150 m, the distance between the release point and the receptor to be 50 m and a coastal current of 0.5 m s^{-1}.

f) The best case for each of these parameters, i.e. a water depth of 13 m, the distance to the shore to be 150 m, the distance between the release point and the receptor to be 560 m and a coastal current of 0.05 m s^{-1}.

53 The results of the worst case marine scenario show that the predicted dose rates will be above screening dose rate for eleven reference organisms. The highest predicted dose rate for the worst case scenario was 191 μGy h^{-1} for a polychaete worm.

54 The results of the best case marine scenario show 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 the best case scenario was 1.7 μGy h^{-1}.

55 Westinghouse used 'expected' discharge values for liquids and gases in its assessment. We would prefer the use of 'maximum' values at this stage of the GDA, however, we recognise that maximum values could be overly conservative. Westinghouse has considered the suitability of the parameters used for its generic site by completing a sensitivity analysis. In its assessment Westinghouse have followed the ERICA guidelines (or used more conservative parameters), and therefore we consider the input parameters to be reasonable at this stage.

56 We noted that its assessment did not include:

a) assessment of releases from a second stack, nor an explanation why not; and

b) they have not considered the impact that discharges of radionuclides might have on freshwater organisms, or stated why not.

57 We raised Technical Queries (TQ-AP1000-178, TQ-AP1000-179 and TQ-AP1000-180) to ask Westinghouse to respond to these concerns. Its response confirmed that under normal operating conditions the second stack would not be expected to have gaseous radioactive discharges, and that at the generic coastal site there would be no effluent discharged to freshwater bodies. The ERICA Model (using IAEA SRS 19 models for dispersion) allows assessment from a single stack only. Westinghouse assumed the total emissions (including the turbine vent emissions) were discharged from the main plant vent stack. However, in the sensitivity testing Westinghouse selected a Scenario to produce a result assuming the total emissions were released from the turbine vent stack height (ERs5.3.1.1). This confirmed that the emissions from the lower stack are well below any dose rate thresholds.

58 We were able to reproduce the results of the assessment carried out by Westinghouse using the ERICA model and R&D 128 when we used its input parameters.

3.7 Our assessment of the Westinghouse AP1000 design

59 To evaluate Westinghouse's results we completed our own ERICA and R&D128 assessments using the input parameters that Westinghouse used in its assessments, and also using predicted activity concentrations calculated by an independent contractor. The results of our assessments are summarised in Table 1.

3.8 Environment Agency ERICA assessment

60 We carried out separate assessments using the independently calculated activity concentrations, using the ERICA Tool at Tier 2 for terrestrial and marine. 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%, for both the marine and terrestrial environments. 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 0.04 μGy h^{-1} (for a mammal).

3.9 Environment Agency R&D128 assessment

61 We carried out separate assessments using the independently calculated activity concentrations, we calculated the highest predicted dose rate to be 0.00004 μGy h^{-1} (for a caterpillar), which does not exceed the screening dose rate of 10 μGy h^{-1}.

4 Variability

62 Some variation does exist between the results we obtained using the discharge data provided by Westinghouse and the predicted activity concentrations calculated by an independent contractor.

63 For the marine assessment, the results obtained using the independent contractor's data are significantly lower than those using the Westinghouse input data. This is due to how the activity concentrations are derived. Westinghouse entered discharge rates into the ERICA Tool which were automatically converted into activity concentrations using the IAEA SRS 19 methodology. The independent contractor derived the activity concentrations from discharge rates using a modelling package called PC CREAM. The SRS 19 method is a more conservative approach, and therefore overestimates the activity concentrations in water and sediment.

64 The results of the terrestrial assessments are different, however it is not possible to make a meaningful comparison because the assessments were completed at different Tiers of the ERICA Tool. The results using the Westinghouse input data and the independent contractor's data are both two or more orders of magnitude lower than the screening dose rate. The R&D 128 assessments were not significantly different.

Table 1 - Westinghouse Assessment Summary Table

Assessment Type	Data Source	Westinghouse Results	Our Results
Terrestrial			
ERICA Tier 1	Westinghouse	No risk for most sensitive combination of reference organisms	No risk for most sensitive combination of reference organisms
ERICA Tier 2	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	Westinghouse	Maximum predicted dose rate is 0.00027 µGy h^{-1} for fungi	Maximum predicted dose rate is 0.0003 µGy h^{-1} for fungi
	Independent	-	Maximum predicted dose rate is 0.00004 µGy h^{-1} for caterpillar
Marine			
ERICA Tier 1	Westinghouse	Maximum predicted dose rate for most sensitive combination of reference organisms is greater than 10 µGyh^{-1}	Maximum predicted dose rate for most sensitive combination of reference organisms is greater than 10 µGy h^{-1}
ERICA Tier 2	Westinghouse	The predicted dose rates exceed the screening value of 10 µGy h^{-1} for 9 reference organisms. The maximum predicted dose rate is 25 µGy h^{-1} for polychaete worm	The predicted dose rates exceed the screening value of 10 µGy h^{-1} for 9 reference organisms. The maximum predicted dose rate is 25 µGy h^{-1} for polychaete worm
	Independent	-	No risk for any individual reference organism. Maximum predicted dose rate is 0.04 µGy h^{-1} for a mammal

“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 Westinghouse.
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 Westinghouse 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 Westinghouse.
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 AP1000 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 that the maximum predicted gaseous releases and liquid discharges for a AP1000 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

65 We did not receive any public comments during this assessment relating to the assessment of the radiological impact of discharges from the AP1000 on non-human species

66 One respondent to our consultation in 2010, the Institution of Mechanical Engineers (GDA146[3]) agreed '*with the consultation document conclusions and that the assessment section was a good section demonstrating the plant will meet all requirements by a good margin and reassuring to see such good agreement between the Westinghouse data and the regulator's independently calculated data. The Institution feels assured that Westinghouse have assessed fully the impact of radioactive discharges and all dose-rates are well below 40 µGy h-1'.*

67 The Committee on Medical Aspects of Radiation in the Environment (COMARE) (GDA129) 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/hand 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'*

68 We provide some additional explanation of our methodology below:

Dose rate comparison

69 As part of non-human assessments we compare predicted dose rates to a screening value of 10 µGy h^{-1} (different to µSvh^{-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).

70 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.

71 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 µGy h^{-1} screening value to see if the sites could be screened out from further assessment.

[3] 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), 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.

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.

72 Westinghouse's predicted dose rates for the AP1000 generic design discharges to the marine environment did exceed the 10 μGy h^{-1} screening level for some organisms. Therefore a more detailed assessment was completed where the predicted dose rates were compared to the 40 μGy h^{-1} action level, and the radionuclides contributing to higher dose rates considered.

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

Confidence in the assessment methodology

74 The assessment methodology for non-humans is less advanced than for humans and therefore it is inevitable that confidence in dose assessments is lower. There are no species-specific models for wildlife, nor detailed assessments of doses to different organs like there are for humans.

75 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.

76 We are participating in model intercomparison exercises as part of a working group of the International Atomic Energy Agency (IAEA). 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).

77 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

78 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.

79 We are working to improve this by actively participating in the working group responsible for the IAEA'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

80 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.

81 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 μGyh^{-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.

82 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.

83 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

84 We consider the assessment carried out by Westinghouse to be conservative and reasonable at the GDA stage and we consider that Westinghouse has used an appropriate approach to the assessment of the radiological impact of the AP1000 on non-human biota.

85 From our assessments we conclude that the expected predicted gaseous releases and liquid discharges from the AP1000 for the generic site are unlikely to pose a risk to non-human species. Although the marine Tier 2 dose rates calculated by Westinghouse exceed the screening dose rate of 10 μGy h^{-1}, they 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. We consider the assessment is suitably conservative at this stage of the GDA process.

86 We have also made an assessment of radiation dose rates to plants and animals near an operating AP1000 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) 0.04 μGy h^{-1} for a marine organism (a mammal).

87 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.

88 We conclude that at the GDA stage we consider that the maximum predicted gaseous releases and liquid discharges for an AP1000 at the generic site are unlikely pose a risk to non-human species. We consider that the assessment is suitably conservative at this stage of the GDA process.

89 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 AP1000 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)

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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

ADMS	Atmospheric Dispersion Modelling System
ALARP	As Low As Reasonably Practicable
BAT	Best available techniques
DCD	Design Control Document
ER	Environment Report
ERICA	Environmental Risk from Ionising Contaminants: Assessment and Management
FREDERICA	Radiation Effects Database for non human species
FSA	Food Standards Agency
GDA	Generic design assessment
HPA-RPD	Health Protection Agency – Radiation Protection Division
HSE	Health and Safety Executive
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
JPO	Joint Programme Office
ONR	Office for Nuclear Regulation, an Agency of the HSE (formerly HSE's Nuclear Directorate)
P&ID	Process and information document
PCSR	Pre-Construction Safety Report
PWR	Pressurised water reactor
QA	Quality Assurance
REPs	Radioactive substances environmental principles
RGN	Regulatory Guidance Note
RGS	Regulatory Guidance Series
RO	Regulatory Observation
SODA	Statement of Design Acceptability
TQ	Technical Query
US NRC	United States Nuclear Regulatory Commission
WEC	Westinghouse Electric Company LLC
WGS	Gaseous radioactive waste system
WLS	Liquid radioactive waste system

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