The Sizewell C Project

6.3 Volume 2 Main Development Site

Chapter 25 Radiological Considerations

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Contents

Tables

Figures

None provided.

Plates

None provided.

Appendices

25 Radiological Considerations

25.1 Introduction

25.1.1 This chapter of **Volume 2** of the Environmental Statement (ES) presents an assessment of the potential radiological effects arising from the construction and operation of the Sizewell C Project (referred to throughout this chapter as the 'proposed development'). This includes an assessment of potential impacts, the requirements for mitigation, and the residual effects.

25.1.2 Detailed descriptions of the construction and operation Sizewell C on the main development site (referred to throughout this volume as the 'site'), are provided in **Chapters 2** to **4** of this volume of the ES. A description of the anticipated activities for the decommissioning of the Sizewell C power station, including a summary of the types of environmental effects likely to occur is provided in **Chapter 5** of this volume. A glossary of terms and list of abbreviations used in this chapter is provided in **Volume 1, Appendix 1A** of the **ES**.

25.1.3 The radiological impact assessment for human and non-human species has been prepared to support the environmental permit application for radioactive substance regulations (RSR). The Environment Agency will assess the Sizewell C environmental permit applications (including the RSR permit) and provide their opinion from determination of the permit application to support the examination of the DCO for consideration by the Secretary of State for the Department of Business Energy and Industrial Strategy (BEIS).

25.1.4 In addition to the assessment of radiological impacts on human and non-human species, this chapter also includes the assessment of the radiological impacts associated with the transport of radioactive materials and waste to and from the proposed development during the operational period.

25.1.5 A construction related dredging assessment has also been completed. This evaluated the radiological exposure to members of the public associated with sea disposal of dredged sediment, containing trace anthropogenic and natural radionuclides, in support of the installation of the cooling water intake and outfalls systems.

25.1.6 This chapter is supported by the following technical appendices:

- **Appendix 25A:** Construction sediment radiological impact assessment from dredging operations;

- **Appendix 25B:** Radiological Substances Regulations permit application: Supporting Document D1 - Human radiological impact assessment for Sizewell C; and

- **Appendix 25C:** Radiological Substances Regulations permit application: Supporting Document D2 - Non-human radiological impact assessment for Sizewell C.

25.1.7 This chapter does not address the decommissioning of Sizewell C or describe the management of solid radioactive waste or spent fuel, which are described in **Chapters 5** and **7** of this volume respectively.

25.1.8 Furthermore, the UK Government and nuclear industry have an emergency preparedness framework in place to mitigate health effects in the unlikely event of major accidental releases of radiation into the environment. The emergency preparedness response for Sizewell C is captured within the **Chapter 27 Major Accidents and Disasters** of this volume.

25.1.9 A standalone ES was prepared for the Sizewell B relocated facilities works for submission with the hybrid planning application under the Town and Country Planning Act 1990 (East Suffolk Council application ref. DC/19/1637/FUL). Chapter 15 of the Sizewell B relocated facilities ES (refer to **Volume 1, Appendix 2A**) included an assessment of likely significant radiological effects and identified mitigation specific to Sizewell B relocated facilities works. However, as the Sizewell B relocated facilities works form part of the Sizewell C Project and consent is sought for these works through the Development Consent Order (DCO), a summary of the assessment of the likely significant effects of these works is also set out in this chapter under **section 25.5** and **25.6**.

25.2 Legislation, policy and guidance

25.2.1 **Volume 1, Chapter 3** of the **ES** identifies and describes legislation, policy and guidance of relevance to the assessment of likely significant effects associated with the Sizewell C Project. Legislation, policy and guidance of specific relevance to the assessment of radiological impacts is presented in **Volume 1, Appendix 6U** of the **ES**.

25.2.2 This section lists the specific legislation, policy and guidance of relevance to the radiological impact assessment that is further described in **Volume 1, Appendix 6U** of the **ES**.

a) International

25.2.3 The following international legislation[1] and guidance is relevant to the assessment of radiological impacts, as described further in **Volume 1, Appendix 6U** of the **ES**:

- International Atomic Energy Agency (IAEA) Basic Safety Standard (BSS), implemented through Council Directive 2013/59 ('Euratom BSS') (Ref. 25.5);
- International Commission on Radiation Protection (ICRP) recommendations (ICRP 103) (Ref. 25.2);
- Euratom Treaty (Ref. 25.20);
- Directive 92/43/ECC on the conservation of natural habitats and of wild fauna and flora ('the Habitats Directive') (Ref. 25.10);
- Directive 2009/147/EC on the conservation of wild birds ('the Birds Directive') (Ref. 25.9);
- IAEA Regulations for the Safe Transport of Radioactive Material (Ref. 25.3);
- United Nations Recommendations on the Safe Transport of Dangerous Goods (Ref. 25.4);
- IAEA Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter (London Convention 1972) (Ref. 25.13); and
- 1992 Oslo and Paris (OSPAR) Convention for the Protection of the marine environment of the North-East Atlantic (Ref. 25.24).

[1] At the point of submission of this application for development consent, the UK is within the transition period for exiting the European Union and the Euratom Treaty. The majority of requirements under the European and Euratom Directives identified through this ES have been implemented within UK domestic legislation, and as such post the transition period the requirements of these directives will remain in place. In addition, number of statutory instruments have been prepared and laid before Parliament address the UK departure from Euratom.

b) National

i. Legislation

25.2.4 The following national legislation is relevant to the assessment of radiological impacts, as described further in **Volume 1, Appendix 6U** of the **ES**:

- The Nuclear Installations Act 1965 (Ref. 25.19);
- Ionising Radiations Regulations 2017 (Ref. 25.14);
- Environmental Permitting (England and Wales) Regulations 2016 (Ref. 25.16);
- The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 (Ref. 25.17).

ii. National Policy Statements

25.2.5 As stated in **Volume 1, Chapter 3** of the **ES**, whilst other matters may constitute important and relevant considerations in the decision making process under section 105(2)(c) of the Planning Act 2008, significant weight should be given to the policies contained within the Overarching National Policy Statement (NPS) for Energy (NPS EN-1) Ref. (25.21) and the NPS for Nuclear Power Generation (NPS EN-6) (Ref. 25.22).

25.2.6 The NPSs include specific criteria and issues which should be covered by applicants' assessments of the effects of their scheme, and how the decision maker should consider these impacts.

25.2.7 NPS EN-1 is limited to non-radioactive waste and so is not specifically addressed in this chapter.

25.2.8 A summary of the relevant NPS EN-6 requirements, together with consideration of how these requirements have been taken into account, is provided in **Volume 1, Appendix 6U** of the **ES**.

c) Regional

25.2.9 There is no regional policy deemed relevant to the assessment of radiological effects.

d) Local

25.2.10 There is no local policy deemed relevant to the assessment of radiological effects.

e) Guidance

25.2.11 Details of the guidance documents which have been considered when undertaking the assessment presented in this chapter are provided in **Volume 1, Appendix 6U** of the **ES**.

25.3 Methodology

a) Scope of the assessment

25.3.1 The generic EIA methodology is described in **Volume 1, Chapter 6** of the **ES**. This section provides a summary of the radiological assessment methodology, further detail is provided in **Volume 1, Appendix 6U** of the **ES.** The radiological assessment applies a different methodology depending on the potential source and/or receptor as follows:

- dredging for construction radiological impact assessment;
- human radiological impact assessment;
- non-human radiological impact assessment; and
- transport radiological impact assessment.

25.3.2 The scope of this assessment has been established through a formal EIA scoping process undertaken with the Planning Inspectorate. A request for an EIA scoping opinion was initially issued to the Planning Inspectorate in 2014, with an updated request issued in 2019, see **Volume 1, Appendix 6A** of the **ES**.

25.3.3 Comments raised in the EIA scoping opinions received in 2014 and 2019 have been taken into account in the development of the assessment methodology. These are detailed in **Volume 1, Appendices 6A** and **6C** of the **ES**.

25.3.4 As outlined in the 2019 EIA Scoping Report, this assessment does not address the management of solid radioactive waste or spent fuel which is described in **Volume 2, Chapter 7** of the **ES**. However, any radiological effects from the presence of radiological waste on the Sizewell C main

development site are accounted for within the radiological impact assessment.

25.3.5 Additionally, the radiological impacts of decommissioning are considered to result in no further effects than those assessed for the routine operational activities, as no additional discharges are proposed during decommissioning. Therefore, these effects are not specifically detailed further in the radiological impact assessment presented in this chapter. The likely significant effects of decommissioning will be confirmed prior to the start of decommissioning works as part of a separate EIA which will need to be undertaken in accordance with the relevant EIA Regulations, such as the Nuclear Reactors (Environmental Impact Assessment for Decommissioning) Regulations 1999 and the Marine Works (Environmental Impact Assessment) Regulations 2007 (refer to **Chapter 5** of this volume for further information).

25.3.6 There are no radiological impacts expected with any of the associated development sites. No radioactive disposals will take place from these locations during construction or operation.

25.3.7 In-combination effects with radiological discharges that form part of the existing baseline, such as those associated with Sizewell A and Sizewell B, are addressed within this chapter. The potential for cumulative effects with other reasonably foreseeable developments is considered in **Volume 10, Chapter 4** of the **ES**.

25.3.8 Further information on the health implications associated with radiological impact of permitted disposals from the main development site are addressed in **Volume 2, Chapter 28** of the **ES**.

b) Consultation

25.3.9 The scope of the assessment has also been informed by ongoing project-wide consultation and engagement with statutory consultees throughout the design and assessment process. The Environment Agency were consulted on the human and non-human biota radiological impact assessments to inform the preparation of the Radioactive Substances Regulation environmental permit application and the assessment presented in this chapter. Due to the approach being well developed, minimal comments on the approach adopted were raised.

c) Dredging radiological impact assessment methodology

i. Scope of assessment

25.3.10 The purpose of the dredging assessment is to evaluate the radiological exposure to members of the public associated with sea disposal of dredge

sediment potentially containing trace levels of anthropogenic and natural radioactivity. The objective is to assess and quantify the radiological exposure to members of the public; hence, identify control measures, if any, that may need to be implemented, if necessary.

25.3.11 The anthropogenic radionuclides that may be present in the sediment would be as a result of previously authorised disposal from existing or historical regulatory approaches and consented activities. The sediment is considered out-of-scope of regulation, if it has been previously lawfully disposed of as a waste or is contaminated as a result of such a disposal, unless subject to a process which causes an increase in radiation exposure. In which case, only the radionuclides associated with the disposal should be considered when deciding whether the resulting dose is significant; background radioactivity can be discounted (Ref. 25.67).

25.3.12 This assessment follows the IAEA recommended approach (Ref. 25.58) and is consistent with that undertaken for Hinkley Point C.

25.3.13 The dredging radiological impact assessment is not intended to address Sizewell C operational discharges. These will only occur after dredging works have been completed and are not therefore relevant in this assessment (see human and non-human radiological impact assessment sections in this chapter for operational discharges).

ii. Study area

25.3.14 The study area for the dredging radiological impact assessment comprises areas subject to dredging, including the locations for cooling water intakes and outfall headworks.

iii. Methodology approach

25.3.15 This assessment considers artificial radionuclides that are clearly of anthropogenic origin, and also radionuclides that occur naturally and are most likely to be presented at natural levels. These radionuclides have been included to ensure that the assessment is robust and bounding.

25.3.16 The assessment is based on the approach of IAEA-TECDOC-1759, a document which determines the suitability of radiological materials for disposal at sea (Ref. 25.58). An outline of the methodology is provided below and further detail can be found in **Volume 1, Appendix 6U** of the **ES**.

25.3.17 The assessment considered annual individual dose (to the boat crew undertaking dredging and sediment disposal, and other members of the public) and annual collective dose (to the crew and to the public).

25.3.18 The IAEA assumes that the two groups consist of different individuals. Thus, it is not appropriate to sum individual or collective doses between the crew and the public.

25.3.19 The annual collective dose is the sum of individual doses across the individuals exposed. The IAEA methodology assumes that there is one dredging vessel with 10 crew members and that the public is exposed to radioactivity over a 10 km length of coastline.

25.3.20 The following exposure pathways have been considered in developing a specific assessment methodology for members of the crew:

- external exposure to radionuclides in the candidate material;
- inadvertent ingestion of candidate material; and
- inhalation of particles re-suspended from the surface of the candidate material.

25.3.21 The following exposure pathways have been considered for members of the public:

- external exposure to radionuclides deposited on the shore;
- ingestion of seafood caught in the area around the dumping site;
- inadvertent ingestion of beach sediments;
- inhalation of particles re-suspended from beach sediments; and
- inhalation of sea spray.

25.3.22 The IAEA notes that its methodology does not consider other individuals who could be exposed to the radioactivity in the material because the doses that these individuals could receive are negligible compared to the exposure routes considered. Such individuals include, for example, swimmers and boaters who can receive doses through external exposure and inadvertent ingestion of water while swimming or sailing.

25.3.23 Samples from the study area have been collected and analysed. Prior to analysis, the samples were dried, ground and homogenised. The analysis was completed using high-resolution gamma spectrometry calibrated to measure a range of radionuclide determinand gamma emitters in the energy range of 60keV and 2MeV.

25.3.24 The assessment has used mean and maximum activity concentration data (Bq/kg dry weight) as set out in the IAEA-TECDOC-1759 (Ref. 25.58).

iv. Assessment criteria

25.3.25 The IAEA TECDOC-1375 (Ref. 25.58) states that radiological assessment for the protection of human health should include estimates of individual and collective doses for comparison with the radiological criteria for exemption. It then notes that:

> *"A practice, or source within a practice, may be exempted without further consideration provided that the following radiological criteria are met in all feasible situations:*
>
> *(a) the effective dose expected to be incurred by any member of the public due to the exempted practice or source is of the order of 10 μSv or less in a year; and*
>
> *(b) either the collective effective dose committed by one year of performance of the practice is not more than about 1 man Sv or an assessment for the optimization of protection shows that exemption is the optimum option."*

25.3.26 It has considered the annual individual and annual collective dose to the crew of a dredging boat and that to other members of the public. Exposure via a range of pathways has been considered using IAEA dose per unit environmental concentration factors.

25.3.27 An individual dose of 10 μSv or less in a year is considered trivial, a 'no danger' level. This value should be assessed relative to the presence of anthropogenic radionuclides. Where levels of naturally occurring radionuclides are elevated by nuclear industry operations, this elevation also needs to be considered against the 10 μSv or less in a year value (but can exclude natural levels of natural radioactivity).

25.3.28 Waste materials that contain trace levels of anthropogenic elevated radioactivity do not need to be regulated as radioactive, if the radiological risk posed from their disposal is 10 μSv or less in a year. The Government provides activity concentration values below which materials do not need regulation under the radiological substances regulations (RSR) environmental permit (Ref. 25.67).

25.3.29 Any radioactivity in dredged sediment due to anthropogenic activities is due to past discharges, however, disposal following dredging would be regulated under the RSR environmental permit if an individual dose of more than 10 μSv was incurred.

25.3.30 Based on the points above, the RSR environmental permit, as applied in England, is consistent with the requirements of the London Convention 1972 and the 1992 OSPAR Convention and an exposure of 10 µSv or less in a year is considered to represent 'no danger' where no radiological protection activities are required. For the purposes of the EIA, an exposure of 10 µSv or less in a year is considered to constitute 'no significant effect'.

v. Result categories

25.3.31 Sediment samples have been analysed for a comprehensive range of radionuclides. The results are divided into two groups:

- Anthropogenic radionuclides typical of the nuclear industry: Co-60, Cs-137 and Am-241.
- Natural radionuclides that may be elevated due to anthropogenic activity, but nonetheless, would still be present in the absence of any nuclear industry activity: Ra-226, Th-232 and U-238.

25.3.32 Where values sampled were below the limit of detection (LOD), the limit of detection value has been used in this assessment. This is precautionary and in reality, the actual values may be much less.

vi. In-combination assessment

25.3.33 No specific in-combination assessment has been conducted for the dredging radiological impact assessment. Any radioactivity from dredging sediments is unlikely to combine with other radiological discharges from Sizewell B or Sizewell A, and even should this occur would not be beyond that described in **section 25.3(d)(v)**.

d) Human Radiological Impact Assessment Methodology

i. Scope of assessment

25.3.34 The scope of human radiological impact assessment considers the radiological impacts associated with the operational radioactive discharges from the proposed development. This includes radiological impacts from discharges of gaseous and liquid discharges to the atmosphere and the marine environment respectively resulting from routine operations. There will not be any disposal of radioactive effluents to groundwater during construction or operation, therefore no radiological impact assessment on groundwater has been undertaken.

ii. Study area

25.3.35 The geographical extent of the study area for this assessment includes:

- the proposed Sizewell C main development site (see **Figure 2.2, Volume 2, Chapter 2** of the **ES**); and
- communities within a radius of approximately 20km of the proposed Sizewell C power station.

iii. Methodology approach

25.3.36 Fission and activation products released from reactor operations are relatively constant throughout the site fuel-use cycle and hence consistent throughout any annual period. Assessment of continuous discharges is therefore appropriate for radionuclides discharged and is discussed in this section. For the assessment of continuous discharges from Sizewell C, the approach advocated by the National Dose Assessment Working Group (NDAWG) (Ref. 25.27) has been adopted. An initial dose assessment (Stage 1 and 2) was performed using the Excel based Initial Radiological Assessment Tool (IRAT) developed by the Environment Agency, based on their Initial Radiological Assessment Methodology (IRAM) (Ref. 25.30, Ref. 25.31).

25.3.37 The initial assessment was then followed by a detailed, more realistic assessment using site-specific assessment parameters in accordance with the regulatory requirements for radiological assessments carried out to support environmental permit applications for nuclear facilities (Ref. 25.26).

25.3.38 Short-term discharges of radionuclides are also assessed to consider the impact of fluctuations in gaseous discharges. This has been done in accordance with guidance published by Public Health England (Ref. 25.51). Low levels of radioactive waste discharged to the marine environment are accumulated in tanks prior to discharge and then released over a short period periodically. Given the other uncertainties in the assessment process, the results based on continuous release are considered appropriate for these normal operational variations in discharges, this is in line with regulatory guidance (Ref. 25.8). The EA also have the ability through the environmental permit to impose shorter-term notification levels (such as Quarterly Notification Levels) which require the operator to notify the regulator and demonstrate BAT has continued to be applied to operations should these levels be exceeded.

25.3.39 Assessments have been carried out based on the proposed annual discharge limits (and using best performance values as part of a sensitivity

analysis) for aqueous and gaseous radionuclides anticipated to be discharged by Sizewell C. These assessments assume that radionuclide discharges are made in a continuous, routine and uniform manner and are consistent through a 60-year operational period. The assessment uses the concentration of radionuclides in the environment in the final year of operation to account for any accumulation that might occur. In this way, the assessment is precautionary.

iv. Result categories and criteria

25.3.40 Candidates considered as representative persons for the following exposures are as follows:

- Exposure to aqueous discharges from routine operations at Sizewell C – a fishing family, houseboat dweller and a wildfowler. The family included an adult, child, and infant;
- Exposure to gaseous discharges from routine operations at Sizewell C – a farming family and a worker at the neighbouring Sizewell B facility. The family included an adult, child, and infant;
- External dose from direct radiation from Sizewell C – a dog walker, a local resident and a worker at the neighbouring Sizewell B facility;
- Exposure to combine aqueous and gaseous discharges and from exposure to direct radiation from Sizewell C – a fishing family. The family included an adult, child, and infant;
- Short-term dose from planned continuous releases – a farming family. The family included an adult, child, and infant;
- Collective dose from discharges of aqueous radionuclides to the marine environment from Sizewell C – UK, European and World populations; and
- Build-up of activity from gaseous radionuclide deposition in the environment over the lifetime of the operation of Sizewell C – a construction worker.

Dose assessment criteria

25.3.41 The criteria used for determining the magnitude of radiological impacts on members of the public are based upon the constraints summarised in the below **Table 25.1**. These criteria transpose the requirements of the BSSD

(Ref. 25.5) and are largely based on the recommendations of the International Commission on Radiological Protection (ICRP) (Ref. 25.2). The radiological exposure criteria serve as benchmarks against which the predicted Sizewell C doses from each result category listed above are compared. For the purposes of the EIA, doses below the criteria set out in **Table 25.1** are considered to constitute 'no significant effect'. An explanation of the assessments/methodologies specific to each category can be found in **Volume 1, Appendix 6U** of the **ES**.

Table 25.1: UK Dose Limits, Constraints and Guidelines derived from International and European Regulations and Guidance

Dose	Source of the Dose Criterion Used in the Assessment
1.0 mSv y^{-1}	An annual dose limit of 1,000 µSv y^{-1} to a member of the public from all historical, current and future sources of radioactivity subject to control.
0.5 mSv y^{-1}	A site dose constraint of 500 µSv y^{-1} to a member of the public from future planned operational discharges (excluding direct radiation) from multiple sources with contiguous boundaries at a single location. This applies to the combined discharges for Sizewell B and C.
0.3 mSv y^{-1}	A dose constraint of 300 µSv y^{-1} to a member of the public due to future planned operational discharges and direct radiation arising from a single new source. For the purpose of legislation, Sizewell C is considered a single new source. It is noted that in 2009 the Health Protection Agency (HPA), now part of Public Health England (PHE), recommended that the UK Government implement a dose constraint not exceeding 150 µSv y^{-1} for members of the public in respect of new nuclear power stations and waste disposal facilities, in recognition of the fact that the design stage of such facilities presents an opportunity to reduce exposures to the public (Ref. 25.6). However, this recommendation is not recognised as a statutory requirement2.
0.02 mSv y^{-1} 0.01 mSv y^{-1}	The Environment Agency, HPA and the Food Standards Agency recognise that where doses are below the former threshold of optimisation (<0.02 mSv y^{-1}) or are below regulatory concern (<0.01 mSv y^{-1}) then the effort to make assessments more realistic may not be warranted (Ref. 25.8). An annual dose of 10 to 20 µSv y^{-1} (0.01 to 0.02 mSv y^{-1}) can be broadly equated to an annual risk of death of about one in a million per year. Nonetheless, the standard Environment Agency permit conditions under EPR16 (for instance that for Hinkley Point C (Ref. 25.7)) is specific in the requirement that the operator shall use the Best Available Techniques (BAT) in respect of the disposal of radioactive waste pursuant to the permit to: • minimise the activity of gaseous and aqueous radioactive waste disposed of by discharge to the environment; • minimise the volume of radioactive waste disposed of by transfer to other premises; and

[2] It was not incorporated in the 2018 revision of EPR 16 which implemented the requirements of the 2013 BSS.

Dose	Source of the Dose Criterion Used in the Assessment
	• dispose of radioactive waste at times, in a form, and in a manner to minimise the radiological effects on the environment and members of the public.

25.3.42 The Environment Agency recommends (Ref. 25.8) that a review of uncertainty and variability associated with key assumptions used in dose assessment be carried out in the event that the estimated dose to the representative person exceeds 20 μSv y-1. The specific assumptions and parameters analysed were:

- Discharges - expected best performance discharges against proposed limits.
- Habits Data - generic food ingestion rate against site specific food ingestion rates.
- Food Source – 100% locally sourced seafood against 50% locally sourced seafood.

v. In-combination assessment

25.3.43 The assessment of impacts from radiological discharges to the atmosphere and the marine environment will be considered in-combination with discharges from Sizewell B. This in-combination assessment is based on:

- The current permitted discharge limits from Sizewell B and the limits that are proposed for Sizewell C within the RSR permit application;
- The status of Sizewell A is currently defuelled and is expected to have entered Care and Maintenance phase before the proposed Sizewell C begins operations. Discharges from Sizewell A have not been included in the assessment of cumulative effects from the combined Sizewell sites; and
- Sizewell B will be shut down and is planned to enter decommissioning in 2035. It is assumed that the discharges from Sizewell B during decommissioning will not increase above current permitted limits. Any changes to the proposed limits at Sizewell B would be subject to regulatory review and approval.

25.3.44 The RSR permit application includes dose constraints to ensure the impacts of neighbouring sites are also considered in the radiological assessment. Therefore, the human and non-human radiological impact assessment

includes an in-combination assessment with Sizewell B in addition to the Sizewell C assessment.

e) Non-human radiological impact assessment methodology

i. Scope of assessment

25.3.45 The scope of assessment considers the radiological impacts associated with the operational radioactive discharges from the proposed main development site. This includes radiological impacts from gaseous and liquid discharges to the atmosphere and the marine environment respectively resulting from routine operations. There will not be any disposal of radioactive effluents to groundwater during construction or operation, therefore no radiological impact assessment on groundwater has been undertaken.

ii. Study area

25.3.46 The geographical extent of the study area for this assessment includes:

- the proposed Sizewell C main development site (see **Figure 2.2, Volume 2, Chapter 2** of the **ES**); and
- habitats of interest in the vicinity of the proposed Sizewell C main development site (as set out in **Appendix 25C** of this volume).

iii. Methodology approach

25.3.47 The assessment of radiological impacts due to discharges from Sizewell C and the neighbouring Sizewell B facility on non-human biota (NHB) was undertaken using the Environment Risks from Ionising Contaminants: Assessments and management (ERICA) Integrated Approach (Ref. 25.37) tool and the associated FREDERICA database (Ref. 25.70, Ref. 25.65). ERICA is the internationally accepted assessment tool.

25.3.48 The ERICA tool is a multi-tiered software programme with supporting databases that allows the assessment of absorbed dose rates to a set of reference organisms that are representative of those commonly found in terrestrial, freshwater and marine ecosystems, for a range of radionuclides. The ERICA reference organisms incorporate the ICRP's Reference Animals and Plants (RAPs) (Ref. 25.15) as well as some species protected under European legislation. It is an internationally recognised tool for NHB radiological assessments.

25.3.49 The Environment Agency's R&D128 methodology (Ref. 25.36) was used to assess the impacts of releases of noble gases, which are not currently

included in the ERICA approach. The Environment Agency's R&D 128 methodology was developed for the assessment of radiological impacts on Natura 2000 sites for compliance with the Habitats Directive (Ref. 25.47). The methodology is accompanied by an Excel spreadsheet-based model which uses a similar approach to that of the ERICA tool, but considers a smaller range of organisms and radionuclides. The assessment of impacts on NHB due to releases of noble gases from Sizewell C, which constitute the largest component of predicted gaseous releases from the facility in terms of activity released, is not possible using the ERICA tool. Such assessments can however be carried out using the R&D 128 methodology (which incorporates representative noble gases) and the R&D 128 approach was used to calculate the dose rates to organisms occupying Habitat 1 (see definition below) arising from the discharge of noble gases from Sizewell C.

25.3.50 The dispersion and subsequent environmental accumulation of radionuclides discharged from the Sizewell C facility were modelled using the supporting modules within the PC-CREAM 08 software (Ref. 25.34). This is a well-established software system used by operators and regulators for human and NHB dose assessment modelling. Site-specific model parameters were used to provide realistic estimates of environmental concentrations arising from radionuclide releases. Further detail on this assessment methodology can be found in **Volume 1, Appendix 6U** of the **ES**.

iv. Assessment criteria

25.3.51 The European research project, "Framework for Assessment of Environmental Impact" (FASSET) (Ref. 25.48) summarised and reviewed the current knowledge of radiation effects on biota and provided a basic dosimetric models and assessment framework for fauna and flora.

25.3.52 The approach to protect non-human species against ionising radiation suggested by FASSET along with the International Commission for Radiological Protection (ICRP) is conceptually similar to environmental protection against hazardous chemicals.

25.3.53 Using radio-ecological models and simplified dosimetric models, the potential exposure of reference organisms can be calculated and compared to dose rate[3] levels ('thresholds') below which no observable effects are expected to occur.

[3] Radiation energy that is absorbed by matter is measured in units called "grays". The levels concerned with in the context of non-human biota are measured in 1 millionths of a gray, known as micro-gray. Where a dose rate is a measure of exposure to radiation with units of micro-Gray (μGy) over a period of time.

25.3.54 Based on international scientific studies it was concluded that the threshold for statistically significant effects in a number of organisms is 100 µGy per hour. Allowing for the dose rate from natural background, which at most is about 60 µGy per hour, the UK Environment Agency have adopted a value of 40 µGy per hour as the level below which they consider there will be no adverse effect on non-human species (Ref. 25.8). Therefore, assessments falling below this regulatory screening level are assumed to cause no measurable harm to non-human species, this is highlighted in the assessment results analysis.

25.3.55 In addition, the internationally accepted assessment tool, ERICA (Environment Risks from Ionising Contaminants: Assessments and management) (Ref. 25.37) includes the conservative screening dose rate of 10 µGy per hour which has also been referred to in SZC Co.'s assessment. This is a factor of 4 lower than the regulator's current assessment value. For the purposes of the EIA, a dose rate below 10 µGy h-1 is considered to constitute 'no significant effect'.

v. Result categories

25.3.56 In order to gather appropriate and aligned data typical of the major environment the ICRP has developed a set of Reference Animals and Plants (RAPs).

25.3.57 Five indicative habitats representative of designated areas found locally around the main development site have been identified as potentially sensitive to radiological impacts due to their ecological significance and their location relative to the proposed main development site. There are:

- Habitat 1, a terrestrial habitat, representative of Sizewell Marshes Site of Special Scientific Interest (SSSI), lies adjacent and to the west and north of the main development site. This terrestrial habitat was selected as it will experience the highest air concentrations and deposition due to both proximity to the site and being in the direction of maximum air concentrations (as modelled in PC CREAM, see **Appendix 25C** of this volume). The dose rates calculated will therefore be the highest of the terrestrial habitats of interest.

- Habitat 2, a marine habitat, representative of the Outer Thames Estuary SPA area to the east of the main development site.

- Habitat 3, a coastal habitat, representative of the area to the north of the main development site within the Minsmere-Walberswick Heaths and Marshes SSSI, SPA and Ramsar includes both shoreline and the

adjacent terrestrial area. This habitat is therefore assumed to be impacted by both aqueous and gaseous discharges.

- Habitat 4, a freshwater habitat, representative of the scrape in the centre of Minsmere Nature Reserve, within Minsmere-Walberswick Heaths and Marshes SPA.

- Habitat 5, encompasses a mixed habitat representative of the marshland within the Minsmere-Walberswick Heaths and Marshes SSSI, SPA and Ramsar.

25.3.58 The model used does not consider the specifics of whether the environment is marine, chalk or heath, etc. Only generic biotas types and their general ecological behaviour are considered. The ERICA tool is used to modify the 'concentration ratio' (CR) values that are used to predict the organism burden relative to an environment concentration. Generic values for the CRs have been used for this assessment for the terrestrial environment, based on the default values within the ERICA tool.

vi. In-combination assessment

25.3.59 The in-combination assessment as described **section 25.3d)v** of this chapter of this chapter also applies to the NHB assessment.

f) Transport radiological impact assessment methodology

i. Scope of assessment

25.3.60 This assessment is to assess the potential radiological impact from the transportation off-site of radioactive materials and wastes to members of the public.

25.3.61 Additional transport assessments are discussed within **Chapter 10** of this volume**.**

ii. Study area

25.3.62 The geographical extent of the study area for this assessment includes:

- the proposed Sizewell C main development site (see **Figure 2.2, Volume 2, Chapter 2** of the **ES**); and

- the general public potentially exposed to radioactive materials and waste from road and rail transport to and from the Sizewell C main development site.

iii. Methodology approach

25.3.63 A generic assessment has been undertaken to estimate the dose from the transport of these materials to and from the main development site. Further details relating to this method can be found in **Volume 1, Appendix 6U** of the **ES**.

25.3.64 Two assessments have been undertaken:

- Representative Model - The first assessment uses dose rate values, exposure times and distances from the source and the receptor from Jones and Cabianca (2017) (Ref. 25.35). This approach is reasonably conservative, using recent data on both exposure times and distances, and a conservative source term. This assessment presents a more realistic indication of the likely impact of transport to and from the Sizewell C main development site.

- Pessimistic / Bounding Model - For comparison purposes a second assessment has been undertaken which uses the maximum legal dose rate for the particular transport package as the source term for the assessment. The exposure times and distances are kept in line with those used in the representative model. This assessment calculates the bounding dose for the transport of radioactive materials and waste to and from the Sizewell C main development site above which the legal limits on transport are at risk of being breached.

iv. Assessment criteria

25.3.65 The Ionising Radiations Regulations 2017 (IRR) state an annual dose limit for members of the public of 1 mSv yr-1 (by way of comparison the legal limit for non-classified radiation workers is 6 mSv yr-1 and for classified radiation workers under the IRR's the limit is 20 mSv yr-1). For the purposes of the EIA, doses below the limits set out within the IRR are considered to constitute 'no significant effect'.

v. Result categories (transport types)

25.3.66 The purpose of the transport radiological impact assessment is to predict exposure dose to the general public associated with the transportation of radioactive materials and wastes from a combination of road and rail shipment scenarios. No radioactive materials and wastes are assumed to be transported by sea. The groups of identified persons included in the assessment are as defined within Jones and Cabianca (2017) (Ref. 25.35). These include:

- A - Habitant of local town (Outside) - This assumes a member of the public is stood at a set of traffic lights, when the vehicle transporting the radioactive material or waste stops 2m from the member of the public for 1 minute per consignment. It is assumed that the same member of the public is exposed for every consignment of that particular type of radioactive material or waste over the year.

- B - Habitant of local town (Inside) - This assumes a member of the public lives near a set of traffic lights and the vehicle transporting the radioactive material or waste stops 5 m from the member of the public for 1 minute per consignment. It is assumed that the same member of the public is exposed for every consignment of that particular type of radioactive material or waste over the year.

- C - Member of the Public at the Railhead – The majority of spent fuel packages will be moved via rail. A member of the public is assumed to be standing 23 m from the railhead for 15 minutes per consignment. It is assumed that the same member of the public is exposed for every consignment of spent fuel over the year.

25.3.67 The types of radioactive materials and waste assessed in the transport assessment are as follows:

- Transport of radiography sources used during construction of the power station;

- Transport of Low Level Wastes (LLW) from Sizewell C to another suitably permitted radioactive waste disposal site in the UK during routine operations;

- Transport of new fuel to Sizewell C during the operational lifespan of the site; and

- Transport of spent fuel from Sizewell C once operations cease.

vi. In-combination assessment

25.3.68 No specific in-combination assessment has been conducted for the transport radiological impact assessment.

g) Establishing the baseline

i. Existing Baseline

25.3.69 SZC Co. has undertaken surveys and monitoring programmes in order to obtain a more detailed understanding of the background radioactivity levels around the Sizewell C main development site and of the potential implications of any planned radiological discharges (refer to **Chapter 18** of this volume for further information on radiochemical data assessment for existing soils, groundwater and surface water).

25.3.70 Baseline information is also available from the Radioactivity in Food and the Environment (RIFE) reports which gather data across all nuclear sites and is administered by the relevant regulatory bodies including the Environment Agency and Foods Standards Agency. Results have been gathered from land quality surveys and water quality surveys (Ref. 25.45).

25.3.71 To inform the dredging radiological impact assessment, SZC Co. has obtained samples of material from the locations of the cooling water intakes and outfall headworks. On obtaining the samples, no sediment was found at these locations, therefore a sample of bedrock material was collected and analysed. Previous sediment samples from locations closer to the shoreline were also assessed and these results and associated analysis has been included in **Appendix 25A** of this volume.

25.3.72 All samples have been analysed for a comprehensive range of radionuclides. With regards to the more recent bedrock samples, all results of anthropogenic activity were below the limit of detection (LOD). Furthermore, the levels of identified naturally occurring radionuclides were consistent with those from the first sediment samples, which gave confidence in the validity of their results. Therefore, the first assessment based on easily dispersed mobile sediment, as opposed to immobile bedrock, is considered most appropriate and bounding. If considered, the bedrock would only reduce the dose even further.

ii. Future Baseline

25.3.73 A review of cumulative schemes has been undertaken to confirm whether there are any new planned radiological discharges to be introduced within the study area before the start of construction and operation of the proposed development. No new schemes have been identified and therefore, the future baseline radiation levels have been assumed to be equivalent to the current baseline for the purposes of this assessment.

h) Inter-Relationships

25.3.74 Potential inter-relationships effects relevant to the radiological impact assessment include:

- Effects on human health due to radiological discharges and impacts related to other assessments presented within the ES (e.g. air quality, noise and transport). These effects are assessed in **Chapter 28 Health and Wellbeing** and are therefore have not been considered further in this chapter.

- Effects on habitats due to radiological discharges in-combination with other effects identified in **Chapter 14 Terrestrial Ecology and Ornithology** and **Chapter 22 Marine Ecology and Fisheries**. These effects are assessed in **Chapters 14** and **23** and therefore have not been considered further in this chapter.

i) Assumptions

25.3.75 The following assumptions have been made in this assessment:

- It is assumed that the radioactive discharges from commissioning of Sizewell C will be no greater than those during operation, therefore, for the purposes of this assessment it is assumed that the impacts from commissioning will be bounded by those for the operation of Sizewell C.

- The assessment of impacts from radiological discharges to the atmosphere and the marine environment have been considered in-combination with operations at Sizewell B;

  - This assessment is based on discharges at current permitted limits for Sizewell B, and the limits applied for Sizewell C in the RSR permit application.
  - This assumes that discharges from Sizewell B continue throughout the operation of Sizewell C and in parallel with the limits proposed for Sizewell C.
  - This is a conservative assumption, as Sizewell B is planned to be shutdown, defueled and decommissioned during the lifetime of Sizewell C.
  - This assumes that discharges do not increase above current permitted levels during the decommissioning of Sizewell B, any

increases are likely to be time constrained, and would be subject to regulatory review and approval.

- It is assumed that, based on the published Lifetime Plan (Ref. 25.46), Sizewell A has entered Care and Maintenance and that there are not any discharges from Sizewell A during the commissioning and operation of Sizewell C.

25.4 Baseline environment

25.4.1 The historical and current permitted discharges from the Sizewell A and Sizewell B power stations as well as the historic impacts of atmospheric weapons testing, the Chernobyl accident and naturally occurring radioactivity all contribute to the background radioactivity levels around the Sizewell C main development site.

25.4.2 The initial dredging assessment was conducted against the latest data at the time, RIFE-20 publication (for 2014 survey results) which identified some, albeit low (< 6 Bq/kg fresh weight) levels, of caesium-137 (Cs-137) in marine sediments in the Sizewell area (Ref. 25.45). The second dredging assessment, which took samples from specific locations such as the cooling water intakes and outfall headworks, was compared to RIFE-23 (refer to **Appendix 25A** of this volume for further details) – the most recent publication at the time - and this found very similar levels of Cs-137 (< 6 Bq/kg fresh weight).

25.4.3 Cs-137 does not occur naturally and is due to anthropogenic activities (nuclear facilities and also trace levels from other sources such as nuclear weapons testing). This Cs-137 activity may be due to former operations of the Sizewell A power station or ongoing operation of the Sizewell B power station, or from former operation of the Bradwell reactor site in Essex. It may also be due to more distant discharges from the Cap la Hague reprocessing facility in France (or from that of Sellafield in the UK). Other anthropogenic radionuclides generated by nuclear facilities that are discharged under regulatory approval to the marine environment include cobalt-60 (Co-60) and americium-241 (Am-241). The RIFE-23 publication does not provide Co-60 data for marine sediment from the Sizewell area. Am-241 is analysed for and results published for the Sizewell area, however, all results reported are below the LOD and, in all instances, less than 0.8 Bq/kg (fresh weight).

25.4.4 RIFE-23 also indicates that total beta emitting radiation may be slightly elevated. This may be due to local or more distant nuclear facility operations, but may also be due to naturally occurring radionuclides (or at least include a component of these). Radionuclides that occur naturally in environmental media such as sediment, include those of the uranium-238 (U-238) decay

series (including radium-226, Ra-226) and those of the thorium-232 decay series).

25.4.5 As described in **section 25.3g** of this chapter, the future baseline radiation levels are expected to be equivalent to the current baseline levels.

25.5 Environmental Design and Mitigation

25.5.1 As detailed in **Volume 1, Chapter 6** of the **ES**, a number of primary mitigation measures have been incorporated into the design and construction planning of the proposed development. Tertiary mitigation measures are legal requirements or are standard practices that would be implemented as part of the proposed development.

25.5.2 The assessment of likely significant effects of the proposed development assumes that primary and tertiary mitigation measures are in place. For the radiological impact assessment, these measures are identified below, with a summary provided on how the measures contribute to the mitigation and management of potentially significant environmental effects.

a) Environmental design and mitigation for the Sizewell B relocated facilities works during Phase 0

25.5.3 In line with the project programme set out in **Chapter 3** of this volume, it is anticipated that the first phase of the Sizewell B relocated facilities works, which is referred to as 'Phase 0', would be carried out pursuant to the planning permission granted by East Suffolk Council on 13 November 2019 (application ref. DC/19/1637/FUL). The second phase of the Sizewell B relocated facilities works would take place in Phases 1 and 2 in parallel with other DCO works due to take place at this time and would be carried out pursuant to the DCO.

25.5.4 Under the existing planning permission, mitigation measures referred to for radiological effects that may occur as a result of Phase 0 of the Sizewell B relocated facilities works include the following:

- Primary mitigation – specification of the proposed outage store within Sizewell B power station complex to protect onsite workers from radiation originating from any radioactive materials stored within the building;
- Tertiary mitigation – compliance of any works undertaken within the Sizewell B power station complex with the existing Sizewell B Nuclear Site Licence, Radiological Substances Regulations environmental permit and the Ionising Radiation Regulations 2017.

25.5.5 These measures are further described in Chapter 15 of the Sizewell B relocated facilities ES (refer to **Volume 1, Appendix 2A** of the **ES**).

25.5.6 It is anticipated that mitigation summarised above would have largely been implemented by the end of Phase 0. However, in order to allow for the mitigation to be implemented in Phases 1 and 2, if required (or if the works are instead carried out entirely under the DCO – see **Volume 2, Appendix 6A** of the **ES**), these measures have also been referenced within the assessment of the Sizewell C Project as a whole, where appropriate.

b) Environmental design and mitigation for the DCO

i. Primary Mitigation

25.5.7 The UK EPR™ is a pressurised water reactor drawing on aspects of previous designs and including additional evolutionary features that, among other things, reduce the amount of radiological waste per unit electrical generation. Generation of electricity by all forms of pressurised waste reactors unavoidably results in the generation of some liquid and gaseous radioactive effluents and solid radioactive waste. Techniques are applied to minimise the amount of radioactive effluents and waste generated, further abatement measures are used to reduce the amount of liquid and gaseous radioactive efflents discharged. Storage buildings and systems on the site are designed and built to minimise direct 'shine' of radiation but nevertheless may result in a very small addition to background radiation from natural radiation (such as soil or materials used in houses).

25.5.8 The Environment Agency concluded its Generic Design Assessment (GDA) of the UK EPR™ in December 2012 and issued a Statement of Design Acceptability (SoDA) for the reactor design and associated radioactive waste management facilities (Ref. 25.71). This included an assessment of the radiological discharges and associated impacts for generic UK sites. This assessment confirmed that the impacts associated with the UK EPR™ design are well within the relevant regulatory limits and constraints.

25.5.9 In addition, as discussed in **section 25.5(a)** of this chapter**,** the proposed outage store within Sizewell B power station complex has been designed to shield on-site workers from any radiation from materials stored within the building.

ii. Tertiary Mitigation

Construction

25.5.10 During construction, contractors will be required to manage sealed sources[4] for radiography under the contractors' mobile source permit, as part of the SZC Co. management arrangements under the Nuclear Site Licence.

25.5.11 In addition, as discussed in **section 25.5(a)** of this chapter, any works within the Sizewell B power station complex would be subject to the requirements set by the existing Sizewell B Nuclear Site Licence and Radiological Substances Regulations environmental permit.

Operation

25.5.12 The UK has a strict regulatory framework to control disposals of radioactive waste from nuclear power stations and direct radiation exposures to workers and the general public. Any new nuclear power station needs permission, under Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2016 (as amended), from the Environment Agency (in England) before making any discharges of radioactivity into the environment or disposals of radioactive waste (referred to as the Radiological Substances Regulations (RSR) permit). In order to grant the RSR permit, SZC Co. need to demonstrate to the Environment Agency the application of Best Available Techniques (BAT) to minimise radioactive waste generated and that the gaseous and liquid effluents discharges are kept As Low As Reasonably Achievable (ALARA). The impacts arising from the radioactive discharges must also be kept ALARA.

25.5.13 There are also supplementary provisions regulated by the Office for Nuclear Regulation, in particular the Nuclear Installations Act 1965 (as amended), and the associated Nuclear Site Licence to control the accumulation of radioactive waste on a licensed site, including storage and transportation.

25.5.14 The operation of buildings that would form part of the Sizewell B power station complex would be subject to the requirements set by the existing Sizewell B Nuclear Site Licence and Radiological Substances Regulations environmental permit.

[4] A sealed radioactive source is radioactive material that is permanently sealed in a capsule or bonded and in a solid form. The capsule of a sealed radioactive source is designed to prevent the radioactive material from escaping or being released during normal usage and under probable accident conditions.

25.6 Assessment

a) Introduction

25.6.1 This section presents the findings of the radiological impact assessment for the construction and operation of the proposed development.

b) Construction

i. Sizewell B relocated facilities effects in Phase 0

25.6.2 An assessment of radiological effects that would occur due to Sizewell B relocated facilities works prior to the implementation of the DCO (referred to as 'Phase 0') is presented in Chapter 15 of the Sizewell B relocated facilities ES (that ES is provided in full at **Volume 1, Appendix 2A** of the **ES**).

25.6.3 The assessment concluded that there is **no potential for likely significant** radiological effects due to the proposed works. In addition, with the exception of the existing Sizewell B outage store, the facilities proposed to be demolished as part of the Sizewell B relocated facilities works have not previously been associated with any work activities or processes which have involved the handling or the production of radioactive items or materials.

25.6.4 The proposed replacement outage store has been designed and would be constructed and operated to restrict ionising radiation exposure originating from the items within the store, in compliance with the existing Sizewell B Nuclear Site Licence and Radiological Substances Regulations environmental permit. There are no other works associated with the Sizewell B relocated facilities project that could give rise to radiological effects. Therefore, **no likely significant** radiological effects associated with Sizewell B relocated facilities works were identified.

ii. Main development site construction (including the Sizewell B relocated facilities works from Phase 1 onwards)

Dredging impact assessment

25.6.5 The results of the assessment of radiological impacts associated with the dredging of the sea floor at the location of the outfall structure are presented in **Appendix 25A** of this volume, with a summary provided below.

25.6.6 The highest annual individual dose summed across the artificial radionuclides considered for the crew, is a mean value of 0.013 μSv yr^{-1} and a maximum value of 0.03 μSv yr^{-1}. These values are over two orders of magnitude below the 10 μSv yr^{-1} limit set out in the London Convention 1972.

25.6.7 The individual public dose summed across all artificial radionuclides is a mean value of 0.00025 μSv $yr^{-1}$and a maximum value of 0.00077 μSv yr^{-1}. These values are over three orders of magnitude below the 10 μSv yr^{-1} and it should be noted that all of these results are based entirely on values that were less than the LOD, so are likely to be even lower.

25.6.8 The annual collective dose summed across the artificial radionuclides considered for the crew is a mean value of 0.0000013 manSv yr^{-1} and a maximum value of 0.000003 manSv yr^{-1}. These values are over five orders of magnitude below the 1 manSv yr^{-1} limit.

25.6.9 The annual collective dose summed across the artificial radionuclides considered for the public is a mean value of 0.0000021 man Sv yr^{-1} and a maximum value of 0.0000077 manSv yr^{-1}. These values are over five orders of magnitude below the 1 man1Sv yr^{-1} limit.

25.6.10 If the annual collective dose was summed across all radionuclides considered (artificial and natural), the dose to the crew is a mean value of 0.0002 man Sv yr^{-1} and a maximum value of 0.00039 man Sv yr^{-1}. That to the public is a mean value of 0.03 man Sv yr^{-1} and a maximum value of 0.056 man Sv yr^{-1}. This approach is highly precautionary as natural levels of naturally occurring radionuclides would not normally be considered in an assessment such as this. Nonetheless, these combined values are well below the 1 man Sv yr^{-1} limit.

25.6.11 Overall, doses predicted from anthropogenic radionuclides are low at maximum 0.03 μSv yr^{-1} for the crew and 0.00077 μSv yr^{-1} to the public. These are well below a 10 μSv yr^{-1} level of 'no danger' and many orders of magnitude below the public dose limit of 1,000 μSv yr^{-1}. Even if naturally occurring radionuclides are included in the dose assessment (which is not necessary), the dose is still trivial (at a maximum less than 4 μSv yr^{-1}) and well below the 'no danger' and public dose limit. On this basis there are **no significant** radiological effects identified from the dredging works associated with the proposed development.

Human radiological impact assessment

25.6.12 A summary of likely effects arising from Sizewell B relocated facilities works has been provided above. There will be no new radioactive materials or waste generated from the remaining of the Sizewell C construction works.

25.6.13 In addition, as described in **Chapter 18** of this volume, radiochemical data assessment has demonstrated that existing radiation levels within the soil, groundwater and surface water do not pose a significant risk to human health.

25.6.14 It is noted that sealed sources are expected to be brought onto the construction site, these will be used by contractors as part of non-destructive testing. These sealed sources will be managed and regulated under the contractors' mobile source permit granted under the Environmental Permitting Regulations and are not expected to generate any radioactive waste.

25.6.15 Therefore, **no significant effects** during construction associated with the Sizewell C Project, existing contamination levels and use of radiography have been identified.

Non-human radiological impact assessment

25.6.16 The conclusions presented above in **section 25.6b)ii)** also apply for non-human radiological impact assessment. Therefore, **no significant effects** during construction associated with the Sizewell C Project, existing contamination levels and use of radiography have been identified.

Transport radiological impact assessment

25.6.17 During construction, there is no movements of spent fuel or radioactive waste, and movements are confined to radiography sources. The effects associated with transporting radiography sources is reported in **section 25.6c** of this chapter.

c) Operation

i. Dredging radiological impact assessment

25.6.18 The majority of the dredging operations would be undertaken during construction. Any maintenance dredging would be bound by the assessment undertaken in **section 25.6 b** of this chapter.

ii. Human radiological impact assessment

25.6.19 The results of the assessment of radiological impacts on members of the public associated with the discharge of low levels of radioactive gaseous and aqueous effluents are presented in **Appendix 25B** of this volume, with a summary provided below.

Continuous discharge

25.6.20 The exposure of members of the public from direct radiation emanating from the Sizewell C reactor buildings will be negligible due to the shielding incorporated into the design of the reactor buildings (for instance as demonstrated by Sizewell B). Direct radiation from Sizewell C is therefore

largely attributable to the Interim Spent Fuel and Intermediate Level Waste storage facilities on site.

25.6.21 The dose to all members of the fishing family arising from discharge at expected best performance was calculated to be 2.4 μSv yr^{-1}, 1.2 μSv yr^{-1} and 0.32 μSv yr^{-1} respectively. The dose to all members of the farming family arising from discharges at expected best performance was calculated to be 1.9 μSv yr^{-1}, 1.5 μSv yr^{-1} and 3.2 μSv yr^{-1} respectively.

25.6.22 The representative person was identified as the adult member of a fishing family living close to the Sizewell site. The dose to the representative person from exposure to the combined aqueous and gaseous discharges and from exposure to direct radiation from Sizewell C was 13 μSv yr^{-1}.

25.6.23 This dose is significantly less than the current source dose constraint of 300 μSv/y. The dose to the representative person from the site (i.e. Sizewell B and Sizewell C) was 17 μSv yr^{-1}, which is 3.4% of the site dose constraint (500 μSv yr^{-1}),

Short-term discharges

25.6.24 The dose to all members of the farming family from exposure to short-term discharges of gaseous radionuclides from Sizewell C, summed across the relevant terrestrial pathways, is calculated to be 3.8 μSv yr-1, 3.5 μSv yr-1and 6.9 μSv yr-1, respectively.

Collective Dose

25.6.25 The collective dose is the time-integrated dose to a population from a single year of discharge. The collective dose from discharges of aqueous radionuclides to the marine environment from Sizewell C at the proposed limits was assessed to be 0.035 manSv yr^{-1}, 0.21 manSv yr^{-1} and 2.3 manSv yr^{-1} to UK, European and World populations respectively. The collective dose from gaseous discharges at proposed annual limits from Sizewell C was estimated to be: 0.23, 1.0 and 25 manSv yr^{-1} to UK, European and World populations respectively.

25.6.26 The per caput dose to UK, European and World population from both aqueous and gaseous discharges was calculated to be between 2.1 nSv yr^{-1} and 4.5 nSv/y for discharges from Sizewell C (and between 2.6 nSv yr^{-1} and 6.0 nSv yr^{-1} for discharges from Sizewell B and C).

Build-up

25.6.27 The dose from the build-up of gaseous radionuclides discharged from Sizewell C deposited on the ground, assessed as total dose to a construction worker, was found to be trivial at 0.0034 μSv yr-1.

Conclusions

25.6.28 All individual doses calculated were significantly less than the corresponding source and site constraints and the public dose limit. Sensitivity analyses have shown that the predicted doses are likely to be bounding and that actual exposure will be less. Collective dose has also been shown to be trivial.

25.6.29 On this basis there are **no significant** effects identified from the routine radiological discharges of the proposed development.

iii. Non-Human Radiological Impact Assessment

25.6.30 The results of the assessment of radiological impacts on non-human biota associated with the discharge of low levels of radioactive gaseous and aqueous effluents are presented in **Appendix 25C** of this volume, with a summary provided below.

Habitat 1 - Terrestrial

25.6.31 The dose rates to terrestrial organisms residing within Habitat 1 from exposure to gaseous discharges from the Sizewell C facility that deposit to ground were assessed based on the pessimistic assumption that the organisms inhabit the location of maximum offsite air concentration and deposition rates. Large and small burrowing mammals (large and small-burrowing) received the highest dose rates of 0.005 μGy h^{-1}. The dose rate to the worst affected terrestrial organism (caterpillar) from exposure to noble gases, calculated using the R&D 128 spreadsheet, was 0.0018 μGy h^{-1}.

25.6.32 The dose rate to the worst affected terrestrial organisms (small-burrowing mammal, large mammal, bird and reptile) from the combined discharges of gaseous effluent from the Sizewell Site (Sizewell B and Sizewell C) is calculated to be 0.0069 μGy h^{-1}.

Habitat 2 – Marine

25.6.33 The dose rates to marine organisms residing within Habitat 2 from exposure to aqueous discharges from Sizewell C main development site were assessed based on the assumption that the organisms inhabit the local marine compartment. The worst affected organism was the polychaete worm with a dose rate of 0.80 μGy h^{-1}.

25.6.34 The dose rate to the worst affected marine organism (polychaete worm) from the combined discharges of aqueous effluent from the Sizewell C main development site is calculated to be 0.91 μGy h^{-1}.

Habitat 3 – Coastal

25.6.35 Habitat 3 is a coastal environment considered to straddle Habitats 1 and 2 (terrestrial and marine) and dose rates calculated for default terrestrial and marine reference organisms in Habitats 1 and 2 are therefore considered bounding for this case, with organisms being assumed to reside permanently within their natural habitat (i.e. either the terrestrial or marine habitats).

25.6.36 Dose rates experienced by bird species inhabiting the coastal environment arising from Sizewell C discharges, assuming a 50/50 occupancy in terrestrial and marine habitats, is calculated to be 0.0035 μGy h-1, which is slightly lower than that for birds occupying only the terrestrial environment.

25.6.37 This habitat is an amalgamation of Habitats 1 and 2 (see above), with the exception of dose rates to coastal birds. The dose rate to the bird from the combined discharges of aqueous effluent from the Sizewell C main development site is calculated to be 0.0052 μGy h-1.

Habitat 4 - Freshwater

25.6.38 The dose rate to the worst affected organism arising from discharges from Sizewell C residing within Habitat 4 (freshwater scrape) is 0.032 μGy h^{-1} to insect larvae, arising from exposure to gaseous radionuclides deposited onto the scrape and its catchment.

25.6.39 The dose rate to the worst affected scrape organism (insect larvae) from the combined discharges of gaseous effluent from the Sizewell C main development site, deposited onto the scrape and its watershed, is calculated to be 0.13 μGy h^{-1}.

Habitat 5 - Marshland

25.6.40 The marshland habitat was assessed as a shallow scrape adopting the same approach used for the freshwater scrape. The dose rate to the worst affected organism arising from discharges from Sizewell C within this habitat is 0.64 μGy h^{-1} to insect larvae, arising from exposure to gaseous radionuclides deposited onto the scrape and its catchment.

25.6.41 The dose rate to the worst affected marshland organism (insect larvae) from the combined discharges of gaseous effluent from the Sizewell C main development site, deposited onto the marshland and its watershed, is calculated to be 2.7 μGy h^{-1}.

Conclusions

25.6.42 For all of the organisms evaluated, dose rates (biological impacts of ionising radiation) remained substantially lower than the Environment Agency assessment threshold of 40 µGy h-1. The dose rates were also lower than broader internationally considered thresholds. These included the:

- ERICA screening value that is considered protective of populations of NHB across all ecosystems (10 µGy h^{-1}); and
- Derived consideration reference levels, the most stringent of which is 4 µGy h^{-1} (for the duck, rat, deer and pine tree RAPs), applicable to planned exposure situations.

25.6.43 The assessment results have shown the dose rate from Sizewell C discharges to the worst affected organism (polychaete worm occupying a marine habitat) to be 0.80 µGy h^{-1}. The worst affected organism from the combined discharges of radioactive effluent from the Sizewell B and C facilities (insect larvae occupying a marshland habitat) was 2.7 µGy h^{-1}. This dose rate is more than one order of magnitude below the threshold dose rate of 40 µGy h^{-1}.

25.6.44 On this basis there are **no significant** effects identified from the routine radiological discharges of the Sizewell C development.

iv. Transport radiological impact assessment

25.6.45 The results of the assessment of radiological impacts associated with the transportation of radioactive material, waste and fuel are summarised below.

25.6.46 Three scenarios have been developed. These consider the likely dose incurred by members of the public from the transportation of the materials, waste and fuel. Estimated annual doses have been predicted based upon the estimated amount of time individuals would likely come into contact with the material and the distance they will be away from the material.

25.6.47 The representative model estimated exposure from the transport of LLW, new fuel, radiography sources and spent fuel at all less than 11 µSv yr^{-1}. This is significantly below (0.4% of) the amount of radiation exposure from natural sources in the UK (2700 µSv yr^{-1}). Whereas the pessimistic / bounding model estimated exposure from the transport of LLW, new fuel, radiography sources and spent fuel at all less than 23 µSv yr^{-1} (1% of background).

25.6.48 It is possible that some people may be exposed to a combination of movements during the operational life-span of the site. However, the only

combination of plausible scenarios where this could happen is during the time period when new-fuel will be delivered and low-level waste is being removed from site. However, again even if in the case one person was exposed to both these types of movement for every consignment in one year the representative dose would only be 3.4 μSv yr^{1}.

25.6.49 The greatest estimated annual dose to the general public from the representative model will be from radiography source with a predicted value of ~ 10 μSv yr^{-1}. It should however be noted that this in itself is pessimistic in nature, as the source used in the calculation is a large cobalt source, when in reality smaller sources with lower doses would more frequently be used, and furthermore the assessment does not take account of the shielding associated with the transport vehicle nor the location of the exposed individual and as such 'actual dose' is likely to be considerably less.

25.6.50 The conclusion of this investigation is that the annual dose to the member of the public is likely to be significantly less than the legal limit of 1 mSv per year from the transport of radioactive materials or waste to and from Sizewell C. On this basis there are **no significant** effects identified from the transport of radioactive materials, waste and fuel as a result of the proposed development.

25.7 Mitigation and Monitoring

25.7.1 Within this ES, secondary mitigation measures have been proposed where a significant effect is predicted to occur. Primary and tertiary mitigation measures which have already been incorporated within the design of the proposed development are detailed in **section 25.5** of this chapter**.** No further mitigation or monitoring measures for radiological effects are required to reduce or avoid a significant effect.

25.8 Residual Effects

25.8.1 The following tables (**Table 25.2** and **Table 25.3**) present a summary of the radiological impact assessment. They identify the receptor groups assessed, the significance of the effect and the mitigation proposed.

Table 25.2: Summary of effects for the construction phase

Receptor	Impact	Primary or Tertiary Mitigation	Assessment of effects	Additional Mitigation	Residual Effects
Sizewell B relocated facilities effects in Phase 0					
Human receptors	Doses to workers and the general public from the construction of relocated facilities due to existing contamination within soils	None required	Not significant	None required	Not significant
	Doses to workers and the general public from the demolition of the outage store and radioactive waste produced as a result of demolition works	Compliance with the requirements of Sizewell B Nuclear Site Licence and RSR Permit for works within Sizewell B site.	Not significant	None required	Not significant
Non-human biota	Doses to non-human biota from the construction of relocated facilities due to existing contamination within soils	None required	Not significant	None required	Not significant
	Doses to non-human biota from the demolition of the outage store and radioactive waste produced as a result of demolition works	Compliance with the requirements of Sizewell B Nuclear Site Licence and RSR Permit for works within Sizewell B site.	Not significant	None required	Not significant

Receptor	Impact	Primary or Tertiary Mitigation	Assessment of effects	Additional Mitigation	Residual Effects
Main development site construction (including the Sizewell B relocated facilities works from Phase 1 onwards)					
Human receptors	Doses to workers and the general public from the construction of the proposed development due to existing contamination within soils	None required	Not significant	None required	Not significant
	Doses to workers and the general public from the construction of the proposed development due to radiography	Contractors' mobile source permit	Not significant	None required	Not significant
	Doses to members of the public associated with sea disposal of dredge sediment potentially containing trace levels of anthropogenic and natural radioactivity	None required	Not significant	None required	Not significant
	Doses to members of the public associated with the transport of radiography sources	Accounted for in the operational phase assessment.			
Non-human biota	Doses to non-human biota from the construction of the proposed development due to existing contamination within soils	None required	Not significant	None required	Not significant

Table 25.3: Summary of effects for the operational phase

Receptor	Impact	Primary or Tertiary Mitigation	Assessment of effects	Additional Mitigation	Residual Effects
Main development site operation (including Sizewell B relocated facilities)					
Human receptors	Doses to members of the public associated with the discharge of low levels of radioactive gaseous and aqueous effluents	Measures embedded within design of UK EPR™ to minimise radiological discharges, as set out during the GDA process. Compliance with the requirements of Sizewell C Nuclear Site Licence and RSR Permit. Design and operation of the Sizewell B outage store to minimise exposure to ionising radiation. Compliance with the requirements of Sizewell B Nuclear Site Licence and RSR permit.	Not significant	None required	Not significant
	Doses to members of the public associated with the transportation off-site of radioactive materials and wastes	Compliance with the requirements of IRRs.	Not significant	None required	Not significant
	Doses to members of the public associated with sea disposal of dredge sediment potentially containing trace levels of	None required	Not significant	None required	Not significant

Receptor	Impact	Primary or Tertiary Mitigation	Assessment of effects	Additional Mitigation	Residual Effects
	anthropogenic and natural radioactivity				
Non-human biota	Doses to non-human biota associated with the discharge of low levels of radioactive gaseous and aqueous effluents	Measures embedded within design of UK EPR™ to minimise radiological discharges, as set out during the GDA process. Compliance with the requirements of Sizewell C Nuclear Site Licence and RSR Permit. Design and operation of Sizewell B outage store to minimise exposure to ionising radiation. Compliance with the requirements of Sizewell B Nuclear Site Licence and RSR permit.	Not significant	None required	Not significant

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