Sizewell C Project

Radioactive Substances Regulation (RSR) Permit Application

Appendix A

Support Document A2 – Integrated Radioactive Waste Strategy

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INTRODUCTION

1.1 Purpose and Scope

1. NNB Generation Company (SZC) Ltd (SZC Co.), a separate legal entity whose majority shareholder is EDF Energy, based in the UK, proposes to build and operate a nuclear power station at Sizewell in Suffolk, known as Sizewell C (SZC). The proposed SZC development is to be a sister site to the one NNB Generation Company Ltd. Hinkley Point C (NNB GenCo (HPC)) is progressing at Hinkley Point C (HPC), namely two UK EPR™ reactor units and associated radioactive waste management and storage facilities. It will be located adjacent to the existing power stations at Sizewell A (SZA) and Sizewell B (SZB). Under the Environmental Permitting Regulations 2016 (EPR16, as amended) [Ref 1], SZC Co. requires a Radioactive Substances Activity permit, granted by the Environment Agency, to dispose of radioactive waste resulting from SZC operations and subsequent decommissioning. To support the Radioactive Substances Regulation (RSR) permit application, a number of supporting documents are provided, one of which is an Integrated Radioactive Waste Strategy (IWS) – this document - that presents how radioactive wastes (gaseous, liquid and solid) and spent fuel will be managed throughout the lifecycle of the SZC installation. Learning from experience from the HPC development is included herein where appropriate.
2. The strategies described in this IWS are to a level of detail that is proportionate to the potential impact and effort necessary to manage the routine radioactive waste and spent fuel arisings. Radioactive waste generated as a result of an accident or emergency is not within the scope of the RSR permit and so is not included in this document. Nuclear safety associated faults and accidents are regulated by the Office of Nuclear Regulation under the Nuclear Installations Act, and the granting of a Nuclear Site Licence (NSL). SZC Co. is in the process of applying for such a licence.
3. The principal objective of the IWS is to ensure that waste and fuel management throughout the lifecycle of the SZC installation is consistent with the SZC Co. policies on Environment and Sustainability and the underpinning principles defined by the Integrated Waste Management Standard [Ref 2], Environmental Optimisation Standard [Ref 3] and Land Quality Standard [Ref 4]. It is therefore intended to be the first point of reference for any internal or external stakeholder who has an interest in how the SZC project is intending to manage its radioactive waste and spent fuel.
4. The content of the document is based on Nuclear Decommissioning Authority (NDA) guidance [Ref 5]. The following aspects of the NDA guidance were not included in this document because the information is already provided in existing documentation/processes:
    - summarising UK regulatory framework for waste management [Ref 2];
    - defining the high level principles of waste management, environmental optimisation and land quality management [Refs 2, 3 & 4];
    - justification of waste management strategies - relevant references provided within this document; and
    - risks and uncertainties associated with waste and spent fuel management as these are managed via the 'Manage Risks and Opportunities' procedure and captured in the organisation's risk management tool [Ref 6].
5. In addition, non-radioactive wastes, which would be expected to be included within a full IWS, as indicated by the NDA guidance [Ref 5], are excluded here as this version of the IWS is to specifically support the RSR Permit Application where the focus is on the radioactive wastes and spent fuels only. The IWS is a live document to be

periodically updated as the SZC project progresses, and future revisions will expand the scope to incorporate non-radioactive wastes and otherwise omitted requirements of the NDA guidance, when the SZC project has reached sufficient maturity to require their inclusion. It should be noted that the non-radioactive waste properties of the radioactive waste are considered within the scope of this document.

1.2 Replication Strategy

6. As far as is practical the design of SZC will replicate that of HPC. A consistent state of design is referred to as a Reference Configuration, the most recent of which for HPC is Reference Configuration 2 (RC2). RC2 describes the design of HPC to be commissioned.

7. The SZC nuclear island will be identical to that for HPC, therefore the radioactive waste generation will be the same including the means to minimise the amount of radioactive waste produced as well as the storage, treatment, abatement and monitoring of radioactive wastes.

8. In order to maintain consistency between HPC & SZC, the initial reference configuration for the SZC project is based on RC2 for HPC. As a result, all system, structure and components codes are retained. The demonstration of Best Available Techniques (BAT) for the SZC design is described in RSR permit application support document A1 [Ref 9]. Any future change to the SZC design will be subject to formal design change process and will be assessed for environmental impact/impact on permit compliance and require a risk-informed and proportionate justification.

9. Documents from NNB GenCo (HPC) that predate RC2 and are incorporated into the design for SZC and have been accepted as part of the replication strategy. Any subsequent changes would be considered by SZC before being accepted into the SZC design.

1.3 Review Requirements

10. In accordance with the NDA guidance [Ref 5] it is intended for the SZC IWS to undergo a full revision at least every 3 years with annual action plan reviews. It will be updated periodically if required following review, if changes to anticipated waste inventory, external requirements, or any other relevant issues, require it.

1.4 Definitions

Term / Abbreviation	Definition
ALARP	As Low As Reasonably Practicable
APG	Steam Generator Blowdown System
BAT	Best Available Technique
DAC	Design Acceptance Confirmation
DEFRA	Department of Environment, Food and Rural Affairs
DiP	Disposal in Principle
DWMP	Decommissioning and Waste Management Plan
EA	Environment Agency
EDRMS	Electronic Document and Records Management System
EoG	End of Generation

Term / Abbreviation	Definition
FDP	Funded Decommissioning Programme
GDA	Generic Design Assessment
GDF	Geological Disposal Facility
GRR	Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulations
HEPA	High Efficiency Particulate Air filter
HHI	Interim Intermediate Level Waste Store
HHK	Interim Spent Fuel Store
HK	Fuel Building
HLW	High Level Waste
HM	Turbine Hall
HQA*	Radioactive Waste Storage Building
HQB*	Radioactive Waste Processing Building
HQC*	Radioactive Waste Preparation Building for Unit 2
HPC	Hinkley Point C
ILW	Intermediate Level Waste
IMS	Integrated Management System
IWS	Integrated Radioactive Waste Strategy
KER	Liquid Radwaste Monitoring and Discharge System
LC	Licence Condition
LLW	Low Level Waste
LLWR	Low Level Waste Repository Ltd
LoC	Letter of Compliance
MRF	Metal Recycling Facility
NDA	Nuclear Decommissioning Authority
NNB GenCo (HPC)	NNB Generation Company Limited Hinkley Point C
NSL	Nuclear Site Licence
ONR	Office for Nuclear Regulation
PTR	Reactor Cavity and Spent Fuel Pond Cooling/Treatment System
PWR	Pressurised Water Reactor
RCV	Chemical and Volumetric Control System
RC2	Reference Configuration 2

Term / Abbreviation	Definition
RD	Responsible Designer
REA	Reactor Boron and Water Make-up System
RPE	Nuclear Drain and Vent System
RSR	Radioactive Substances Regulations
RWM	Radioactive Waste Management Ltd
SHE	Waste Oil & Inactive Water Drain System & Storage
SEK	Conventional Island Drainage System
SEO-EP	Plant Sewer System
SFA	Spent Fuel Assembly
SoDA	Statement of Design Acceptability
SWESC	Site Wide Environmental Safety Case
SZA	Sizewell A
SZB	Sizewell B
SZC	Sizewell C
SZC Co.	NNB Generation Company (SZC) Ltd
TEG	Gaseous Waste Treatment System
TEP	Coolant Storage and Treatment System
TER	Additional Liquid Waste Discharge System
TES	Solid Waste Treatment System
TEU	Liquid Waste Treatment System
VLLW	Very Low Level Waste
WAC	Waste Acceptance Criteria
WMP	Waste Management Plan

*HQA/HQB/HQC are referred to elsewhere as the Effluent Treatment Buildings

1.5 References

Ref	Title	Document No.	Version	Location	Author
1.	The Environmental Permitting (England and Wales) Regulations 2016, as amended, 11th December 2016	No. 1154	-	http://www.legislation.gov.uk/uksi/2016/1154/contents/made	Statutory Instruments
2.	NNB GenCo Standard - Integrated Waste Management Statement and Principles	100178704	3.0	EDRMS	NNB GenCo (HPC)
3.	NNB GenCo Standard Environmental Optimisation Statement and Principles	100173216	1.0	EDRMS	NNB GenCo (HPC)
4.	NNB Land Quality Management Standard	100124363	1.0	EDRMS	NNB GenCo (HPC)
5.	Specification and Guidance on the Content and Format of an Integrated Waste Strategy, 19th October 2012	ENG01	3.0	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/517827/ENG01-Specification-and-Guidance-on-the-Content-and-Format-of-an-Integrated-Waste-Strategy.pdf	NDA
6.	Manage Project Risk, Issues and Opportunity procedure	NNB-205-PRO-000058	5.0	EDRMS	NNB GenCo (HPC)
7.	NNB GenCo EPR™ Corporate Decommissioning Strategy and Plan	100108219	5.0	EDRMS	NNB GenCo (HPC)
8.	SZC RSR Permit Application Head Document	100115743	1.0	EDRMS	SZC Co.
9.	SZC RSR Permit Application Support Document A1 – Environment Case	100198762	1.0	EDRMS	SZC Co.
10.	SZC RSR Permit Application Support Document C1 – Plant Monitoring	100199173	1.0	EDRMS	SZC Co.
11.	Generic Design Assessment DAC for UK EPR™, 13th December 2012	ONR-GDA-DAC-12-001	-	http://www.onr.org.uk/new-reactors/reports/step-four/close-out/epr70475n.pdf;	ONR
12.	Meeting the Energy Challenge: A White Paper on Nuclear Power	Cm 7296	-	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/228944/7296.pdf	Department for Business, Enterprise & Regulatory Reform (BERR)
13.	Determination of Revised Spent Fuel Disposal dates for HPC	100109174	1.0	EDRMS	NNB GenCo (HPC)
14.	UK Strategy for the Management of Solid Low Level Waste from the Nuclear Industry, February 2016	URN 15D/472	-	assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/497114/NI_LLW_Strategy_Final.pdf	DECC
15.	The Future of Nuclear Power. The Role of Nuclear Power in a Low Carbon UK Economy: Consultation Document, May 2007	-	-	https://webarchive.nationalarchives.gov.uk/+/http:/www.berr.gov.uk/files/file39197.pdf	Department of Trade and Industry
16.	Managing Radioactive Waste Safely. A Framework for Implementing Geological Disposal	Cm 7386	-	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/68927/7386.pdf	DEFRA
17.	Geological Disposal: Disposal System Specification Part A High Level Requirements	DSSC/401/01	-	https://rwm.nda.gov.uk/publication/geological-disposal-disposal-system-specification-part-a-high-level-requirements/	NDA

Ref	Title	Document No.	Version	Location	Author
18.	The Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009	No. 1348	-	http://www.legislation.gov.uk/uksi/2009/1348/data.pdf	Statutory Instruments
19.	Strategy for the demonstration of disposability for waste and spent fuel – Timescales for HPC Letter of Compliance Submissions	100111985	3.0	EDRMS	NNB GenCo (HPC)
20.	Implementing geological disposal – working with communities: long term management of higher activity radioactive waste	-	-	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766643/Implementing_Geological_Disposal_-_Working_with_Communities.pdf	BEIS
21.	EDF Energy Sustainable Business Company Policy	-	3.0	IMS	EDF Energy
22.	SZC RSR Permit Application Support Document E1 – Company Manual	100200202	1.0	EDRMS	SZC Co.
23.	SZC RSR Permit Application Support Document E3 – Compliance Matrix	100133371	1.0	EDRMS	SZC Co.
24.	Operational Solid Radwaste Process Manual	100111890	2.0	EDRMS	NNB GenCo (HPC)
25.	Scope of and Exemptions from the Radioactive Substances Legislation in England, Wales and Northern Ireland: Guidance document, 2018	-	-	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/731733/RSL_Guidance_update_BEIS_format_v5_180803.pdf	BEIS
26.	Identification of the preferred option for the Storage and Disposal of Non Fuel Core Components at HPC-UKX	NNB-GEN-U9-000-REP-100000	2.0	EDRMS	NNB GenCo (HPC)
27.	Management Strategy for Operational Intermediate Level Waste	100176280	2.0	EDRMS	NNB GenCo (HPC)
28.	HPC ILW Decay Storage Strategy Review	HPC-NNB-OSL-XX-000-STR-100004	1.0	EDRMS	NNB GenCo (HPC)
29.	Management of the Treatment of ILW Resins	HPC-NNBOSL-U9-HQX-REP-100000	1.0	EDRMS	NNB GenCo (HPC)
30.	Study for the Management of ILW Resins on the Hinkley Point C Site	HPC-UK1421-AU-TES-STU-02025	C	EDRMS	NNB GenCo (HPC)
31.	Geological Disposal: An Overview of the RWM Disposability Assessment Process	WPS/650/03	-	https://rwm.nda.gov.uk/publication/wps65003-geological-disposal-an-overview-of-the-rwm-disposability-assessment-process/	NDA
32.	Effluent Release Options from Nuclear Installations: Technical Background and Regulatory Aspects	OECD, 2003, ISBN 92-64-02146-9	-	https://www.oecd-nea.org/rp/pubs/2003/3690-effluent.pdf	OECD
33.	SZC – RA - Justification of Stack Height for the Proposed Sizewell C Nuclear Power Station	100101549	1.0	EDRMS	SZC Co.
34.	Hinkley Point C Revised MADA Study for Storage of Spent Fuel	HPC-NNBOSL-U9-000-REP-100009	2.0	EDRMS	NNB GenCo (HPC)
35.	Geological Disposal Steps towards implementation March 2010	NDA/RWM/013.	-	https://rwm.nda.gov.uk/publication/geological-disposal-steps-towards-implementation-march-2010/	NDA

Ref	Title	Document No.	Version	Location	Author
36.	Geological Disposal – Feasibility studies exploring options for storage, transport and disposal of spent fuel from potential new nuclear power stations, Jan 2014	NDA/RWMD/060/Rev 1	1.0	https://rwm.nda.gov.uk/publication/geological-disposal-feasibility-studies-exploring-options-for-storage-transport-and-disposal-of-spent-fuel-from-potential-new-nuclear-power-stations/	NDA
37.	Technical Note Outline Design for a Reference Repository Concept for UK High Level Waste-Spent Fuel 2005	502644	-	https://rwm.nda.gov.uk/publication/technical-note-outline-design-for-a-reference-repository-concept-for-uk-high-level-waste-spent-fuel-2005/	NDA
38.	Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulation	-	1.0	https://www.sepa.org.uk/media/365893/2018-07-17-grr-publication-v1-0.pdf	EA/SEPA/NRW
39.	An Overview of the Processes for Ensuring Records Necessary for Decommissioning Planning and Management of Higher Activity Waste and Spent Fuel are Generated, Received and Stored.	100121822	2.0	EDRMS	NNB GenCo (HPC)
40.	EDF Energy Environment Policy	-	6.0	IMS	EDF Energy
41.	Interim Spent Fuel Storage Safety Report	HPC-NNBOSL-U9-000-REP-10011	2.0	EDRMS	NNB GenCo (HPC)
42.	Radioactive Waste Strategy, 16th September 2019	n/a	-	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/831727/Radioactive_Waste_Management_Strategy_September_2019.pdf	NDA
43.	Generic Design Assessment SoDA for UK EPR™, 13th December 2012	LIT 7566	-	https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/301517/LIT_7566_df69bf_1_.pdf	EA

2 SITE DESCRIPTION

11. The SZC site is situated in Suffolk, on the coast of the North Sea, to the east of Leiston and to the north of Thorpeness. To the north of the site lies Minsmere; a 1,000-hectare Royal Society for the Protection of Birds site consisting of reed bed, lowland heath, acid grassland, wet grassland, woodland and shingle vegetation. The nearest main road is the A12, which lies approximately 8 miles to the west of the site, and connects Lowestoft to the north and Ipswich to the south.

12. The SZC installation is close to two other nuclear power station sites:

    - SZA - a gas-cooled reactor of the Magnox design and managed by Magnox Ltd on behalf of the NDA. Electricity generation at SZA ceased in 2006, the station is now being decommissioned and all fuel has been removed from the site; and
    - SZB - a Pressurised Water Reactor (PWR) operated by Nuclear Generation Limited (formerly British Energy, a separate operating unit of EDF Energy). This station still generates electricity and is expected to continue operating beyond 2030.

13. It is not anticipated that SZC will share any facilities relevant to waste or spent fuel management with these sites, with the exception of local transportation routes.

2.1 Site Development

14. The SZC programme shows the project will be undertaken in a number of key phases, as summarised below.

2.1.1 Pre-construction

15. The purpose of the pre-construction phase to produce a detailed design of structures, systems and components making up the SZC UK EPR^{TM} to ensure that they will perform their required functions, for SZC this has followed the replication strategy. This involves undertaking detailed design of structures and components to ensure that they will perform their required functions. Detailed design typically concludes with a design freeze, the generation of specifications for manufacture (with further design, if necessary) and an agreement to move forward into construction. Although no radioactive waste will be generated, or spent fuel managed, during this phase the decisions taken with regard to management of design and operational strategies and arrangements will have a major impact on these aspects during subsequent phases. The process of eliminating or reducing waste at the design stage is the highest priority option under the waste hierarchy. The Environment Case A1 describes elements of the design which contribute to the implementation of the waste hierarchy.

16. As described above, the starting SZC design has been adopted from HPC which has already undertaken some detailed design. It is expected that further detailed design will take place for both HPC and SZC, including site specific details, and the management arrangements in place for SZC to manage and control the design will ensure these are appropriately incorporated to a future SZC reference configuration.

2.1.2 Construction

17. The construction phase includes the construction of SZC and the associated developments that support the main site. This stage involves the construction of structures and the manufacture and installation of components. Many of the structures and components will be manufactured and/or constructed at locations remote from SZC.

2.1.3 Commissioning

18. Commissioning of a reactor and its supporting waste and spent fuel management facilities involves a series of tests to demonstrate, to the extent practicable, that the installations, as built and including all components and systems, are capable of safe and reliable operation in accordance with their design specifications, performance objectives and safety and environmental protection requirements. SZC commissioning comprises two phases:

- Non-active commissioning of systems and components, including functional testing, where functional testing by pressure testing and examinations of the nuclear components ensures that the reactor is safely operable under full temperature and pressure conditions, albeit without fuel – these tests being completed before fuel is loaded into the reactor; and
- Active commissioning of system and components, including testing the spent fuel storage systems before fuel loading, loading of fuel into the reactor vessel, initial criticality and power ascension testing, where the reactor is progressively increased in power and the operational and safety performance is verified. Radioactive waste may be produced during the active commissioning phase.

2.1.4 Operations

19. A UK EPR^{TM} reactor unit has an operational design lifetime of approximately 60 years, plus up to 10 years of spent fuel storage in the ponds inside the plant; before transfer to the Interim Spent Fuel Store (HHK). The expected electrical output of SZC will be approximately 1,670 megawatts (MWe) per unit giving a total site capacity of 3,340MWe per year of operation. The SZC design is such that once the fuel is loaded in the reactor core the reactor can operate at full power continuously in a 'fuel cycle' of up to 22 months. Electricity that is generated in the turbine halls will be converted by transformers to high voltage (400 kilovolts), before being exported by two overhead lines connected to the National Grid. While all measures have been taken to avoid, and where this is not possible, minimise the generation of radioactive waste, small quantities of radioactive waste are unavoidably created during operations. These radioactive wastes, including liquid and gaseous discharges, are safely disposed of in a way to minimise the impact on the environment and members of the public.

2.1.5 Decommissioning and Site Restoration

20. The Decommissioning strategy for SZC is Early Site Clearance [Ref 7]. Fundamentally the strategy means that decommissioning would commence as soon as practicable after End of Generation (EoG) at the site, and would proceed without significant delay to complete the decommissioning process. High level decommissioning plans for SZC estimate that site decommissioning, with the exception of the HHK, could be achieved approximately 20 years after the EoG. Best Available Techniques are applied to minimise the amount of radioactive waste produced during the decommissioning and site restoration phase. As described below, the spent fuel and Intermediate Level Waste (ILW) stores are designed to provide interim cooling and storage until the packages have cooled to suitable levels to enable long term storage/disposal to national facilities, as available. Once the spent fuel and ILW is removed from site, the remaining structures (HHK and Interim Intermediate Level Waste Store (HHI)) will be decommissioned and the operator will seek to surrender the RSR permit.

3 PLANT DESCRIPTION

21. SZC will comprise two UK EPR^{TM} units of the same fundamental design as assessed under the Generic Design Assessment (GDA) process for which the regulators, the Office for Nuclear Regulation (ONR) and the EA, granted a Design Acceptance Certificate and Statement of Design Acceptability respectively. SZC is a PWR of the same design as HPC and similar in design to other units currently in operation and under construction worldwide.

22. As for many other PWRs, the design of SZC physically separates nuclear facilities from non-nuclear facilities, as far as practicable, in order to minimise radiation doses to workers and minimise radioactive waste associated with routine operations. Therefore, the design is based on two main components, namely the "Nuclear Island" and the "Conventional Island". The SZC layout locates the Reactor Building at the centre of the Nuclear Island, which houses the main equipment of the Nuclear Steam Supply System.

23. SZC has a number of key facilities for the processing and interim storage of radioactive waste and spent fuel:

- The Active Drains and Vents (RPE) system, which collects and channels liquid and gaseous waste from the primary circuit and related facilities to the appropriate treatment system e.g. the system for treatment of primary liquid effluent, the Liquid Waste Treatment System (TEU) for non-recycled effluents and the Gaseous Waste Treatment System (TEG);
- The Solid Waste Treatment System (TES) for the processing and treatment of solid radioactive waste;

- The HHI, which stores solid radioactive waste pending ultimate disposal in the Geological Disposal Facility (GDF); the storage facility will also be utilised for the decay storage of solid short-lived ILW to enable subsequent disposal as Low-Level Waste (LLW);
- The HHK, dry storage for all the spent fuel generated at SZC, pending ultimate disposal in the GDF;
- The Conventional Island Drainage System (SEK), which collects and channels potentially chemically contaminated effluents (such as those from the Turbine Hall (HM) and the Demineralised Water Production Building), and channels them to the SEK or the Liquid Radwaste Monitoring and Discharge System (KER) tanks where they are monitored and, if required, treated, prior to discharge; and
- The discharge tunnel, which is common to both reactor units, for the final disposal of treated liquid effluent into the North Sea.

24. The above facilities are discussed in more detail in subsequent sections of this IWS. Environmental permits will be sought to cover all relevant activities across the whole installation. Demonstrating compliance against these permits will require the monitoring of discharges, details for which are covered in [Refs 8, 9 & 10].

25. It is important to note that, apart from the shared facilities noted above, the design of the two UK EPR^{TM} units comprising the SZC installation is essentially the same as considered during GDA. The initial reference design for the SZC project is the RC2 design of HPC. Where there has been changes/development of the design for HPC (to incorporate learning from other EPR^{TM} construction projects, to adapt to the UK context, etc.) since GDA, these have gone through a formal design change process between NNB GenCo (HPC) and the Responsible Designer (RD). A similar process will be adopted for the SZC project with any subsequent changes to the SZC design managed between SZC Co. and the RD.

4 RISKS AND OPPORTUNITIES

26. The following sub-sections highlight the constraints, from various perspectives leading to the current iteration of the SZC Integrated Waste Management Strategy.

4.1 Design Maturity and Dependencies

27. The initial SZC reference configuration (termed RC0) is based on the HPC design configuration RC2 that is mature. RC2 refers to a design configuration that is fit for commissioning and includes detailed design of systems to far greater extent than was assessed at GDA. The concept of replication from HPC to SZC offers significant safety benefits as well as a more economic and efficient means of construction. Importantly, the nuclear island, the areas of plant which will result in the generation, treatment, storage, monitoring and disposal of radioactive waste will be unchanged and are not affected by site specific factors. Therefore, there is a low risk that future design enhancements will significantly impact the management and disposal of radioactive waste and spent fuel. Thus, the content of this IWS is unlikely to significantly change as a result of any future changes in the SZC design.

4.2 Regulatory Risks and Opportunities

28. The UK regulatory framework for the management of radioactive waste and spent fuel is complex, with a range of legislation and policy covering solid radioactive waste and radioactive discharges, decommissioning, sustainable development, health and safety, and security. There are a number of regulatory requirements that affect waste management at SZC, which are taken into account in the design and are presented in [Ref 2].

29. The UK EPR™ was originally designed to comply with French regulatory requirements for nuclear installations and the protection of the environment, which are aimed at reducing the impact of discharges incurred by industrial activities and protecting populations and the environment. These aims are consistent with those of corresponding UK regulation and legislation and derive from the same international principles, guidance and legislation on nuclear safety and radiological and environmental protection, such as the Basic Safety Standards, relevant European Directives issued under the EURATOM treaty and other European Directives, which address environmental protection.

30. Having satisfied the nuclear regulator's, in England and Wales, GDA requirements, EDF and AREVA as joint requesting parties were granted on the 13th December 2012 a Design Acceptance Confirmation (DAC) from the ONR and a Statement of Design Acceptability (SoDA) from the EA for the UK EPR™ [Ref 11][Ref 43]. This is valid for 10 years and therefore remains extant for the permitting and licensing phase of the SZC project, noting that SZC Co. does not plan to make significant changes in design from GDA, or that now of HPC.

31. The EA produced a decision document during the determination process for HPC, outlining the considerations and decisions for the RSR permit application, including intended permit conditions and limits. This included regulatory justification and review of the HPC IWS, SZC Co. have considered this document in the development of the SZC IWS.

4.3 Financial Risks and Opportunities

32. The 2008 Nuclear White Paper [Ref 12] sets out the Government's policy that the owners of new nuclear power stations must set aside funds over the operating life of the power station to cover the full costs of decommissioning and their full share of waste and spent fuel management and disposal costs. This includes the costs of providing safe, secure, environmentally acceptable interim storage for spent fuel and ILW until a GDF is ready to accept this material. A legal framework that implements this policy was established through the Energy Act 2008, which requires new nuclear power station operators to develop a Funded Decommissioning Programme (FDP) and gain approval from the Secretary of State before the site can be developed by virtue of the site licence.

33. The costs for decommissioning, waste and spent fuel management and disposal for SZC will be defined by a FDP. SZC Co. must set aside funds over the operating life of the SZC to cover these costs in full. In parallel with the FDP arrangements, a waste transfer contract will be agreed between the SZC Co. and Government, whereby Government will take title to and liability for the ILW and spent fuel in exchange for a payment from the operator to cover the costs of their management and disposal.

4.4 Timing Risks and Opportunities

34. During the 60-year operational period, radioactive waste will be produced and processed on a continuous basis. The current strategy for the management of LLW relies on its transfer off-site to the Low Level Waste Repository (LLWR) and other available suitably permitted radioactive waste providers for treatment/disposal as it arises. It is recognised that the LLWR has a current estimated lifetime shorter than that for the operation of SZC. It is assumed that, as stated in Government policy and enshrined in Part 4 of Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2016, as amended [Ref 1], a new disposal facility will be provided by the NDA to cover the period after the LLWR has ceased to receive waste. If the new disposal facility is not provided at the required time, this will require SZC to store LLW on site until a disposal facility becomes available. However, noting that the volumes of operational arisings are expected to be relatively low, the SZC design incorporates a buffer zone in the waste treatment building that will allow waste to be stored temporarily, as necessary. In addition, the ongoing application of the waste hierarchy and waste segregation

practices, as well as the use of potential alternative disposal routes, such as via exemption provisions (formerly Very Low Level Waste (VLLW)) and facilities for metals recycling, is expected to reduce reliance on LLWR and thus minimise the potential need to store LLW at SZC.

35. The disposal of ILW from SZC is dependent on the availability of the GDF and the timing of it being able to receive waste from SZC. The GDF will not be available to receive ILW on the expected timescales for when SZC starts operating, nor is it likely to be available for many years thereafter. The strategy for ILW management at SZC is, therefore, to store the waste on-site in a safe form pending future disposal. Due to the current uncertainties in the date when the GDF will be available to receive waste, provision will be made at SZC to store all of the expected ILW that could arise during all phases of the SZC.

36. The 2008 Government White Paper, Cm 7296 [Ref 12] concluded that any new UK nuclear power station should proceed on the basis that spent fuel will not be reprocessed and that plans for, and financing of, waste management should proceed on this basis. The strategy for spent fuel management at SZC is, therefore, to store all of the spent fuel on-site, pending disposal as a waste, in such a manner that does not foreclose the option for reprocessing should this become a viable alternative in the future. Provision will be made at SZC to store the spent fuel on-site for up to 55 years following the EoG [Ref 13] until the spent fuel is sufficiently cooled for disposal. Radioactive wastes arising from the operation of on-site spent fuel stores will be managed in a manner similar to that for similar wastes produced as a result of station operations.

4.5 Sustainability Risks and Opportunities

37. Sustainable development and protection of present and future generations is taken into account in the development of radioactive waste and spent fuel management strategies for SZC. The design process has taken account of the implications of strategies on future generations by means of optimising the use of resources, including waste disposal facilities, and applying the waste hierarchy. SZC is designed to minimise waste arisings and their impact on the environment so that there is no undue burden on future generations. The financial arrangements made under the FDP and the waste transfer contract, ensure that all waste and decommissioning liabilities are covered by a programme, which can be implemented and has secure financing.

38. The SZC project will provide a reliable source of low carbon electricity for the UK to support the Government's decarbonisation policies. The design of the plant and the protection systems take into account climate change considerations to ensure the safe operation of the facility for the duration of its design life.

39. In line with sustainability drivers, decisions around waste management at SZC respect the proximity principle where practicable to minimise any unnecessary detriment, particularly associated with the transport of wastes for disposal.

4.6 Waste Disposal Constraints and Dependencies

40. Where disposal routes are available, such as for LLW, disposal of radioactive wastes from SZC will be progressed. However, where these are unavailable, such as for ILW and spent fuel, suitable storage arrangements will be provided at SZC.

41. In line with the Government's LLW policy, it is assumed that a route for disposal of waste via exemption provisions (formerly VLLW) to a suitably permitted facility will be available throughout the lifetime of SZC and that this will provide a viable management option for a range of UK EPR^{TM} waste streams, particularly those arising from decommissioning. To assist in implementing a LLW minimisation strategy, the approach at SZC is for appropriate wastes to be transferred off-site for high force compaction or incineration to reduce the volume of waste ultimately requiring disposal. Pursuit of the strategy of incineration is aligned with the UK Strategy for

the Management of Solid Low Level Waste from the Nuclear Industry [Ref 14]; it is widely used both here in the UK and abroad. Metals recycling will also be considered for appropriate waste, which is consistent with the objective of maximising the capacity of LLWR, as set out in the aforementioned LLW strategy [Ref 14].

5 ASSUMPTIONS

42. It is assumed that new nuclear power stations will be built in the UK and all the disposal routes discussed above will be available within the timescales required by a new station, as indicated in the base case assumptions that Government has given for operators to develop their Decommissioning and Waste Management Plans [Refs 15 & 16]. A number of specific assumptions relating to this IWS are presented in Table 5-1, which also presents information on potential opportunities relating to waste management.

Table 5-1 Assumptions relating to this IWS

Assumptions	Reasoning and Impact on IWS/Design of SZC
The full lifetime arisings of spent fuel will be stored on-site for up to 55 years following the EoG.	A national GDF for spent fuel will not be available to accept new build spent fuel until 2145 [Ref 17]. As described by reference [Ref 13] disposal of spent fuel can commence 55 years after the EoG. This employs a strategy of mixing long and short cooled spent fuel.
ILW will be stored safely and securely on site until the GDF is available for its disposal.	In the UK ILW is normally stored on the site at which it arises as there are no alternative storage locations. The SZC design incorporates capability for sufficient storage capacity for ILW arisings over the design lifetime.
Spent Fuel will be processed and packaged for disposal at an on-site facility	Each new nuclear power station will include facilities for the encapsulation of spent fuel prior to despatch to the GDF. SZC Co. may seek to utilise shared facilities with its proposed series of UK EPR™ stations but this concept is not well developed at this stage.
ILW and spent fuel can be conditioned and packaged into passive forms to meet the standards required by NDA-RWM, for disposal at the proposed GDF.	As part of the GDA process, the views of Radioactive Waste Management Ltd (RWM) on the acceptability for disposal of ILW and spent fuel from UK EPR™ units were sought. RWM concluded that, in principle, conditioned ILW and spent fuel will be acceptable for disposal. NNB GenCo (HPC) has since received a conceptual Letter of Compliance from RWM for the disposal of operational ILW that covers HPC. NNB GenCo (HPC) has also developed a schedule for HPC for making future disposability submissions for ILW and spent fuel [Ref 19]. A Letter of Compliance (LoC) schedule for SZC will be produced and follow the same logic.
SZC can utilise the work undertaken by HPC on ILW and spent fuel packaging and disposal to develop and obtain its own LoC.	It is expected that the SZC ILW and spent fuel will also be acceptable for disposal and that their justification can be based on that work undertaken for HPC.
LLW and ILW will be segregated so far as is reasonably practicable and managed to ensure that volumes are minimised	This will be achieved through the application of BAT to minimise arisings, in both the engineered systems, and in management systems.
Authorised disposal routes for LLW will be available throughout the design life of SZC.	This assumption is based on the current UK LLW policy [Ref 14] and strategy and infers that capacity for long term storage of large volumes of LLW on site is not required in the SZC design.

Assumptions	Reasoning and Impact on IWS/Design of SZC
Appropriate radioactive wastes can be disposed of via commercially operated incineration companies.	A number of radioactive wastes arising from nuclear power operations are treated through incineration. SZC Co. recognises the need to ensure that appropriate wastes meet the Conditions for Acceptance for incineration routes. It is noted that combustible radioactive wastes from SZB are already managed by incineration in the UK. There is no plan to build and operate an incinerator at SZC.
Radioactive metallic wastes that are suitable for treatment (e.g. by melting) will be sent off-site where practicable.	Facilities for the treatment of metallic wastes are available in the UK and in Europe. Their use is consistent with the UK's LLW strategy.
A disposal route will be available for waste (formerly VLLW) via an exemption provision, throughout the operational and decommissioning phases of SZC.	This is based on the current UK LLW strategy. Availability of such disposal routes waste will reduce waste disposal costs and enable more effective segregation of radioactive wastes, thereby minimising future LLW disposals. This is of particular importance for decommissioning waste. It is noted that there is a volume limit on waste that can be disposed of via the exemption provision. SZC Co. do not consider this volume to be of concern for SZC, the most appropriate and suitable waste route will be sought in each case in application of the waste hierarchy.
LLW generated by SZC is disposable at LLWR	As part of the RSR permitting process waste characteristics will need to be submitted to LLWR for a disposability assessment to ensure that all of the identified LLW generated at SZC will meet the current Waste Acceptance Criteria (WAC) at LLWR. Disposability in Principle (DiP) arrangements have been obtained for all UK EPR™ LLW including combustible waste to an incinerator and exemption provision disposals to a suitably permitted landfill.
Waste volume estimates are based on GDA, taking account that there are two UK EPR™ units at SZC.	These estimates determine the capacity for waste storage and processing facilities for SZC. They are based on extensive review of PWR operating experience for EDF stations in France and more widely across Europe, and take account of best practice in PWR operation. The waste arisings are therefore based on practical experience rather than theoretical estimates, consequently there is expected to be a lower margin of uncertainty associated with them. They are also consistent with waste volumes identified during GDA and at the permitting and licensing stage at HPC.
Decay storage of wastes containing short-lived isotopes will be used where practicable to reduce the volume of waste disposed of as ILW.	Decay storage of suitable wastes to enable disposal as LLW is already used in the UK and will be employed at SZC where practicable.
Disposal facilities for ILW and spent fuel will be available to SZC on the timescales indicated in this IWS.	GDF is the UK Government's policy for ILW and spent fuel disposal and a timeframe for GDF operations [Refs 17, 19 & 20] is consistent with the timescale identified in this IWS for the anticipated disposal for SZC ILW and spent fuel.

6 WASTE MANAGEMENT ORGANISATION AND ARRANGEMENTS

6.1 SZC Co. Policy and Principles

43. SZC Co. has an Environment Policy and a Sustainability Policy [Refs 40] [Ref 21], which are presented on the SZC project Integrated Management System (IMS) that set out key principles to be applied in all work activities. Care for the environment and waste management are central tenets of these policies.

44. The development, construction, operation and decommissioning of SZC will have an impact on the environment because of the use of natural resources and generation of wastes and discharges. It has been SZC Co.'s policy

during the design of SZC to minimise these impacts as far as reasonably practicable, consistent with sustainability principles. With respect to the environment and waste management, it is the policy of SZC Co. to demonstrate compliance with all current environmental legal requirements for SZC as an absolute minimum and to optimise waste production and effluent discharges to ensure they are kept As Low As Reasonably Achievable.

45. All the organisations that have been involved in the design of SZC, including sub-contractors, are committed to developing and maintaining a focus on best environmental practices, and to ensure that the design minimises the impact on people and the environment. Beyond the design, SZC Co. is committed to construction, operation and the ultimate decommissioning of SZC in a manner which minimises its impacts on workers, the public and the environment.

46. In support of the Environment Policy, a standard has been developed relating to Integrated Waste Management [Ref 2]. The standard provides core waste management principles that cover all waste with a subset that are of specific relevance to radioactive wastes.

6.2 Links to project phases

6.2.1 Pre-Construction Phase

47. Before construction starts on site, a large amount of work is undertaken to set up the organisation, adopt and accept the design and arrangements into SZC Co. which could have an impact on the environment, now or in the future. Permit and licence applications are made during this phase to facilitate this process.

6.2.2 Construction Phase

48. It is recognised that radioactive waste may be discovered or produced on site during construction and commissioning, through the identification of pre-existing ground contamination, incorrect or error of radioactive sources (e.g. from radiography, these will be managed via appropriate permits as necessary). Construction related environmental permits will be applied for separately to this RSR application, at an appropriate time as judged by the operator SZC Co. [Ref 22]. There is negligible risk of migration of radioactivity from neighbouring nuclear reactor sites given that there will be a dividing (cut-off) wall between the SZB/SZC sites, which would prevent the migration of radionuclides via groundwater.

49. However, the construction phase is very important from a waste management perspective as it is when the configuration of the plant is locked in place; including the structures, systems and components that will give rise to the waste. It is recognised that from this point onwards the strategy must focus on how the waste is managed rather than what waste will be produced.

6.2.3 Commissioning Phase

50. This phase of the project involves a thorough programme of testing to demonstrate that the reactor plant, as built and including all components and systems, is capable of both safe and reliable operation as far as it is practicable. This is in accordance with its design specification performance objectives and safety environmental requirements, including confirmation that the IWS is suitable. The commissioning of the reactor comprises two phases:

- Non-active Commissioning: This includes both systems and components and their functional testing. Functional testing by pressure testing and examinations of those components of nuclear safety significance ensures that the reactor is safely operable under full temperature and pressure conditions, albeit without fuel. These tests are completed before fuel is loaded into the reactor.

- Radioactive (Active) Commissioning: This phase of commissioning commences with fuel delivery and involves the active commissioning of the reactor components, e.g. testing the fuel storage systems before fuel loading, loading of the fuel into the reactor vessel, initial criticality and power ascension testing. During power ascension testing the reactor is progressively increased in power and the operational and safety performance is verified. This phase will generate waste and effluent of the same nature as those generated during the operational phase.

6.2.4 Operational Phase

51. The waste management organisation for SZC operations is currently being developed by SZC Co. and will form part of the broader arrangements necessary to comply with the requirements of the expected nuclear site licence and Environmental Permits, in addition to other essential business and regulatory requirements. The development of the waste management organisation will take account of the operation of other similar stations in France and the UK to ensure that the organisation meets UK regulatory requirements.

6.2.5 Decommissioning phase

52. The FDP and DWMP will be further reviewed and revised, including changes to the organisation structure and management arrangements (processes and procedures) to recognise the change in work activity required for decommissioning.

6.3 Company Manual

53. SZC Co. has produced a Company Manual (incorporating the necessary elements of the Safety and Environmental Management Prospectus in parallel to this IWS to support the RSR permit application [Ref 22]; where details of the strategic arrangements for the control, leadership and direction of nuclear safety, conventional health and safety, environmental safety and security are presented. The Company Manual is supported by a Management System Manual which sets out the structure of the Integrated Management

Figure 6-1 Relationship between the IWS and other key project documentation

System and Nuclear Baseline that sets out the staffing and competency requirements in order for SZC Co. to deliver against its numerous requirements, including environmental permits.

54. As with the operational waste management organisation, the SZC waste management arrangements are yet to be developed in detail and will form part of the overall arrangements for regulatory compliance and the operational needs of the installation. The relationship of the IWS to other SZC Co. documentation is presented in Figure 6-1. This shows how the IWS interfaces with other documentation relevant to waste management on the SZC project. The IWS does not introduce any new justification/ substantiation beyond what is recorded elsewhere, it simply summarises how radioactive waste and spent fuel will be managed at SZC. The detailed justification for why radioactive waste and spent fuel is managed in a certain way can be found in the supporting references. The Radioactive Waste Management Case, still to be developed, will map to the IWS and be a key reference for understanding how radioactive waste and spent fuel will be managed at SZC. A permit compliance matrix has been developed as part of the RSR permit application supporting document on management arrangements [Ref 23]. The proposed conceptual structure of the waste management arrangements is presented in Figure 6-2. This structure identifies the IWS at the core of the arrangements. It is informed by regulatory framework and compliance principles outlined in the Integrated Waste Management Standard [Ref 2], Environmental Optimisation Standard [Ref 3] and Land Quality Standard [Ref 4]. Under the IWS are a series of waste management framework documents. The role of these documents is to identify the process for management of the waste streams based on the strategy in the IWS, including the specific sets of procedures to manage each waste stream. This enables a 'golden thread' to run through the arrangements and allows traceability from Company policies through the environmental standards and the IWS to the procedures. Specific Work instructions will then sit under the developed procedures along with relevant guidance.

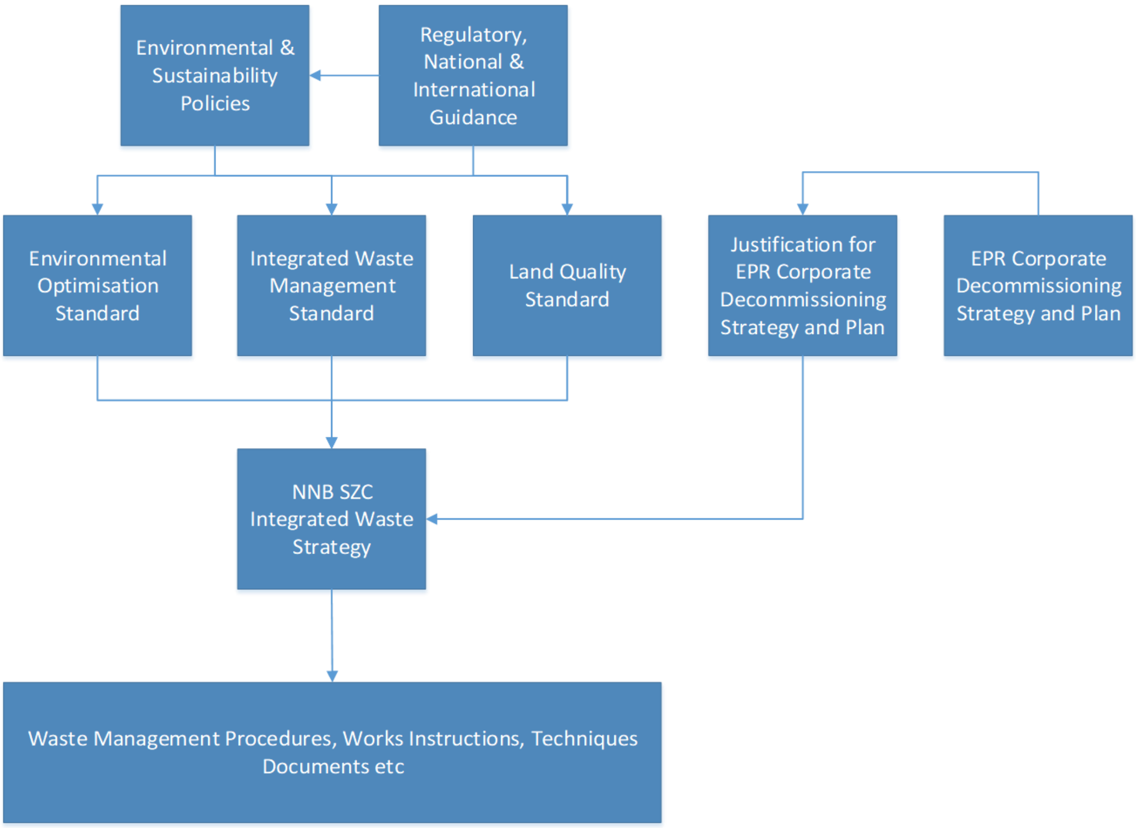

Figure 6-2 Proposed structure of integrated waste management framework

55. The development of suitable and accredited environmental management arrangements will be carried out by SZC Co. and be available prior to SZC's operational phase - details provided in the RSR permit application support document E1 [Ref 22].

56. All technical reports undergo review by Suitably Qualified and Experienced Persons within SZC Co., and subcontractors if required, to check accuracy, consistency and compliance with the project requirements. The waste and spent fuel management practices and associated plant will be reviewed as part of this process, in conjunction with an accredited Radioactive Waste Adviser with respect to the methodology adopted, the completeness of the justification presented, and the validity of the results, taking account of the work already carried out as part of the GDA and at HPC.

7 INTEGRATED WASTE MANAGEMENT STRATEGY

57. The following sections summarise the strategies for specific groups of radioactive waste and provide an overview inventory of the expected arisings from the operation and decommissioning of SZC. The strategies are based on the application of BAT, incorporating the need to minimise arisings and to minimise the impacts of the waste disposals and discharges to the environment.

58. The strategies for radioactive waste and spent fuel management are based on the principles defined by SZC Co.'s Integrated Waste Management standard [Ref 2] and Environmental Optimisation standard [Ref 3].

7.1 Overview of Radioactive Waste Arisings from Sizewell C

59. The SZC project can be split into the following phases (See section 2.1), where radioactive waste management will be required in all but the first two phases (from the point of fuel on site):

- Pre-construction - site preparation activities;
- Construction - SZC units' main and ancillary buildings;
- Commissioning - tests leading to electricity production;
- Operation - electricity production;
- Decommissioning and Site Restoration - cessation of electricity production, followed by defueling; and the clearance of site (including the continued storage of spent fuel following reactor decommissioning).

60. The SZC design is similar to other PWR's operating worldwide in that the basic production "unit" is based on a primary system, a secondary system and a cooling system. Considerable detail concerning the make-up and operation of these systems is presented in the Environment Case. Whilst waste will arise from operation of all three sub-systems, the generation of radioactive wastes is principally associated with operation of the primary (reactor) circuit during start up, normal operation, and shutdown (fuelling and maintenance) conditions. Various radioisotopes arise from fuel fission and the activation of reactor circuit components, various constituents of the liquid coolant and corrosion products. Once present in coolant, radioactive materials are readily transported to all parts of the coolant circuit and thereby into other reactor support systems. A number of effluent processing systems are therefore employed to capture and treat such arisings from the primary circuit, leading to the production of the following three general radioactive waste streams for recycling, interim storage or disposal:

- solid waste (which includes mobile wastes such as resins and sludges that are treated and consigned off-site for disposal);

- liquid waste (discharged via the liquid effluent discharge pipeline); and
- gaseous waste (discharged via stacks).

61. Further detail regarding the generation of radioactive wastes and the key systems involved is provided in the RSR permit application head document [Ref 8].

62. Radioactive wastes generated during active commissioning will also be categorised as solid, liquid or gaseous and will wherever practicable be managed in the same manner, from the defined strategy, as those arising during operations.

63. In the UK, the following definitions are used (taken from the "Managing Radioactive Waste Safely" White Paper (2008) [Ref 16]):

- High level waste (HLW) is waste "in which the temperature may rise significantly as a result of their radioactivity, so that this factor has to be taken into account in designing storage or disposal facilities";
- ILW is waste "with radioactivity levels exceeding the upper boundaries for low-level wastes, but which do not require heat to be taken into account in the design of storage or disposal facilities"; and
- LLW is "radioactive waste having a radioactive content not exceeding four gigabecquerels per tonne (GBq/te) of alpha or 12 GBq/te of beta/gamma activity".
- Spent Fuel "is not currently classified as waste", [Nuclear fuel that has been irradiated and permanently removed from a reactor core. It is not expected that the fuel from SZC will be reprocessed.

64. It is noted that there are also non-radioactive properties of these radioactive wastes which could impact their management strategy or disposal route. For example, where the type of waste is recognised as 'radioactive' yet, either immediately or following decay the levels of the radioactivity have sufficient reduced to below permittable levels (to become exempt) there could still remain non-radioactive management controls necessary – such as hazardous chemical substances which may not be allowed to be directly disposed of at a landfill.

7.2 Operational Radioactive Wastes

7.2.1 Solid radioactive wastes

65. The strategy for solid radioactive wastes is that they are to be disposed of as soon as reasonably practicable where a viable disposal route is available. ILW and spent fuel for which there are no available disposal routes will be accumulated and safely stored on-site in compliance with the expected requirements of the NSL) and RSR Environmental Permit until a suitable disposal route or an alternative management route becomes available.

66. Detailed arrangements for radioactive waste management will be covered at a suitable phase of the project in SZC Co. operating procedures, required to demonstrate compliance with NSL and RSR requirements. For LLW, these instructions are anticipated to cover minimisation, segregation, characterisation/assessment, packaging, labelling, record keeping and consignment for transfer/disposal.

67. The application of BAT to the management of solid radioactive waste is demonstrated by the RSR permit application support document A1 [Ref 9] and outlines how the generation of solid radioactive waste will be avoided or reduced wherever possible. Waste that is unavoidably produced will be reduced in volume by

employing techniques such as shredding and/or low force compaction to minimise the volume of solid radioactive waste transferred to other facilities. Decay storage of solid ILW will be employed to divert waste away from the GDF.

68. The SZC design incorporates a number of measures aimed at minimising the volume/activity of solid waste arisings by facilitating their segregation and volume reduction; taking account of the review of the performance and operating experience from similar reactors.

- The composition of the primary circuit component materials has a direct impact on the radioactive inventory in the primary coolant, especially on the activation of corrosion products. Therefore, chemistry and radiochemistry are optimised in the SZC design to reduce the primary circuit radioactive inventory and lower the dose rate levels, which in turn will minimise the activity of corrosion products that contribute to solid waste arisings;
- Improved efficiency of recycling (e.g. coolant) and effluent processing systems to reduce solid waste volumes associated with the treatment of coolant and effluents; and
- Zoning of rooms and controlled areas to maximise the segregation of radioactive and non-radioactive wastes and thus minimise radioactive waste arisings.

69. The disposal of the waste from SZC will depend on the radioactivity level and physical characteristics of the waste produced. A number of treatment and disposal routes are anticipated to be available for waste generated by SZC and are outlined in the following sections:

- recycling of metals using commercially available routes;
- incineration of combustible wastes using commercially available routes;
- disposal to facilities authorised to accept exempt waste (notably for soil, rubble and aggregates) where no reuse or recycling options are viable;
- disposal of LLW at LLWR where the above alternatives are not viable;
- on-site interim storage of ILW pending decay to LLW or availability of an ILW disposal route; and
- on-site interim storage of spent fuel pending the availability of a disposal route.

7.2.2 Liquid and gaseous radioactive wastes

70. The RSR permit application support document A1 [Ref 9] describes how avoidance and minimisation of waste (including discharges) is achieved. Wastes that are unavoidably produced are planned to follow the 'concentrate and contain' principle as far as achievable. This results in gaseous and liquid waste streams being abated with a transfer of activity into a solid form. It is recognised that for tritium and carbon-14 (C-14) it is not viable to abate the discharges and there is no net benefit from the transfer of these radionuclides into a solid waste form. However, preferential partitioning in liquid or gaseous waste is applied to discharges of tritium and C-14 to reduce radiological impacts. Where radioactive wastes are generated with radionuclides of short half-lives then the principle of "delay and decay" is pursued, where practicable. This includes some noble gases in gaseous effluents and some shorter-lived fission and activation products in liquid and solid wastes.

The partitioning of total activity across the waste streams is summarised in Table 7-1.

Table 7-1 Partitioning of Activity based on Expected Best Performance (all nuclides) for Sizewell C (based on two UK EPRTM units)

Waste Stream	Expected best performance activity per annum (TBq), normal operations.
Solid	12.8
Liquid (excluding tritium)	0.04
Liquid tritium	104
Gaseous	3.30

71. In numerical terms discharges of liquid waste are dominated by tritium (as shown in Table 7-1). Due to the chemical and physical properties of the substances in which tritium is found, and the impracticability of effective abatement, the minimisation of tritium production at source is very important. Tritium's relatively low radiological impact means that, following minimisation of tritium generation at source, the tritiated waste which cannot be avoided is discharged to the environment. This is predominantly in liquid form; approximately 95% of the tritium produced will be discharged to sea. This is considered preferable as discharges to the marine environment have a lower dose per unit discharge than that of gaseous releases to atmosphere. It is assumed that there will be no organically bound tritium released.

72. Based on expected best performance the majority of C-14 discharges into the environment (80 – 95%) are in the gaseous form, with typically only 5 to 20% being discharged in liquid and solid wastes. It is estimated that the majority of gaseous discharges are as methane (about 80%) and a smaller part is discharged as CO_2 (around 20%). The majority of C-14 is degassed during the treatment of the primary effluents in the primary effluent Coolant Storage and Treatment System (TEP) and directed into the TEG to be discharged as gaseous effluent. Gaseous species containing C-14 are not expected to be retained in the filters and delay beds used in the TEG, or in the filters used in active ventilation systems. A proportion of C-14 is contained in the primary liquid effluents which may be retained on filters and ion-exchange resins in the primary effluent treatment systems, thereby giving rise to some C-14 incorporated into solid wastes.

73. Where a practicable means of abatement is available and is deemed to represent BAT, the principle of concentrate and contain of radioactivity into solid waste arisings in accordance with Government policy, will be achieved for SZC.

7.2.3 Management of Low Level Radioactive Waste

74. Table 7-2 provides a description of the LLW that will be generated from SZC operations. These can be grouped in two broad categories:

- LLW generated through routine operations; and
- LLW generated during maintenance and refuelling operations.

Table 7-2 Categories of LLW that will be generated at SZC

Waste Type	Waste Description
Steam Generator Blowdown System (APG) Ion-Exchange Resins	Ion-exchange beds are utilised in the APG to trap activation and fission products from the primary coolant circuit. In recycling the APG blowdown water from the SZC secondary circuit, the blowdown water is purified by the use of two parallel filters to remove suspended solids and two parallel demineralisation lines which use ion-exchange resins to perform the demineralisation

Waste Type	Waste Description
LLW Wet Sludge	During SZC operations, particulate will settle as sludges in various buffer and storage tanks associated with the auxiliary water circuits (e.g. Liquid Waste Processing System). These are contaminated with a range of fission and activated corrosion products. This sludge is periodically cleaned out and removed for treatment prior to disposal as solid LLW.
LLW Cartridge Filters	Filters are used to capture particulate in SZC water auxiliary circuits. Spent filter cartridges arise from the treatment lines of the following water auxiliary circuits: Chemical and Volumetric Control System (RCV), Reactor Boron and Water Make-up System (REA), TEU, and the Reactor Cavity and Spent Fuel Pond Cooling/Treatment System (PTR). Water filters are withdrawn from operation on the basis of clogging, dose rate or after a fixed period of operational use (whichever occurs first) and then treated as waste. The physical form of this waste stream consists of filter cartridges that are composed principally of stainless steel supports with glass fibre filter media and some organic materials. The amount of radioactive particulate (metallic oxides) trapped on each filter can vary. The majority of waste within this category is anticipated to be ILW at the point of generation but some LLW is expected at point of generation and from the decay of ILW.
Evaporator Concentrates	SZC proposes to make use of evaporation for the minimisation of activity in radioactive liquid effluents arising from the non-recyclable TEU Evaporation is an energy intensive process and therefore only used to treat effluents which are not compatible with demineralisation (i.e. chemically contaminated effluents). Evaporation will minimise the discharge of active aqueous effluents to the environment. It results in the production of a sludge-like concentrate that will contain the bulk of the radioactivity initially present in aqueous effluent streams as activated metal oxides. Although the sludge will be high in boron and chloride; therefore very hazardous, it's disposability is covered under the DiP from LLWR.
Air and Water Filters	All radiological controlled areas of the nuclear auxiliary building, fuel building, safeguards buildings, reactor building, operational production centre, access building and effluent treatment building are served by dedicated ventilation systems. The extract from these systems is subject to a number of airborne activity abatement techniques, including the use of High Efficiency Particulate Air (HEPA) filtration, before discharge to the environment. The HEPA filters remove particulate material to ensure doses to workers are as low as reasonably practicable (ALARP) and discharges to the environment are minimised. This also ensures that the doses to members of the public from airborne discharges are also minimised. The abatement systems will produce a number of spent LLW pre and HEPA filters over the course of reactor operations, although they're use is primarily for abatement in the event of an accident rather than for normal operations. In addition to the filters serving the primary systems, LLW water filters will be generated from the filtration of low activity effluent (TEU, APG). The physical form of this waste stream consists of filter cartridges that are composed principally of stainless steel supports with glass fibre filter media and some organic materials.
Dry Active Wastes	Dry Active Wastes comprise the combustible and non-combustible LLW generated through routine and maintenance operations at SZC and consist of contaminated personal protection equipment, monitoring swabs, plastic, clothing, contaminated tools, segregated pieces of metal, glassware and other process consumables. These wastes mainly arise during outages.
Oils and Solvents	Oils are used in the lubrication of various components, such as circulators and process pumps, and have the potential to become radiologically contaminated during normal service. Contaminated liquids, such as chemical cleaning solutions and solvents, used as decontamination agents also arise and will be included within this waste stream.
Metal Scraps and other metallic wastes (Dose rate < 2 mSv/h)	Metal wastes arise during maintenance operations from the replacement of equipment and components and may become contaminated and require disposal as radioactive waste.

LLW Volumes and Processing Strategy

75. The precise volume of solid LLW produced is dependent on the future management of the various systems associated with the operation of SZC. However, Table 7-3 provides the annual estimated production of raw

(untreated) LLW for two UK EPR™ units based on information from the French fleet, as presented in the GDA, and is consistent with that expected for HPC. The volume and activity of LLW requiring disposal from SZC will be minimised by the use of the Waste Hierarchy and the application of BAT. The figures presented in Table 7-3 are considered best estimates of solid LLW arisings from SZC. In addition to the volumes presented in Table 7-3, approximately 10 years following the start of generation, ILW that has decayed to LLW will be removed from the HHI, as indicated in Table 7-5, and disposed via the most appropriate route.

76. The anticipated volumes and processing strategy for the SZC LLW streams is summarised below in Table 7-3.

Table 7-3 LLW Generation, Processing and Disposal Strategy for SZC

Waste Type		Estimated Annual Raw Waste Volume (m^3)	Preferred Waste Arrangement	Alternative Waste Arrangement
APG Ion-Exchange Resins		15	Package as required to meet the WAC and transfer for disposal under exemption provisions.	Transfer for Incineration
Wet Sludge (from sumps, tanks)		1	Condition/package as required to meet the WAC and transfer for disposal to LLWR.	No alternative available
LLW Cartridge Filters from auxiliary circuit treatment		0.10	Condition/package as required to meet the WAC and transfer for disposal to LLWR.	No alternative available
Evaporator Concentrates		6	Condition/package as required to meet the WAC and transfer for disposal to LLWR.	No alternative available
Air and Water Filters		8	(Water Filters) Condition/package as required to meet Conditions for Acceptance and transfer for disposal to LLWR (Air filters) Transfer for high force compaction (air filters) and onward disposal to LLWR	Direct disposal to LLWR
Dry Active Wastes (excluding metals)	Non-Combustible	25	Transfer for High Force Compaction before onward disposal to LLWR.	Direct disposal to LLWR
	Combustible	75	Package and transfer for off-site incineration.	Direct disposal to LLWR
Waste Oils and Solvents		4	Package and transfer for off-site incineration.	No alternative available
Metal Scraps and metallic Waste		12	Package and transfer for off-site metals treatment.	Direct disposal to LLWR

LLW Management Facilities

77. LLW generated during the operational period from SZC will be transferred to the Radioactive Waste Storage and Processing Buildings (HQA/B) of Unit 1. This facility is designed to manage waste through, buffer storage, segregation and application of suitable treatments in preparation for off-site transport and disposal. LLW will be processed and packaged as required to meet the WAC of the appropriate off-site disposal facility. LLW from Unit 2 will be packaged for cross site transfer in Unit 2 Radioactive Waste Preparation Building (HQC). The key activities carried out in HQA/B are as follows:

Segregation

78. Solid wastes will be segregated and sorted at source to minimise secondary handling as far as practicable. Waste streams that generate mixed wastes will be sorted in a dedicated unit within the Radioactive Waste Processing Building (HQB) to optimise their subsequent management and disposal. If no further benefit can be obtained from further segregation then the waste will be transferred to the next stage. The benefits associated with waste segregation need to be balanced with the detriments associated with increased operator exposure.

79. Waste segregation will be carried out on the basis of different physical and chemical properties, e.g. combustible, non-combustible and compactable, and non-compactable waste streams.

Size Reduction/Shredding

80. Bulky solid combustible and compactable waste may be size reduced by cutting/shredding prior to further treatment, including hot spot removal.

Low Force Compaction

81. A low force compactor in the HQB will be used on-site to assist in the volume reduction of dry active wastes and air filters prior to transfer off-site for disposal.

Conditioning of LLW for Disposal

82. Some LLW, e.g. filters, sludges and resins, may require processing within the HQB either by dewatering, drying, or encapsulation in a mortar matrix within the waste disposal package prior to transfer from the site in order to meet the WAC for the proposed disposal site.

Handling and Transfer of Final Packages

83. Following treatment, the waste will be placed in an appropriate container for transport or disposal. After being sealed, the containers will be checked for the presence of external contamination prior to transfer out of the HQB. Waste containers awaiting transfer off-site will be placed in buffer stores and transferred into transportation containers; prior to loading onto the transportation vehicle.

84. Further detail on the management of LLW is documented by the Operational Solid Radwaste Process Manual [Ref 24].

LLW Disposal Strategy

85. A key consideration of the choice of preferred disposal route has been the commitment to demonstrate best use of existing UK LLW management assets. Therefore, direct disposal to LLWR is seen as the least desirable option and where a reasonably practicable alternative disposal route exists, e.g. incineration or metal melting, this has been chosen as the preferred option. This approach is consistent with the national strategy for LLW and SZC Co. will aim to utilise alternative disposal routes to the LLWR when available and demonstrated as being the BAT. This will contribute to the minimisation of disposal to the LLWR and maximise its remaining operational lifetime.

86. The strategy for LLW is that waste unavoidably generated will be disposed of as soon as reasonably practicable, following treatment to minimise volume and perform appropriate conditioning or packaging, as set out by Claim 3 within the RSR permit application support document A1 [Ref 9]. This will be following the application of BAT to minimise the amount of radioactive waste generated in the first place, through nuclear power plant operations and decommissioning. The ultimate disposal of the wastes is expected to be via one of the following main routes depending on the radioactivity level of the waste produced, its physical characteristics and its chemical properties:

- recycling of metals via commercially available routes;
- incineration of combustible wastes using commercially available routes;
- disposal to facilities authorised to accept exempt waste (notably for soil, rubble and aggregates) where no reuse or recycling options are viable;
- disposal of LLW at LLWR where the above alternatives are not viable.

87. SZC Co. will apply BAT to sort, segregate and sentence LLW before disposal. SZC Co. has reviewed the potential treatment and disposal options for LLW from SZC. The BAT for management of LLW generated at SZC are set out in Table 7-3 and diagrammatically in Figure 7-1.

Off-Site Metal Recycling Facility Operations

88. Where the metallic waste generated by operational maintenance work cannot be adequately decontaminated on-site, the waste will be transferred to an off-site commercial Metal Recycling Facility (MRF). The volume of metallic waste requiring disposal could be reduced by up to 95% using metal recycling techniques.

89. Once transferred to the MRF, a range of techniques will be applied. The metallic waste is decontaminated and cleaned using methods, such as dry grit blasting, so that the resulting materials can either be recycled in the UK or potentially sent to a facility for further cleaning by melting.

Off-Site Incineration Operations

90. LLW will be segregated to separate combustible from non-combustible waste items. There will be no on-site incineration. Combustible waste suitable for incineration will be transferred to an appropriately permitted commercial incinerator off-site; and incinerated in a specially engineered kiln up to around 1000ºC. Any gases produced during incineration are treated and filtered prior to emission into the atmosphere and will conform to international standards and national emissions regulations.

91. Incineration of combustible wastes is applied to both radioactive and other wastes in the UK. In the case of radioactive waste, incineration has been used for the treatment of LLW from nuclear power plants, fuel production facilities, research centres (such as biomedical research), the medical sector and waste treatment facilities.

92. Modern incineration systems are well engineered and designed to burn the waste efficiently whilst producing minimum emissions. Ash remaining following incineration will be disposed of by the operator off-site facility under their relevant permits; none is expected to be returned to SZC for subsequent management.

Off-Site Super Compaction Facility Operations

93. Suitable LLW will be transferred off-site to a super compaction facility to minimise its volume. In this process drums or boxes of waste are compacted under high pressure of up to 2,000 tonnes per square metre. Following super compaction, the waste will be packaged and transferred onward to LLWR for disposal.

Exemption Provisions

94. Where practicable, waste will be disposed of in accordance with the Exemption Provisions in the Environmental Permitting (England and Wales) Regulations 2016 (as amended), and the associated guidance from the Department of Environment, Food and Rural Affairs (DEFRA) [Ref 25].

LLWR Operations

95. LLW unsuitable for disposal via the above disposal routes, but which meets the WAC for LLWR, will be packaged on-site and transferred directly for disposal to LLWR in approved transport packages e.g. Half Height ISO Containers.

Disposability of LLW

96. To support the RSR permit application process a DiP has been obtained from LLWR to demonstrate that SZC does not generate any orphan wastes (i.e. wastes for which a disposal route does not exist) evaluated against the current waste acceptance criteria. SZC Co. will, in due course, develop appropriate commercial arrangements with waste service provider(s) having applied BAT and the waste hierarchy to dispose of radioactive waste from SZC.

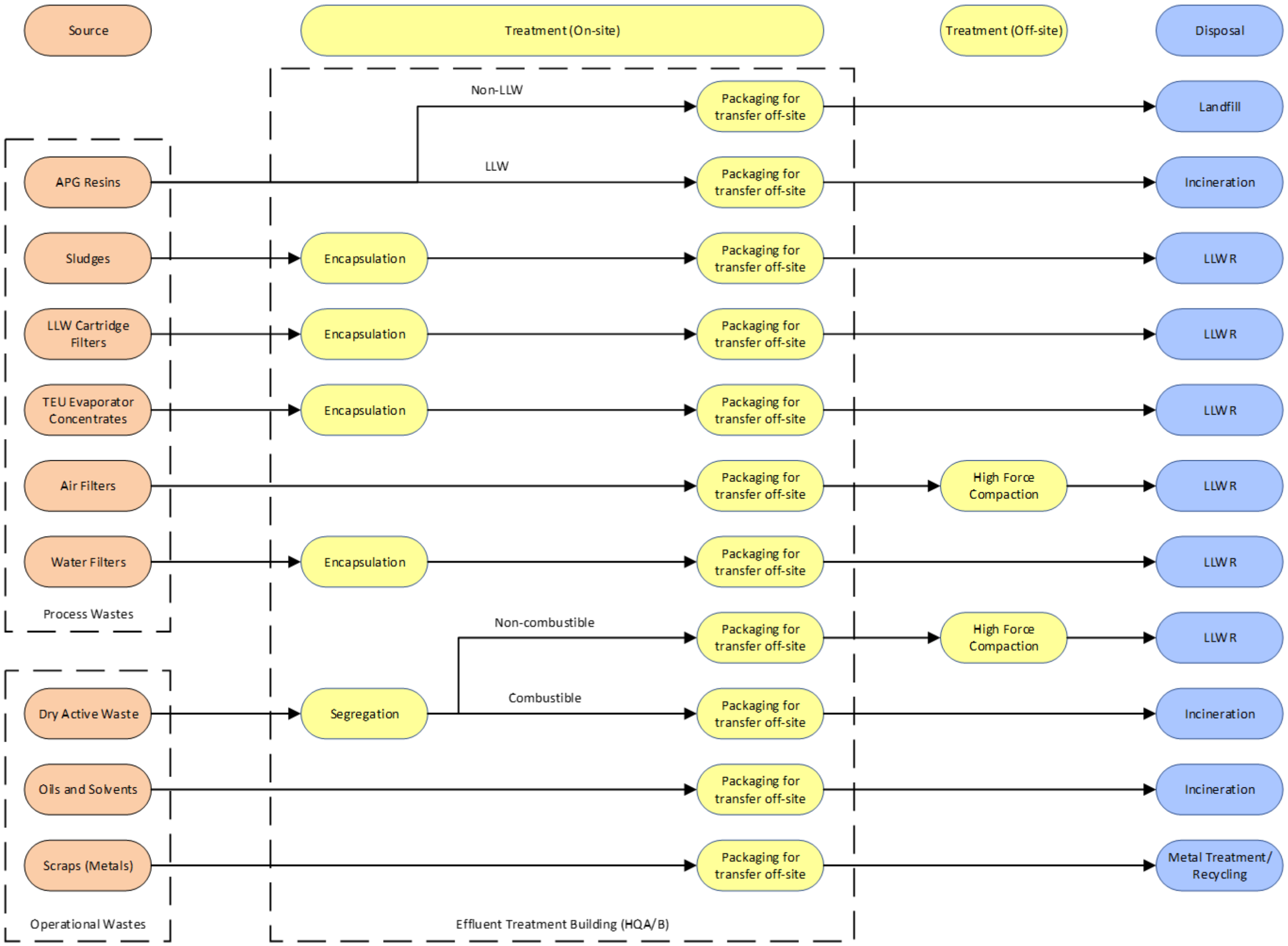

Figure 7-1 LLW Treatment and Disposal Strategy

7.2.4 Management of Intermediate Level Waste

97. The majority of ILW will arise from the treatment of liquids and gases in order to optimise worker doses and discharges of radioactivity to the environment.

98. In addition to the process wastes, a variety of ILW streams may be generated as a result of maintenance work carried out during reactor operation and work performed during reactor outages. A waste stream will also be generated from performing reactor flux measurements and routine replacement of certain components, which may have become activated or contaminated.

99. The ILW streams that are anticipated to arise from normal operation and maintenance of SZC are set out in Table 7-4 below.

Table 7-4 Categories of ILW Arisings from SZC

Waste Type	Waste Description
ILW Ion-exchange resins	Ion-exchange beds are used to capture and minimise soluble radioactive material in liquid. This material results from corrosion in the primary circuit (mainly in the steam generators and activation of chemicals in the primary circuit) and in the following UK EPR™ water auxiliary circuits: • RCV; • TEP; and • PTR. The ion-exchange resins are periodically changed to optimise their performance.
ILW Cartridge Filters	This waste consists of filters used in the clean-up of primary circuit water and water from the Liquid Waste and Spent Fuel Pond Treatment Systems. There are several designs of filters depending on the abatement required. A proportion of the filters generated will fall into the ILW category.
ILW Sludges	During SZC operations, particulates will settle as sludges in the storage tanks associated with the auxiliary water circuits e.g. TEU. These are contaminated with a range of fission and activated corrosion products. This sludge consists of settled particulate and will be periodically cleaned out and removed for treatment prior to disposal. Only a proportion of the sludge generated will fall into the ILW category.
Operational wastes >2mSv/hr	This comprises a range of materials, including contaminated metal, plastics, cloth, glassware and rubble, arising from operations during planned shutdown periods. This waste stream also includes aeroballs, which are small metallic balls that are briefly injected into the core to provide a flux measurement.

Non Fuel Core Components

100. Rod Cluster Control Assemblies; Thimble Plug Assemblies; Primary (neutron) Source Assemblies; and Secondary (neutron) Source Assemblies are anticipated to be in part ILW. They will be stored with spent fuel. This approach justified for HPC by [Ref 26], is equally applicable to SZC. Importantly co-storage minimises storage and waste management requirements and does not foreclose final disposal options.

101. There is potential that some in core instrumentation, such as Self Powered Neutron Detectors, which are anticipated to be in part HLW at the point of generation to require moving from their reference storage location before the end of generation. Feasible options have been identified for their management should this scenario arise and work is ongoing for HPC to identify the BAT/ALARP preferred option. The SZC project will replicate the finalised approach for the management from HPC.

Evolution of ILW Management Strategies

102. The ILW Management Strategy was initially defined for HPC [Ref 27]. Since then the strategy at HPC for managing waste that will decay over the life of the station (Cartridge filters, Dry Active Waste and Sludges) has been reviewed [Ref 28] and the management strategy for ILW resin has since been further justified [Ref 29]. The following sections provide a summary of the current ILW strategy for all waste streams. The evolution of solid radioactive waste strategy documentation is illustrated by Figure 7-2. This approach is considered to be equally applicable at SZC underpinned by the same justification.

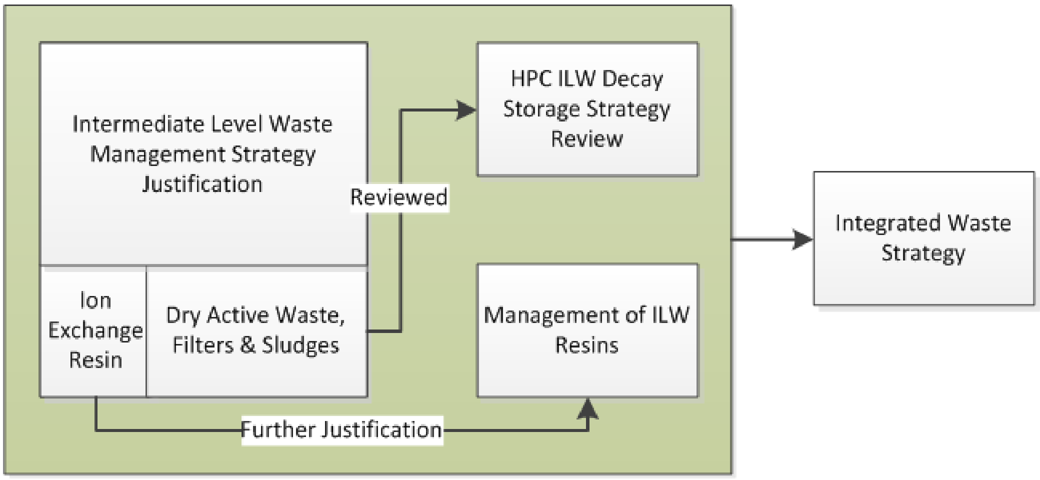

Figure 7-2 Evolution of Solid Radioactive Waste Strategy

ILW Volumes and Processing Strategy

103. Two types of ILW packages are proposed for use at SZC. Cylindrical pre-cast concrete casks, designated C1s are for resins and 500L drums are for Cartridge Filters, Dry Active Waste and Sludge. The C1 casks can include internal mild steel shielding of flexible thickness to provide shielding against different concentrations of gamma emitting radionuclides. ILW will be packaged as follows:

- ion exchange resin will be encapsulated into a C1 container using epoxy resin1;
- cartridge filters will be encapsulated into a 500L drum using cement2;
- dry active waste will be placed into a 500L drum un-encapsulated to take advantage of currently available disposal routes following decay;
- sludges will be encapsulated into the 500L drum using cement.

104. The radioactivity of a proportion of the ILW that will be generated during operation of SZC will be dominated at the time of arising by relatively short lived radionuclides, including cobalt-60 (half-life of 5.27 years) and iron-55 (half-life of 2.7 years). Waste identified as being suitable for decay storage will be packaged within the HQB;

[1] The process of epoxy resin encapsulation is established as a technique for treating ILW ion-exchange resins in the UK, at the Magnox site at Trawsfynyyd, and in France using mobile processing units and is consistent with the proposed technology solution presented at GDA.

[2] Encapsulation of waste into 500L drums using cement is widely implemented in the UK.

and transferred into the HHI for a period of storage. Following a period of decay storage, the radioactivity of selected wastes will have reduced to such levels that the waste will no longer be classified as ILW. This waste will be removed from the HHI and managed as LLW. Decay storage is considered an appropriate strategy because it minimises the accumulation of waste onsite and diverts waste away from the planned GDF. All ion exchange resin and 75% of filters are anticipated to remain as ILW [Ref 29]. The anticipated volumes and processing strategy for the SZC ILW streams is the same as HPC and summarised below in Table 7-5.

Table 7-5 ILW Waste Volumes and Processing Strategy for SZC

ILW Stream	Waste Description	Anticipated Annual Raw Waste Volume from two UK EPR™ units (m^3)	Lifetime (60yr) Raw Waste Volume from two UK EPR™ units (m^3)	SZC Processing Strategy
ILW Ion-exchange resins	Organic resins that arise from the clean-up of primary circuit water, water from the effluent treatment systems and the reactor fuel ponds.	6	360	Polymer immobilisation in C1 casks followed by interim storage on-site awaiting availability of a GDF. This is illustrated by .
ILW Spent cartridge filters	Filters from the clean-up of primary circuit water and water from the TEU. The filters consist of a stainless steel support, with a glass fibre or organic filter media.	10	600	Cement grouted in 500L drums followed by interim storage on-site until either the waste decays to LLW or a GDF becomes available. This is illustrated by Figure 7-4. It is anticipated that 25% of filters could decay to LLW.
Operational wastes >2mSv/hr	A range of materials, contaminated metal, plastics, cloth, glassware, aeroballs and rubble arising from operations during planned shutdown periods.	2	120	Placed into 500L drums followed by decay storage until the waste can be managed as LLW. It is anticipated that all Operational ILW will decay to LLW during the life of the station. This is illustrated by Figure 7-5.
ILW Wet sludge	Sludge arising from cleaning the bottoms of liquid waste treatment tanks and various sumps.	2	120	Cement grouted into a 500L drum followed by decay storage until the waste can be managed as LLW. It is anticipated that all active sludge will decay to LLW during the life of the station. This is illustrated by Figure 7-6.
Totals		**20m^3**	**1200m^3**	

ILW Management Facilities

105. HQA/B includes functions for safe handling, treatment, conditioning, buffer storage, packaging and monitoring of any solid radioactive wastes prior to transfer of packages to the HHI. ILW generated during SZC operation will be conditioned in HQA/B, and further details on the operational management of ILW are provided in [Ref 24] which, whilst developed for HPC, is equally applicable for SZC given the replication of the Nuclear Island including waste management facilities.

The key solid ILW waste management functions of HQA/B are:

- receipt into buffer storage tanks of spent ion exchange resin transferred via pipework from demineralisers on Unit 2;
- buffer storage of ion exchange resin in tanks prior to conditioning;

- conditioning of solid waste (including cementation and resin encapsulation).

106. The conditioning process will meet the requirements for transfer for storage in HHI and eventually transfer off site to a GDF or, following decay, the most appropriate LLW treatment/disposal route.

107. ILW from unit 2 will be packaged for cross site transfer in Unit 2 HQC, which will have the same waste packaging facilities as HQB with the exception of the encapsulation cell and interfaces with the mobile resin encapsulation plant [Ref 30]. This approach was developed for HPC and is equally applicable to SZC given the replication of the Nuclear Island, including waste management facilities

108. HHI will be a shielded store with an area to stack stillages, each containing 4 x 500L drums, and an area to stack C1 containers. The store will also include an area for inspection and quarantine of waste packages.

Disposability of ILW from SZC

109. Before conditioning and packaging of ILW that is not anticipated to decay (Ion Exchange resin and Filters), regulatory arrangements require that sites produce an ILW packaging proposal [Ref 31]. This will include a demonstration that, following conditioning, the waste will be compatible with existing or future planned management and disposal options. This requires that a LoC is obtained for the packaging proposal. The LoC process is the mechanism that RWM utilises to provide confidence that a waste package can be accepted at a future GDF.

110. The overall objective of the LoC assessment process is to give confidence to all stakeholders that the future management of waste packages has been taken into account as an integral part of their development and manufacture. This is achieved by the site operator working with RWM to demonstrate that the waste packages produced by a proposed packaging process and their subsequent storage will be compliant with the generic waste package specification and compatible with plans for transportation and emplacement in the planned future GDF.

111. In cases where the assessment has concluded that the waste package is compliant with the GDF and is sufficiently underpinned, RWM is prepared to confirm this by the issue of a LoC.

112. NNB GenCo (HPC)[3] made a conceptual LoC submission (applicable to HPC and SZC projects), which sought the opinion of the RWM on the likely acceptability for disposal in a GDF of all EPR^{TM} waste streams. RWM granted a conceptual LoC and identified a number of action points, which will have to be addressed to progress to the interim LoC stage and ultimately the final LoC stage [Ref 19]. SZC Co. will continue to work with RWM through the LoC process to ensure that packaged ILW that is not anticipated to decay to LLW will be acceptable for disposal in a GDF (SZC RSR Commitment (CMT) 8).

Transport of ILW to GDF

113. At the end of the interim storage period it is SZC Co.'s responsibility to ensure that the package is safe for export off-site and is compliant with the transport regulations in force at that time. Assessments for the LoC process also address transportation, so packages in receipt of a LoC can have confidence that transportation issues have also been addressed.

114. All radioactive waste despatched from the site will need to comply with applicable UK and international legislation at the time of despatch, including the relevant requirements of the Carriage of Dangerous Goods and Use of Transportable Pressure Equipment Regulations 2009 [Ref 18]. Each consignment will undergo the required contamination monitoring and external radiation measurements before leaving the site.

[3] Before the creation of 2 separate legal entities each covering HPC and SZC respectively

115. Radioactive waste is transported in specially designed and approved packages. The packages provide protection to operators and members of the public and are required to be sufficiently robust to withstand an accident.

Disposal of ILW to GDF

116. The UK Government has assessed that a GDF could be operational for the disposal of legacy ILW in the 2040s [Ref 20]. Disposal of legacy waste will take priority over waste from newer operators. The SZC FDP[4] is assumed to follow the same strategy to that of HPC in that disposal of operational ILW to the GDF will be carried out during main site decommissioning.

117. The potential impact of the disposal of UK EPR™ operational and decommissioning ILW on the size of a GDF has been assessed by RWM. Although the impact depends to some extent on the type of package, it has been concluded that in all cases the volume increase is relatively small, corresponding to less than approximately 60m of disposal vault length for each UK EPR™. This represents less than 1% of the area required for the UK legacy ILW, per reactor.

[4] SZC Co. is preparing a FDP to support the Financial Investment Decision prior to start of construction

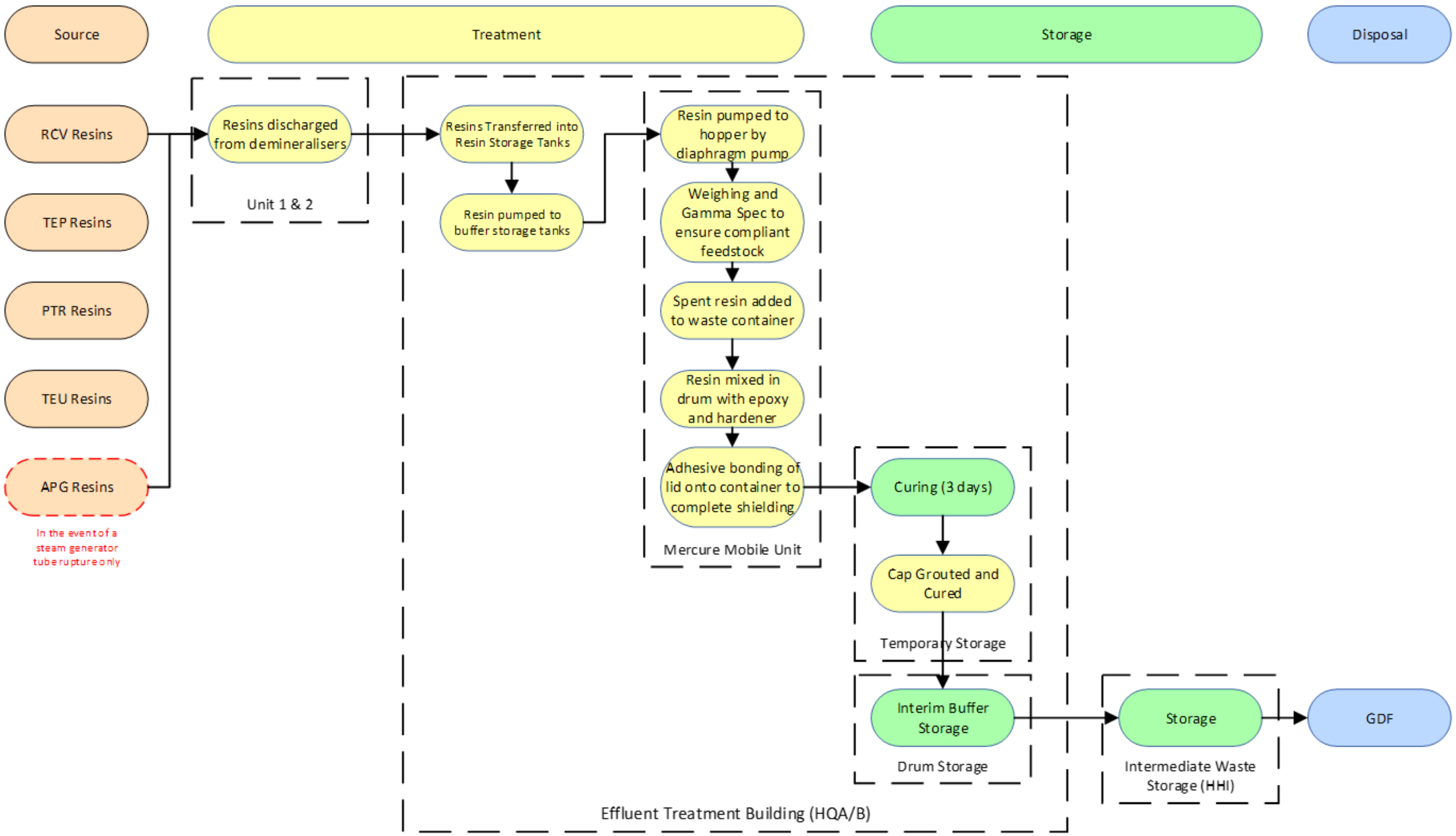

Figure 7-3 Treatment of ILW Resin

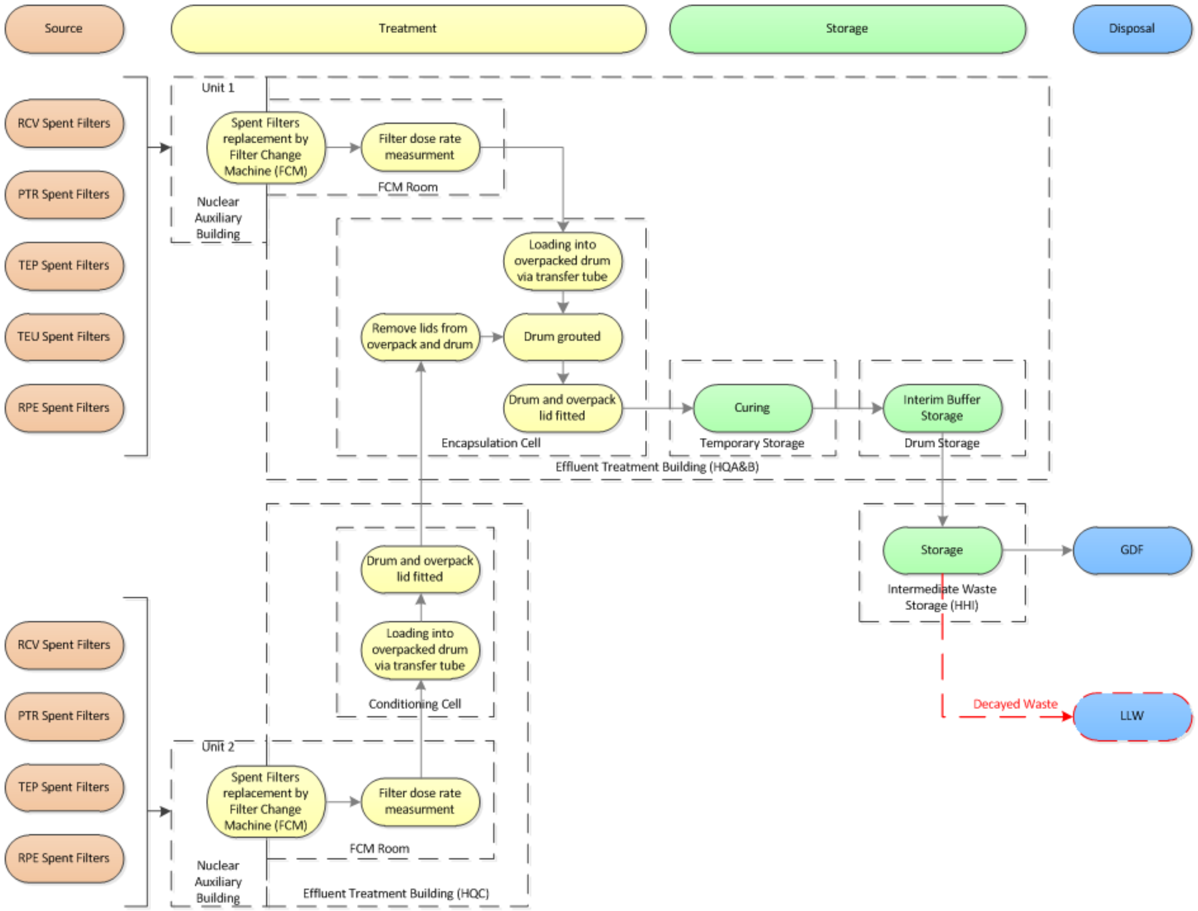

Figure 7-4 Treatment of ILW Filter Cartridges

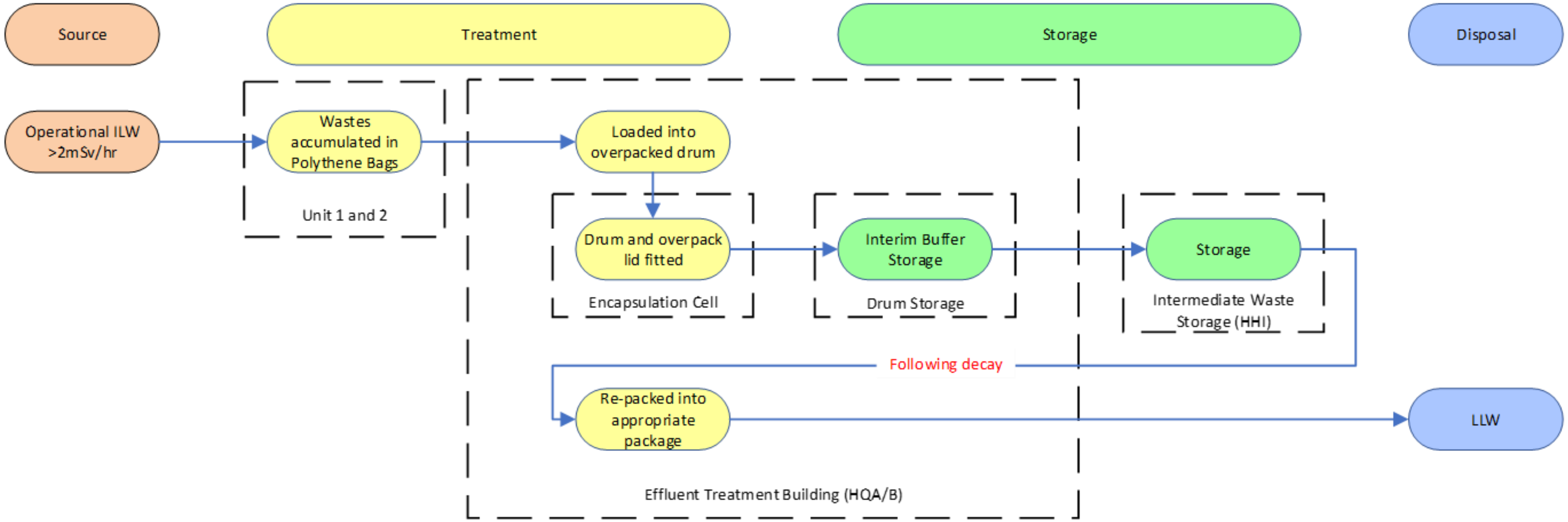

Figure 7-5 Treatment of ILW Operational Waste

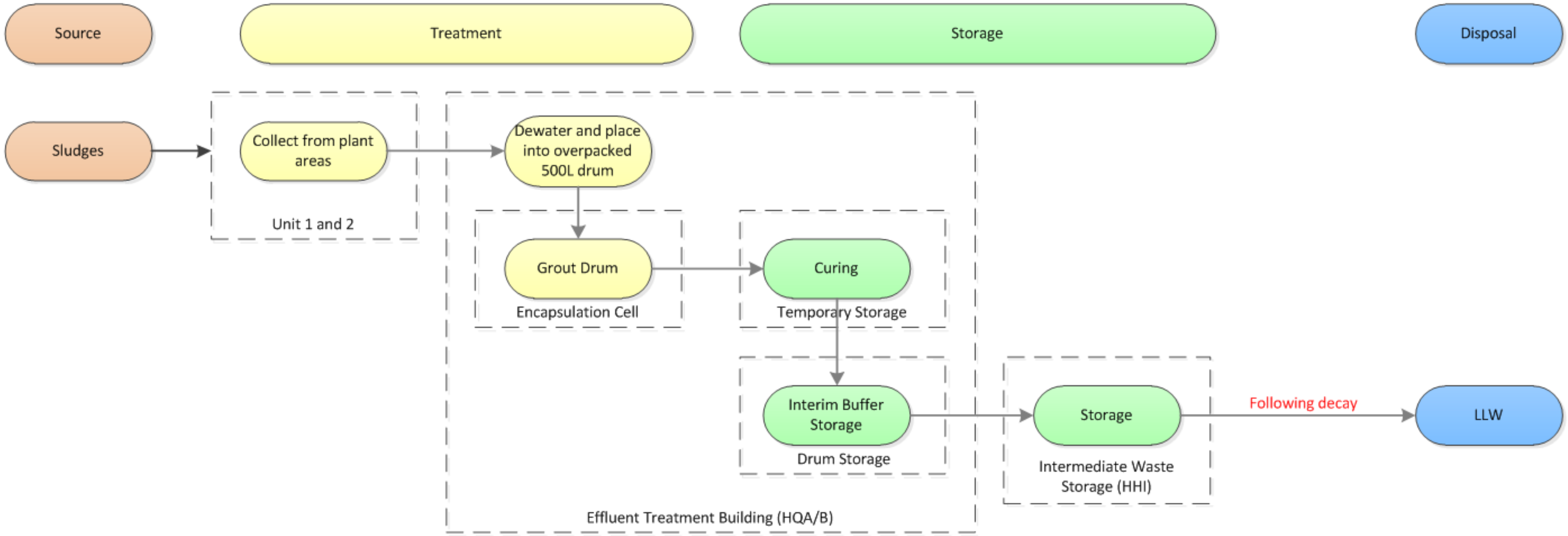

Figure 7-6 Treatment of ILW Sludge

7.2.5 Liquid Radioactive Wastes

118. The UK EPR[TM] design includes a number of processing systems to minimise discharges of radioactive liquid effluent, including the RPE as well as those indicated in Figure 7-7. In accordance with waste minimisation, these systems receive and process effluent before recycle/discharge. They focus on reduction at source, collection and segregation, treatment, reuse/recycling and ultimately, residual substances are monitored and discharged to sea. Figure 7-7 below summarises the source, treatment and disposal of liquid radioactive effluent at SZC.

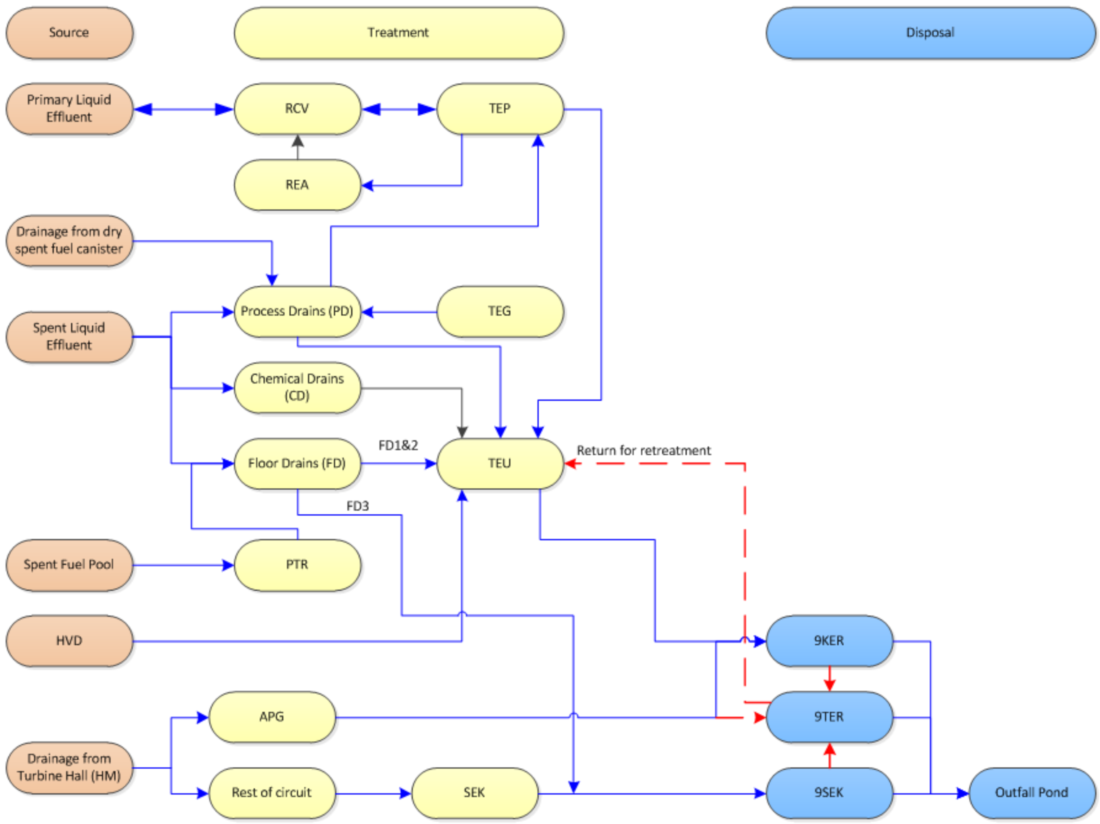

Figure 7-7 Liquid Radioactive Waste

119. The overall SZC strategy for the management of liquid radioactive wastes is:

- minimising the production of activity in effluents at source;
- take advantage of preferential partitioning of radionuclides, where appropriate, to minimise environmental risks and impacts;
- use of segregation and effluent treatment systems to afford the greatest flexibility in their treatment;
- abatement to concentrate and contain radionuclides, where appropriate, through the use of demineralisation, evaporation and filtration, ensuring minimisation of all entrained solids, gases and non-aqueous liquids from aqueous waste;
- optimum use of suitable storage systems, taking advantage of any delay and decay that may arise;

- assessment and sentencing of liquid wastes prior to discharge;
- optimise the manner and timing of any discharge to sea to minimise the impacts on the environment and members of the public.

120. Efforts have been made at the design stage on reducing/minimising the production of radioactivity in effluents at source, taking account of operational feedback and experience of EDF and Framatone. A number of recommendations from the Electric Power Research Institute have also been taken into account, such as the improvement of collection and effluent treatment systems. In addition, mitigation measures for the storage and treatment of effluents before discharge and the methods of storage and discharge have been optimised in the light of the best techniques currently available. The techniques applied within the SZC effluent treatment systems correspond well with recent operating feedback.

121. Demonstration that the approaches and processes represent BAT is recorded in the RSR permit application support document A1 [Ref 9]. Application of BAT has been determined by achieving a balance between a wide range of factors and competing demands to achieve an optimum solution, for example, the worker doses and costs incurred in treatment compared to the public doses and other environmental impacts incurred by discharges.

122. The approach for the reduction of the production of liquid radioactive effluent at source, following the application of BAT, is based on:

- the choice of materials that result in the process generating radioactive elements (reducing stellites, for example, a source of cobalt, which produces cobalt-60);
- reinforced leak-tightness requirements for active parts (pumps and valves) and the recovery of primary coolant leaks;
- choice of a specific primary coolant chemistry control regime to minimise corrosion processes and the build-up of activated particulate material, which contributes to the radioactivity present in effluent;
- optimised design of coolant treatment systems;
- optimised recycling of borated primary coolant.

123. In addition, operational and management controls contribute to the application of BAT via the rigorous management of effluent, which minimises the volumes and activities of waste at source, and controls and optimises treatment and decisions regarding their discharge. These management procedures are used at all stages of plant start up, operation at power and unit shutdown and refuelling.

124. The concentration and containment of the radioactivity contained in liquid effluents is a key principle of the waste management strategy. The treatment of the effluent results in the concentration of activity in the form of solid waste and a controlled amount of residual radioactivity in liquid form, which can be discharged to the environment in compliance with the requirements of the RSR Environmental Permit.

125. The TEU will use degassing, filtration, demineralisation and evaporation to treat radioactive liquid effluents. Filtration removes insoluble materials from the primary coolant or other effluent streams. Demineralisation (also known as ion exchange) removes soluble materials from aqueous streams. Evaporation involves evaporating the liquid effluent and then condensing the purified distillate for subsequent disposal with the evaporator concentrate being further treated prior to disposal as solid radioactive waste. These techniques are described from a BAT perspective in the RSR permit application support document A1 [Ref 9]. They are established technologies in current use in the nuclear industry worldwide, and offer various efficiencies on treating different types of effluent recognising, in particular, that some radionuclides are better removed than others by the different treatment processes. In addition, substantial advantages and higher decontamination

factors are achieved, where required, by combining two or more processes for the consecutive or simultaneous treatment of effluent. This approach allows discharges to be reduced as far as practicable.

126. The use of the segregated system allows flexibility in the management of liquid wastes. The availability of segregated collection systems at SZC for the different liquid effluent streams in the RPE (process drains, chemical drains and three streams of floor drains) is shown in Figure 7-8. These effluent streams have differing characteristics and will be treated separately in the TEU by the most appropriate methods. Methods include filtration, demineralisation and evaporation. Segregation of effluents at source minimises the activity and volumes of radioactive effluents discharged (the treatment of less dilute effluents improves the decontamination that can be achieved) while optimising the production of solid radioactive waste from the effluent treatment systems (filters, concentrates and ion-exchange resins).

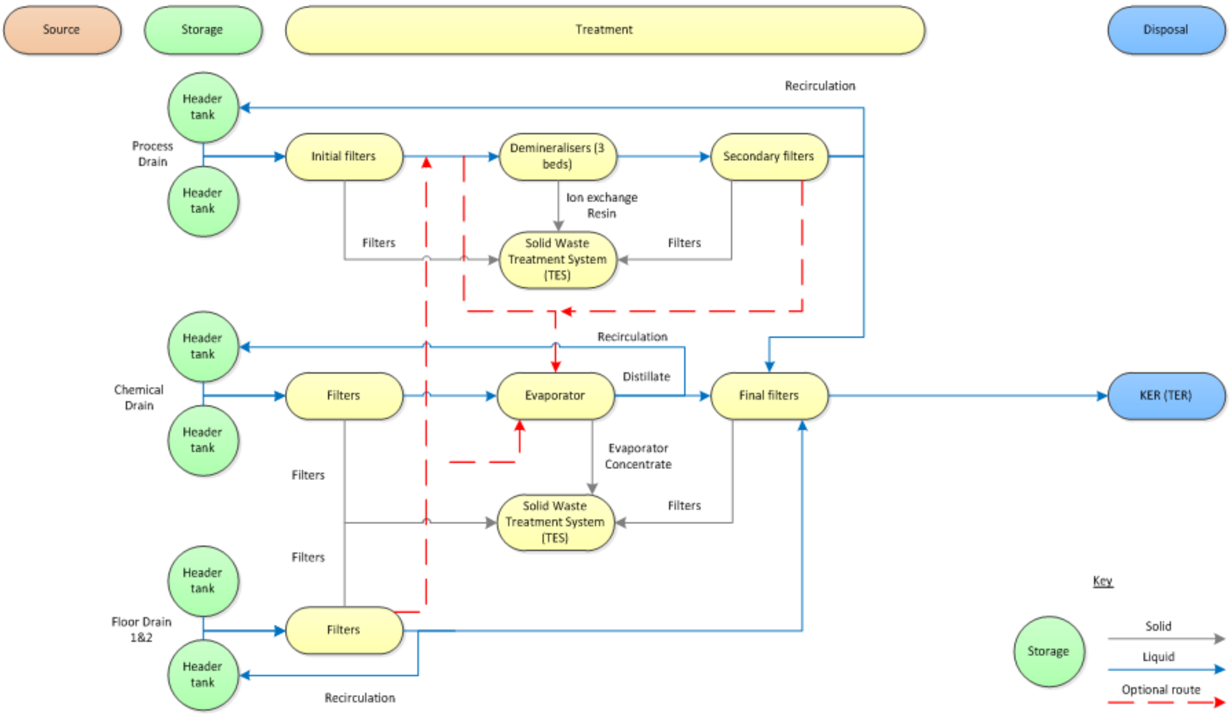

Figure 7-8 The Liquid Radioactive Waste Treatment System

127. RPE Floor Drain 3 (not shown in Figure 7-8): coming from leakages and purges of equipment, and from floor washings arising from non-controlled areas are routinely directed to the Conventional Island Liquid Waste Discharge System; and only directed to TEU when considered polluted and requiring treatment prior to discharge.

Main Discharge Systems

128. The effluent is eventually collected in the KER tanks and sampled for suitability for discharge and, if it meets the required specification, is discharged to sea. Effluent that is out of specification can be routed back to the TEU for further treatment. The KER collects treated effluents from a number of sub-systems, including the TEU and APG.

129. The KER is the principal route for discharging radioactive liquid effluents. There is an Additional Liquid Waste Discharge System (TER) with tanks that are held in reserve to provide buffer capacity for the same systems

serviced by KER and can be discharged via the same route or to enable out of specification effluents to be routed back to the TEU for further treatment. The TER can also provide reserve capacity for the SEK and In-containment Refuelling Water Storage Tank. Although the TER tanks are held in reserve there is the capacity to discharge routine permitted active effluent via shared pipework with the KER system to the Outfall Building.

130. The SEK tanks collect effluents that are not chemically or radioactively contaminated and store them prior to discharge. Wastewater from the Turbine Hall and uncontaminated water from Floor Drain 3 are ultimately collected in this system. The discharge from the SEK is of minor significance because the effluent in normal conditions will not be contaminated. The segregated system means uncontaminated effluents are kept separate from active effluent streams. It is anticipated that any formal accountancy monitoring at this point is likely to return results at the limit of detection. Should these results be multiplied by the volume of liquid discharged, an artificial quantity of radioactive material discharge could be inferred. Whilst the exact amount cannot be quantified the contribution that it makes to the total site discharge is a very small fraction of the limits. As this cannot be demonstrated in advance of operation, the discharge from the SEK tanks has been identified as main discharge outlet. Once the plant is operational, experience will inform whether in the future the discharge from the SEK tanks needs to be considered as a minor outlet. Importantly, the effluent will still be monitored prior to discharge regardless of its designation and if the results do not meet the discharge standards they will be returned to TEU for further treatment.

Proposed Minor Discharge Routes

131. SZC will have a number of other liquid effluent systems. In all cases it is expected that these effluent streams will not normally contain radioactive waste, but in certain situations, the presence and detection of trace quantities of radioactivity cannot be ruled out from these effluent systems:

- Water run off collection systems from on-site car parks, referred to as the Waste Oil & Inactive Water Drain System & Storage (SEH) system, and from buildings and off-site car parks via the Plant Sewer System (SEO-EP) are routed through the bypass interceptor and fore-bay prior to discharge, via the Outfall Pond, to the Outfall Tunnel. During abnormal circumstances, such as contamination of buildings and roadways, small amounts of radioactivity may enter the storm water drains system. The storm water drains empty into the Outfall Pond prior to transfer, via the Outfall Tunnel, to the North Sea. The discharge from the bypass interceptor, which collects water run-off collection systems from onsite car parks (SEH system) and buildings and off-site car parks (SEO-EP (Roof/Road) network of the SEO-EP system), is proposed to be included in the permit as a minor outlet [Refs 8 & 9];
- Return line of the circulating seawater cooling system. The seawater should be uncontaminated in normal operation. The seawater feed serves various systems, each of which should have internal sample points for detection of contamination at the point of return to the main system. The discharge from the return line of the seawater cooling system is proposed to be included in the permit as a minor outlet in the RSR permit application support document A1 [Ref 9];
- Spillway system is designed to return seawater from each unit's fore-bay in the event of a cooling water pump failure coinciding with a high tide event. The discharge is via drainage through the sea wall and is proposed to be included in the permit as a minor outlet in the RSR permit application support document A1 [Ref 9];
- Sea wall drainage system returns rainwater and wave topping of the sea wall drained back though integral drains in the sea wall. The discharge from sea wall drainage system is proposed to be included in the permit as a minor outlet in the RSR permit application support document A1 [Ref 9].

132. The contribution from these minor discharge outlets to the proposed site limits represents a very small fraction of the total site discharge.

133.A diagram describing these systems is presented in Figure 7-9.

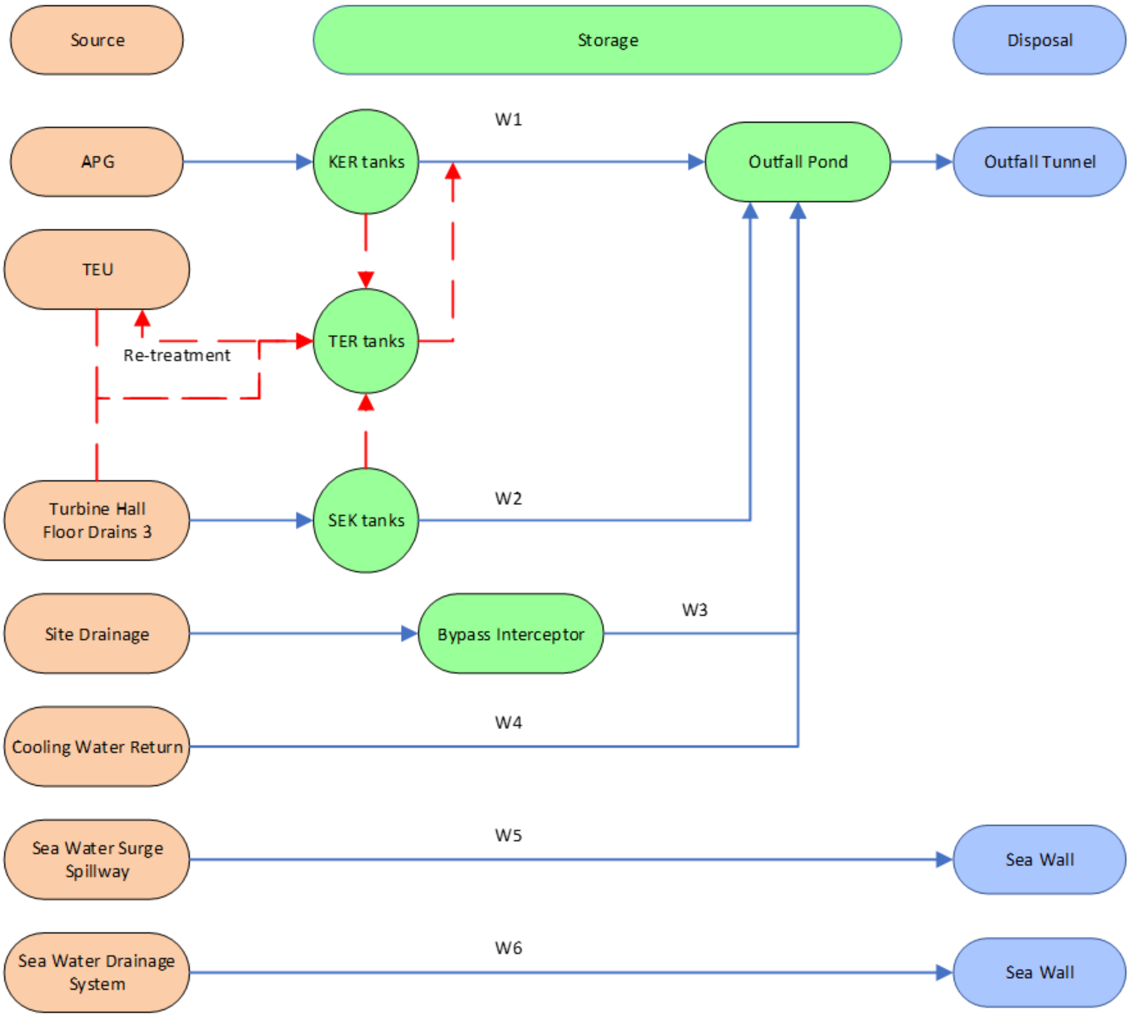

Figure 7-9 Summary of Discharge Routes from Sizewell C site

7.2.6 Radioactive Gaseous Wastes

134.Gaseous effluent is segregated at source and treated in different systems depending on its nature. Gaseous radioactive discharges fall into one of four categories

Gaseous Effluent from the Primary Circuit

135.This effluent comes from degassing in either the primary-effluent degassers in the Coolant Storage and Treatment System, or in the head spaces of tanks and vessels containing primary effluent. It comprises mainly of hydrogen, nitrogen and the gaseous products of fission and activation, and therefore is radioactive. Nitrogen sweeping is used to maintain low levels of hydrogen and oxygen for safety reasons. Primary gaseous effluent is discharged directly to the TEG where noble gases are abated in activated charcoal delay beds. The gaseous effluent is then discharged through HEPA filters and iodine traps (if necessary) via the ventilation system of the Nuclear Auxiliary Building and then to the main unit vent discharge stack, together with other gaseous discharges from SZC.

Gaseous Effluent from Ventilation

136. This effluent is the exhaust of ventilating areas that may be contaminated or have a risk of contamination originating in the Nuclear Auxiliary Building, the Fuel Building, the Safeguard Buildings, the Reactor Building, the Access Building and the Effluent Treatment Building. Air is collected in the ventilation circuits of the different buildings, where it is further treated using HEPA filters and iodine traps (if necessary) before being discharged into the main unit stack.

Gaseous Effluent from the Secondary Circuit

137. Gaseous radioactive effluent from the secondary circuit is largely air that may contain radioactive gases, particularly tritium, in the event of leakage from the primary circuit into the secondary circuit at the steam-generator tubes level. Gas is collected in the condenser vacuum system and then sent to the nuclear auxiliary building ventilation system, where it is HEPA filtered before being discharged into the main unit stack.

Gaseous Effluent from Other Minor Sources

138. Gaseous radioactive effluent from other minor sources, such as the interim storage facilities, will be assessed and subject to BAT consistent with the strategy below.

Gaseous Effluent Management Strategy

139. The overall SZC strategy for the management of gaseous radioactive wastes (see Figure 7-10) is:

- minimising the production of gaseous effluents at source;
- taking advantage of preferential partitioning of radionuclides, where appropriate, to minimise the environmental risks and impacts;
- abatement of gaseous waste streams through the use of activated charcoal beds to decay noble gases, activated charcoal traps to abate isotopes of iodine, and HEPA filters to trap particulate activity;
- monitoring of gaseous wastes prior to discharge;
- optimising the design of the stacks such that emissions minimise the impacts on the environment and members of the public.

140. The management strategy to minimise radioactive gaseous discharges from the operating activities of SZC is based on the design of the plant and their operational practices. The design uses BAT to minimise gaseous discharges at source and to minimise the impacts of discharges by means of abatement and discharge plant, while optimising worker doses and costs incurred during treatment in the plant with public doses from discharges. Systems and plant are managed and operated in a manner so as to minimise the environmental impacts of discharges so far as is reasonably practicable, and it is ensured that all discharges are monitored and recorded to demonstrate that they will comply with expected limits and levels that will be specified in the RSR permit.

141. Once the liquids pass from the primary coolant system into other systems and degassing occurs, a range of design features ensure abatement of the gases and their associated discharge. The SZC's primary circuit TEG is based on the established German Konvoï reactor plant design. A key feature of this design is the recovery of

purge gas (nitrogen) which is compressed and recycled into the system to ultimately minimise discharges and retain short-lived radioactive gases to allow decay.

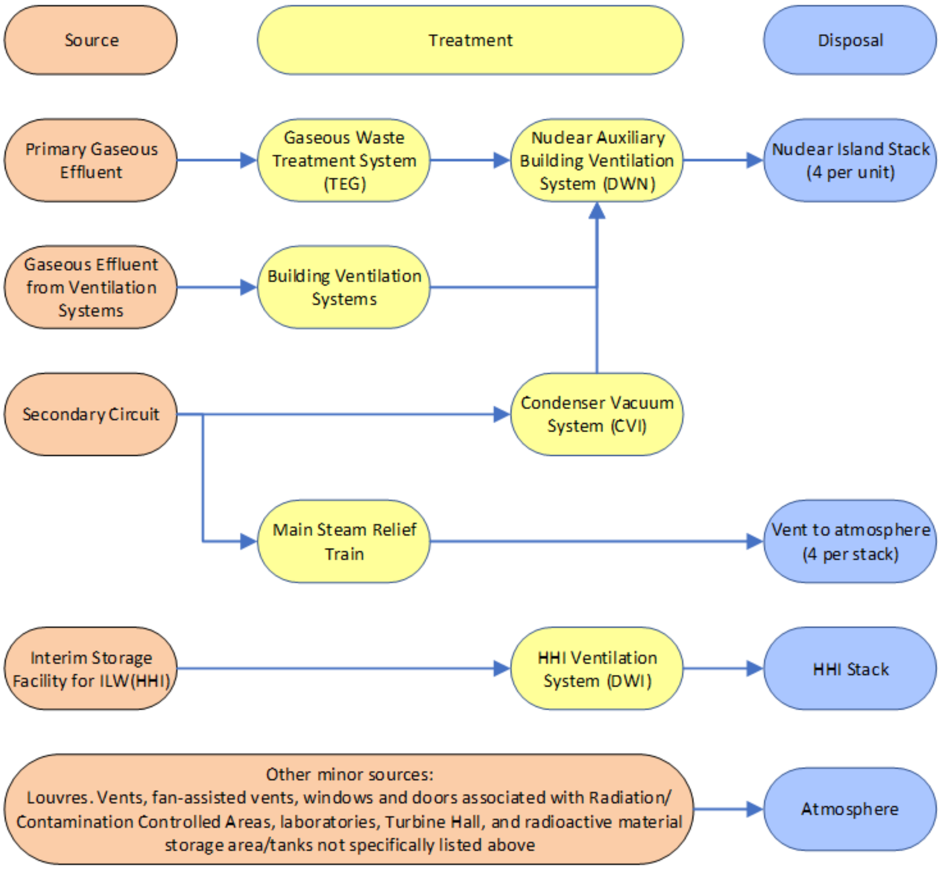

Figure 7-10 SZC Radioactive Gaseous Effluent Routes

142. In addition, treatment of potentially radioactive gases is implemented to ensure that the most hazardous isotopes are removed from effluent streams and contained within solid filters. The SZC gaseous abatement techniques focus upon technologies considered as BAT, as identified by the OECD [Ref 32]. These are primarily:

- dry HEPA filtration to remove particulate and aerosols;
- activated charcoal adsorption technologies (delay beds) to hold-up for decay or remove volatile chemically reactive gases.

143. The RSR permit application support document A1 [Ref 9] provides information on the demonstration of BAT for identified specific radionuclides, such as C-14 and tritium, in gaseous radioactive effluents and discusses how discharges are minimised and how they are distributed between gaseous, liquid and solid wastes, noting there is not any specific abatement technique applied to these radionuclides.

144. Suitable final monitoring is carried out and residual gaseous effluents are discharged via main unit vent stacks designed to ensure maximum rapid dispersion and dilution in the air. The height of the discharge stacks has been determined for adequate dispersion of these discharges and takes account of local site topography and wind patterns [Ref 33].

7.3 Spent Fuel

7.3.1 Description of Spent Fuel Generated during the Operation of SZC UK EPR^{TM} Units

145. SZC's core contains the nuclear fuel in which the fission reaction occurs. The remainder of the active core structure serves either to support the fuel, control the chain reaction or to channel the coolant.

146. Each reactor core at SZC will typically consist of fuel assemblies providing a controlled fission reaction and a heat source for electrical power production. Each fuel assembly is formed by an array of Zircaloy M5 tubes, made up of fuel rods and guide thimbles. The fuel rods consist of uranium dioxide pellets stacked in a Zircaloy M5 cladding tube, which is then plugged and seal welded.

147. It is currently assumed that a maximum of 90 spent fuel assemblies (SFA) will be removed every 18 months of operation from each reactor. With time included for planned outages for maintenance over the 60 years operation, a total of approximately 3,400 assemblies per reactor unit are expected to be generated. Through the lifetime of the two reactors at SZC a total of around 6,800 fuel assemblies will be generated.

7.3.2 Requirement for Interim On-Site Storage of Spent Fuel

148. As stated in the 2008 Government White Paper [Ref 16], in the absence of any proposals from industry (for reprocessing) any new nuclear power station that might be built in the UK should proceed on the basis that spent fuel will not be reprocessed and that plans for, and financing of, waste management should proceed on this basis.

149. There is currently no disposal facility for spent fuel and whilst there is a Government programme in place to develop a GDF, it is not expected to be available when the SZC starts generating spent fuel. The strategy for spent fuel management at SZC is, therefore, to store the spent fuel on-site pending availability of a GDF. Although it is possible that, over the life of the station alternative facilities could become available that might allow spent fuel to be transported offsite, it is prudent to plan on the basis that sufficient capacity is provided on-site to store the lifetime arisings of SZC spent fuel.

150. Spent fuel is highly radioactive when it is removed from the reactor. All radioactive materials eventually become non-radioactive but while some lose their radioactivity within fractions of a second, others take many thousands of years. The radioactivity of spent fuel falls to about one hundredth of its original level within a year and to one thousandth of its original level within 40 years. The high level of radioactivity concentrated within spent fuel results in a significant level of heat being produced. This characteristic makes a period of interim storage, during which the level of heat production reduces, an important element of spent fuel management ahead of its eventual disposal.

151. Spent fuel removed from a reactor must be cooled for an initial period before it can be placed into interim storage. For SZC, spent fuel assemblies removed from the reactor will be cooled underwater in a reactor fuel pond for up to 10 years. The reactor fuel ponds are not designed for the full life-time arisings of spent fuel.

152. Following this initial storage period in the reactor fuel pond, the spent fuel assemblies will be prepared for transfer to the separate HHK where they can be safely stored until a GDF is available for transfer and the spent fuel is ready for final disposal.

7.3.3 Interim Spent Fuel Storage at SZC

153. The HHK will provide storage for spent fuel at SZC from around 10 years after the first unit's start up until the spent fuel is transported off-site for disposal at the GDF. The operational design life of the HHK is sufficient to enable interim cooling and storage of the SZC lifetime of spent fuel, the safety case of the HHK will be reviewed periodically (every 10 years) to ensure continued operation. This will allow interim storage to be maintained

until a GDF, or an alternative disposal/management route, has been established and allow the heat levels within the spent fuel to reduce to a level that permits its disposal.

154. Under normal operating conditions the design of HHK must be capable of meeting the following requirements:

- to provide storage for all spent fuel generated at SZC;
- to ensure safe operations (e.g. by preventing a criticality incident and maintaining effective containment;
- to provide radiological protection to the public, workers and the environment at all times in compliance with dose limits and ensuring that all doses are ALARP and discharges to the environment are demonstrated to be minimised in accordance with BAT;
- to provide a means to reverse the process at any stage such that the spent fuel assemblies can be retrieved for inspection/repackaging;
- to ensure cooling to maintain spent fuel integrity;
- to maintain spent fuel in a condition appropriate for transport and final disposal.

155. SZC Co. has reviewed the options available for on-site interim storage of spent fuel and although all options considered performed well against safety and environmental criteria it was concluded that the preferred approach for SZC is dry interim storage within canisters [Ref 34] and [Ref 9].

156. Dry spent fuel storage using canisters has been licensed in the UK and is the preferred strategy for HPC [Ref 41]. It is a strategy that is capable of providing SZC with a safe, secure and technically flexible solution; until the spent fuel is suitable for transfer and disposal to the GDF or other off-site management facility becomes available.

7.3.4 Interim Spent Fuel Storage Process

157. The SZC Interim Spent Fuel Storage process can be broken down into stages.

- Spent fuel will be removed from reactor fuel pond and packaged into a canister within a transfer cask for transfer to the HHK;
- On arrival at HHK the canister is removed from the transfer cask and loaded into a storage shelter.
- The canister within its storage shelter is positioned appropriately and undergoes passive cooling5;
- At the end of interim storage the SFAs will be transferred to a packaging plant to allow disposal to a GDF.

7.3.5 Management of Radioactive Waste and Discharges from the Dry Fuel Storage System during Operations

158. Dry interim storage of spent fuel will result in the generation of small quantities of liquid, gaseous and solid radioactive wastes during packaging and potential inspection activities. There will be no liquid discharges or solid waste generated from the dry storage canisters during storage. A small quantity of tritiated gas could evolve in the casks and diffuse through the cask. This is expected to be at low rates and low activities to the point where no worker protection controls will be required within the facility. The discharges would be a very small fraction of the proposed site limit for gaseous tritium. The ISFS will therefore not require any systems for the management of liquid, gaseous or solid radioactive wastes.

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[5] *Reversal of the entire packaging process is undertaken should physical inspection of the SFAs be necessary.*

159. The minimisation of wastes and discharges from the dry storage system will be achieved by applying BAT when developing the design and operating procedures. It is anticipated that liquid and gaseous discharges generated during fuel loading and drying operations will be discharged via the same route as for other liquid and gaseous discharges from the Fuel Building (HK). They are expected to be included within the current proposed limits covering the already small radioactive discharges from SZC operations.

7.3.6 Spent Fuel Management Following End of Generation

160. At the EoG all remaining spent fuel will be removed from the reactors and transferred to the HHK, following the initial cooling period in the reactor storage ponds. During the main site decommissioning phase, the spent fuel will continue to be stored in the HHK, which will be modified to allow it to be a standalone facility as the rest of the site is being decommissioned. This will include the construction of a hot cell to carry out spent fuel inspection in the absence of the HK and eventually a packaging plant to allow for the transfer of spent fuel to the GDF.

161. Following the end of the main site decommissioning the spent fuel will remain within HHK. The facility will continue to be permitted and licensed and will include the provision of a number of additional facilities to accommodate the requirements for a small workforce to operate the storage facility, ensure security of the site, and maintain the continuation of all safety and environmental obligations. The costs for these modifications and the operation will be funded by the SZC Co. FDP. Only when all the spent fuel has been removed from HHK, and decommissioning of the facility is complete, will this remaining part of the site be de-licensed, the RSR permit surrendered and the land released for an alternative use. Figure 7-11 sets out the proposed spent fuel management strategy.

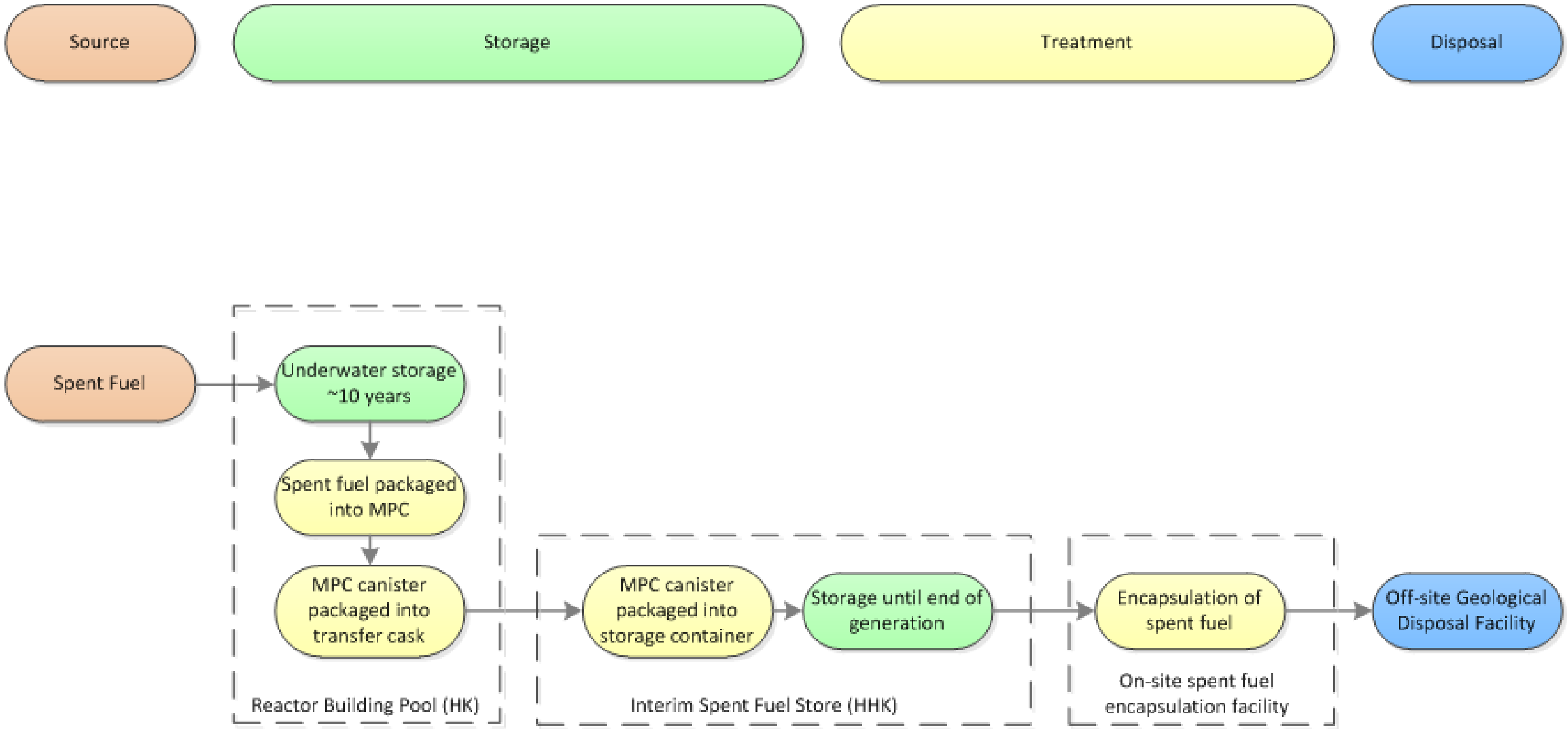

Figure 7-11 Spent Fuel Management Strategy

7.3.7 Timing of Transfer of Spent Fuel to GDF

162. The time that will be required for the safe and secure on-site interim storage of spent fuel prior to disposal depends on a two key factors:

- the availability of a GDF;
- the requirement that spent fuel characteristics are suitable to allow disposal to the GDF (i.e. the spent fuel has sufficiently cooled to allow disposal to GDF).

163. The Government published a policy document [Ref 20] which sets out the timescales for identifying a suitable site and construction; it is expected that a GDF will be in operation for 100 plus years and the first waste emplacement would take place in the 2040s.

164. RWM has published its plans for the scheduling and implementation of the GDF [Refs 17, 20 & 35] providing a timeline, which schedules the disposal of spent fuel from NNB Generation Company Ltd. For the UK EPR™ to the GDF once available [Ref 17].

165. As outlined by [Ref 36] the required storage period to enable sufficient cooling of spent fuel from SZC prior to disposal is 55 years after the end of generation.

166. On completion of transfer of the spent fuel from site for encapsulation and disposal, HHK will be decommissioned. The final stage of decommissioning will be the removal of the nuclear licensing requirements from the site.

7.3.8 Alternative Scenarios for Long Term Interim Storage of Spent Fuel

167. There are a number of alternative scenarios that could result in spent fuel being transferred from the site earlier therefore allowing earlier decommissioning of the HHK and subsequent site de-licensing and permit surrender:

- the provision of a UK centralised spent fuel interim storage facility;
- reprocessing becoming a more preferable approach during the lifetime of the HHK;
- a reduction of the pessimisms in the cooling assessment;
- optimisation of the GDF to accommodate earlier new build spent fuel.

168. However, none of these alternative options is foreclosed by the current plan outlined in section 7.3.7 for SZC.

7.3.9 Packaging (Encapsulation) of Spent Fuel for Disposal

169. RWM is developing disposal concepts for HLW and spent fuel, undertaking work on several related areas. RWM has developed a reference disposal concept based on the Swedish KBS-3V method. This is known as the UK Reference HLW and Spent Fuel Repository Concept [Ref 37]. The concept was developed in order to demonstrate the viability of the geological disposal of HLW and spent fuel in the UK.

170. Under this concept, spent fuel will be over-packed before disposal into durable, corrosion resistant disposal canisters, manufactured from suitable materials, which will provide long term containment for the radionuclides contained within the spent fuel. This process is known as encapsulation.

171. Encapsulation of spent fuel under the UK reference strategy will require the construction of a complex and expensive facility. Government's waste base case envisages on-site encapsulation of spent fuel. For liability estimation purposes the FDP assumes that the encapsulation facility will be built on-site. This ensures FDP costs are conservative. It is an option to upgrade the on-site hot cell required for inspection purposes into the encapsulation plant. There is also potential for the government's base case to change so that a single UK facility

is developed to encapsulate both legacy and new build spent fuel and HLW. Such a facility could be co-located with the eventual repository site.

7.3.10 Transport and Disposal of Spent Fuel to GDF

172. RWM has undertaken, as part of the GDA, a Disposability Assessment for the spent fuel expected to arise from the operation of SZC. This assessed the disposal implications of the proposed spent fuel disposal packages against the waste package standards and specifications developed by RWM and the supporting safety assessments for a GDF. The safety of transport operations, handling and emplacement at a GDF, and the longer term performance of the system have been considered, together with the implications for the size and design of a GDF.

173. RWM has concluded that spent fuel from operation of the UK EPR™ units, such as at SZC, should be compatible with its plans for transport and geological disposal of legacy spent fuel [Ref 19]. Compared with the existing UK spent fuel inventory, no new issues challenge the fundamental disposability of the spent fuel expected to arise from operations at SZC. This conclusion is supported by the similarity of the fuel to that expected to arise from SZB. Given a disposal site with suitable characteristics, the spent fuel from SZC is expected therefore to be disposable.

174. NNB GenCo (HPC) has developed a programme for making LoC submissions to ensure spent fuel will be disposable to the GDF [Ref 19]. A conceptual LoC (or equivalent) will be sought, before fuel at SZC is loaded into the reactor. Advancing to the interim LoC stage will not be possible until a site has been selected for the GDF, allowing for detailed geology specific acceptance conditions to be developed.

7.4 Decommissioning Wastes

175. The SZC decommissioning strategy is outlined at a high level by the SZC Corporate Decommissioning Strategy [Ref 7]. In addition, a Decommissioning and Waste Management Plan (DWMP) is being prepared and describes in further detail the work required to decommission the site. This DWMP is a key component of the FDP to be approved by the Secretary of State (see Section 4.3). The following sections summarise the aspects of decommissioning planning relevant to waste management.

7.4.1 Design for Decommissioning

176. SZC has been designed with decommissioning in mind, enabling radiation doses to workers and radioactive waste quantities to be minimised when decommissioning takes place.

177. The design incorporates a number of features to achieve this objective, these are taken from the RSR permit application support document A1 for SZC and support the demonstration of BAT [Ref 9] including:

- choice of construction materials to minimise activation - low cobalt steels are to be used wherever possible and appropriate;
- optimisation of neutron shielding - neutron shielding is utilised between the core and reactor vessel to reduce irradiation of the steel and reactor compartment;
- optimisation of access routes to nuclear areas - the layout of the primary circuit plant takes account of the handling and access routes for decommissioning;
- reactor systems design - designed to minimise activation products and circuit contamination;
- ease of removal of major process components - major components can be removed as a single item for size reduction in purpose built facilities elsewhere;

- submerged disassembly of the reactor pressure vessel - the design of the Reactor Compartment facilitates flooding for underwater dismantling of the reactor vessel;
- modular thermal insulation - the design facilitates easy removal minimising worker dose;
- fuel cladding integrity - improved fuel clad reduces contamination of the circuit with fission products;
- careful control of primary circuit chemistry - minimises activity levels in the primary circuit;
- design for decontamination - plant design facilitates decontamination;
- prevention of contamination spread - containment, ventilation and segregation are utilised to prevent contamination spread;
- minimisation of hazardous materials - the use of materials which will result in the creation of hazardous waste during decommissioning is minimised as far as possible.

178. In summary, the design of SZC includes measures which will:

- minimise the activity level of irradiated components;
- reduce worker dose during decommissioning;
- permit easy decontamination;
- minimise the spread of contamination;
- facilitate the access of personnel and machines for decommissioning and waste removal from the reactor building;
- minimise the volume of radioactive waste;
- reduce the operator intervention time;
- minimise the toxicity of the waste.

179. The SZC decommissioning strategy is Early Site Clearance [Ref 7], which fundamentally means that decommissioning will commence as soon as practicable after the EoG, and will proceed without significant delay until decommissioning of the site is complete. High level decommissioning plans for SZC estimate that the decommissioning of the site, with the exception of the HHK, could be achieved approximately 20 years after the EoG.

7.4.2 Decommissioning Milestones

180. The process of decommissioning will be divided into a number of activities leading to the complete decommissioning of the site. For SZC these are as follows:

- Activity 0: Pre-Closure Preparatory Work;
- Activity 1: Spent Fuel Management;
- Activity 2: Site Operation and Plant Preparation;
- Activity 3: Management of Operational Wastes;
- Activity 4: Plant Decommissioning;
- Activity 5: Site Clearance and Release for Re-use.

181. In many cases the activities overlap significantly in time, and are not necessarily sequential. It is important to note that it is currently assumed that for this twin reactor site, Unit 2 will cease generation approximately 18 months after Unit 1.

7.4.3 Management of Decommissioning Wastes

182. The end of the lifecycle for SZC is when the site is released from radioactive substances regulation allowing the site to be released for reuse. The Guidance on Requirements for Release from Radioactive Substances Regulation (Ref 38) provides guidance over what is needed to release a site from Radioactive Substances Regulation. An optimised waste management approach, in conjunction with an environmental safety case, will be required to ensure that all decommissioning waste is managed and disposed of appropriately whilst minimising the impact on people and the environment.

183. During decommissioning, waste would be generated as a result of removing plant, equipment and structures, buildings and facilities at the SZC site. The largest volume of this waste would be non-radioactive and suitable for reuse, recycling or disposal at suitably authorised sites. LLW generated during the decommissioning process would be disposed of to a suitably authorised site, this may include disposal via the exemption provisions to an available licensed disposal site where this represents BAT.

184. The full range of waste minimisation methods identified in this document will be used to reduce the amount of waste produced during decommissioning to as low a level as possible, in line with the UK Radioactive Strategy [Ref 42], including decontamination, volume and size reduction and appropriate segregation of the waste to enable:

- the maximisation of materials recycling;
- minimal production of waste which is difficult to dispose of; particularly, long-lived, high activity waste;
- minimal production of 'secondary' waste (equipment used for the decommissioning phase and contaminated during the operations);
- maximum use of exempt crushed demolition material for backfilling voidage and the minimum importation of clean material onto the site.

185. During decommissioning, waste will be generated as a result of removing plant, equipment and structures, buildings and facilities at the site. Estimates of the volume and characteristics of radioactive waste generated during decommissioning have been developed as a basis for the development of the site decommissioning plan, and the costs that will need to be covered by the FDP.

186. ILW and LLW generated during decommissioning will consist of primary and secondary wastes. Primary waste varies widely in terms of type, activity, size and volume, and consists of both activated and contaminated components. Secondary waste is generated during activities that support the decommissioning process and includes items such as liquid waste, spent ion-exchange resins, spent filters, and dry active waste, personal protective equipment, swabs and used supporting equipment. These wastes will be processed and conditioned using the same procedures and facilities as for primary waste. Appropriate segregation and decontamination procedures will be implemented to reduce, as far as is reasonably practicable, the volume of radioactive materials requiring treatment or disposal.

187. Estimates of the quantities and characteristics of primary decommissioning ILW have been developed based on modelling of the neutron flux (a measure of the radioactivity within the reactor), the projected power history, and material composition data for the core of the SZC reactor. Activated components will have both short lived and long lived radionuclides resulting from the activation of the reactor material.

188. In addition to the activated waste, some surfaces, including building materials and process equipment and components, will be contaminated by radioactive deposits. These deposits result from the transport of activated corrosion products and fission products which may, in exceptional circumstances, be released from the fuel assemblies during reactor operation. By treatment of the contaminated surface, the amount of waste for final disposal can be reduced substantially. In particular, the use of chemical cleaning or blasting of the surface and melting of metallic material can increase the amount of material suitable for unrestricted or restricted release. The use of these methods will have to be justified by BAT assessment, balanced against the possible liquid and gaseous discharges arising from their use.

189. To manage these wastes a Decommissioning Waste Processing Facility will be constructed on the site during the plant decommissioning phase. It is anticipated that a single facility will be constructed in the Turbine Hall of Unit 1, to serve the management of the decommissioning wastes from both Units.

190. Uncertainties in waste characterisation will be reduced to a minimum to avoid unnecessarily high waste categorisation. This applies, in particular, to the unnecessary classification of non-radioactive hazardous waste as radioactive waste.

191. ILW arising during decommissioning from decontamination and dismantling activities, i.e. secondary waste will have similar characteristics to those wastes generated during SZC operations. Therefore, SZC Co. is confident that all secondary wastes will be acceptable for disposal. SZC Co. is developing its decommissioning plans with due consideration of the potential disposability of any waste produced.

192. Assessment work completed since GDA, as part of the design development at HPC, has established that a proportion of the heavy reflector reactor component is likely to be High Level Waste and would therefore require a period of decay storage on-site prior to transfer to the GDF. Preliminary assessment has estimated that the decay period would be approximately 20 years.

193. During the GDA process the views of the RWM were sought on the likely acceptability for disposal in a GDF of packaged primary radioactive waste generated during SZC decommissioning. RWM indicated that, in principle, any of the proposed waste packages will be acceptable for disposal [Ref 19]. SZC Co. will continue to work with RWM to ensure that packaged decommissioning waste from SZC will be acceptable for disposal in a GDF.

194. LLW generated during the decommissioning process will be disposed of to a suitably authorised site, this may include disposal of exempt waste to an authorised landfill or on-site burial where this can be justified (see also Section 7.4.5).

7.4.4 Decommissioning of Spent Fuel Interim Storage Facility

195. The HHK will store the full operational lifetime arisings of spent fuel from the SZC reactors. The current assumptions regarding availability of a GDF for spent fuel, and the length of cooling time before the spent fuel is suitable for disposal, means that a period of storage at SZC will be required after the decommissioning of the other facilities (see Section 7.3).

196. The HHK will be decommissioned once spent fuel has been encapsulated and transferred off-site for disposal. HHK decommissioning is likely to include:

- size reduction of the empty spent fuel canisters and storage shelters;
- demolition of the HHK building;
- segregation of materials according to activity and treatment/disposal route.

197. Appropriate radiological precautions will be employed throughout the process to avoid the spread of contamination and minimise the quantities of radioactive waste, so as to ensure the safety of the public and workforce.

7.4.5 Site Clearance and Release for Re-use

198. The completion of the decommissioning process is the complete radiological clearance and de-licensing of the site.

199. Site clearance monitoring, remediation and landscaping will be undertaken in two phases. The first and largest phase will be undertaken following completion of the decommissioning of the power station plant. At this stage HHK will still be operational. The second phase will be undertaken on completion of emptying and decommissioning the HHK.

200. It is proposed that the original site licence and licensed area will be reduced to the minimum required for continued operation of the HHK. For the remaining area a radiological survey will be undertaken and any necessary remediation carried out. On completion of this the site will be clearance monitored to check that all radioactive materials of regulatory concern have been removed from the site. Subject to the Health & Safety Executive being satisfied that there is no danger from the radioactivity on site (see below), it could then be de-licensed. Upon completion of spent fuel transfer and decommissioning of HHK a further radiological survey will be undertaken and any necessary remediation carried out. At this stage it is assumed for liabilities estimation purposes that the whole site will be de-licensed.

201. For each phase, an environmental monitoring programme will be undertaken to check for the presence of any residual radiological or chemical hazards on the area of site concerned. On completion of the final phase, the site will be made available for re-use, thus completing the decommissioning process.

202. The final stage of decommissioning will be the removal of the nuclear licensing requirements from the site. A licensee's period of responsibility does not end until there is no longer any danger from radioactivity on the site. Therefore, in seeking to end the licensee's period of responsibility, a safety submission will need to be made for the ONR agreement. To de-license the site the ONR will establish that residual radioactivity on the site represents no danger to future site users from:

- licensee's evidence;
- ONR's own independent assessment;
- evidence provided by the Environment Agency.

203. De-licensing will run in parallel with the environmental permit surrender process. The environmental permit surrender process will comply with the 'Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulation' (GRR), which was published in July 2018 [Ref 38]. The GRR requires operators to develop optimised plans that detail the approach to be taken to manage radioactive wastes from the decommissioning and clean-up of a nuclear site. This approach to decommissioning may include disposal of suitable wastes in situ, or disposal of waste into existing below-ground structures, if this represents the optimised approach and receives all necessary regulatory approvals. SZC will submit an optimised Waste Management Plan (WMP) and a Site Wide Environmental Safety Case (SWESC) in line with Environment Agency expectations and guidance to demonstrate how the core criteria of the GRR will be achieved. The SWESC and WMP will develop over time and become key constituents in the management of wastes and by default will be very much interlinked with the IWS and its development.

NOT PROTECTIVELY MARKED

7.5 Land Quality Management

204. Radioactively contaminated land on a nuclear licensed site is considered by the ONR as an accumulation of nuclear matter (unless it arises from authorised disposals). As such, it is expected that the NSL Licence Condition (LC) 32 ("accumulations"), and LC34 ("leakage and escape") in particular will apply. In addition, disposals of radioactive waste arising from contaminated land should be in accordance with LC33 ("disposal of radioactive waste"), and with the arrangements under the RSR permit.

205. There is a possibility, although unlikely, that radioactive wastes might be generated from construction activities due to the presence of land contamination. In addition, there is the potential that during operation and decommissioning, land contamination could be created.

206. A standard [Ref 4] for land quality management has therefore been developed for the lifecycle of the site, which considers contamination which may (i) already be on the site, or (ii) which may be in land adjacent to the site (and which may be influenced by site activities). The standard is interpreted and supported by a land quality management strategy [Ref 4], which describes in further detail the approach to LQM activities at SZC.

8 MONITORING ARRANGEMENTS

207. Monitoring requirements will be specified in the relevant permit and vary dependent on the activities being undertaken. The SZC monitoring schedule will be developed as part of the RSR permitting process. Arrangements for the monitoring of effluents, discharges and solid wastes, and the environment during the operational phase, is described in Claim 5 of the RSR permit application support document A1, regarding monitoring [Ref 9].

208. The aim of monitoring is to check and demonstrate that relevant conditions and limitations in the Environmental Permits are complied with. Radiological monitoring is undertaken to ensure the application of BAT and to demonstrate compliance with the limits and conditions of the RSR permit, and in particular to ensure that:

- the generation of radioactive waste is prevented or minimised at source;
- wastes are adequately segregated;
- the treatment and disposal of radioactive waste are optimised;
- systems and components serving an environmental protection function are operating as expected and efficiently;
- the amount of radioactivity discharged or disposed to the environment is minimised;
- radioactive discharges remain below the limits set in the RSR permit;
- the volume of radioactive waste disposed to other premises is minimised;
- the WAC for the relevant waste disposal routes are complied with; and
- the impacts on the environment and members of the public are minimised from radioactive discharges and radioactive waste disposals to other premises.

209. In-process monitoring includes sampling, on-line measurements (which may also be referred to as on-line monitoring), analysis and assessment. Analysis is referred to in its broadest sense i.e. in-situ measurements,

tests, surveys and laboratory analyses. In the context of radioactive solid wastes, monitoring includes waste characterisation, clearance monitoring and assay of waste packages.

210. Detailed information on the monitoring techniques proposed or being considered for SZC is provided in the RSR permit application support document C1 [Ref 10]. This includes demonstration that the design and sampling techniques will enable representative samples to be taken for laboratory analysis or on-line measurements, in line with relevant regulatory guidance, national (Environment Agency of England & Wales Monitoring Certification Scheme) and international standards.

211. The range of radionuclides and their detection limits for the analytical techniques will be broadly consistent with those already applied on the UK's current operating PWR at SZB. Several separate assessments have been carried out to show that the methods used at Sizewell over the last 20 years have ensured that short and long term trends in discharge data can be recorded and used to show the extent of compliance with its discharge authorisation and that short term trends have allowed full fault identification.

9 RECORD KEEPING

212. The two main drivers for record retention associated with the construction, commissioning, operation and subsequent decommissioning of a nuclear power station are:

- The legal requirement to retain records in order to comply with regulations, the expected conditions of the Nuclear Site Licence or Permit etc;
- The practical requirement to enable the operator to know and manage the hazards and risks associated with its site.

213. SZC Co. has procedures and processes in place for the production, review, approval and control of documentation. Retention schedules have been developed to ensure records generated at each phase of the project are retained for the correct period of time. These retention schedules are consulted when uploading documentation to the SZC Electronic Document and Records Management System (EDRMS) to ensure the required retention period is specified.

214. Compliant document and record control and storage are required from the point of permit issue for key areas of the permit that will be granted: for example, records relating to the design of the facility. From an IWS perspective, a full record schedule, including the records that will be generated in the management of waste disposals, will be required to be in place before active commissioning is entered. Records management arrangements for higher activity radioactive waste and spent fuel management will be developed to an appropriate level of detail as the project progresses in accordance with [Ref 39].

215. The management arrangements associated with the retention of operational records will demonstrate compliance with the requirements of the NSL and RSR and will allow reference and interrogation of historic events, permit the original version of the record to be viewed (even if subsequently amended) and will protect against changes in technology, to ensure the future availability of records is maintained.

216. The IWS will be maintained as a live document to be updated in parallel with the development of the SZC design, safety case and Environment Case as the installation moves through the project phases of construction, commissioning, operation and decommissioning, including expansion to a full IWS (akin to the NDA IWS guidance). SZC Co. will continue to optimise its waste management strategies, taking note of UK and international operating experience as well as developments in waste management technology, policy and legislation.

10 CONCLUSIONS

217. This IWS provides a baseline summary of the waste management strategy proposed for SZC; focusing on the radioactive aspects of waste management to specifically support the RSR permit application. It shows that there is an appropriately planned management strategy for all the waste streams to be produced by the two UK EPR^{TM} units. This document, together with its supporting references, provides confidence that the challenges associated with the management of wastes and spent fuel at SZC are fully understood and that solutions are available within the envelope of current UK and international experience. SZC does not propose to generate any orphan wastes (i.e. wastes for which a disposal route does not exist) evaluated against the current waste acceptance criteria from RWM Ltd. The SZC RSR Forward Work Plan provides further detail regarding the steps required to put the necessary arrangements and plans in place to ensure waste management in line with the proposed strategy [SZC RSR CMT7] [Ref 8].

218. SZC Co. will continue to optimise its waste management strategies, taking note of UK and international operating experience as well as developments in waste management technology, policy and legislation.

219. This version of the IWS has been written for the application of permits and has been based on, and taken learning from, the IWS generated for the HPC development. The UK EPR™ is an evolutionary design, which has incorporated optimisation and lessons learned from the Flamanville 3 design, and previously from its gradual development across the EDF fleet of PWR's in France.

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