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3.1 DEFINITIONS AND ABBREVIATIONS

3.1.1 Project Definitions and Abbreviations

The standard project glossary of terms, abbreviations, and plant systems is provided in SMR-300 Plant Breakdown Structure, Acronyms, and Glossary of Terms [1]. The following additional definitions and abbreviations are used herein:

Term	Definition
ALARA	As Low as Reasonably Achievable
ALARP	As Low as Reasonably Practicable
BAT	Best Available Techniques
Bq	Becquerel
BSO	Basic Safety Objective
BSS	Basic Safety Standards
BSSD	Basic Safety Standards Directive
DECC	Department for Energy and Climate Change
DPUC	Dose Per Unit Concentration
DPUR	Dose Per Unit Release
EA	Environment Agency
EC	European Commission
EPR	European Pressurised Reactor
EPR16	Environmental Permitting (England and Wales) Regulations 2016
ERICA	Environmental Risk from Ionising Contaminants: Assessment and Management
EURATOM	European Atomic Energy Community
FA	Forward Action(s)
FASSET	Framework for the Assessment of Environmental Impact
FRED	FASSET Radiation Effects Database
GDA	Generic Design Assessment
GDP	Generic Developed Principles
GSD	Generic Site Description
GSE	Generic Site Envelope
Gy	Grays
HPA	Health Protection Agency
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
ICRU	International Commission on Radiation Units and Measurements
IRAT2	Initial Radiological Assessment Tool 2
IRR17	Ionising Radiations Regulations 2017
NDAWG	National Dose Assessment Working Group
NRPB	National Radiological Protection Board
ONR	Office for Nuclear Regulation

Term	Definition
PC CREAM 08	Consequences of Releases to the Environment Assessment Methodology 2008 computer code
PER	Preliminary Environmental Report
PGIRE	Practitioner Group on the Impact of Radioactivity in the Environment
PHE	Public Health England
PSR	Preliminary Safety Report
PWR	Pressurised Water Reactor
RADD	European Commission RAdioactive Discharges Database
REPPIR19	Radiation (Emergency Preparedness and Public Information) Regulations 2019
RI	Regulatory Issue
RIA	Radiological Impact Assessment
RO	Regulatory Observation
RP	Requesting Party
RSR	Radioactive Substances Regulations
SAP	Safety Assessment Principles
SDG	Sustainable Development Goals
SMR-300	Holtec's 300 MW Small Modular Reactor
SRS	Safety Reports Series
SSEC	Safety, Security and Environment Case
Sv	Sieverts
UK	United Kingdom
UKHSA	United Kingdom Health Security Agency

3.2 INTRODUCTION

This section introduces the reader to the purpose and scope of this document in relation to Radiological Impact Assessment (RIA) for the generic Small Modular Reactor (SMR)-300 design. More detailed scope regarding RIA specifically appears later within this document.

This report comprises Chapter 3 – Radiological Impact Assessment of the generic SMR-300 Preliminary Environmental Report (PER). The PER forms part of the Generic Design Assessment (GDA) for the generic SMR-300.

As a nuclear power plant, the generic SMR-300 will discharge radionuclides into the environment throughout its lifetime. Discharged radionuclides will result in exposure to wider populations than those present at the nuclear power plant site. This report will consider the discharges of radionuclides to the environment related to the operation of a twin unit generic SMR-300 reactor site, and the doses that could result, in relevant population groups and wildlife, using the Initial Radiological Assessment Tool version 2 (IRAT2) calculation spreadsheets provided by the Environment Agency (EA) in Initial Radiological Assessment Tool 2: Part 1 User Guide [2], Part 2 Methods and Input Data, Chief Scientists Group Report [3]: Summary [4], Initial Radiological Assessment Tool - Air [5], Initial Radiological Assessment Tool - River [6], Initial Radiological Assessment Tool - Sewer [7], and Initial Radiological Assessment Tool – estuary coast [8].

This report will describe the calculations that will be used to assess collective doses from effluent discharges from the generic SMR-300 design.

3.2.1 Purpose

This chapter provides methods and data for prospective dose impact on people and the environment of any proposed discharges of gaseous and aqueous-liquid radioactive effluents. It will demonstrate that doses from effluent discharges to any population will be As Low as Reasonably Achievable (ALARA) and in line with EA guidance and limits.

3.2.2 Scope

This chapter will cover the assumptions and representative information for calculating doses to members of the public and dose rates to non-human species from aqueous-liquid and gaseous discharges during operation[1] of the generic SMR-300 using the IRAT2 methodology. Dose calculations will be completed during the GDA; this preliminary chapter will not attempt to provide values for doses to populations. The following variables impact on dose calculations and will be considered:

- Stack height.
- Radionuclides and discharge limits.
- Positions of stacks.
- Incineration sources on site (if planned).
- Location impact: sea/estuary.
- Location impact: river/lake.

The management routes from generation to discharge and disposal of aqueous-liquid and gaseous wastes, quantification of aqueous-liquid and gaseous waste and Best Available Techniques (BAT) demonstration for radioactive waste management are outside of the scope

[1] Any radioactive discharges during commissioning or decommissioning of the Generic SMR-300 are not included within the scope of this chapter. These assessments will be completed as part of site specific permitting applications.

of this chapter, however, this chapter will provide supporting arguments to claims related to these topic areas.

The central scope for this GDA is to produce the following:

- Assessment of Exposure to public exposure groups from routine discharges.
- Assessment of Exposure to wildlife from routine discharges.
- Comparison of results against proposed limits and constraints and other reactors.
- Sensitivity Analysis of parameters and results for generic sites.
- Development of methodologies and identification of data needs for site specific assessment.

The following assessments are excluded from the scope of this GDA assessment:

- Discharges during/following accident conditions, during commissioning or during decommissioning.
- Radiological impact of on-site and off-site transport of radioactive wastes and new fuel.

3.2.3 Chapter Structure

This chapter is structured to provide information required for a meaningful GDA assessment. The main structure of this chapter consists of:

- Sub-chapter 3.2 introduces the objective, scope, interfaces and assumptions for RIAs.
- Sub-chapter 3.3 presents the regulatory context, such as regulatory expectations and requirements, Radioactive Substances Regulations (RSR) principles, codes and standards considered for RIA.
- Sub-chapter 3.4 presents the methods for assessment of radiological impacts, as deemed relevant to this GDA.[2]
- Sub-chapter 3.5 presents the structure of the results and discussions section to be completed at Revision 1.
- Sub-chapter 3.6 summarises this chapter.
- Sub-chapter 3.7 presents the references in this chapter.

3.2.4 Interfaces With Other Chapters

To define the interfaces between this chapter and other chapters in the Safety, Security and Environment Case (SSEC) in order to demonstrate that the environment case in this chapter works together with them to form an overall strategic environment case, this is detailed in Table 1.

Table 1: Interfaces with Other SSEC Chapters

Chapter Title	Interface
Holtec SMR GDA PER Chapter 1 Radioactive Waste Management Arrangements [9]	Chapter 1 presents the management arrangements for solid, liquid and gaseous radioactive waste arising over the lifecycle of the generic SMR-300, providing detail in how the effluents will be generated.
Holtec SMR GDA PER Chapter 2 Quantification of Effluent Discharges and Limits [10]	Chapter 2 will provide the source term for these assessments. Initial assessments will inform quantification chapter on key radionuclides to include in assessments.

[2] Note that Chapter 3.4 will present a discussion of methods and data required to complete a full radiological impact assessment at site specific stage within Revision 1 of this document.

Chapter Title	Interface
Holtec SMR GDA PER Chapter 4 Conventional Impact Assessment [11]	Chapter 4 considers the non-radiological environmental impacts of the generic SMR-300. The RIA provides the developed Generic Site Description (GSD) used by both chapters and Chapter 4 provides more detail on sustainability.
Holtec SMR GDA PSR Part A Chapter 1 Introduction [12]	Chapter A1 of the Preliminary Safety Report (PSR) provides the information required of the GDA, and the structure of the PER, which this chapter follows.
Holtec SMR GDA PSR Part A Chapter 2 General Design Aspects and Site Characteristics [13]	Chapter A2 of the PSR provides the general design aspects and defines the Generic Site Envelope (GSE) used throughout the SSEC. This chapter expands the GSD to include sensitivity analysis of these assumptions with respect to radiological impacts and confirms the bounding nature of the assumptions.
Holtec SMR GDA PSR Part A Chapter 4 Lifecycle Management of Safety and Quality Assurance [14]	Chapter A4 of the PSR provides a description of the processes and procedures that will result in the management of risks during the respective lifecycle phases. The Management of Safety and Quality Assurance will also provide the processes and procedures for assuring quality assessments within this chapter.
Holtec SMR GDA PSR Part B Chapter 10 Radiological Protection [15]	Chapter B10 of the PSR aims to provide information on source terms and dose rates for direct radiation exposure to members of the public. Where generic SMR-300 specific data is not available, this will be supplemented with Operational Experience (OPEX) from similar facilities, taking cognisance of the site layout.
Holtec SMR GDA PSR Part B Chapter 13 Radioactive Waste Management [16]	The design and operation of the radioactive waste facilities is described and evaluated in Chapter B13 of the PSR. Correct operation of these facilities will ensure that discharges are minimised. Demonstration that the design of these facilities optimises the balance between discharges and generation of solid radioactive wastes will be presented within the BAT chapter.
Holtec SMR GDA PSR Part B Chapter 14 Design Basis Accident Analysis [17]	Chapter B14 presents the deterministic analysis for the SMR-300 following accident conditions and presents the basis for demonstration that the risk is As Low as Reasonably Practicable (ALARP) in comparison with the numerical targets introduced in Chapter A2 [13]. Source terms for expected events will be presented in Chapter 14 and used to derive short term discharges in PER Chapter 2 [10]. This will inform the short-term discharge assessment methodology.
Holtec SMR GDA PSR Part B Chapter 23 Reactor Chemistry [18]	Chapter B23 of the PSR describes the reactor chemistry, and the design decisions made to minimise the source term in support of the demonstration that risks are reduced to ALARP. The outcome of the RIA will feed back into Chapter 23 to either support the ALARP argument or point to further measures required to reduce source terms.

The BAT demonstration for generic SMR-300 will be developed in line with Approach and Application of the Demonstration of BAT [19] and SMR-300 UK GDA Scope [20], to indicate how the generation and disposal of radioactive waste will be prevented and minimised to reduce the impact on the members of the public and environment to ALARA. The RIA will present the radiological impact on the public and environment of the BAT design, at this stage, however, it will be used as a tool in the identification of BAT.

Sampling and monitoring techniques will be used to measure and record effluent discharges, ensuring they are within limits. These will be developed within the GDA.

3.2.5 Assumptions

The following assumptions are made to underly the development of the RIA methodologies considering the ‘Base Case’ in the Funded Decommissioning Programme [21].

- The operational lifetime of a generic SMR-300 is 80 years. Assessment of impacts to the public and the environment will be made at year 50, due to the limitations of the IRAT2 models.
- The assessments will not take into consideration changes to the design as a result of future technologies which may alter the radionuclide fingerprint or the periodicity of the discharges.
- The assessments also assume that the exposure groups (human and wildlife) do not change substantively throughout the reactor lifetime.
- The radioactive waste management systems are shared by the dual-unit in the generic SMR-300, resulting in a single discharge point for gaseous discharges.
- The regulations, codes and standards applied to radioactive waste management, discharges and decommissioning, are those in force during the development of site permit applications.
- Dose limits for workers and the public will remain unchanged from those in current use in the United Kingdom (UK), as defined in the Ionising Radiations Regulations 2017 (IRR17) [22] and the Environmental Permitting (England and Wales) Regulations 2016 (EPR16) [23] .
- Definitions of waste categories will remain unchanged from those in current use in the UK.

Additional assessment specific assumptions are discussed in Sub-chapter 3.4.

3.3 REGULATORY CONTEXT

This section outlines the requirements of this topic area within the GDA, the RSR Principles that these requirements stem from and then covers other requirements including the international regulatory context. As this is an assessment that is required by UK regulators and as specified in GDA requirements, it does not go into detail how these specific assessments are carried out in US.[3]

3.3.1 GDA Requirements

To capture the requirements in GDA guidance that are related to RIA, effluent discharges and limits for the whole GDA process (see also [13]).

To guide the development of environment case for a new reactor power plant in the UK, Generic Design Assessment Guidance for Requesting Parties [24] details the information required for environment case for the whole GDA process including the information related to RIA. This is summarised in Table 2, together with how this will be addressed within the PER, highlighting any shortfalls in meeting the regulatory requirements at this current design stage.

[3] US NRC Regulatory Guides 1.109 Calculation of Annual Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I, 1.111 Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors, and 1.112 Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors provide guidance on assessment of releases, dispersion and annual doses to members of the public from light water reactors.

Table 2: Summary of GDA requirements supporting and information to be produced

GDA requirement for Step 2 assessment	Information as part of GDA
The Requesting Party (RP) must provide a radiological assessment of proposed limits for: • **annual dose to most exposed members of the public for liquid discharges** • **annual dose to most exposed members of the public for gaseous discharges (separately identify the dose associated with on-site incineration where applicable)** • **annual dose to the most exposed members of the public for all discharges from the facility***	PER Chapter 3, sub-chapter 3.4 provides information on the methodology for assessing annual doses to members of the public for aqueous-liquid and gaseous discharges as applicable to a Step 2 GDA, based on the discharge limits to be defined in PER Chapter 2 [10]. These methods have been developed utilising two GSDs as described in the GSE. Assessment of these doses will be carried out within the GDA once discharge source terms are available. Results of the assessment will be presented in sub-chapter 3.5. Further, more refined, assessment will be required at the site-specific stage.
• **annual dose from direct radiation to the most exposed members of the public**	PSR Chapter 10 [15] provides information on assessment of direct radiation doses to most exposed members of the public, this will be summarised in PER sub-chapters 3.4 (methodology) and 3.5 (results) once source terms and direct radiation assessments have been completed. As the facility layout is developed and detailed shielding and dose assessment is completed at the site-specific stage further assessments will be required to ensure direct radiation doses are ALARP
• **annual dose to the representative person for the facility**	Annual dose to the representative person for the facility will be assessed for the two siting scenarios and presented in sub-chapter 3.5. This will be refined at site-specific stage
• **potential short-term doses, including via the food chain, based on the maximum anticipated short-term discharges from the facility in normal operation**	Short-term dose assessment requires more input information than is available at this stage of a GDA, however, methods for assessing short term discharges, and discussion of short-term releases will be developed as site operations and source terms are produced. This will be presented in sub-chapter 3.4. Assessment of potential short-term doses will be carried out at a later date when a detailed site description has been defined.
• **a comparison of the calculated doses with the relevant dose constraints**	A comparison of calculated doses will be carried out against dose limits, targets and constraints where dose assessments have been possible, these will be presented in sub-chapter 3.5. Full assessment will be carried out at the site-specific or a future Step 3.
• **an assessment of whether the build-up of radionuclides in the local environment of the facility, based on the anticipated lifetime discharges, might have the potential to prejudice the activities of other legitimate users or uses of the land or sea**	Methods for assessing whether build-up of radionuclides will affect future uses of the site will be developed and presented in sub-chapter 3.4, to support assessments carried out at the site-specific stage.
• **collective dose truncated at 500 years to the UK, European and world populations**	Collective dose assessment cannot be completed within the GDA as siting of the facility within the UK needs to be defined. The method for assessing collective dose will be developed and presented in sub-chapter 3.4. Collective dose assessments will be completed at the site-specific stage.
• **dose-rate to non-human species**	The methods for screening dose rate assessments to representative non-human species for gaseous and aqueous-liquid discharges are presented in sub-chapter 3.4. The results of these assessments will be presented in Sub-chapter 3.5 once source term data is available. Detailed assessments for habitats within or in close proximity to the site will be assessed at the site-specific stage.

3.3.2 Radioactive Substances Regulations Principles

The RSR Objective and Principles [25] set out the regulatory principles applied by the EA as set out in EPR16 [23] and government policy. These are supported by a set of RSR Generic Developed Principles (GDPs), which lay out the EA's expectations on radioactive substances permit holders: Regulatory Guidance Series RSR 1: Radioactive Substances Regulation – Environmental Principles (Version 2) [26], Guidance: Management and leadership for the environment: GDPs [27], Guidance: Radioactive substances management: GDPs [28], Guidance: Site evaluation - GDPs, Guidance: Engineering: GDPs [29] and Guidance: Radiological protection of people and the environment: GDPs [30]. The key RSR principles and GDPs that are taken into account and complied with when developing the RIA of discharges on population groups and wildlife are presented in Table 3.

Table 3: RSR Principles relevant to RIA

RSR Principle	Information as part of GDA
Principle 3 - *Radiation doses to the public from radioactive substances activities must be kept within statutory dose limits*	PER Chapter 3 presents the methods for assessing radiation doses to members of the public, together with listing all relevant statutory limits. Assessment of doses to representative persons will be carried out.
Principle 4 - *Radioactive substances activities must not cause wildlife to be exposed to levels of ionising radiation that would have adverse consequences for ecosystems, designated conservation sites and protected species.*	PER Chapter 3 presents the methods for assessing radiation dose rates to a range of reference organisms. Assessment of dose rates and comparison against screening values will be carried out.
RSMDP12 – *limits and levels on discharges,* *Limits and levels should be established on the quantities of radioactivity that can be discharged into the environment where these are necessary to secure proper protection of human health and the environment.*	PER Chapter 2 [10] will present the limits and levels for effluents proposed to be discharged by the generic SMR-300. Initial assessment of whether proper protection is achieved will be carried out and detailed assessments will be considered at the site-specific stage.
RPDP1 – *optimisation of protection,* *All exposures to ionising radiation of any member of the public and of the population as a whole shall be kept as low as reasonably achievable (ALARA), economic and social factors being taken into account.*	The Application of BAT document [19] will demonstrate BAT. Implementation of BAT should drive the design to achieve exposures that are ALARA.
RPDP2 – *dose limits and constraints,* *Radiation doses to individual people shall be below the relevant dose limits and in general should be below the relevant constraints*	PER Chapter 3 presents the methods for assessing radiation doses to members of the public, together with listing all relevant statutory limits, targets and constraints. Assessment of doses will be carried out and compared against limits and constraints. Assessment of doses to members of the public from direct radiation will be developed in PSR Chapter 10. Detailed assessments considering short-term discharges will be considered at the site-specific stage.
RPDP3 – *Protection of non-human species,* *Non-human species should be adequately protected from exposure to ionising radiation.*	PER Chapter 3 presents the methods for assessing radiation dose rates to a range of reference organisms. Assessment of dose rates and comparison against screening values will be carried out.
RPDP4 – *Prospective dose assessments,* *Assessments of potential doses to people and to non-human species should be made prior to granting any new or revised permit for the discharge of radioactive wastes into the environment.*	PER Chapter 3 presents the methods for assessing exposures to people and non-human species based on discharges at proposed permit levels. Detailed assessments of exposures will be carried out at the site-specific stage.
SEDP1 - *General principle for siting of new facilities,* *When evaluating sites for a new facility, account should 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 GSD, within the GSE provides high level factors that have been considered to complete this GDA. Site characterisation, including geology, hydrogeology, meteorology, topography, soil science, marine, riverine or lake parameters, habits and habitats etc. will need to be made at the site-specific stage.
SEDP2 – *migration of radioactive material in the environment,* *Data should be provided to allow the assessment of rates and patterns of migration of radioactive materials in the air and the aquatic and terrestrial environments around sites.*	PER Chapter 3 will present the methods for generating data to allow assessment of migration of radioactive materials in the environment. Generation of data will be made at the site-specific stage.

RSR Principle	Information as part of GDA
DEDP4 – *Discharges during decommissioning*: *Aerial or liquid radioactive discharges to the environment during decommissioning should be kept to the minimum consistent with the decommissioning strategy for the site.*	Data on discharges during decommissioning will not be available during GDA. High level assessments and optimisation of discharges during decommissioning will be completed as part of the site-specific environmental impact assessment.

3.3.3 Other Requirements Related to Radiological Impact Assessment

3.3.3.1 International Context

The system of radiation protection that is used worldwide is based upon the recommendations of the International Commission on Radiation Protection (ICRP) and the International Commission on Radiation Units and Measurements (ICRU). This system is based upon three fundamental principles: justification, optimisation, and dose limitation as written in Publication No. 103: The 2007 Recommendations of the International Commission on Radiological Protection, Annals of the ICRP, vol. 37 no. 2-4 [31].

The International Atomic Energy Agency (IAEA) Basic Safety Standards (BSS) are widely adopted as the foundation for national legislation. Their purpose is to safeguard workers, patients, the public, and the environment from the risks associated with ionising radiation. Schedule III.3 sets for public exposures an effective dose limit of 1mSv/y. The European Commission (EC) Directive 2013/59/EURATOM (Basic Safety Standards Directive, or BSSD) [32] is based upon the IAEA BSS and brings the international standards into European law. UK RSR legislation (EPR16 (as amended) [23], Environmental Authorisations (Scotland) Regulations 2018, [33]), IRR17 [22] and the Radiation (Emergency Preparedness and Public Information) Regulations 2019 (REPPIR19) [34] all stem from this directive.

The IAEA BSS extends protections beyond worker, patient and public exposures to radiation, to protection of the environment, explicitly stating that protection of the environment includes the protection and conservation of non-human species and their biodiversity. No exposure limits for non-human species are defined in the BSS.

Within Europe, the EC fifth framework project FASSET (Framework for the Assessment of Environmental Impact) created a framework for the assessment of impacts on the environment. The FASSET Radiation Effects Database (FRED) database was created within this project, with its main use to gather literature data to help summarise dose-effect relationships between radiation exposures and their effects on organisms. A further deliverable from this piece of work was the Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) project, where a tool for the assessment of exposures to a range of reference organisms was created. Within this tool, screening values were provided based upon international research into radiation effects on biota (including data entered into the FREDERICA database).

3.3.3.2 Regulation in England and Wales

Schedule 23 of EPR16 [23] sets out how discharges of radioactive substances from nuclear power plants to the environment are controlled. These, together with equivalent legislation in Scotland [33] come under the umbrella term RSR.

Part 4 Section 1 specifies the following with regards to optimisation and dose limits

1. In respect of a radioactive substances activity that relates to radioactive waste, the regulator must exercise its relevant functions to ensure that—

a) all exposures to ionising radiation of any member of the public and of the population as a whole resulting from the disposal of radioactive waste are kept as low as reasonably achievable, taking into account economic and social factors, and
b) the sum of the doses resulting from the exposure of any member of the public to ionising radiation does not exceed the dose limits set out in Article 13 of the BSSD subject to the exclusions set out in Article 6(4) of that Directive. Specific dose limits and calculation.

2. (1) In exercising those relevant functions in relation to the planning stage of radiation protection, the regulator must have regard to the following maximum doses to individuals which may result from a defined source—
    a) 0.3 millisieverts per year from any source from which radioactive discharges are first made on or after 13th May 2000, or
    b) 0.5 millisieverts per year from the discharges from any single site.

The 1mSv/y dose limit in EPR16 implements the BSS/BSSD requirements for protection of members of the public from exposure to ionising radiation. The dose constraint requirements are implemented through Schedule 23(2), restricting the dose to individuals from single sources and sites. The Health Protection Agency (HPA, now the United Kingdom Health Security Agency, UKHSA) recommended in Application of the 2007 Recommendations of the ICRP to the UK: Advice from the HPA [35] a dose constraint of 150µSv/y for new nuclear power stations, on the basis of uncertainties in health effects in response to the ICRP 2007 recommendations [31]. This recommendation has not been incorporated within any regulation or guidance. A UK government Review of Radioactive Waste Policy, Cm2919 [36] set a threshold of optimisation for exposure to members of the public from radioactive waste of 20µSv/y, equating to a risk of death of approximately 1 in 10^6, as being broadly acceptable and in line with Target 3 of Office for Nuclear Regulation (ONR) Safety Assessment Principles (SAPs) for Nuclear Facilities, 2014 Edition Revision 1, i.e. the Basic Safety Objective (BSO) for public exposures [37].

Statutory Guidance was issued from the Department for Energy and Climate Change (DECC) to the EA [38]. This guidance recommends: provided that the holder of a permit continues to apply BAT, the EA should not seek to further reduce any discharge limits in place, for sources of radiation where the dose to the most exposed member of the public is below 10µSv/y.

The Principles for the Assessment of Prospective Public Doses arising from Authorised Discharges of Radioactive Waste to the Environment [39] is a document produced by all UK environment agencies and provides the basis for assessment of public exposures. This document introduces trivial dose and states that average annual individual doses in the nSv/y range or below should be ignored in the decision making process, as associated risks are miniscule, and up to a few µSv/y can be considered trivial. Calculated doses in excess of this however, should prompt careful consideration of the discharge options.

Assessment of potential impact on non-human species is a GDA requirement [24], and will be a consideration for future site permits as detailed in How to apply for an environmental permit Part RSR-B3 – New bespoke radioactive substances activity permit nuclear site – unsealed sources and radioactive waste; Guidance notes [40] and Criteria for setting limits on the discharge of radioactive waste from nuclear sites [41]. In generic developed principle RPDP-3 presented in Guidance: Radiological protection of people and the environment: GDPs [30] (see Table 3), the EA considers that there will be no adverse effects at population level to

reference species below a guideline dose level of 40µGy/h. A more restrictive screening level of 1µGy/h is used within IRAT2 to determine whether a refined dose assessment is required [2] [3].

3.3.3.3 UK Guidance on Radiological Assessments

Further guidance on radiological assessments is provided by UK competent bodies including the UKHSA (previously Public Health England (PHE), HPA and National Radiological Protection Board (NRPB)), the National Dose Assessment Working Group (NDAWG) and its successor, the Practitioner Group on the Impact of Radioactivity in the Environment (PGIRE).

NDAWG reports and guidance form UK relevant good practice for the assessment of radiological impacts of discharges on members of the public. The NDAWG reports and guidance that will inform RIAs and comparisons listed here.

NDAWG reports:

- Short duration releases to atmosphere. [42]
- Short term releases to rivers. [43]
- Acquisition and use of habits data for prospective assessments. [44]
- Overview of radiological assessment models - key gaps and uncertainties. [45]
- Methods for assessment of total dose in Radioactivity in Food and the Environment (RIFE) reports. [46]
- An overview of uncertainty in radiological assessments. [47]
- Radiological assessment exposure pathways checklist (common and unusual). [48]
- Use of measurements in assessing doses to the public. [49]

NDAWG Guidance Notes:

- GN 7 Use of habits data in Prospective Dose Assessments. [50]
- GN 6B Short term release assessments. Updated June 2020. [51]
- GN 5 The estimation and use of results on exposure to direct radiation. [52]
- GN 4 Considering uncertainty and variability in radiological assessments. [53]
- GN 3 Exposure pathways. [54]
- GN 2 Initial/simple assessment tools. [55]
- GN 1 Assessment of radiation doses from routine discharges of radionuclides to the environment. [56]

UKHSA and predecessor documents that will inform assessments include:

- The methodology for assessing the radiological consequences of routine releases of radionuclides to the environment used in the Consequences of Releases to the Environment Assessment Methodology 2008 computer code (PC-CREAM 08). [57]
- Assessment of dose rates to Biota in PC-CREAM 08. [58]
- Guidance on the assessment of radiation doses to members of the public due to the operation of nuclear installations under normal conditions. [59]
- Generalised Habit Data for Radiological Assessment. [60]
- Methodology for estimating the doses to members of the public from the future use of land previously contaminated with radioactivity. [61]

- Atmospheric dispersion from releases in the vicinity of buildings. [62]
- A methodology for assessing doses from short term planned discharges. [63]
- Contaminated Land guidance documents:
  - Risks from land contaminated with radioactivity [64]
  - Principles for assessing risks from land contaminated with radioactivity [65]
  - Application of the planning regime for radioactivity in the ground: Wales [66]
  - Application of the radioactive contaminated land regime: Wales [67]
  - Application of the radioactive contaminated land regime: England [68]
  - Application of the planning regime for radioactivity in the ground: England [69]
  - Guidance on remedial actions for land contaminated with radioactivity [70]
  - FAQ: Land contaminated with radioactivity [71]

3.3.4 Lessons Learned

A review of relevant Regulatory Issues (RIs) and Regulatory Observations (ROs) raised for previous GDA submissions has been completed. This review allowed learning from the experiences in earlier GDA submissions, to give a greater understanding of the regulatory focus within RIA, and to seek to develop these topic areas at the earliest opportunity. Concerns were raised during the earliest GDAs regarding the lack of information in following areas related to RIA: GSD, dose assessment, impact on non-human species. This chapter demonstrates that these issues have been taken into consideration.

3.3.5 Sustainability

In line with the requirements in The UK Policy Framework for Managing Radioactive Substances and Nuclear Decommissioning [72], the development of RIAs should consider internationally recognised best practices in sustainability, especially the United Nations Sustainable Development Goals (SDG) [73], which aim to protect the environment and the current and future generations. The SDGs of most relevance to RIA are goals: 3 (Good Health and Wellbeing), 6 (Clean Water and Sanitation), 12 (Responsible Consumption and Production) and 14 (Life Below Water) which all have targets related to minimising pollution and releases of hazardous materials.

In the development of the environment case in the generic SMR-300 GDA process, application of the waste hierarchy and a risk-informed approach are recognised as key principles in the lifecycle of radioactive waste management, which ensure that the radioactive wastes, including those discharged from the site are managed in a safe, secure, environmental, and sustainable approach. The main aspects from the RIA perspective that contribute to sustainable development in the generic SMR-300 include:

- BAT will be used to inform the deployment of the generic SMR-300 in the UK as well as applying the waste hierarchy principles to prevent and/or minimise the impacts of radioactive discharges on the public and environment, so as to avoid burdening future generations.
- In the optimisation process of radioactive effluent discharges (and solid radioactive wastes generated through the filtration of the effluents), all relevant competing factors, such as safety, technical feasibility, environment, and socio-economic benefits, etc., will be considered appropriately to give a single solution through the risk-informed decision-making approach. These criteria are aligned with the United Nations SDGs, and will be incorporated within Holtec SMR-300 GDA Reference Design Process and GDA Prospective Design Change Register [74].

- A significant contribution to sustainability is to remediate, clean-up, decommission, and manage the waste as soon as practicable considering all the relevant factors such as the availability of resources (people, supply chain, funding, waste management infrastructure). This chapter will assess the buildup of radioactive materials in the vicinity of the reactor site which will provide the input data to support the remediation and decommissioning planning post operation.

3.4 METHODOLOGY FOR RADIOLOGICAL IMPACT ASSESSMENT

This section introduces the EA method for assessing RIA as a screening exercise, as applicable to a GDA. It covers the background to the assessment, the input parameters selected for assessment based on the GSD and details the habit data of the representative persons to be assessed, as well as covering the habitat/reference organisms to be assessed for the wildlife study.

3.4.1 Background to Radiological Impact Assessment Method

The overall approach to assessing the radiological impacts of routine discharges of gaseous and aqueous-liquid radioactive effluents from the generic SMR-300 to the environment is based on the staged approach advocated by NDAWG [55] [39]. The staged approach comprises three tiers of radiological assessments, characterised by increasing level of detail and complexity. The EA have produced an initial radiological assessment methodology to support operators and inspectors in assessing radiological impacts from routine radiological discharges. The EA Initial Radiological Assessment Methodology 2 [2], [3], [4], and associated tool IRAT2, provide Dose Per Unit Release (DPUR) values for radioactive discharges to air [5], marine [8], river [6] and sewer [7]. Stage 1 of IRAT2 is a scoping calculation, carried out using default values which are deemed to be cautious and should bound the majority of UK based discharges. Stage 2 of IRAT2 requires user inputs to scale the doses to model site parameters more accurately. Stage 3 involves the use of detailed modelling methods to more accurately assess the build-up and distribution of radioactivity through the environment, and the habits of local populations.

3.4.2 Initial Radiological Assessment Method

The purpose and scope of the initial radiological assessment methodology are to provide a system for undertaking an initial cautious prospective assessment of the dose arising from radioactive waste discharges to the environment, and to identify those discharges for which a more detailed assessment should be undertaken. It should be noted that this methodology is generic for any radiological practice.

The assessment consists of three stages. At the first stage (Stage 1), default values are used in IRAT2. Proposed discharge limits are input, as presented in [10], and calculated doses to individuals and non-human species are presented in the tool.

A Stage 2 assessment uses refined data which is more suited to the site in question. The GSD within Generic Site Envelope Report for SMR-300 UK GDA, [75], summarised in PSR Chapter A2 [13] provides the parameter values for a Stage 2 IRAT2 assessment.

IRAT2 provides robust and acceptable screening to identify where further resource should be expended to review radioactive effluent discharge quantities and facility design to ensure impacts on members of the public and non-human species are ALARA. Simple cautious assumptions are made regarding the behaviour of radionuclides in the environment and the habits of persons possibly exposed.

In IRAT2, all discharges are assumed to be continuous (for a period of 50 years), uniform, routine releases. Effective dose is calculated based on an integration time of 50 years. Therefore, for a reactor facility with a longer planned operating lifetime, IRAT2 will underestimate the build-up of radioactivity in the biosphere, especially so for Cs-137 with a

long half-life and properties that result in the radioactivity being retained close to the soil surface. A Stage 3 assessment would therefore be required to fully account for this discrepancy. However, due to the conservatisms inbuilt within IRAT, it is not unreasonable to assume that the data is still sufficiently conservative to adequately cover impacts following 80 years of discharges.

IRAT2 calculates the dose to the worst affected individuals by multiplying the predicted discharge rates by DPUR factors (μSv y^{-1} per Bq y^{-1}). DPUR factors are provided for many radionuclides (including all key nuclear activation and fission products), internal and external exposure pathways, and four age groups (adult, child, infant and offspring). IRAT2 consists of separate models for each of the four potential discharge routes. Dose data is presented as a summary value for each radionuclide broken down by exposure pathway, based on the bounding DPUR value across the four age groups.

IRAT2 is capable of providing a screening dose assessment for a range of non-human species reference organisms utilising the same input data as for public exposures. The reference organisms in IRAT2 are taken from the lists of reference organisms in D-ERICA: An integrated approach to the assessment and management of environmental risks from ionising radiation. Description of purpose, methodology and application [76] and the associated tool [77] .

Discharges into lakes cannot be suitably assessed using IRAT2 models. The river model utilised in IRAT2 is a simplistic dispersion model that cannot closely replicate dispersion into a much larger water body. Assessment of dispersion within a small lake (denoted as water bodies with a surface area smaller than 400 m^2) can be completed using the methods described in IAEA Safety Reports Series No 19 (SRS-19) which provides generic models for assessing the impact of discharges of radioactive substances to the environment [78]. Radionuclides in water and sediment, under the conditions of a routine, long term release, can be considered to be in equilibrium.

The radioecology modelling code ERICA is capable of calculating activity concentrations in water and sediment using the SRS-19 small lake compartment model. The radiological impact on non-human species can then also be assessed in ERICA. Assessment of impact on members of the public will be made utilising data and methods presented in [3] based on activity concentrations calculated using the SRS-19 small lake model in ERICA.

3.4.3 External Doses from Direct Radiation

In addition to exposures from discharges of radioactive materials. Members of public, and non-human species may be exposed to external radiation emanating from the reactor site facilities. The GSD [75] provides information on exposure parameters for this exposure scenario. Calculation of direct radiation dose rates is discussed in PSR Part B Chapter 10 [15]. External dose rates will be determined once facility design has progressed sufficiently using appropriate radiation transport codes. Direct radiation dose is combined with the calculated discharge doses to establish the total dose from the generic SMR-300 site for both members of the public and non-human species. A key component of offsite external dose is exposure to stored waste materials – specifically Intermediate Level Waste and Spent Fuel which will need to be stored onsite for many decades. The siting of these facilities with respect to the site boundary is therefore a significant factor in determining the scale of exposures.

3.4.4 Initial Radiological Assessment Input Data

The GSD [75] provides parameter values to enable a Stage 2 RIA to be completed for two site location scenarios. The first site is assumed to be UK coastal or estuarine location, with low dispersion to the wider marine environment. The second site is assumed to be adjacent to a freshwater watercourse such as a lake or low flow river. Atmospheric and marine discharges are modelled using IRAT2, freshwater discharges into a lake are modelled using methods described in [78].

3.4.5 IRAT 2 Data – Air and Marine Model

Stage 1 and 2 user editable parameters utilised in IRAT2 Air and Marine models are presented in Table 4.

Table 4: Summary of Stage 1 and Stage 2 IRAT2 Input Parameters

IRAT 2	Air Model		Marine Model	
Stage	**Parameter**	**Value**	**Parameter**	**Value**
1	Stack Height	0 m	Volumetric Exchange Rate	30 m^3/s
2		0 m		100 m^3/s

Detailed parameters characterising the local compartment, as assumed in the initial radiological assessment methodology in generating the DPUR values are presented in Table 5 for Stage 2 assessment.

Table 5: Local Marine Compartment Characteristics

Parameter	Value
Volume	10^8 m^3
Depth	10 m
Coastline length	10 km
Volumetric exchange rate	100 m^3/s
Suspended sediment load	10^{-5} t/m^3
Sedimentation rate	4.9 10^{-3} $t/m^2/y$
Density of dry sediment particles	2.6 t/m^3
Diffusion rate (sediment diffusion coefficient)	3.15 10^{-2} m^2/y

3.4.6 SRS-19 Data – Lake Model

The Stage 1, Screening Assessment for lake discharges assumes no dispersion/dilution of radionuclides within the water volume, i.e., the activity concentration in the discharge effluent is equal to that in the lake. The parameters for characterising the lake have been developed through a combination of SRS-19 default parameters [78], typical lake feed river flow rates from the national river flow archive [79] and estimated lake volume and area (as detailed in the UK Lakes Portal [80]) based on Llyn Trawsfynydd, the only UK lake connected to a reactor site. These are replicated in Table 6.

Table 6: Freshwater Body Characteristics

Parameter	Value	Reference
River flow rate (lowest)	0.05 m^3/s	[79]
Suspended sediment load	5 10^{-2} g/l	[78]
Irrigation rate	0.3 m^3 per m^2	[3]

Parameter	Value	Reference
Surface area	4,930,000 m^2	[80]
Lake volume	40,400,000 m^3	[80]
Lake depth (mean)	5.3 m	[80]

3.4.7 Source Term

The Stage 1 and Stage 2 radiological assessments will be completed using the annual gaseous and aqueous-liquid discharge limits as discussed in [10]. The proposed limits will be derived using the approach described in the EA guidance on setting limits for new nuclear licenced sites [41], Developing Guidance for Setting Limits on Radioactive Discharges to the Environment from Nuclear-Licensed Sites (Science Report SC010034/SR) [81] and presented in [10].

3.4.8 Habit Data for Representative Groups

The habits assumed in these preliminary screening assessments are as described in [3]. The doses calculated using DPUR values in IRAT2 are cautious screening values, and not directly equivalent to a representative person.

Four age groups are considered: foetus (or 'offspring'), 1-year old infants, 10-year-old children and adults. The DPUR for the most exposed age group for each discharged radionuclide is presented in IRAT2. The exposed adults may receive a proportion of their exposure whilst working, for example farming or fishing. Assumptions regarding occupancy and food consumption are at the higher end of applicable ranges [60].

For discharges to air, the exposure group considered is the 'local resident family' with the following exposure pathways:

- internal radiation from the inhalation of radionuclides in the effluent plume;
- external radiation from radionuclides in the effluent plume;
- external radiation from radionuclides deposited to the ground;
- internal radiation from consumption of terrestrial food containing radionuclides deposited to the ground (not considered for radionuclides with half-lives of less than 3 hours).
- Habit data for these pathways is presented in Table 7. This very conservatively assumes that food consumption is at the 97.5th percentile for all food groups.
- For discharges to the marine environment, the exposure group considered is a 'fishing family'. Exposure pathways for Liquid Marine discharges are assumed to be as follows:
- internal radiation from the consumption of seafood contaminated with radionuclides;
- external radiation from radionuclides in beach and shore sediment.

Habit data for these pathways is presented in Table 8. Exposures to contaminated fishing gear, inhalation of seaspray and suspended sediment and inadvertent ingestion of seawater were not included as doses from these pathways are insignificant in comparison to the two assessed pathways.

Table 7: Habit Data for Resident Family

Parameter	Infant	Child	Adult
Food Consumption Rates (kg/y)			
Green vegetables	15	35	89
Root Vegetables	45	95	130
Fruit	35	50	75
Sheep meat	3	10	25
Sheep liver	2.75	5	10
Cow meat	10	30	45
Cow liver	2.75	5	10
Cow milk	320	240	240
Breathing rates (m^3/h)	0.22	0.64	0.92
Occupancy at habitation (h/y)	8760	8760	8760
Fraction of time spent indoors	0.9	0.8	0.5
Cloud shielding factor (indoors)	0.2	0.2	0.2
Shielding factor for deposited radionuclides	0.1	0.1	0.1

Table 8: Habit Data for Fishing Family

Parameter	Infant	Child	Adult	Fraction in compartment	
				Local	Regional
Food Consumption rates (kg/y)					
Fish	5	20	100	0.5	0.5
Crustaceans	0	5	20	1	0
Molluscs	0	5	20	1	0
Occupancy on beach (h/y)	30	300	2000	1	0

For discharges to a lake or river, the exposure groups considered are an ‘angling family’ and an ‘irrigated foods family’. Exposure pathways considered here include:

Angler Family:

- internal radiation from the consumption of drinking water, assuming commercial abstraction from the river/lake or a well on the bank;
- internal radiation from the consumption of freshwater fish;
- external radiation from radionuclides in bank sediments.

Irrigated Foods Family:

- external radiation from radionuclides in contaminated soil;
- internal radiation from the consumption of appropriate terrestrial food types incorporating radionuclides from irrigation water;
- consumption of drinking water containing radionuclides

Habit data for these pathways is presented in Table 9 and Table 10 for angling family and irrigated foods family respectively.

Table 9: Habit Data for Angling Family

Parameter	Infant	Child	Adult
Consumption rates			
Freshwater fish (kg/y)	1	5	20
Water (l/y)	260	330	600
Occupancy on bank sediments (h/y)	30	500	1000

Table 10: Habit Data for Irrigated Foods Family

Parameter	Infant	Child	Adult
Consumption rates (kg/y)			
Green vegetables	15	35	80
Root vegetables	45	95	130
Fruit	35	50	75
Breathing rates (m^3/h)	0.22	0.64	0.92
Occupancy at habitation (h/y)	8760	8760	8760
Fraction of time spent indoors	0.9	0.8	0.5
Shielding factor for deposited radionuclides	0.1	0.1	0.1

As a lake/freshwater body may be located very close to the site, the irrigated foods receptor could reasonably be assumed to be the local resident family. Therefore, assessments of exposures to local resident family for a freshwater discharge will also consider exposures due to irrigation from the contaminated lake.

Note that the habits that are relevant today are likely to be very different to habits following 80 years of operation. Through a combination of climate change, dietary changes in effort to reduce carbon footprints, consumption trends, working activities, and leisure activities are expected to be quite different to those exhibited today.

3.4.9 Habitat Data

DPUR values in IRAT2 have been generated using dose per unit concentration (DPUC) data calculated in the ERICA tool [76] [77]. The ERICA tool does not incorporate assessment methods and tools for noble gases; instead, the Ar-Kr-Xe dose calculator for wildlife dose assessment [82], a spreadsheet-based tool was used to derive DPUC factors for noble gas radionuclides used in IRAT2.

In lieu of a defined habitat, IRAT 2 assesses exposures to a set of reference organisms as applicable to terrestrial, freshwater and marine environments. These organisms, replicated in Table 11, are taken from the ERICA list of reference organisms [76] [77].

Table 11: Reference Organisms Assumed for Wildlife Impact Assessments

Terrestrial Reference Organisms	Marine Reference Organisms	Freshwater Reference Organisms
Amphibian	Benthic fish	Amphibian
Annelid	Bird	Benthic fish
Arthropod - detritivorous	Crustacean	Bird
Bird	Macroalgae	Crustacean
Flying insect	Mammal	Insect larvae
Grasses and herbs	Mollusc - bivalve	Mammal
Lichen and bryophytes	Pelagic fish	Mollusc - bivalve

Terrestrial Reference Organisms	Marine Reference Organisms	Freshwater Reference Organisms
Mammal - large	Phytoplankton	Mollusc - gastropod
Mammal - small burrowing	Polychaete worm	Pelagic fish
Mollusc - gastropod	Reptile	Phytoplankton
Reptile	Sea anemone and true corals	Reptile
Shrub	Vascular plant	Vascular plant
Tree	Zooplankton	Zooplankton

3.4.10 Sensitivity Analysis

All parameter values derived for annual dose assessments are chosen to be realistically conservative for a UK site. There will be uncertainties in these parameter values as a result of, for example, changes and differences in individual habits and farming practices, including as a result of climate change over the planned 80-year operating lifetime of the reactors.

A comparison between volumetric exchange rates of 30, 100, 231 and 3170 m^3/s will be carried out for marine discharges to ensure that the assessment of marine discharges are suitably conservative. These rates have been selected as they represent: the IRAT2 default value; the assumed bounding GSD value; and the lowest and highest exchange rates of the EN-6 reactor sites.

For freshwater discharges, volumetric flow rates will be varied to identify the impact of flow rate on dispersion and sedimentation – noting the difference in dispersion between a low flow river and a large volume, predominantly still lake.

For gaseous discharges, a review of stack height will be carried out as the design develops, taking onto consideration factors such as entrainment and building wake, exhaust velocity and temperature. Additionally, a review of weather conditions around UK coastal and inland sites will be carried out to assess whether the 50% Category D assumption (Table 12) is sufficiently bounding for all potential sites as an annual average. Changes in stack height or weather category could result in peak air concentrations and deposition at different distances to those assumed in the GSD for the public and non-human receptors and food production.

Table 12: Atmospheric Conditions Assumed in IRAT2 - 50% Category D

Pasquil stability category	Frequency of occurrence (%)	Wind speed at 10 m (m/s)
A	1	1
B	9	2
C	21	5
D	50	5
E	8	3
F	10	2
G	2	1

3.4.11 Demonstration of Best Available Techniques

RIAs are a tool that can be used as part of the optioneering process to determine the BAT option and identify where design improvements or operation changes may be required to achieve BAT, this will support arguments that source terms have been minimised. Demonstration that doses to members of the public and the environment are trivial (and ALARA) can assist in arguing that the design and operation of the reactor utilises BAT throughout. Radiological impact and dispersion assessments will be carried out at the site-

specific stage to optimise the dispersion of discharges, through assessment of stack height with respect to the site (layout, topography, meteorological conditions etc.) and optimisation of aqueous-liquid discharge point.

3.5 PRELIMINARY RADIOLOGICAL IMPACT ASSESSMENT

This section presents the structure of the results section of the chapter. As no assessments have been completed, this just shows how the results will be presented in tabular form and indicates how results will be evaluated.

At this stage, discharge source terms for the operation of a single or twin generic SMR-300 have not yet been derived, therefore a preliminary RIA is not presented here.

3.5.1 Stage 1 Assessment

The presentation format for Stage 1 IRAT2 screening assessment results for site description Scenarios 1 is shown in Table 13 and Table 14 for aqueous-liquid (both marine and lake scenarios) and gaseous discharges respectively. All doses will be presented in µSv/y.

Table 13: Stage 1 Dose - Aqueous Discharges - example presentation

Radionuclide	Dose uptake µSv y^{-1}			% Contribution
	Ingestion	External	Total	
All nuclides listed in the proposed liquid discharge permit [10]				Contribution of individual nuclide to total dose

Table 14: Stage 1 Dose - Gaseous Discharges - example presentation

Radionuclide	Dose uptake µSv y^{-1}				% Contribution
	Inhalation	External	Ingestion	Total	
All nuclides listed in the proposed gaseous discharge permit [10]					Contribution of individual nuclide to total dose

The presentation format for Stage 1 IRAT2 screening assessment results for non-human species for site description Scenarios 1 and 2 (gaseous and aqueous-liquid) is shown in Table 15: Results are to be presented in separate tables for marine, freshwater and gaseous discharges. Freshwater non-human species data is sourced from a Tier 2 ERICA assessment.

Table 15: Stage 1 Non-Human Species Dose Rates – example presentation

Nuclide	Dose Rate µGy h^{-1}	% Contribution	Worst Affected Reference Organism
All nuclides listed in the proposed gaseous discharge permit [10]		Contribution of individual nuclide to total dose	Reference organism that receives highest dose for given nuclide

3.5.2 Stage 2 Assessment

The presentation format for Stage 2 IRAT2 screening assessment results for site description Scenarios 1 and 2 is as show in Section 3.5.1. All doses to members of the public will be presented in µSv/y, and to non-human species in µGy/h.

As part of the Stage 2 assessment, total doses from all discharges for site description Scenarios 1 and 2 will be presented. Additionally total doses from the site – including direct radiation. The presentation format for these will be as for the example in Table 16 (noting total

doses from all discharges will not include a direct radiation contribution). Separate tables will be presented for Scenarios 1 and 2.

Table 16: Example presentation of total dose to site for a Stage 2 assessment

Exposure Route	Dose uptake μSv y^{-1}
Aqueous Discharges – to Marine/lake	
Gaseous Discharges	
Direct Radiation	
Total Dose	

The presentation format for Stage 2 IRAT2 screening assessment results for non-human species for site description Scenarios 1 and 2 is as shown in Table 15. Results are presented in separate tables for marine, freshwater and gaseous discharges in the units μGy/h. Freshwater non-human species data is sourced from a Tier 2 ERICA assessment. As there is no common overlap between freshwater, marine water and terrestrial non-human species, there will be no combination of exposures from multiple discharges for non-human species at this stage.

3.5.3 Evaluation of Results

Results of the Stage 2 initial radiological assessment will show the total dose to a representative member of the public from all the pathways considered for the two reactor siting locations. These will be compared against the source dose constraint of 300μSv/y [39]; as well as the more restrictive constraint of 150μSv/y recommended to be applied at the design stage of new nuclear facilities [35]. Total dose will also be evaluated against the threshold of 20μSv/y at which further refinement of assessed doses using more realistic data are required [30], and the Target 3 BSO in the ONR SAPs [37]. This is the annual dose target for any person off the site from sources of ionising radiation originating on the site.

The estimated dose rate to the worst affected organisms for both aqueous-liquid and gaseous discharges predicted to arise from the operation of a twin generic SMR-300 will be compared against the statutory guidance value of 40μGy/h [30], and the IRAT2 screening value of 1μGy/h [3].

Calculated doses to members of the public and non-human species will be compared against prospective doses for other reactor designs that have followed the GDA process, and operational dose assessment data for Pressurised Water Reactor (PWR) facilities worldwide. To ensure consistency, the results will be compared on a per GWh power basis. Cognisance will be taken regarding the difference between operational/retrospective dose data against a bounding prospective dose assessment when weighing the impacts.

3.5.4 Sensitivity Studies

Sensitivity studies carried out to test the robustness of the GSD to provide suitably bounding parameters are presented here. These studies will support the GSD section of the GSE.

3.5.4.1 (REDACTED)

3.5.4.1.1 (REDACTED)

Table 17 – REDACTED

REDACTED

Figure 1 – REDACTED

REDACTED

Figure 2 – REDACTED

REDACTED

Table 18 – REDACTED

REDACTED

Figure 3 – REDACTED

REDACTED

3.5.4.1.2 (REDACTED)

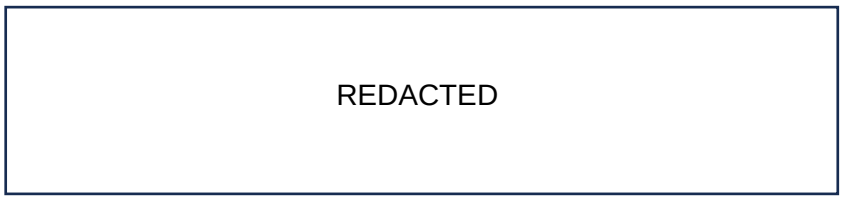

Figure 4 - REDACTED

3.5.4.1.3 (REDACTED)

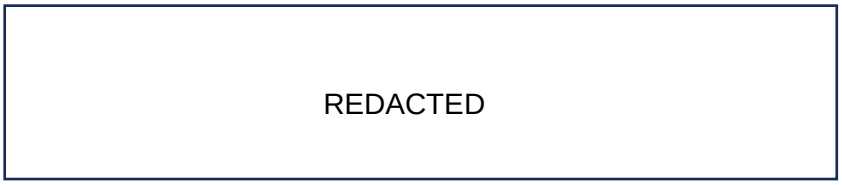

Figure 5 - REDACTED

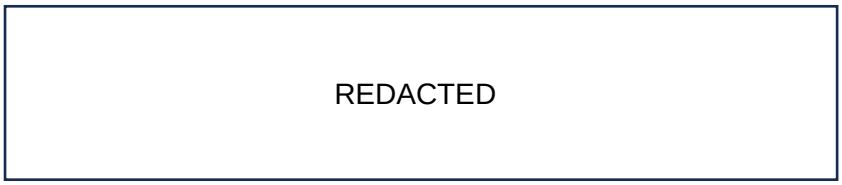

Figure 6 – REDACTED

Figure 7 - REDACTED

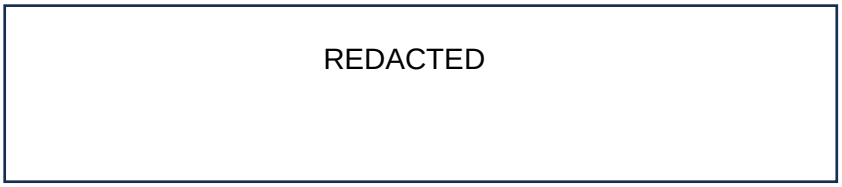

Figure 8 - REDACTED

3.5.4.2 (REDACTED)

Figure 9 - REDACTED

Table 19 - REDACTED

REDACTED

3.6 SUMMARY

This section summarises the discussion throughout the report, including the method of assessment and evaluation of results. As the assessment are yet to be completed, this is a short summary.

This chapter provides information concerning the methodologies and approaches that will be used to perform assessments of the radiological impacts on people and the environment from gaseous and aqueous-liquid discharges from a twin generic SMR-300 facility at a generic UK site as required by the UK regulators of RPs within the GDA process. These approaches will be based on the generic SMR-300 design, data determined from design specifications and operations of other PWRs, and discharge data from the generic SMR-300, as well as site specific variables as defined for the generic site. A discussion of Stage 1 and Stage 2 RIA is included, as well as sensitivity analysis for the listed models and formulae. The method for determining specific radionuclides for more detailed assessments will also be discussed.

This assessment will demonstrate that doses from effluent discharges to any population will be ALARA and in line with EA guidance and limits. The generic SMR-300 design is underway, and a primary source term is being developed so that calculations of doses can be made. The underlying assumptions, parameter values, operating experience data and engineering design presented in this report are subject to change.

At this stage of design, data requirements have been identified in order to be able to conduct the initial impact assessments. Next steps have been determined to ensure a meaningful GDA assessment can be undertaken within this chapter, together with Forward Actions (FA) for detailed assessments to be completed during the site-specific stage. FA have been collated and are managed via the process described in [14].

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