Site Restoration

Winfrith End State:
Waste Management Plan

Project report – ES(23)P378 Issue 3, December 2024

WINFRITH END STATE: Waste Management Plan

Review/Revision Register

A review/change of this document was carried out as follows:

Version	Date	Author	Amendments / Change
ES(17)P158, Draft 1	May 2017	T Baldwin	First issue as part of the GRR trial.
ES(17)P158 Version 1	July 2019	H Edwards	Delivered to the NDA meet the Termination Milestone
Issue 3	December 2024	J. Roberts	Written to support the application to vary the RSR permit.

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Executive Summary

The Winfrith nuclear site in Dorset is a former nuclear power research and development site owned by the Nuclear Decommissioning Authority (NDA) and operated by Nuclear Restoration Services (NRS). It is located approximately four miles from the south Dorset coast, two miles west of the village of Wool and ten miles east of Dorchester. Extensive decommissioning has been completed at the site with a significant portion of the original land area has been released from regulation and reused for commercial purposes. Decommissioning and restoration activities are on-going, and Winfrith will be the first NRS site to reach its Interim End Point (IEP), the point at which all physical decommissioning and waste management activities are complete.

The UK environment agencies have issued Guidance on Requirements for a site's release from Radioactive Substances Regulation (RSR), known as the GRR. This guidance states that its aim is to set out:

- The requirement for optimised plans for the management of the radioactive wastes from decommissioning and clean-up of a nuclear site;
- The standards that must be met if these optimised plans identify that radioactive wastes are best managed by on-site disposal;
- The standards that a nuclear site must meet if it is to be released from RSR.

Implementation of the proposed end state, including on-site disposals, will require several regulatory permissions. These include:

- A variation to the site's RSR (EPR16) permit to allow disposal in-situ and for a purpose of radioactive wastes (under the terms of the GRR);
- A permit for a 'deposit for recovery' (DfR) operation to allow recovery of suitable non-radioactive waste from specified decommissioned facilities on site and its deposit in the below-ground voids;
- Planning consent for the disposals and the site's change of use.

The GRR identifies management requirements for nuclear operators to demonstrate appropriate lifecycle management of wastes and operations. Two key management requirements (Requirement 2 and 7) of the GRR require the production and maintenance of a Waste Management Plan (WMP) and a Site Wide Environmental Safety Case (SWESC). The WMP and SWESC, and supporting documentation, set out and justify the optimised waste management approach and end state for the Winfrith site.

This WMP is produced in compliance with requirement 2 of the GRR. The WMP also supports the application to vary the Winfrith site RSR permit for the proposed on-site disposals at SGHWR and Dragon..

The role of the WMP is to provide information on how the management of all wastes has been, and will continue to be, optimised. These wastes include solid radioactive waste as well as liquid and gaseous discharges. The management of contaminated ground, which is outside the legal definition of waste, is also addressed within this WMP.

The management of the waste remaining at Winfrith has been optimised to define the preferred management approach for each waste stream. Extensive optimisation assessments have been completed over the last 10 years. The assessments have included community and stakeholder views in decision making, either through attending workshops or through defining important issues in decision making.

Using the GRR guidance, disposal in-situ and for a purpose has been demonstrated as the preferred and optimised approach for the:

- Steam Generating Heavy Water Reactor (SGHWR) and Dragon – The below ground structures will be retained in place (disposal in-situ). The above ground structures will be

demolished and used to backfill the below ground structures. Demolition rubble from existing rubble stockpiles will supplement the backfilling of the underground voids.

- Dragon Mortuary Holes (MH) and B78 slab – the below ground Mortuary Holes will remain in-situ and will be filled with grout as there are no other practical solutions for the management of this feature. The B78 slab will remain in-situ with no further modifications.

All other radioactive wastes, including wastes that are currently accumulated on-site or will be generated in the future, will be managed off-site via optimised management routes.

Radioactively contaminated ground is being managed in accordance with the site's Licence Condition requirements under the Nuclear Installations Act (1965, as amended) and standard industry protocols. The general optimised approach at Winfrith is to remediate land identified as being in-scope of RSR.

Non-radioactively contaminated ground will be managed in a way that is consistent with the defined end state and acceptable to the local authority and regulator. Management approaches are defined through risk assessments and carrying out options appraisals to define any remediation approaches on a case by case basis.

This WMP presents the current approach to management of radioactive and non-radioactive wastes via optimised disposal routes. Work to characterise and further optimise the management of waste disposal will continue throughout the site's decommissioning programme. Further updates of the WMP will be issued to reflect the status at either 10-year intervals or prior to significant end state milestones (as appropriate).

The WMP is presented in two parts – this report, which discusses the scope of the WMP, the Winfrith site decommissioning plan and the optimised disposal routes for remaining radioactive wastes, and a detailed spreadsheet of information and references relevant to waste and materials on the Winfrith site.

Acronyms

ALARA	As Low As Reasonably Achievable
ALARP	As Low As Reasonably Practicable
ALES	Active Liquid Effluent System
BAT	Best Available Techniques
BPM	Best Practicable Means
CLD	Concrete Lined Drums
DC	Dorset Council
DCC	Dorset County Council
DSR	Design Substantiation Report
EA	Environment Agency
EAC	Emplacement Acceptance Criteria
EAST	External Active Sludge Tanks
EDMS	Electronic Data Management System
EPR	Environmental Permitting Regulations 2016 (as amended)
GDF	Geological Disposal Facility
GRR	Guidance on Requirements for Release from Radioactive Substances Regulation
HAW	Higher Activity Waste
HVA	Heavy Vehicle Airlock
IBC	Intermediate Bulk Container
ILW	Intermediate Level Waste
IWS	Integrated Waste Strategy
JWMP	Joint Waste Management Plan
LAW	Lower Activity Waste
LLRAD	LLW Radioactive Database
LLW	Low Level Waste
LLWR	Low Level Waste Repository
LQMP	Land Quality Management Plan
LTP	Lifetime Plan
MH	Mortuary Hole
MMO	Marine Management Organisation
MoD	Ministry of Defence
NDA	Nuclear Decommissioning Authority
NRS	Nuclear Restoration Services
ONR	Office for Nuclear Regulation
PDC	Purbeck District Council
PGPC	Purge Gas Pre-cooler
PIE	Post Irradiation Examination
PSA	Pressurised Suit Area

RSR	Radioactive Substances Regulation
RSRL	Research Sites Restoration Limited
RWMC	Radioactive Waste Management Case
SGHWR	Steam Generating Heavy Water Reactor
SIMP	Staged Inventory Management Plan
SWMMP	Site Wide Materials Management Plan
UA	Uncertainty Assessment
UMP	Uncertainties Management Process
VLLW	Very Low-Level Waste
WMP	Waste Management Plan
WSSG	Winfrith Site Stakeholder Group

Glossary of terms

Disposal for a purpose - DfaP	Infilling unwanted voids with radioactive waste. Defined in the **GRR** as "On-site disposal of solid radioactive waste by permanent deposit where, if radioactive waste were not available, other materials would have to be found to fulfil the purpose".
Deposit for recovery - DfR	Depositing waste for recovery is when you use waste material instead of non-waste material for: • Construction; • Reclamation; • Restoration or improvement of land.
End State	The condition of an NDA site (or part thereof), following all physical decommissioning and clean-up activities required to conclude the NDA's mission for that site (or part thereof) – hence the site can be de-designated.
Interim End Point - IEP	Interim End Point. The point in time at which the Winfrith IES is achieved.
Interim end state - IES	Interim End State – The condition of the Winfrith site following all physical decommissioning and clean-up activities required for the next planned use of the site.
Optimisation	The principle of ensuring that all exposures to ionising radiation of any members of the public and of the population as a whole are kept as low as reasonably achievable (ALARA), economic and social factors being taken into account.
Out of Scope - OoS	Out of Scope material or waste whose level of radioactivity is below that required to be regulated under RSR.
Radioactive substances	Any substance or article that satisfies the definitions of radioactive material or radioactive waste or radioactive contamination.
Radioactive waste	Radioactive material that is no longer of use, is discarded, or is required to be discarded.
Radioactive Substances Regulation	The schedule in the Environmental Permitting Regulations relating to the regulation of radioactive substances, including wastes.
Site end state	The condition of the entire site (including the land, structures and infrastructure) once decommissioning and clean-up activities have ceased.
Site Reference State - SRS	The condition of a nuclear site when it is fully compliant with the requirements for release of the site from RSR.
Site Wide Environmental Safet Case - SWESC	A documented set of claims, made by the operator of a nuclear site, to demonstrate achievement by the site as a whole of the required standard of environmental safety.

1 INTRODUCTION

1.1 Background and context

The Winfrith site (Figure 1), situated near the south coast of Dorset, had its primary role in the research and development of nuclear reactor technology. Nine experimental reactors in total, each with a unique design, were developed and operated on the site between 1957 and 1995. The site is owned by the Nuclear Decommissioning Authority (NDA) and operated by Nuclear Restoration Services (NRS) Ltd and is in the process of being decommissioned in order to ultimately achieve its site end state.

Figure 1: Aerial view of the Winfrith site

Activities involving radioactive substances at the Winfrith site are regulated by the Environment Agency (EA) under the Radioactive Substances Regulations (RSR) set out in the Environmental Permitting Regulations (England and Wales) 2016. Currently, the Office for Nuclear Regulation (ONR) regulates the generation and storage of radioactive wastes via the relevant conditions of the Nuclear Site Licence.

As Winfrith progresses through its decommissioning programme, it is envisaged that the current legislation will be updated, in line with the Energy Act 2023, to allow the Nuclear Site Licence to be fully relinquished at the site's Interim End Point (IEP), and at this point all activities associated with radioactive waste will be regulated by the EA via the RSR permit.

Once all radioactive waste management activities have ceased, the site will have achieved the Site Reference State (SRS) and the RSR permit will be surrendered. This will occur once all of the prescribed activities, such as radioactive discharges and disposals, are complete. The process for releasing nuclear sites from RSR is described within the "Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulation"; identified within this document as 'GRR' (Ref. 1).

Two key requirements of GRR are the production and maintenance of a Waste Management Plan (WMP) (Requirement 2) and a Site-Wide Environmental Safety Case (SWESC) (Requirement 7). The WMP and SWESC are required to justify that the optimised management approach has been identified for all radioactive wastes generated up to the SRS. The WMP and SWESC will remain "living documents" throughout the life cycle of the site until the SRS is achieved and release from RSR is agreed.

The GRR sets out the requirements for sites in planning decommissioning activities, including optimising the management of radioactive wastes. Optimisation requires the structured assessment of options for managing wastes to balance the relative benefits and detriments of each option. Optimisation assessments have been completed for the remaining materials, assets and wastes at Winfrith. This process has identified a preferred approach for managing some wastes as disposal in-situ and disposal for a purpose.

Therefore the WMP, SWESC and supporting documents justify the disposal in-situ and for a purpose of suitable radioactive wastes by demonstrating that they meet the requirements set out in the GRR.

This WMP proposes a number of radioactive features to be managed on-site as part of the optimised End State. These disposals will be either a disposal in-situ (for the underground structures of SGHWR and Dragon basement) or a Disposal for a Purpose (DfAP) for the infilling of the associated voids. Collectively, these are referred to as “on-site disposals”.

The scope of radioactive wastes proposed for on-site disposal at Winfrith are:

- Disposal in-situ of:
    - The below ground parts of SGHWR and Dragon reactors;
    - The Dragon Mortuary Holes;
    - The B78 building base slab.
- Disposal of the above ground parts of SGHWR and Dragon reactors for the purpose of filling the unwanted voids.

1.2 Limitations and assumptions

Decommissioning activities are ongoing at Winfrith and hence this WMP is issued using the following assumptions and limitations:

- Characterisation of wastes will continue throughout the decommissioning programme. Therefore, parts of the radioactive and non-radioactive inventories are based upon cautious assumptions. It is assumed that the radioactive and non-radioactive inventory for the on-site disposals, once they have been implemented, will be less than the current inventory estimate that has been produced for the application to vary the RSR permit;
- Detailed design of the proposed disposals will be completed after removal of higher activity wastes from SGHWR and Dragon but is unlikely to fundamentally alter the management approach presented in this document.

In addition, references are signposted where detailed waste management information is available within other parts of the Winfrith management arrangements, for example:

- Intermediate Level Waste (ILW) is managed under the existing Higher Activity Waste (HAW) strategy and Radioactive Waste Management Case (RWMC);
- Management of radioactive liquid and gaseous effluents is managed under the existing liquid and gaseous effluent management arrangements in accordance with the current environmental permit (Ref. 2).

1.3 Objectives and scope of the WMP

The requirement for a WMP is set out in Requirement 2 of the GRR (paragraph A3.16):

> *“Operators should prepare a waste management plan (WMP) to manage the programme of disposals of radioactive waste from their nuclear site, and implement the plan to achieve the site reference state.”*

To this end, this WMP presents the following:

- Evidence that an optimised approach for managing radioactive and non-radioactive waste on and off-site has been identified;

- A forward programme of work is identified where an optimised approach is not yet fully determined.

This evidence and forward programme will be revised as decommissioning works continue. This iterative approach of optimisation and assessment will continue until the site reaches the point where all activities related to the management of radioactive wastes have been completed, known as the Interim End Point (IEP).

The NRS management arrangements (outlined in Section 5) detail how Winfrith complies with the requirements of the RSR permit. Much of the information relevant to the management of wastes is detailed in other documents and is summarised here to avoid repetition. Conversely, information related to the optimisation of on-site disposals is a bespoke approach for the wastes remaining at Winfrith and these aspects are described in detail within this document.

The scope of this WMP does not include wastes that have been removed from Winfrith prior to publication. These wastes have either been disposed of or are being stored at another location pending final disposal.

The WMP is presented in two main parts; this report together with a separate spreadsheet (see Appendix A) that provides a detailed summary of the current status of radioactive and non-radioactive waste characterisation and management strategies.

Appendix A provides this information for solid waste, ground and groundwater contamination, liquid discharges and gaseous discharges.

1.4 Physical scope

The physical scope of this WMP is defined by both the permitted boundary of the site (Figure 2) including the route of the Sea Discharge Pipeline, referred to as ‘the pipeline’ (Figure 3).

Figure 2: Licensed and permitted areas on the Winfrith site

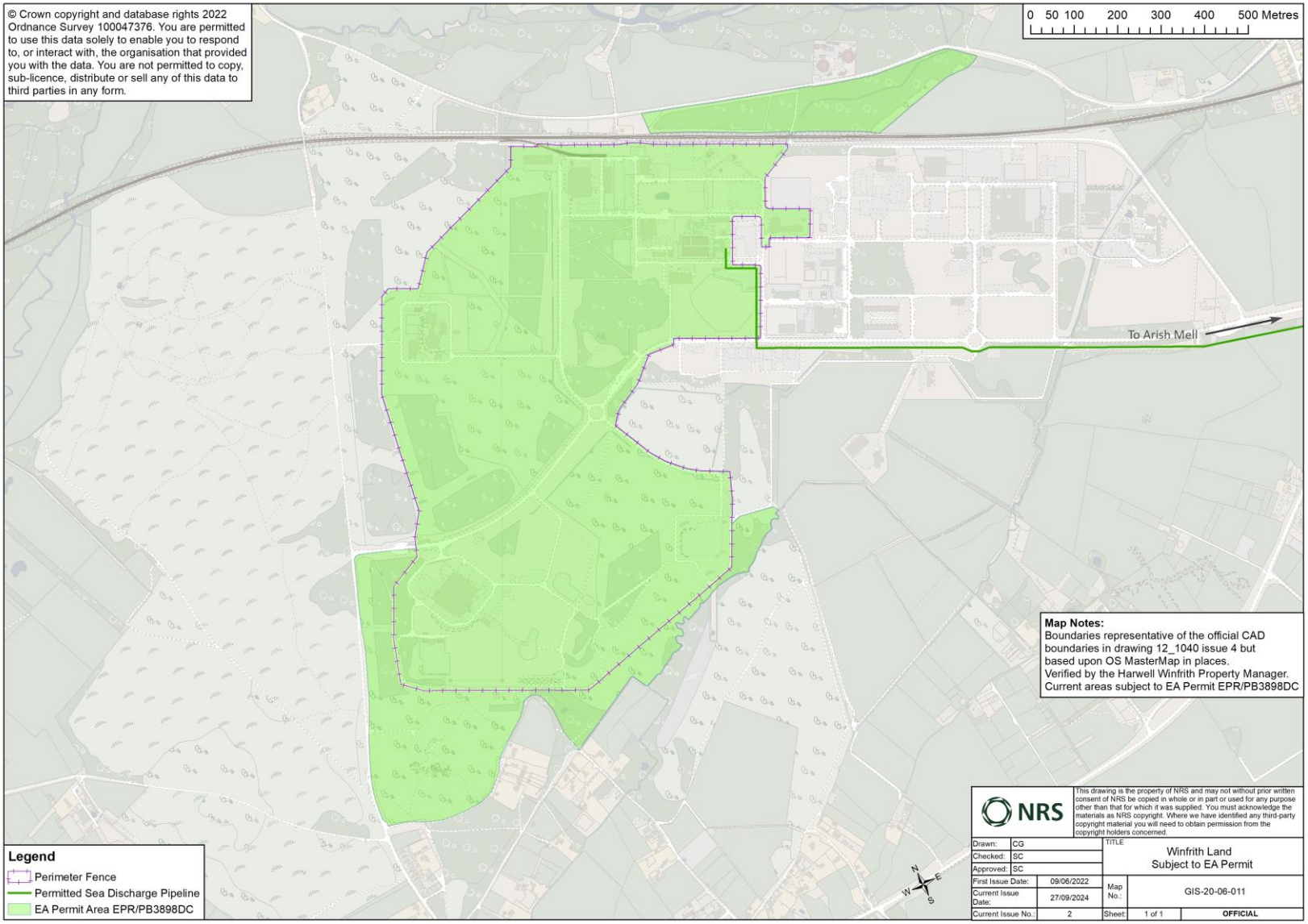
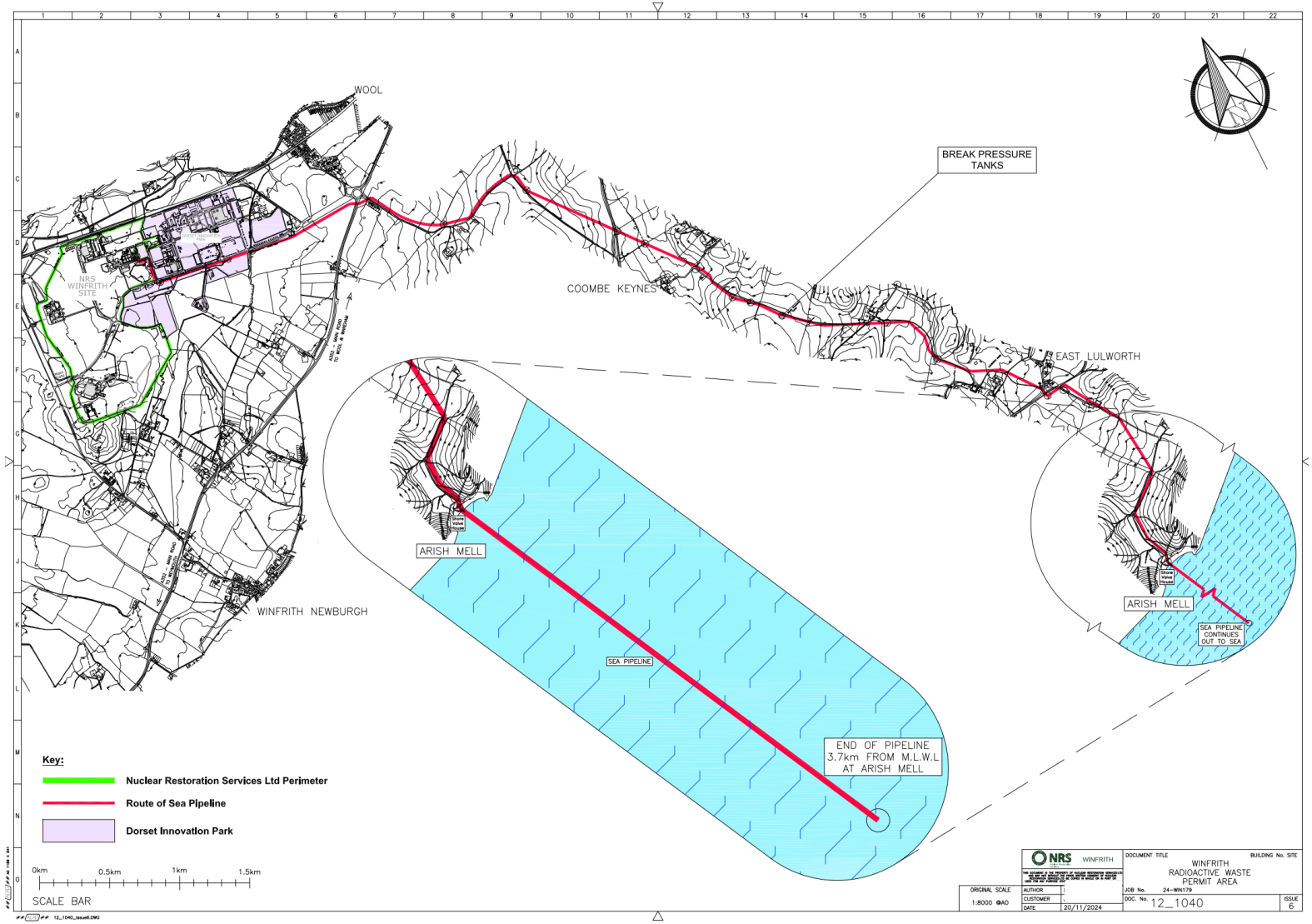


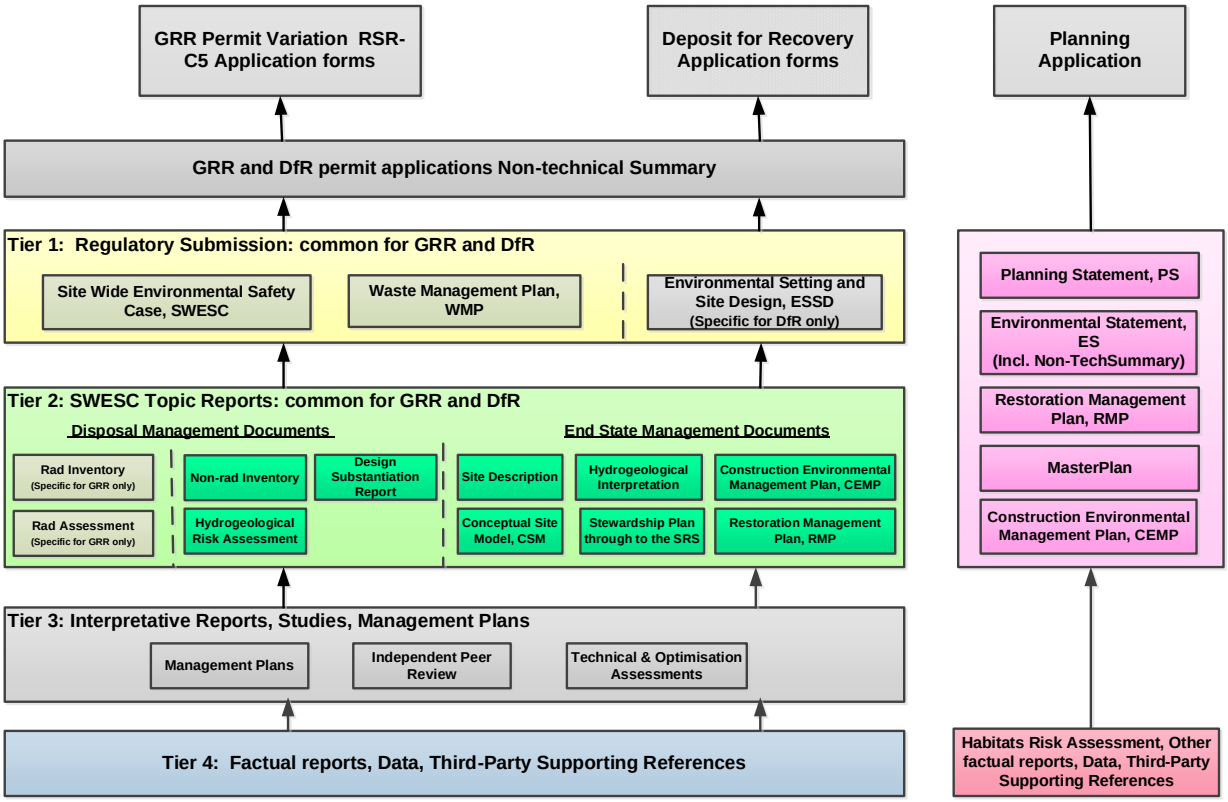
Figure 3: Route of the sea discharge pipeline



1.5 Context of the WMP

The WMP forms part of a document hierarchy that support the application to vary the RSR permit, as well as the application for a DfR permit and for planning consent for the proposed waste disposals (Figure 4).

Figure 4: RSR, DfR permit and planning applications document hierarchy



Where appropriate, information contained in other documents has been signposted through referencing, rather than duplicating the information.

Uncertainties are identified in the WMP and will be managed as required to reduce uncertainty and meet permit requirements. The uncertainties detailed in this WMP reflect the high-level nature of the document. Detailed uncertainties, such as parameter uncertainty or model uncertainty associated with the proposed disposals, are recorded in the underpinning assessment reports that support the WMP. Where necessary, uncertainties recorded in this WMP feed into a scope of further work designed to reduce or remove uncertainties. Uncertainties identified through the WMP are detailed in Appendix B, in accordance with the Uncertainties Management Process (UMP) (Ref. 3). Uncertainties are given unique reference numbers in the form of [WMP-UMP-XXX].

The WMP spreadsheet (Appendix A) is organised by the categories of wastes considered in the WMP report. The spreadsheet is structured as follows:

- Cover sheet tab: introduction to the WMP spreadsheet including the review history;
- Main WMP tab: the main sheet identifying the wastes on site, including a description, summary of the management strategy and optimisation status;
- References tab: lists the references identified in the main WMP tab.

2 THE REGULATORY CONTEXT OF THE WINFRITH WASTE MANAGEMENT PLAN

2.1 Relation to Radioactive Substances Regulations (RSR)

Winfrith conducts decommissioning and waste management operations under an RSR permit (Ref. 4). The key requirements of this permit are that wastes must be:

- Managed in an optimised manner in accordance with Best Available Techniques (BAT) and must consider the radioactive waste hierarchy;
- Disposed of in a manner that minimises the impact on human health and the environment;
- Characterised using BAT for waste assay;
- Segregated at source;
- Stored in a manner that prevents degradation;
- Compliant (when being disposed off-site) with the Waste Acceptance Criteria of the receiving organisation.

2.2 Relation to GRR

The key requirements from the GRR are repeated below.

The GRR sets out a “Fundamental Protection Objective”:

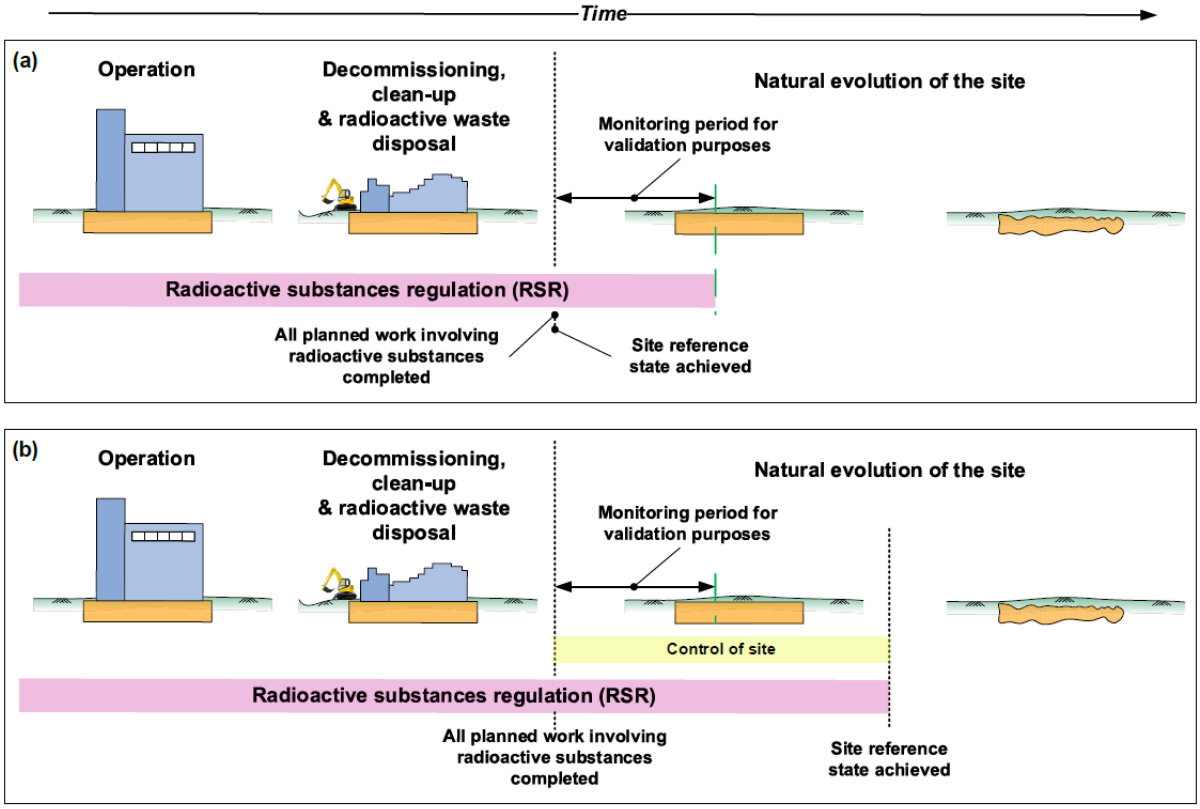
> *“Our [the environment agencies’] fundamental protection objective is to ensure that a nuclear site is brought to a condition [the SRS] at which it can be released from RSR, through a process which protects the health and interests of people and the integrity of the environment, both during the period of regulation and afterwards, and which inspires public confidence and takes account of costs.”*

The requirement for a WMP is set out in Requirement 2 (R2) of the GRR (paragraph A3.16):

> *“Operators should prepare a waste management plan (WMP) to manage the programme of disposals of radioactive waste from their nuclear site, and implement the plan to achieve the site reference state.”*

For Winfrith, the SRS will be achieved after several decades of environmental monitoring has been completed as set out in Pathway (b) of Figure 5.

Figure 5: Pathways to achieving the site reference state and release from RSR (diagram taken from GRR (Ref. 1))



Paragraph A3.19 of the GRR (part of the guidance under Requirement R2) states that:

"The WMP has three principal aims. It should:

- *Show that radioactive waste management is optimised;*
- *Describe how the site will be brought to a condition [the SRS] that meets our requirements for release from RSR;*
- *Support the arguments and claims presented in the SWESC."*

Paragraph A3.19 also states that

"…as a minimum, the WMP should:

- *Demonstrate that radioactive waste management has been optimised (R1);*
- *Identify all current and prospective disposals of radioactive waste;*
- *Demonstrate that any proposed on-site disposals of radioactive waste are optimised (R13);*
- *Demonstrate that [such] disposals are consistent with the evidence and arguments presented in the SWESC."*

Optimisation of radioactive waste management is expressed in two specific GRR requirements:

"Requirement R1. Optimisation of waste management options:

Operators should use a proportionate process to select options, for managing radioactive waste arising from decommissioning and clean-up, that are optimised. This process shall ensure that the radiological risks to individual members of the public and the population as a whole are kept as low as reasonably achievable (ALARA) taking account of economic and social factors. The process should also consider the need to manage radiological risks to other living organisms and to manage the non-radiological hazards associated with radioactive waste."

“Requirement R13. Optimisation of on-site disposals:

> *Operators shall, through a process of optimisation, ensure that the radiological risks to individual members of the public and the population as a whole, from the on-site disposal of radioactive waste, are kept as low as reasonably achievable (ALARA) taking into account economic and social factors. Radiological risks shall be optimised throughout the period of radioactive substances regulation and afterwards, as far as can be judged at the time when relevant actions are taken. The process should also consider the need to manage radiological risks to other living organisms and to manage the non-radiological hazards associated with radioactive waste.”*

Although both these requirements identify that the management of non-radiological hazards associated with radioactive waste needs to be considered, they do not apply to non-radioactive waste or non-radioactively contaminated land.

It is also noted that the GRR (paragraph 2.5.3) states that:

> *“Optimisation in nuclear site decommissioning and clean-up should ensure that radioactive waste and contamination are managed in a way that is safe but may not necessarily lead to all radioactive substances being removed from a site.”*

2.3 Relation to the Nuclear Site Licence

The ONR and EA provide joint regulation of environmental protection and waste management on nuclear licensed sites (Ref. 5). However, the ONR is also responsible under the Nuclear Installations Act 1965 (NIA65) (Ref. 6) for the licensing of nuclear installations. There are 4 licence conditions that relate directly to radioactive waste management (LC 32, 33, 34 and 35) these are described in more detail within Table B.6 of the SWESC (Ref. 10). The requirements of the management system and activities at Winfrith reflect the site licence conditions.

2.4 Relation to waste management hierarchy

For non-radioactive wastes, the Waste Framework Directive (Ref. 7) requires application of the waste management hierarchy objectives (Ref. 8). For radioactive wastes, the requirement for defining the optimised and BAT approach for managing radioactive waste is detailed in the site Environmental Permit. The UK Strategy for the Management of Solid Low Level Waste from the Nuclear Industry (Ref. 9) defines the preferred approach to off-site management in order of preference:

1. Prevention (avoidance of generation of waste by volume and/or activity);
2. Waste generation minimisation (minimise waste generated by volume and/or activity);
3. Re-use or preparation for re-use (as the same product);
4. Recycling (as a different product);
5. Waste volume reduction (minimise the volume that requires management);
6. Recovery (including energy recovery);
7. Disposal, where radioactive wastes should be diverted from national strategic assets so far as achievable.

Radioactive waste management strategies must consider a broader range of factors than are assessed for non-radioactive wastes. To recognise this complexity, operators are required to define the overall optimal management route by assessing the performance of available options against a set of relevant attributes, e.g., risk, dose, sustainability and cost etc. The waste hierarchy is an integral part of this decision-making process but for radioactive wastes the overall optimised management route is informed, rather than defined, by the waste hierarchy.

3 SUPPORT TO THE ARGUMENTS MADE WITHIN THE SWESC

This WMP provides the evidence that supports the relevant claims and arguments made within the SWESC (Ref. 10) and these are listed within Table 1.

Table 1: SWESC claims and arguments supported by the WMP

Claim: Optimisation: Strategic options assessments have demonstrated that the preferred approach of disposing of radioactive wastes on the Winfrith site as part of the site end state is optimised. This end state presents the best overall approach when assessing a range of safety, environmental and social factors relating to management of wastes generated on the site. Evaluation of specific waste management and design options for the on-site disposals to optimise their configuration is ongoing and will continue until their implementation.		
Topic	**Argument**	**WMP supporting section**
Optimisation Process	NRS procedures are used to ensure that Best Available Technique (BAT) and optimisation assessments are undertaken consistently and with sufficient scope to ensure that radiological risks are as low as reasonably achievable (ALARA), and that the assessments are appropriately documented.	Section 5
Strategic Optimisation of Waste Management	Strategic options assessments have demonstrated that leaving some radioactive structures on site is optimal in comparison to attempting a site end state free of radioactive substances.	Section 7
Optimisation of on-site disposals	Waste management and design options for the final configuration of the proposed disposals have been assessed. Provisionally optimised configurations for each on-site disposal have been defined by considering the relative performance of the different options against agreed attributes. These assessments considered option feasibility, effectiveness, impact on risk and feedback from stakeholder engagement.	Section 7.2
Future Optimisation Assessments	Optimisation assessments will continue to be undertaken and reviewed to support decisions about future decommissioning of the site (GRR Requirement R1) as well as optimisation of the proposed on-site disposals (GRR Requirement R13).	Future optimisations assessments will be completed in support of the detailed design with updates provided in revisions to this WMP

4 OVERVIEW OF THE WINFRITH WASTE MANAGEMENT STRATEGY

The decommissioning strategy for Winfrith reflects the NDA's overall strategy to decommission NRS sites as soon as reasonably practicable, taking account legal requirements. to appropriately manage risks to people and the environment and other relevant factors (Ref. 11).

The strategy at Winfrith can be considered in the following phases:

- Final site clearance: Complete decommissioning of the reactors, other facilities and site-infrastructure so that the site is suitable for its next planned use. The end of this phase is defined within NRS as the IEP, when all decommissioning works and waste management activities are complete;

- Stewardship: During this phase the site will be suitable for its next planned land use. Validation monitoring will continue to ensure that the on-site disposals are performing as predicted and are not presenting an unacceptable risk to the public. This period is expected to last for a period of several decades. The end of this phase is defined as the SRS;
- Permit surrender (SRS): On the basis that validation monitoring demonstrates the disposals are performing as expected, an application to surrender the RSR permit will be submitted. This point is defined as the SRS, and it signifies the end of regulatory control. At this point all environmental monitoring associated with the site will cease. This may coincide with the site's end state, depending on the land condition and any other liabilities that may be present.

5 WINFRITH APPROACH TO MANAGEMENT OF RADIOACTIVE WASTE

5.1 Integrated waste management

Within NRS, integrated planning of activities is achieved through the company-wide Integrated Decommissioning and Waste Strategy (IWS) (Ref. 12) in accordance with the associated Licence Conditions and permit requirements.

All of the options assessments followed the relevant NRS, Magnox or RSRL procedures extant at the time and included common approaches:

- Defining and selecting the available options for assessment;
- Assessing options against a set of relevant attributes. Attributes are defined to reflect the potential impacts and risks of different options and include safety, environmental and socio-economic topics. Attributes are used to assess the relative benefits and detriments of different options. Options are scored against attributes to identify a preferred option;
- Completing a sensitivity analysis to determine the extent to which the output of the study changes with changes to key input parameters.

This WMP demonstrates that:

- An integrated waste management approach for all wastes and materials, both radioactive and non-radioactive is identified;
- Strategic planning is performed for wastes that are yet to be generated and this is consistent with regulatory requirements and current national waste management policy, regulation and strategy;
- That programmes exist for the future management of wastes over the lifetime of the site.

Appendix D provides an overview of the life-cycle management approaches to waste and material management at the Winfrith site.

5.1.1 Implementation

NRS has well-established arrangements for off-site management of both radioactive and non-radioactive wastes. These are defined within PD-026 'Management of Waste' (Ref. 13). The scope of the waste arrangements within PD-026 is illustrated within Figure 6. The procedures under PD-026 also set requirements for the minimisation of secondary waste. The key waste management arrangements signposted in PD-026 are:

- S-454: Management of Higher Activity Waste;
- S-415: Implementation of Radioactive Waste Management Cases;
- S-078: Management of Lower Activity Waste;
- S-100: Management of Controlled Waste;
- PRC 0159, Management of Liquid Discharges;
- PRC 0193 – Management of Radioactive Airborne Discharges;
- S-037 The Assessment of Radioactive Liquid Discharges;
- S-070 The Assessment of Radioactive Gaseous Discharges;
- S-391: Options Assessment for Radioactive Substances Legislation BAT/BPM Compliance;

- Arrangements for management of land contamination (which are not wastes until excavated) are set out in STD 0016 'Land quality management at Harwell and Winfrith (Ref. 14).

In addition, the following local documentation summarises how wastes are managed at Winfrith:

Radioactive Waste:

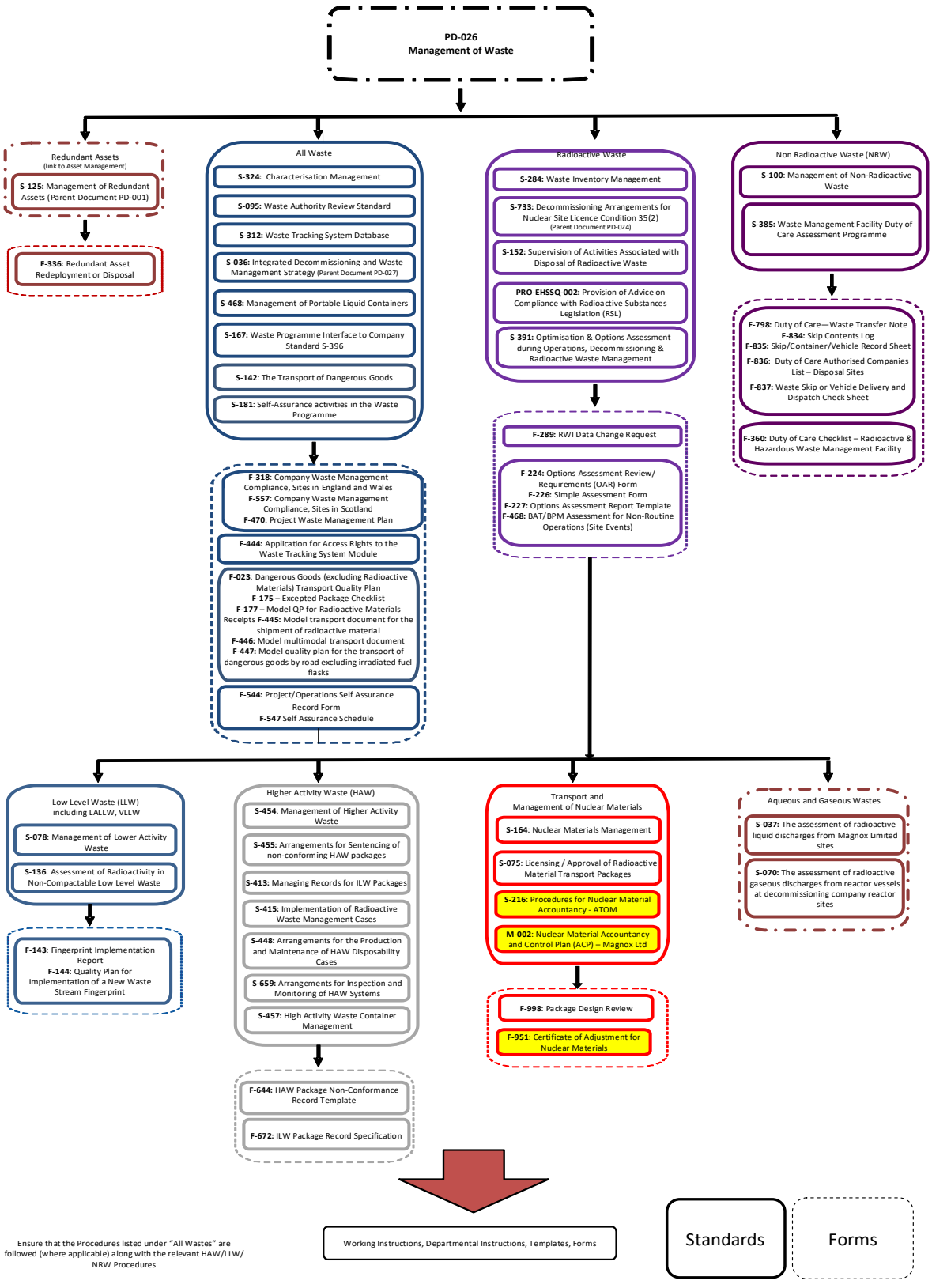
- The Winfrith Site RWMC (Ref. 15) provides a summary of HAW and solid Low Activity Waste (LAW) management, as well as aqueous and gaseous discharges.
- A Joint Waste Management Plan (JWMP) is maintained by the site to plan the waste disposal activities over a 3-year cycle. This plan is produced by identifying the decommissioning activities within the Lifetime Plans1 (LTP) for each of the Winfrith decommissioning projects that will produce radioactive waste. The JWMP is maintained on an annual basis to ensure that resources are available for the processing and disposal of projected waste arisings.

Non-Radioactive Waste:

- S-100 sets out the requirements and arrangements for managing 'clean' and out of scope (OoS) wastes generated at Winfrith;
- The Winfrith Site Wide Materials Management Plan (SWMMP) (Ref. 16) describes how demolition and excavation arisings, including materials not considered to be wastes, will be managed through the remaining lifetime of the site;
- Land Quality: The Winfrith Site Land Quality Management Plan (LQMP) (Ref. 17) and the site's Land Quality Register (Ref. 18) identify areas of potential land quality and groundwater contamination to define onward management suitable for achieving the end state.

1 The Lifetime Plan (LTP) is the project plan that sets out how the decommissioning of the Winfrith site will be completed. These are produced by each of the decommissioning projects and integrated for the site to ensure the individual projects do not produce conflicts.

Figure 6: Diagram from PD-026 (Ref.13) NRS waste management arrangements



6 OPTIMISING THE MANAGEMENT OF RADIOACTIVE WASTE

Winfrith undertakes BAT and optimisation assessments for managing radioactive waste that will be produced through decommissioning activities in accordance with S-391 (Ref. 19). An overview of the management approaches to radioactive wastes at Winfrith is summarised below with more detail provided within Appendix A.

6.1 Higher activity waste (HAW)

The status of the optimised approach to characterisation, processing and storage of HAW is maintained within the Winfrith RWMC (Ref. 15).

6.2 Lower activity waste (LAW) from decommissioning operations

Generic options appraisals have been completed for the majority of LAW waste streams to be produced in the remaining site lifecycle. These are listed within the NRS BAT/BPM database (Ref. 20). The principal waste streams relevant to Winfrith are set out below. The generic options appraisals set out the optimised approach for managing the most common Low Level Waste (LLW) and borderline wastes (including lower activity ILW) (Ref. 21), these include:

- Combustible LAW – waste is incinerated via an appropriately permitted facility. Waste not suitable for incineration is disposed by burial (avoiding the Low Level Waste Repository (LLWR) where possible);
- LLW Oils - incineration at an appropriately permitted facility is the preferred management route;
- LLW Metals - metallic wastes are recycled where possible unless grossly disproportionate costs would be incurred. Treatment was historically undertaken via on-site decontamination. Currently, off-site metal recycling routes are used;
- Low Level Waste asbestos and asbestos containing waste management depends on the levels of radioactivity present and material characteristics:
  - Disposal by burial if the waste meets the acceptance criteria for the receiving site;
  - Long term (decay) storage of any wastes which do not meet the acceptance criteria;
  - Packaging for disposal as ILW if the decay time to reach the acceptance criteria is beyond the agreed storage period;
- LLW Sources – are returned to manufacturer/supplier for re-use if possible, or transferred to NRS Harwell for onward management if not possible;
- VLLW demolition wastes (concrete/brick/soils/gravel/sand) – disposal by burial with specific options assessment required to determine if on-site or off-site management is preferred. Optimisation assessments at Winfrith have demonstrated that on-site disposal is the preferred approach for some of the remaining large concrete structures.

6.3 Currently stored LAW

The current status of characterisation and optimisation for wastes on the Winfrith site is detailed in Appendix A. The key aspects of the management approach for LAW currently stored at Winfrith are summarised below:

- 5G11[1]: LLW Concrete Lined Drums (CLD's). This waste stream includes four LLW CLD's that were generated in the 1970's and 1980's as part of the sea disposal programme. These drums will be disposed of by standard waste routes i.e. VLLW/LLWR as appropriate[2];
- 5G308: Legacy decommissioning wastes. Optimised management routes will be defined following detailed characterisation of the wastes. It is expected that management of these

1 The alphanumeric codes provided here are the unique identifier for the waste stream in the UK's Radioactive Waste Inventory (RWI). UK Radioactive Waste Inventory (UKRWI).

2 There are further CLDs currently stored at Winfrith and their management approach is defined within the RWMC (Ref. 15).

wastes will be via established waste routes e.g., metals recycling, combustion, and disposal, following appropriate sorting and segregation;

- 5G21: Organic Wastes. This waste stream constitutes contaminated oils, solvents and scintillant. Approximately 500 litres of wastes are currently awaiting sentencing with a further 2,000 litres predicted to arise in the future. The current optimised disposal route for these wastes is disposal via appropriately permitted incineration site.

6.4 Future arisings of LAW

In all cases waste arisings are managed and processed in accordance with the waste hierarchy to ensure that volumes are minimised for example via decontamination, super-compaction, sorting and segregation, and minimisation of secondary waste. The key future arisings of LAW at Winfrith are summarised below:

- SGHWR (5G301) and Dragon (5G303) decommissioning arisings. These wastes will include civil structures, legacy plant and equipment, materials contaminated through the decommissioning works and secondary wastes. These wastes are expected to be LLW or VLLW and will be characterised once decommissioned and the optimal disposal route selected from standard management options e.g., incineration, metals recycling, VLLW and LLWR. On-site disposal has been demonstrated as the optimised approach for the large concrete structures associated with these waste streams as discussed in Section 7;
- 5G313: Sea Discharge Pipeline. Optimisation has identified removal as the preferred approach for the pipeline. Following removal of the pipeline the resulting wastes will be managed via the most appropriate routes as per standard waste management processes;
- 5G307: Other facilities decommissioning LLW. This waste stream encompasses the wastes generated from decommissioning of the remaining non-reactor facilities at Winfrith, for example:
  - The Active Liquid Effluent System (ALES): The ALES facility is currently operational. It receives active effluent from both SGHWR and Dragon facilities for processing and onward discharge. The wastes generated from the decommissioning of ALES will be managed via the BAT disposal routes (Ref. 21);
  - Contaminated Drains: Waste generated from the removal of contaminated drainage infrastructure will be managed via the BAT disposal routes (Ref. 21).

7 SITE WIDE OPTIMISATION (GRR R1 AND R13)

GRR Requirement 1 requires operators to carry out a systematic and iterative options assessment to define the preferred approach for managing radioactive wastes over the lifecycle of decommissioning a site. This holistic approach is intended to ensure that the management of radioactive wastes from a site is assessed to ensure exposures of people and the environment are ALARA, whilst taking due account of aspects such as sustainability and socio-economic factors.

The remaining contaminated facilities and areas of radioactively contaminated land are identified in Figure 7.. These facilities and land areas have been systematically assessed to define the optimised approach for management through the remaining lifecycle.

Where on-site management is identified as the optimised approach to managing decommissioning wastes, Requirement 13 details that the approach to implementation of such disposals is also optimised (Section 7.2) to ensure exposures are ALARA. Further options assessments are completed to assess the preferred approach to engineering and implementation of the on-site disposals.

In 2006/07 the NDA undertook consultation to establish preferred end uses for each of its sites. The potential uses of the Winfrith site were considered by the Winfrith Site Stakeholder Group (WSSG) and the local community was consulted on options. The output recommended the site end state to be ‘heathland, with public access’. Building on this consultation, in

2013/14, RSRL undertook a comprehensive assessment of how the site could achieve this end state.

To determine how best to implement the Winfrith end state, NRS has completed options assessments for all of the remaining facilities and areas of radioactively contaminated land on the site. All of the assessments follow an iterative approach designed to identify the preferred outcome at an early stage using preliminary data. For proposed on-site disposals at SGHWR and Dragon, more detailed technical assessments have been completed once the preferred approach has been defined. The outputs of the technical assessments are compared against the original options assessments to ensure they are consistent with the original assessments.

Optimisation of the engineering of the proposed on-site disposals at SGHWR and Dragon will continue through the detailed design and implementation phases. This will include, but is not limited to, further optimisation of the detailed design of the disposals, the design of the disposal caps and finalising the backfilling scheme.

During implementation the disposals will be managed through assessment against the requirements for the radiological, physical, chemical and biological form of the waste specified within the Emplacement Acceptance Criteria (EAC) (Ref. 22). The EAC specifies:

- Specific activity limits for the disposals (Bq/g);
- The waste materials that can be accepted into the disposals. This requires that materials such as plastics, metals and hazardous materials e.g. asbestos, are removed where practicable to do so;
- Limits for the concentrations of hazardous materials that can remain within the disposal;
- The size grade of the demolition arisings (< 150 mm^3).

Options assessments have been completed in accordance with requirement 1 of the GRR for all the remaining radiologically contaminated structures and radiologically contaminated land remaining at the Winfrith site. Figure 7 indicates where the key structures and land areas are located and Table 2 provides a summary of the options assessments completed. Further details of the options assessments are provided within Sections 7.1 and 7.2.

Figure 7: Aerial photograph with the principal features of the Winfrith site and its surroundings

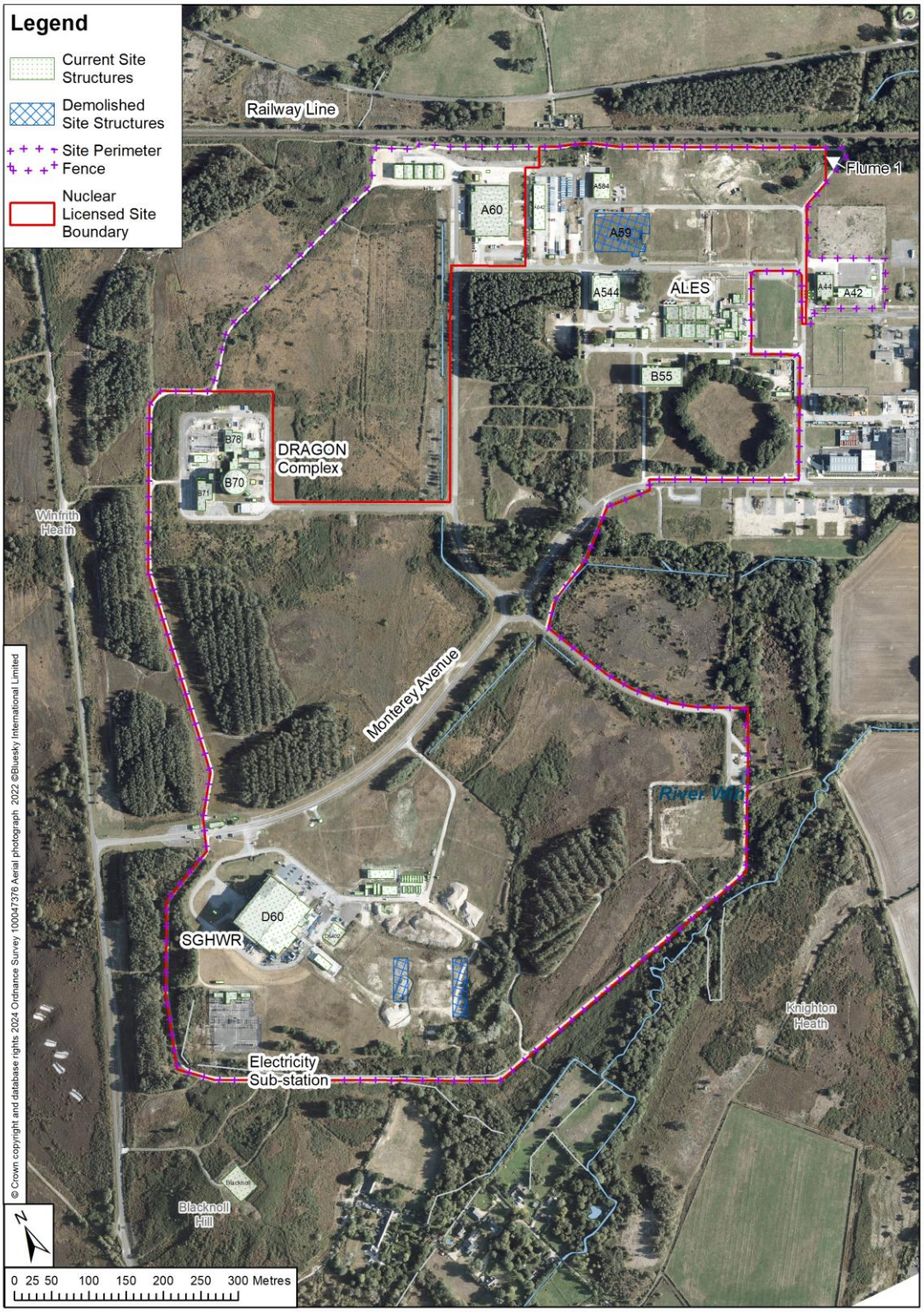


Table 2: Summary of R1 options assessments

Feature/ Assessment reference	Preferred option	Key benefits
Contaminated structures		
SGHWR (Ref. 23)	Disposal on-site	Reduced worker risk, environmental impact and cost.
Dragon (Ref. 24)	Disposal on-site	Reduced worker risk, environmental impact and cost.
ALES (Ref. 25)	Disposal off-site	Insufficient underground voids available to support on-site disposal.
The Sea Discharge Pipeline[3] (Ref. 26)	Disposal off-site	Removes the hazard and long-term liability from third party land.
Contaminated ground		
A59 land area (Ref. 27)	Remediate ground to out of scope levels	Removes the hazard and long-term liability from third party land.
D69 land area (Ref. 28)	Remediate ground to out of scope levels	Removes hazard and is lowest cost.

NRS has engaged extensively with the local community and other stakeholders and has used the opinions expressed to guide the options assessments. Further details of community engagement are provided within the SWESC (Ref. 10).

This section provides a detailed summary of each of the studies (outlined in Table 2) in order to provide clear demonstration that the proposed end state is optimised and the application to vary the site's RSR permit meets requirement 1 of the GRR.

7.1 Overview of R1 options assessments

The suite of strategic options assessments present a methodical appraisal of the remaining radiologically contaminated structures and land that demonstrates the end state for the Winfrith site is optimised.

The views of both regulatory and non-regulatory stakeholders have been sought and incorporated into the options assessment process to ensure that the preferred options reflect the range of stakeholder priorities.

The output from the assessments has concluded that the site end state will include on-site disposals of radioactive wastes at SGHWR and Dragon. This will be a combination of disposal in-situ and for a purpose. Optimisation of other structures (such as ALES and the pipeline), wastes and contaminated land has identified these will not form part of the optimised site end state, and will be managed off-site.

[3] Referred to in this document as 'the pipeline'.

7.1.1 Optimising the end state of large structures

7.1.1.1 Optimising the SGWHR end state

SGHWR is Winfrith's largest and most complex structure. SGHWR was a water based reactor that commercially generated power for nearly 30 years. The structure included multiple fuel ponds and process areas. Most of the plant and equipment has been removed and areas have been extensively decontaminated. The reactor core will be removed in the coming years. It has over 200 separate rooms, extensive underground areas and has the most significant radiological inventory of the remaining buildings on the Winfrith site. The size and scale of the SGHWR structures and the distribution of contamination pose substantial challenges in decommissioning and waste management.

A series of options assessments were conducted to assess the preferred approach to decommissioning and to determine the optimised end state for the above and below ground structures at SGHWR (Ref. 23).

Central to the assessment were a series of workshops to define the options to be assessed, define the options and gather stakeholder views. The workshops included internal experts, regulators, stakeholders from the EA, the ONR, Dorset County Council[4] and Purbeck District Council, Natural England, Dorset Wildlife Trust and representatives of the local community. These workshops were supported by a programme of technical work that included characterisation of the SGHWR structure, engineering feasibility assessments, a long-term radiological risk assessment and an assessment of the risk of an alkaline plume arising from groundwater interacting with demolition arisings.

These workshops produced:

- A preliminary list of options to consider within the assessment;
- A refined short list of options that would be taken forward for the final stakeholder workshop;
- An assessment of the options against a set of attributes to determine the preferred end state for SGHWR[5] structures.

The final workshop assessed two credible end states for the SGHWR above and below ground structures with stakeholders and local community representatives:

- Option 1: Full excavation of all the below ground structures, waste processing and disposal off-site;
- Option 2: Below ground structure left in situ and decontaminated to a level required to ensure protection of people and the environment as set out in an environmental safety case. The structure is backfilled with demolition wastes.

The workshops also defined the attributes that were used to assess the performance of options. Attributes include aspects related to safety, environment and socio-economic factors including risk to workers, long term impact on the environment and cost.

The options were assessed against the attributes to determine the overall performance. The option scores are then compared to define the preferred option.

Option 2 (on-site disposal) was found to perform best across a broad range of attributes including carbon footprint, worker safety and cost. Option 2 also offered a greater scope for sustainable management of materials/waste than Option 1 (full excavation).

[4] Dorset County Council and Purbeck District Council formed a unitary authority, Dorset Council, in 2019.

[5] This workshop was completed in February 2017 and involved a wide range of attendees which included the Environment Agency, Scottish Environmental Protection Agency, Office for Nuclear Regulation, and Dorset County Council as well as representatives from the local community.

The preferred option for the end state for the SGHWR structure was identified as **managing the structure in-situ and backfilling with demolition arisings** from the above ground structure.

This option:

- Minimises worker risk by removing the need to excavate the below ground structures and manage off-site;
- Minimises road transport, carbon footprint and public risk as there is no need to transport wastes large volumes of wastes off-site;
- Minimises impact on local habitats as there is no need to excavate the below ground structure, with the consequent disruption and dust generation;
- Minimises costs from operations and waste management activities;
- Supports national decommissioning mission by preserving capacity at permitted disposal sites;
- Enables the next planned land use of heathland with public access;
- Is safe in the short and long term as risks to human health and the environment are below guidance levels set by the EA.

The stakeholders in attendance indicated a desire to optimise the preferred option further, through the reduction, where possible, of lorry movements importing capping and landscaping material.

A sensitivity analysis was conducted on the options assessment to assess the relative importance of different attributes, and the data used in the assessment. The sensitivity analysis included assessing changes to the radiological inventory of the structure and variations in cost of different options. The sensitivity analysis identified that the selection of the preferred option was robust across a wide range of factors.

NRS has since completed further technical assessments, the results of which are summarised within the SWESC (Ref. 10).

7.1.1.2 Optimising the Dragon facility End State

The Dragon facility constitutes both the reactor building (B70) a fuel store building (B78) and a connecting wide corridor. The Dragon reactor has a smaller below ground component than SGHWR, but there are substantial concrete structures remaining. The reactor was operational for a short period in the 1970's and radioactivity levels are very low. Decommissioning of the reactor core is on-going, with the intent to package the waste and transport to Harwell for long term storage. The Mortuary Holes (90 in number) were originally used for spent fuel storage but were emptied in the 1990's. The Mortuary Holes are located in the neighbouring B78 building.

An assessment of the optimised end state for the Dragon facility was completed in 2017 (Ref. 24). This work followed the SGHWR assessment and it included a number of learning points resulting in a less detailed scope.

As for SGHWR, the Dragon options assessment was completed at an early stage using preliminary data including comparison to risk assessments for the SGHWR and Trawsfynydd projects; both of which have significantly higher radioactive inventories than Dragon.

The aim of the Dragon options assessment was to determine its optimised end state for the above and below ground structures. This included the reactor building structures, bioshield[6] and the Mortuary Holes structure.

[6] The Dragon thermal shield was also considered but was excluded as it will be removed as part of the Dragon decommissioning programme.

The optimal end state for Dragon was determined by comparing the following options:

- Option 1: Leave the Dragon sub-surface bioshield in-situ at a depth of 1m below ground level. Infill the voids with rubble from demolition of the above ground part of the bioshield and reactor building and other suitable demolition rubble from on-site sources;
- Option 2: Remove all LLW from the Dragon reactor structures (mostly from the bioshield) and emplace in the SGHWR basement. Infill the Dragon void with (OoS) decommissioning material from on-site sources;
- Option 3: Remove all LLW from the Dragon reactor structures (mostly from the bioshield) and dispose in a suitably licenced facility off-site. Infill the Dragon void with OoS decommissioning material from on-site sources.

The Dragon options assessment considered the same set of attributes used for the SGHWR options assessment. The assessment identified Option 1, **management of radioactive structures in-situ and backfilling with demolition wastes as the preferred end state** for the Dragon reactor building as it minimises:

- Environmental impact by reducing transport miles and carbon footprint as well as disruption to habitats;
- Risk to workers through reducing demolition and excavation operations;
- Costs associated with demolition, excavation and waste management.

This option is safe in the short and long term as risks to human health and the environment are below guidance levels set by the EA and enables delivery of the next planned land use.

For the Dragon Mortuary Holes structure the options were assessed against the same attributes as per the SGHWR study. The study compared the following options:

- Option 1: Stabilise the structure and make a case for it to be disposed of in-situ;
- Option 2: Remove the structure in its entirety and backfill/re-profile the void. Fill material would need to be suitable and subject to an appropriate risk assessment.

The study found that Option 1, stabilising and managing the Dragon Mortuary Holes structure **in-situ is the preferred option**. This is preferred as it minimises overall environmental impact and risk, whilst delivering a safe end state suitable for the next planned land use.

Since the Dragon options assessments were completed, further technical underpinning and risk assessments have confirmed that the risks from disposal of the Dragon reactor building and Mortuary Holes are within the risk levels set in the EA's GRR and on-site disposal remains the preferred option.

Full details of the claims, arguments and evidence that support the on-site disposal of the Dragon reactor building and Mortuary Holes structure are provided within the SWESC (Ref. 10).

7.1.1.3 SGHWR and Dragon engineering concept design

Following the identification of on-site disposal as the preferred end state for SGHWR and Dragon structures, further work was completed to understand how the proposed disposals would perform in a variety of scenarios, over very long time periods. A number of engineering assessments have been completed to define how best to implement the disposals and the optimal design in accordance with requirement 13 of the GRR.

This work identified a number of common design features for all the options e.g., demolition approach, installing an engineered cap, eliminating large penetrations in the below ground boundary structures by grouting, and arrangements for surface drainage, environmental monitoring and landscaping requirements.

This work included a workshop (Ref. 29) that identified stakeholder views on how the concept design of the SGHWR and Dragon disposals will be developed. The workshop attendees

included representatives from the EA, the ONR, Dorset Council, Natural England and Dorset Wildlife Trust.

The objectives of the workshop were to:

- Engage with the regulators and other external stakeholders on work to determine the preferred engineering concept design options for the SGHWR and Dragon end states;
- Present the approach to determining the preferred options;
- Invite the regulators and other external stakeholders to share their views on the process, assessment and output;
- Seek to understand the key factors that influence the decision.

The external stakeholders were not asked to score the options or to identify a preferred option but rather to comment on the process and the relative importance of attributes.

The main variable that distinguished between the engineering options was the amount of grouting of the backfill in the below ground structure (summarised in Section 7.2.1.1) and the associated environmental impacts.

The workshop reviewed the proposed attributes and the initial evaluation of the options' performance. This discussion raised a number of questions regarding how the options had been defined ahead of the options assessment as well as how they have been scored.

Following the feedback received throughout the workshop, additional evaluations and assessments were completed to ensure that the preferred options were robust.

7.1.1.4 Active Liquid Effluent System (ALES) facility

The ALES facility was constructed in the early 1960's to receive and treat active effluent from across the site prior to its discharge to the English Channel via the Sea Discharge Pipeline. The facility has limited underground structures that could be feasibly be disposed in-situ.

An options assessment was completed to determine whether the on-site disposals of the ALES structures should form part of the Winfrith end state (Ref. 30). The assessment compared the benefits and disbenefits of on-site disposal and off-site management of the waste resulting from the facility's demolition.

The study identified that:

- There are limited underground voids at the ALES facility for management in-situ or usable space for backfilling;
- The demolition rubble to be generated is expected to be OoS and could be managed via conventional routes and local facilities;
- The limited contamination identified within the underground structures could be readily removed using standard decontamination techniques;
- The relatively high groundwater level in this area will make it difficult to demonstrate that a disposal would comply with groundwater regulations.

Due to these factors the assessment concluded that the case for on-site disposal would be difficult to justify on balance of benefits and detriments. The preferred approach is therefore to decontaminated and demolish the facility and **manage the waste through off-site routes**.

7.1.1.5 Winfrith Sea Discharge Pipeline

A 14km long pipeline runs roughly south-southwest from the site into the English Channel at Arish Mell. The terrestrial section of the pipeline is 9.3km long (Figure 3) and the marine accounts for the remaining 3.7km. The pipeline has been used since the early 1960's to discharge effluent arisings from the site and is included within the Winfrith RSR permit.

An options assessment was completed in 2018 (Ref. 31) to determine whether the pipeline should be disposed of in-situ or whether it should be removed and managed through off-site management routes.

NRS assessed the options for managing different parts of the pipeline separately by defining 'zones'. These zones were devised to reflect the land use, land ownership, stakeholder views, technical challenges and other factors that affect short and long-term safety.

The options assessment was supported by a large body of work completed over several years, this included:

- A preliminary options assessment to define the potentially viable options (the long list);
- The costs, radiological risks and engineering feasibility associated with these options;
- An internal technical assessment of the 'credible' options with industry experts;
- Engagement with landowners, via a landowners forum, to seek views on the proposed land uses, the options and the assessment process;
- An external stakeholder workshop to determine views on the process being followed, the assessment's attributes, the relative importance of the attributes and the performance of each option against the stakeholder attributes. This workshop was attended by landowners and representatives from the EA, Dorset County Council (DCC), Purbeck District Council (PDC), the Marine Management Organisation (MMO) and Natural England.

The assessment concluded that the preferred approach for managing the marine and shallow[7] terrestrial sections (including all ancillary structures) is **removal** followed by management via an off-site facility. This is the preferred approach as:

- It was identified as acceptable by stakeholders for the majority of the zones;
- This approach allows for any potential future use of land and removal of easements and covenants to allow re-development;
- This will removes the hazards and the long-term liability and any associated expense;
- Is consistent with the case-by-case assessment approach adopted in the nuclear and non-nuclear industries.

The depth of the Pipeline in the MoD Lulworth and Bovington firing range and the current and planned land use resulted in this zone required further technical underpinning to inform the options assessment:

- The greater burial depth and presence of unexploded ordnance in the MoD range increases the risk to workers for options that involve excavation of the Pipeline;
- Early site visits indicated the groundwater levels are close to the Pipeline depth, which may have prevented a disposal in-situ being compliant with groundwater regulations.

Following site investigation and further assessment (Ref. 32), the preferred option for this Pipeline in the MoD range is also **excavation and management via an off-site facility**. This is the preferred approach as the presence and sensitivity of groundwater would make it difficult to demonstrate compliance of in-situ disposals with groundwater regulations. Removal of the deeper sections of the Pipeline in the MoD range will also enable efficiency savings in transport and waste management.

7.1.2 Optimising the management of radioactively contaminated ground

GRR requires that the optimised management route for ground contamination that is in-scope of RSR be identified as part of the overall case for defining an optimised end state for the site. This section presents a summary of the options assessments that have identified the optimised route for managing the known areas of contaminated land at Winfrith.

7.1.2.1 A59 land area

The A59 land area is located in the north-eastern part of the Winfrith site near to the site boundary with the London to Weymouth rail-line. The area is the former location of the A59

[7] The term 'shallow' is used to distinguish from the deeper sections that run through the MoD firing range.

facility which undertook Post Irradiation Examination (PIE) of fuel from the reactors at Winfrith, other nuclear sites within the UK and reactors around the world.

A59 was decommissioned during the 1990s and the surrounding ground was subject to extensive remediation in the 2000s. The remediation works were complicated by high groundwater levels and the sandy soil type that required dewatering and led to excavation profile stability issues.

However, through assessment of the characterisation data collected during and since the ground remediation campaign it is known that there remains some spotty radiological contamination in the ground and that this is potentially in-scope of RSR in two sub-sections of the A59 land area.

An options assessment (Ref. 27) was therefore completed to determine the optimised end state for these parts of the A59 land area, namely:

- The Pit 3/Pressurised Suit Area (PSA) – an area of ground contamination which is between 1.0 and 2.0m below ground level (bgl), there are very low levels activity that are borderline out of scope but activity is dominated by longer lived radioisotopes e.g. Am 241, Pu-239 and Pu-240;
- The A591/Heavy Vehicle Airlock (HVA)– an area of relatively deep ground contamination (between 4.5 and 6.5m (bgl)), the activity is also borderline out of scope and dominated by Cs-137 and Sr-90 (which both have ~30 year half-lives);

The assessment identified a long list of potential options for management of the contaminated land, which were refined to a short list of options based on technical assessments. The short list of options were:

- Option 1: Manage the contaminated ground in-situ;
- Option 2: Remediate the ground by excavating and assaying the soil and disposing of any radioactive waste generated through established routes.

Attributes were defined from company standard S-391 to ensure the potential benefits and detriments of the options were fully assessed. A series of workshops involving a wide range of internal technical experts were completed to evaluate the options against the selected attributes.

Pit 3/PSA

An improved understanding of the contamination distribution (depth and extent) has identified that this area of contamination is similar to other minor/low complexity remediation projects completed elsewhere on-site. The contamination is:

- Dominated by long-lived radionuclides (Am 241, Pu-239 and Pu-240) that, if managed in-situ, will take a very long time to decay and therefore potentially require longer management timeframes;
- Shallow and can be readily removed using simple excavation techniques and routine decommissioning operations.

For these reasons, the assessment concluded that the optimised strategy for this area is to **remediate the potentially in-scope contamination** and manage via an established off-site waste route. This option requires the ground to be excavated and assayed to determine whether it needs to be disposed of or can be reused as backfill.

In summary, remediating this area is a routine and low value activity and as such this option was the clear preferred choice.

A591/HVA

The options assessment identified that there were only minor differences between the technical performance of the two options (manage in-situ or excavate) and that the short and long-term impacts of the options were finely balanced.

The currently assumed next planned land use for the site will be 'heathland with public access', however there may be alternative uses for the land, notably associated with the rail head and siding. Managing the contamination in-situ would restrict any alternative future land use and would necessitate the on-going management (termed Stewardship) of substantially larger land area.

As remediation of the contamination in this area would require dewatering, it can only be achieved while Winfrith maintains the ability to process and discharge the expected ~100m^3 of dewatering effluent per day. As the dewatering can only be accomplished whilst the effluent management route is available (i.e. before decommissioning ALES and the Pipeline), remediation is required in the near term or potential alternative land uses would be foreclosed.

For these reasons, the assessment concluded that the optimised strategy for this area is to **remediate the potentially in-scope contamination** and manage via an established off-site waste route. The options assessment concluded that the A591/HVA area should be remediated as this would:

- Remove the hazard and liability from this area;
- Allow a smaller and simpler end state to be defined for Winfrith through the Stewardship period;
- Enable alternative land uses (if required).

7.1.2.2 D69 options assessment

The former External Active Sludge Tanks (EAST) area of the Winfrith site has been decommissioned and the majority of the land has been remediated. There remained some residual radioactively contaminated land associated with the former draw pit H active-sludge pipeline route and the D69 (supernatant pumphouse) facility.

An options assessment (Ref. 28) was completed to determine whether the contamination should be removed from this small area of the site and thereby complete the remediation of the land to the east of SGHWR, or whether a case for in-situ management as part of the Winfrith end state should be made.

The assessment considered four options:

Option A Remediate to out-of-scope levels i.e. remove the concrete structures and retrieve the contamination for disposal elsewhere – assumes no contamination below the concrete structures.

Option B Remediate to out-of-scope levels i.e. remove the concrete structures and retrieve the contamination for disposal elsewhere – assumes measurable contamination above out-of-scope levels below concrete structures.

Option C Make the case to leave all the existing contamination (and the concrete structures) in-situ – this option requires full characterisation.

Option D Remove the concrete structures and the associated contamination, and if there remains some contamination below the concrete structures at some depth below the current ground surface, then dependent on the amount and extent of this contamination, make the case to leave it in-situ.

The options assessment compared the options against attributes based upon the NDA value framework i.e., worker dose and risk, As Low As Reasonably Practicable (ALARP) arguments,

waste volume, complexity of the disposal case, cost, risk to achieving public access and opportunity to assess what is potentially acceptable to the regulator.

The attributes were weighted and scored and Option A, **remediation and off-site management via an existing waste route** was identified as the preferred end state as it:

- Is relatively inexpensive to implement;
- Does not require any regulator permissions to enact;
- Does not impact the Winfrith next planned land use of heathland with public access.

Remediation of the D69 ground contamination was completed in 2023 with approximately 51 tonnes of contaminated soil removed and disposed of as VLLW. The work remains in progress and further remediation will remove the remaining contaminated (i.e. in scope) soil.

7.2 Optimisation of the proposed on-site disposals (GRR R13)

GRR Requirement 13 requires that features identified for on-site disposal are themselves subject to optimisation to ensure that the radiological risks to people and the environment are ALARA.

This section provides a summary of each of the studies that have been completed (to date) to optimise the proposed on-site disposals of SGHWR and Dragon. These scope and outcomes of these options assessments are summarised within Table 3.

Table 3: Summary of R13 optimisation assessments

Scope	Preferred option	Key benefits
Form of the backfill within the disposals (Ref. 29).	Complete disposals without the use of grout.	Reduced: material use/ carbon footprint and nuisance effects (from additional lorry movements).
SGHWR pond liner (Ref. 33).	Include with the disposal.	Lower worker safety risk, lower cost and low environmental impact.
SGHWR oil-stained concrete (Ref. 34).	Include with the disposal.	Lower worker safety risk, lower cost and low environmental impact, within relevant limits.
SGHWR encast and in room (structural) metals (Ref. 35).	Include with the disposal.	Lower worker safety risk, lower cost and low environmental impact, within relevant limits.
SGHWR Reactor residual asbestos (Ref. 36).	Include with the disposal.	Reduced worker dose, lowest deployment difficulty, minimal long-term hazard, within relevant limits.
Dragon demolition cut-line (Ref. 37).	Complete demolition to ground-level.	Dragon is constructed within a recess and an expected 3.0m thick engineered cap means that demolition to current ground level is optimised.

Scope	Preferred option	Key benefits
Purge-Gas Pre-Cooler spill (Ref. 38).	Remediate to 200Bq/g.	Justifying this option will require a simpler technical case.

7.2.1 Summary of the completed R13 detailed options assessments

7.2.1.1 Optimising the backfill for the SGHWR and Dragon disposals

The SGHWR and Dragon disposals have been further optimised through extensive engineering assessment. This work provides the necessary underpinning that together demonstrates that the two on-site disposals can be delivered safely and compliantly. This design work is summarised within the Design Substantiation Report (DSR) (Ref. 39). This document provides the underpinning of the concept design for the disposals. Optimisation will continue through the detailed design stage.

One aspect of the design that required a specific options assessment was whether or not to use grout as well as demolition wastes to backfill the SGHWR and Dragon underground voids (Ref. 29). This assessment was supported by non-radiological and radiological risk assessments as well as engineering assessments. The views expressed by external stakeholders were taken into account throughout the options scoring process.

The options assessment reviewed the available approaches to backfilling the SGHWR and Dragon underground structures. Once option screening had been completed there remained two options, i.e. including grout in the backfill, or only using demolition wastes.

The assessment identified the following benefits to not using grout:

- Lower worker conventional safety risk;
- Less environmental nuisance from dust;
- Lower greenhouse gas emissions (from grout) and carbon footprint (from transport);
- Reduced waste export off-site;
- Reduced use of new materials and therefore less material to import to site;
- Fewer lorry journeys to and from the site and therefore lower transport miles;
- Supports the NDA clean-up mission;
- Shorter implementation phase.

The corresponding benefits of adding grout to the backfill were a reduction in the long-term risks associated with the disposal. However, the assessment identified this benefit would be minor as the long-term risks associated with the disposals are expected to be very low.

In summary, grouting the disposal's backfill was not preferred at this concept stage as the benefits to long term disposal performance from grouting would be minor in comparison to the detriments associated with material use, carbon footprint and short-term environmental impacts.

7.2.1.2 SGHWR Pond Liner

A detailed BAT assessment (Ref. 33) was written to determine the optimised end state for managing the fibreglass lining of the SGHWR fuel ponds. This was undertaken as part of the R13 optimisation of the proposed on-site disposal of SGHWR.

The assessment compares two options: complete removal of the fibreglass liner versus the liner being left in-situ.

The options analysis considered the nature of the material, its evolution over time and the corresponding implications for the disposability of the SGHWR fibreglass lining of the fuel ponds as well as the claims and arguments made within the SWESC. The assessment

defined the available options and the assessment attributes and subjected these to a semi-quantitative assessment to identify the preferred approach.

The analysis concluded that the option to dispose of the liner in-situ was the preferred option due to it having a reduced worker dose/conventional safety risk and was the simplest (and likely cheapest) option to deploy. Disposal in-situ was also found not to adversely affect any key safety arguments within the SWESC.

7.2.1.3 SGHWR Oil Stained Concrete

A number of locations within SGHWR below ground concrete structures are contaminated with mineral oil from operations. A detailed BAT assessment (Ref. 34) was completed to determine the optimised management route for the residual oil staining within the SGHWR[8] structure. The assessment compared the following options:

- Complete removal of oil staining within SGHWR below ground structure;
- Disposal of the oil staining in-situ.

The options study estimated the mass of oil present within SGHWR as being 68.6kg of oil within a total mass of concrete of 66,560,000kg.

The assessment found that in-situ disposal performed better than decontamination and removal of oil staining as it minimises worker radiological and conventional safety risk, is easier to deploy and has a lower cost. The assessment also identified that in-situ disposal did not affect impact the overall environmental safety or any of the relevant key arguments in the SWESC.

The preferred option for the oil contamination present within SGHWR was therefore not to remove the oil prior to the disposal.

Characterisation has now been completed of the oil-stained concrete within SGHWR (Ref. 40) and a revised total mass of oil has been calculated using a combination of the data and conservative assumptions. This characterisation estimated that the mass of oil contamination (hydrocarbons) is ~10kg, which is less than the total mass estimated within the BAT assessment and as such the assessments preferred option remains unchanged.

7.2.1.4 SGHWR encast and in-room (structural) metals

All accessible materials that are suitable for recycling will be removed from the disposals prior to the demolition of SGHWR and Dragon commencing. However a proportion of metals within the structure are either inaccessible or are needed to provide structural support through the decommissioning and demolition process, including:

- Steel rebar used within the facility's reinforced concrete;
- Steel pipes and support beams that pass through thick concrete walls (which will be cut flush to the wall surface);
- Other steel pipes and supporting beams within rooms (i.e. not encast within walls) that would be challenging to remove without affecting the structural stability of the area.

An options assessment (Ref. 35) has been completed to determine the optimum route for managing these metals. The options compared were disposal in-situ and full-removal of all metal components.

The assessment considered the total inventory of metals, the risks to people/environment, and engineering aspects that are relevant to the potential disposal of metal elements within the proposed on-site disposal of SGHWR.

[8] A visual survey of Dragon has identified no visible oil contamination within its structures.

Assessment of the risks to the environment from the metals over decades and centuries identified the risks to be minimal and within relevant environmental thresholds.

Removal of the metal components would reduce the potential for dissolution of the metals within the disposal and subsequent discharge to groundwater, however these benefits were shown to be insignificant as the overall risks are very low.

The assessment identified in-situ disposal as the BAT approach due to the reduced radiological and conventional safety risk to workers, reduced waste transport miles, reduced deployment difficulty and reduced costs.

7.2.1.5 SGHWR reactor residual asbestos

Bulk asbestos contained within SGHWR and Dragon will be removed as part of the preparations for demolition and on-site disposal. However, residual asbestos may be present in inaccessible areas or cast into concrete structures at SGHWR. Asbestos surveys of the Dragon facility has identified that all asbestos is readily removeable.

The BAT approach for any residual asbestos that remains following this bulk removal was assessed as part of the R13 optimisation for SGHWR (Ref. 36). The assessment compared the options of complete removal of the asbestos (which would require works that could undermine the SGHWR structure) or disposal in-situ as part of the concrete structure.

The options assessment considered the potential quantity of residual asbestos, and associated radiological contamination, its intrinsic physical and chemical stability, evolution within the disposal, how it may interact with other contamination disposed of as well as the risks to people and the environment. The options assessment identified that the long term risks to human health and the environment from managing the asbestos as part of the disposal would be low.

Removal of the asbestos would result in risk to workers (i.e. working at height, asbestos) and compromise the structural integrity of the building, increasing the hazards associated with the demolition process. As the long term risks from management of the asbestos in-situ are minimal, the option to manage the asbestos as part of the disposal performed better across all attributes in comparison to the option to remove the asbestos.

Disposal in-situ was identified as the BAT approach for the residual asbestos due to lower worker dose/intrinsic safety risk, lowest deployment difficulty and lowest cost, whilst the long term risks are very low.

7.2.1.6 BAT assessment for the Dragon base slab contaminated following the Purge Gas Pre-Cooler (PGPC) spill

In March 2021, a small section of the Dragon base slab was contaminated following a spill of contaminated liquor contained within the PGPC. The activity of the contaminated concrete is dominated by Cs-137 and the concentration is estimated to be above the threshold for ILW.

A BAT assessment (Ref. 38) compared the potential options for managing the contaminated concrete:

- Option 1: Decontamination of the PGPC contaminated concrete to 200Bq/g activity concentration (as already established in risk assessments);
- Option 2: Decontamination of the PGPC contaminated concrete to the upper LLW boundary (12GBq/tonne beta/gamma).

Decontaminating the concrete to the lower level of 200Bq/g (Option 1) would require more time and work, and therefore risk to operators, than Option 2. It would also increase the volumes of waste requiring off-site management. However, Option 1 would only marginally increase overall worker dose from operations.

Option 2 would require substantial changes to the long-term risk assessments and increase the complexity of the case for on-site disposal at Dragon, with no guarantee this would be acceptable to the regulators.

For these reasons Option 1, decontamination to 200Bq/g, is the preferred solution for the concrete contaminated by the PGPC liquor spill. This option results in relatively minor increase in short term dose / risk to workers but will reduces the complexity of the case for on-site disposals at Dragon as a whole.

7.2.1.7 Dragon cut-line

The Winfrith end state specification states that demolition of structures and services should be completed to 1.0m below ground level (bgl) [Ref. 41]. This depth has been identified to ensure the next land use of Heathland with Public Access can be delivered. However, there are a number of complexities associated with the Dragon reactor building that need to be considered when interpreting this requirement:

- The Dragon reactor building is set into a 1.5m depression on its south-western side;
- The Dragon on-site disposal will include an engineered cap that is between 1.5m and 3.8m thick, depending on detailed design;
- Significant landscaping will be required to ensure that the profile of the disposal and the engineered cap supports surface water run-off and blends in with the surrounding landscape.

For these reasons the current ground level will bear little relation to the finished ground level following demolition, backfilling of the below ground structures, construction of an engineered cap and landscaping.

The optimum position of the line where demolition stops and in-situ disposal begins, known as the ‘demolition cut-line’, has been assessed for the Dragon structures (Ref. 37).

The assessment considered two options: a cut-line at the current ground level and at 1.0m bgl, and compared their performance against a list of relevant attributes.

The assessment identified the following benefits for the assessed options:

- Option 1: Demolition to ground level - reduced dose and conventional risks to workers. This approach is also technically less complex and less expensive to complete
- Option 2: Demolition to 1.0m bgl – reduced public dose (from inadvertent human intrusion) and a reduced risk from long-term intervention (although both of these benefits were assessed as being very minor).

The assessment identified Option 1, demolition to ground level, as the preferred approach as the benefits were seen to outweigh the minor performance improvements for Option 2.

8 NON-RADIOACTIVE WASTE MANAGEMENT

8.1 Overview of NRS management arrangements

The IWS (Ref. 12) is the source reference for generic information related to the generation and management of non-radioactive wastes for NRS. To avoid duplication Appendix A does not include detailed information related to all non-radioactive waste streams. However, the management of demolition waste arisings are discussed in more detail, as some of these wastes will be used in delivering the site end state.

8.2 Off-site management of non-radioactive wastes

Non-radioactive wastes will be generated through demolition of radioactive and non-active facilities, site infrastructure and through general operational activities. Off-site management of non-radioactive wastes follows established NRS processes (Ref. 13) to ensure both legal compliance and application of the waste hierarchy. These processes will continue to be applied up to the point that Winfrith reaches the IEP.

8.3 On-site management of non-radioactive wastes

Some non-radioactive structures that are currently in-situ and wastes from previous demolition activities stored at D630 will be used to deliver the Winfrith end state. These non-radioactive wastes will be recovered, under suitable environmental permissions, to enable them to be used in the backfilling of voids at SGHWR and Dragon. Recovery of non-radioactive wastes, alongside disposal of radioactive wastes, is key to delivering an end state suitable for heathland with public access.

The SWMMP (Ref.16) has defined the forward management of all concrete and brick demolition arisings that are currently stockpiled or will be generated through future demolition activities. The Waste Recovery Plan (Ref. 42) sets out the justification for the infilling of the SGHWR and Dragon below ground voids. Any wastes that are not suitable for on-site recovery, or where there is a surplus, will be sent off-site for management in accordance with the waste hierarchy.

9 LAND QUALITY MANAGEMENT

The Winfrith approach to managing land quality can be considered in two parts:

- Radioactive contaminated land: GRR requires the management of radioactively contaminated land to be optimised in accordance with Requirement 1. If leaving the contamination in-situ is identified as the optimised management approach then the risk to the public and environment must be shown to meet the numerical standards stipulated within GRR;
- Non-radioactive contaminated land is managed in accordance with the contaminated land management regime. Risk assessments and options appraisals are used to define the preferred approach to management of contaminated land.

Potentially radioactively contaminated land at Winfrith has been assessed through the NRS standard land quality management and assessment process. Where land is assessed as being OoS no further action is taken and records are retained to demonstrate its status. Where land is assessed as being radioactively contaminated to in-scope levels, options assessments will be completed to determine the preferred management approach. If there are significant challenges to remediation, further assessment may be undertaken to define the preferred management strategy.

To date, there are no areas of contaminated land that have been demonstrated as optimised for management in-situ. Optimisation assessments completed to date, as set out in optimisation of the A59 land area (Ref. 43, Section 7.1.2.1) and the D69 land area (Ref. 28)

show a preferred approach for remediation to out of scope levels. Radioactive wastes generated from land remediation will be managed via established off-site waste routes.

Where non-radioactive contamination of land is identified, risk assessments and options appraisal are completed to determine the preferred approach to management, taking into account key factors such as risk to the public and environment, suitability for next planned land use and cost.

The land quality status of Winfrith has been and will be assessed and documented within the Land Quality Management Plan (LQMP) (Ref. 17) and the Winfrith Land Quality Register (Ref. 18).

10 RADIOACTIVE GASEOUS DISCHARGES

There are five authorised points of gaseous discharge in the site's Environmental Permit (Ref. 2 and Appendix A). Currently only two of the outlets discharge gaseous radioactivity to the environment, SGHWR and Dragon. Discharges are made to the atmosphere, via either engineered or passive ventilation systems.

A key part of the decommissioning of the site will be the removal of the gaseous discharge points as they will no longer be required once decommissioning is complete. There will be no discharge of radioactive gaseous effluent after the IEP.

Table 4 presents the gaseous discharges for years 2019-2023. Current discharges are several orders of magnitude lower than the respective annual limits.

Table 4: Aerial radioactive discharges from the Winfrith site during 2019-2023.

Period	Tritium (TBq/y)	Carbon-14 (GBq/y)	Alpha particulate (MBq/y)	Other Radionuclides (MBq/y)
2019	6.51E-02	2.04E-01	1.12E-03	1.35E-02
2020	3.56E-02	2.21E-01	1.71E-03	9.53E-03
2021	2.65E-02	1.80E-01	1.35E-03	9.43E-03
2022	6.50E-03	1.34E-01	1.22E-03	1.26E-02
2023	4.56E-03	1.31E-01	8.42E-04	4.76E-02
Annual Limit	4.95E+01	5.90E+00	2.00E+00	5.00E+00

The potential for increased gaseous discharges at both SGHWR and Dragon through the reactor core segmentation phase has been assessed (Ref. 44 and 45).

The SGHWR assessment identified that discharges resulting from the dismantling of the SGHWR reactor core would increase public dose by an estimated 4µSv. This is less than the dose (10µSv) set by the EA at which no further action is required (as long as BAT has been applied). Due to this low impact the corresponding BAT assessment (Ref. 46) identified the preferred managed of these discharges to be via the currently permitted routes. However, the ventilation plant will be upgraded to ensure that obsolescent components are replaced to improve their reliability.

The Dragon core dismantling assessment identified that the ventilation system requires additional abatement during the core segmentation activities. An options assessment was then completed to determine the BAT approach (Ref. 47). This assessment initiated improvements to the abatement plant that included a dust collector and two parallel banks of

double HEPA filters (placed in series). These modifications have been made and the ventilation system is operational.

Gaseous discharges will also be made from the ALES Mobile Filtration Units during the decommissioning of ALES, and discharges are expected to be low and well within existing site discharge limits (Ref. 48).

11 RADIOACTIVE AQUOEUS DISCHARGES

There are three permitted discharge points for aqueous discharges at Winfrith:

- ALES to Arish Mell via the Sea Discharge Pipeline;
    - Inner pipeline for discharging of higher activity effluent approximately 3.7km offshore;
    - Outer pipeline for discharging lower activity effluent approximately 15m from the mean low water level;
- Discharge of groundwater into the Win Ditch (a tributary of the River Win).

The management system for compliance with these aspects of the site's Environmental Permit are captured in the EPR Compliance Matrix for the Winfrith site (Ref. 49).

Detailed information on the three aqueous discharge routes i.e., the inner and outer parts of the Sea Discharge Pipeline and the Win Ditch are presented within Appendix A.

Current aqueous radioactive discharges are significantly below the permitted limits and have been demonstrated, through the environmental monitoring programme, as having negligible impact on the environment. The previous five years of active discharges are presented within Table 5 for the inner pipeline and Table 6 for the outer pipeline.

Table 5: Aqueous discharges from the Winfrith inner pipeline between 2019-23

Period	Tritium (GBq/y)	Caesium-137 (GBq/y)	Alpha (GBq/y)	Other Radionuclides (GBq/y)
2019	1.17E+00	1.99E-01	1.10E-03	2.62E-02
2020	1.78E+00	9.11E-02	8.50E-04	1.72E-02
2021	1.00E+00	<7.75E-02	3.80E-04	1.76E-02
2022	6.50E-01	5.03E-02	3.90E-04	7.92E-03
2023	3.60E-01	4.15E-02	3.90E-04	1.00E-02
Annual Limit	4.00E+04	1.98E+03	1.40E+01	9.80E-01

Table 6: Aqueous discharges from the Winfrith outer pipeline between 2019-2023

Period	Tritium (GBq/y)	Alpha (GBq/y)	Other Radionuclides (GBq/y)
2019	9.06E-02	9.64E-04	2.03E-03
2020	1.01E-01	9.16E-04	2.10E-03
2021	7.68E-02	6.45E-04	3.03E-03
2022	6.96E-02	6.78E-04	1.52E-03
2023	7.02E-02	6.17E-04	1.61E-03
Annual Limit	1.50E+02	2.00E+00	1.00E+00

To enable the ALES facility to be decommissioned an alternative discharge route will be required to support the ongoing decommissioning works on site. A BAT assessment is currently in development to define the optimised alternative route for managing aqueous radioactive effluent arising at Winfrith.

The decommissioning of ALES and the Sea Pipeline will allow the Permit for the Pipeline discharge points to be surrendered prior to the IEP.

The source of the activity that discharges via groundwater to the Win Ditch is thought to be contaminated ground in the D69 area. Remediation of this area of contaminated land is currently in progress (Section 7.1.2.2). Discharges to the Win Ditch are therefore expected to decrease and once they have reduced to an acceptably low-level NRS will request that this discharge route be removed from the RSR permit.

There will be no on-going permitted discharges of radioactive aqueous effluent after the IEP.

12 MAINTAINING THE WMP

This WMP represents the current status of waste management arrangements and plans at the Winfrith site. The purpose of this revision of the WMP is to provide sufficient information to support the application to vary the site's RSR permit to enable the on-site disposal of radioactive wastes.

As the site's decommissioning programme progresses and more is understood about the waste being generated, further options assessments will be completed to ensure that waste continues to be managed in an optimised manner. The WMP and SWESC will be developed in an iterative fashion. Once disposals have been made, the SWESC and WMP will be updated on a minimum review period or at the EA request. NRS has defined the minimum review period (Ref. 50) with the main review points for the Winfrith project repeated below:

- Update (where necessary) and issue the WMP and SWESC in advance of any permit application for on-site disposal (this version);
- Review the WMP and SWESC at least once every 10 years;
- Update the WMP and SWESC on achieving a significant decommissioning milestone such as entering a quiescent phase or disposing/delicencing land. For Winfrith this will be:
  - Prior to achieving the IEP;
  - In order to demonstrate that permit can be surrendered (at the SRS).

13 RETENTION OF RECORDS

This section identifies how records relating to the disposal of radioactive and non-radioactive wastes from Winfrith will be managed. These records include:

- Off-site disposals: Managed as per the requirements of the RSR permit and waste regulation. The NRS arrangements for managing these records are set down within PD-023 'Records Retention' (Ref. 51) and S-419 'Records Management' (Ref. 52);
- On-site disposal records will be managed using the IMAGES software as described within the SWESC (Ref. 10);
- Land Quality Register (Ref. 18): for the maintenance and collation of land quality files;
- The NRS central Options Assessment (BAT/BPM) database (Ref. 20): provides a record of current and archived options assessments for the management of radioactive wastes in accordance with S-391;
- The Winfrith BAT register (Ref. 53)
- Low Level Radioactive Database (LLRAD): the live tracking of all waste (in-scope and OoS) on the Winfrith site at any time, including all waste that has been disposed in the last decade;
- Electronic Document Management System (EDMS): Winfrith site document management system for radioactive waste consignment paperwork.

14 SUMMARY

This WMP forms part of the body of evidence that supports the application for a variation to the Winfrith RSR permit to allow on-site disposals of radioactive wastes at the SGHWR and Dragon Reactors.

The primary role of this document is to demonstrate that waste generation and management for the remainder of the site decommissioning programme is understood and that optimised management routes have been identified for radioactive wastes. This is achieved by:

- Demonstrating that optimised management routes have been identified for all radioactive wastes and radioactively contaminated land remaining to be generated on the site;
- Documenting the plan for how Winfrith will manage radioactive substances on or adjacent to the site through the remainder of the site's lifecycle;
- Describing how Winfrith will be brought to a condition that meets the GRR requirements and allow the eventual release from RSR, identified as the SRS;
- Supporting the arguments made in the SWESC.

The WMP demonstrates that GRR Requirement 1 has been met by presenting a summary of the optimisation studies completed for the remaining wastes at Winfrith, including:

- Higher Activity Waste;
- Lower Activity Waste;
- The remaining large concrete structures;
- Radioactively contaminated land;
- Gaseous and aqueous discharges.

Optimisation assessments (which included community and stakeholder input) have identified on-site disposal as forming part of the site end state for:

- The SGHWR and Dragon reactors where the optimised approach is to retain the below ground concrete structures in-situ and demolish the above ground structures and use the resulting rubble to infill the below ground voids;
- The Dragon Mortuary Holes (numbered 41-90) which are to be retained in-situ and filled with grout to form part of the on-site disposals.

Assessment of the optimised approach to implementing on-site disposals (GRR Requirement 13) has commenced and is reported in this WMP, however this optimisation will be ongoing throughout design and implementation phases of each disposal. The case for how the proposed disposals comply with the GRR risk and dose guidance criteria is provided within the SWESC.

All other radioactive wastes and radioactive contamination will be managed by approved off-site disposal route prior to the IEP, to allow the eventual release of the site from RSR.

The management approach for non-radioactive waste and contaminated land is also summarised within this WMP.

This WMP will be maintained and updated to reflect the status of waste management at Winfrith prior to important decommissioning milestones and within a minimum time period of 10 years.

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51 Knowledge and Information Management. PD-023. Issue 9.3. February 2023

52 Creation, Storage and Management of Records. S-419. Issue 2. November 2021

53 EHSSQ2100602, Winfrith BAT register

Appendix A: Winfrith WMP Spreadsheet

The WMP spreadsheet is located within the Winfrith End State Document Register.

Appendix B: Winfrith WMP uncertainties assessment

An Uncertainties Assessment (UA) is the standardised way GRR-related uncertainties are recorded in documents for subsequent sentencing in the Uncertainties Management Database. This table has been completed in accordance with the Uncertainties Management Methodology (UMM)[1].

The potential significance of uncertainties, assumptions and gaps are rated as Low, Medium or High defined as follows:

- Low: Low likelihood to affect near term activities or SRS.
- Medium: Low likelihood to affect near term activities, but potential to affect SRS.
- High: High likelihood to affect near term activities.

A number of uncertainties identified within previous versions of the WMP have been closed in accordance with the UMM. These are WMP-UMP-01, 05, 08, 09, 11, 12, 13, 14, 17, 18, 20, 22, 23, 24 and 28 these uncertainties are not listed within Table B. Furthermore, it has been decided (again in accordance with the UMM) that some uncertainties can be tolerated meaning that no action is required. These are WMP-UMP-05, 10, 15 and 16; again these uncertainties are not listed within this Appendix.

Reference No.	Feature, Event or Process subject to Uncertainty	Description of Uncertainty	Treatment of Uncertainty / Statement of Assumption	Originator's Rating of Potential Significance/ Impact (High/Medium /Low)	Originator's Recommended Action
WMP-UMP-02	Application of the Groundwater Daughter Directive (GWDD) to on-site disposals.	There is uncertainty connected with the future regulatory stance on the interpretation of the GWDD with respect to on-site disposals in accordance with the GRR.	The optimisation of the engineering concept designs for the SGHWR and Dragon reactor on-site disposals will address the requirements of the GWDD.	High	Engage with the Environment Team addressing this area of work. Finalise the assessment strategy and seek specialist advice on the application of the GWDD to Winfrith's proposed on-site disposals . Finalise the radiological groundwater modelling for on-site disposals. Finalise the optimisation of the engineering concept designs for the SGHWR and Dragon reactor on-site disposals. Form a NRS position on how the implementation of on-site disposal at Winfrith complies with the GWDD.
WMP-UMP-03	Timing of LAW generation for on-site disposal.	The exact timing of when waste destined for on-site disposal will begin to arise is uncertain.	No assumptions are currently made for when demolition begins. No assumptions are either made for time constraints on when waste can begin to be generated, and how it should be managed if it is generated prior to disposal.	Medium	Establish the time-constraints for when LAW can begin to be generated for on-site disposal. Develop timeline for demolition as part of the on-site disposals Concept Design and feed this into the LTP.
WMP-UMP-04	LAW volumes for on-site disposal	It is uncertain what volume of LAW will remain in-situ/emplaced in the below-ground voids at SGHWR and Dragon. This impacts what is recorded in the RWI for off-site disposal, as well as what the remaining volume requiring fill will be.	The RWI and LTP currently assume all LAW generated from reactor decommissioning and demolition is being managed for off-site disposal.	Medium	Establish robust estimates of LAW volumes for on-site disposal. Share with RWI and LTP change control team. Input into the SWMMP to determine remaining fill material

[1] DD/REP/0030/19, Methodology for Managing Magnox Sites' GRR Uncertainties (and Guidance on the use of the associated database). Issue 1. April 2022

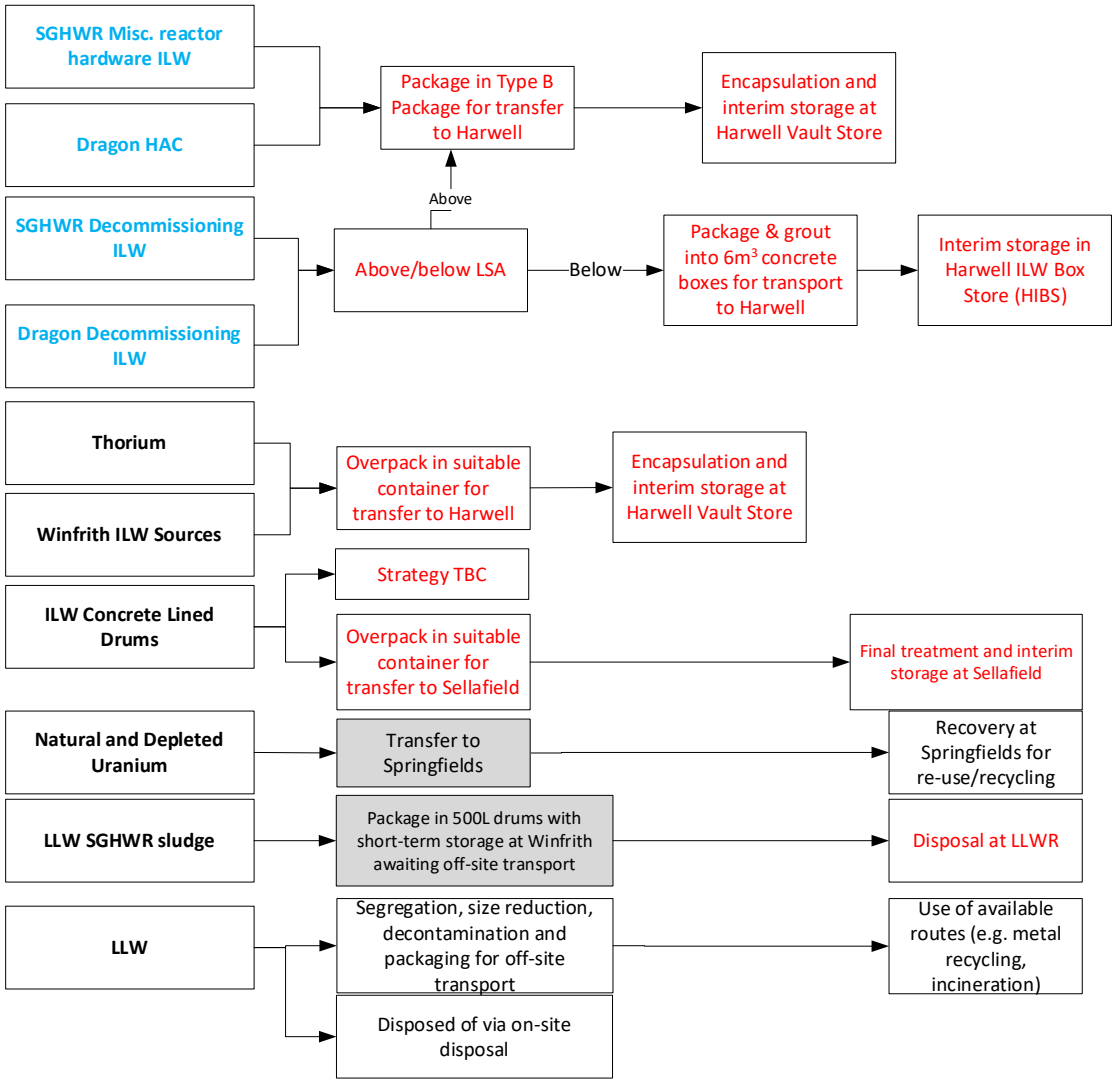
Reference No.	Feature, Event or Process subject to Uncertainty	Description of Uncertainty	Treatment of Uncertainty / Statement of Assumption	Originator's Rating of Potential Significance/ Impact (High/Medium /Low)	Originator's Recommended Action
WMP-UMP-06	Chemical properties for LAW for on-site disposal.	There is uncertainty associated with the chemical properties of the in-situ structure and backfill which has been highlighted in the non-radiological inventory.	Lack of characterisation data means that the assessment of non-radiological releases from the disposals is based on limited sample numbers from the D60 stockpile. Compliance with the pending Emplacement Acceptance Criteria is assumed.	Medium	Review the uncertainties and gaps in the non-radiological inventory to ensure the non-radiological assessments are sufficiently underpinned, and that the Emplacement Acceptance Criteria is suitable for the chemical properties of the disposals.
WMP-UMP-07	Optimisation to support on-site disposal.	It is uncertain what optimisation assessments are required before on-site disposal can be sought.	It is assumed that the optimisation assessments already identified will meet the requirements of the GRR.	Medium	Develop a plan of optimisation needs and build it into the project programme, to ensure there are no gaps or items that are missed.
WMP-UMP-14	Non-radioactive aqueous discharges – post IEP	Whether a Groundwater Activity permit under Schedule 22 of the EPR for non-radiological releases to groundwater will be needed for releases from on-site disposals. Such activities may relate to the recovery of non-radioactive waste and may therefore not be covered under the Schedule 23 EPR permit.	It is currently assumed that no permit under Schedule 22 is required during the period between the IEP and the SRS for aqueous releases to groundwater.	Medium	Finalise the assessment strategy (42) and form a Magnox position on the need for permitting under Schedule 22 of EPR from releases to groundwater from end state components. Finalise the radiological and non-radiological groundwater modelling. Depending on the result of (42), reflect in the LQMP that groundwater permitting implications need to be assessed when determining the End State strategy.
WMP-UMP-19	Disposal design	The final / detailed design for the on-site disposals is uncertain. It is uncertain that the assumptions used to develop the concept design will be either implementable and/ or optimised when it comes to defining the final design.	It is assumed that the detailed design will be developed by the principal contractor for the on-site disposals for both SGHWR and Dragon	Medium	Complete an options assessment to determine the optimal detailed design of the SGHWR and Dragon disposals
WMP-UMP-21	Storage of infill material	It is uncertain what storage arrangements will be required for the material created from the demolition of the above ground parts of SGHWR and Dragon prior to emplacement within the reactor voids.	It is assumed that an optimised form for the concrete blocks will be identified and that this will be implemented in accordance with the concept / detailed designs.	Medium	Define how blocks created from the above ground parts of the SGHWR and Dragon civil structures will be stored pending emplacement within the below ground voids.
WMP-UMP-25	Aqueous effluent alternative discharge route	It is uncertain whether an optimised alternative discharge route has been identified for radioactive effluent arising at the Winfrith site	It is assumed that the current BAT assessment will be approved and the application to vary the permit will be approved.	Medium	The BAT assessment that defines the optimal route for radioactive aqueous discharges from Winfrith that will enable the ALES facility to be decommissioned requires final sign-off.

Reference No.	Feature, Event or Process subject to Uncertainty	Description of Uncertainty	Treatment of Uncertainty / Statement of Assumption	Originator's Rating of Potential Significance/ Impact (High/Medium /Low)	Originator's Recommended Action
WMP-UMP-26	Win ditch permitted discharge route	It is uncertain how the permitted discharge to the Win ditch will be managed post SRS.	It is assumed that the Win ditch permitted aqueous discharge route will not require a permit by the time the site reaches its SRS date. It is possible that regulatory changes will identify how legacy ground contamination will be managed following Winfrith's release from the permit.	Medium	Define an optimised end state for the Win ditch permitted discharge. This will need to determine the discharges projected to the current SRS date and a strategy for removing this discharge route from the RSR permit at this time.
WMP-UMP-27	Control of design modifications	It is uncertain how changes to the disposal designs will be managed through the permit variation determination period. A process is required to ensure that such design changes do not undermine the claims made in the site wide environmental safety case.	It is assumed that a process will be developed to ensure design changes are made in a controlled manner and that the environment agency approves of this process.	Medium	Define a process that ensures changes to the disposal design are managed in a controlled manner in keeping with the requirements of GRR.

Appendix C: Approaches to the management of wastes at the Winfrith site through the decommissioning life cycle

Waste / material		**Solid Lower activity waste (LAW)**				**Non-radioactive solid waste**				**Demolished and/or excavated materials**	**Gaseous radioactive waste**	**Aqueous radioactive waste**	**Radioactively contaminated ground and/or groundwater**	**Non-radioactive contaminated ground and/or groundwater**
Sub-category (where applicable)	**Higher activity waste (HAW)**	**Metallic Waste**	**Demolition waste from above-ground structures**	**Subsurface redundant structures**	**Others**	**Metals**	**Asbestos-containing waste**	**Other hazardous waste**	**Inert demolition waste**					
Example(s) for Winfrith site	Reactor core ILW	Pipework, tanks, active drains	Demolition of above-ground SGHWR	Below-ground bioshields, Ponds	Asbestos lagging	Rebar removed from demolition waste	Pipe insulation	Oily concrete	Demolition waste	Demolition concrete and brick	Emissions from reactors	Aqueous waste discharges from ALES	Contamination from historical leakage of cooling ponds	Contamination from historical leakage from turbine hall oily drains system
Principal legislation relevant for pre-IES phase	Nuclear Installations Act 1965 (as amended) (NIA65)	NIA65				The Waste Regulations	Hazardous waste regs and WM3	Hazardous waste regs and WM3	EPR	Deposit for Recovery (DfR)	RSR (EPR)	RSR (EPR)	NIA65	EPR
Principal relevant Government policy	UK Government Policy for HAW in England & Wales	UK Government Policy for LLW (2007)				Waste Strategy: England	Strategy for Hazardous Waste Management in England	Strategy for Hazardous Waste Management in England	Waste Strategy: England	Waste Strategy: England	N/A	OSPAR Convention 1992	N/A	N/A
Generic strategy (S-036)	Retrieve and package at Winfrith, interim store on Harwell site pending GDF	Recycle off-site where practicable	Subject to optimisation (potential for on-site disposals).	Subject to optimisation (potential for on-site disposals).	Mostly off-site disposal	Recycling as appropriate	Off-site disposal	Off-site disposal	Reuse on-site. Potential to be used alongside on-site disposals of RSR waste.		Application of BAT.		Surface contamination to be removed and in-situ contamination with institutional controls for deeper contamination.	Remediated as required to meet contaminated land & groundwater regulations.
Arrangements for defining site-specific strategy	LC35 Decommissioning Programme													
Arrangements for defining site-specific plan	RWMC	S-391 & WMP				S-100	S-100 (17) and local work instructions	S-100	SWMMP & WMP	SWMMP & WMP	S-391 & WMP	S-391 & WMP	LQMP & SWESC	LQMP
Is on-site disposal credible?	No	No	Yes	Yes	No	No	No	No	Yes	Yes	No	No	No, but could remain in-situ	No
Principal legislation relevant for IES	Not applicable	N/A	RSR (EPR)	RSR (EPR)	N/A	N/A	N/A	N/A	EPR	DfR	N/A	N/A	EPR	EPR

Appendix D: Management of radioactive wastes at Winfrith



The following key is used for this diagram:

- Grey boxes – work completed
- Black text – waste currently in stock and how it is currently managed
- Blue text – waste that is yet to arise
- Red text – work to be undertaken prior to entering the interim end state