Site Restoration

Winfrith End State:

Emplacement Acceptance Criteria to support Winfrith End State

Project report – ES(18)P191 Issue 3, April 2025

WINFRITH END STATE:

Emplacement Acceptance Criteria to support Winfrith End State

Author:

Signature: Date 10 April 2025

Reviewed by:

Signature: Date 11 April 2025

Approved by:

Signature: Date 11th April 2025

Review/Revision Register

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

Version	Date	Author	Amendments / Change
Issue 1	May 2018	J Weatherill	Original for EA Review
Issue 2	August 2024	T Sanderson	Update for application
Issue 3	April 2025	T Sanderson	Further update to present the relevant criteria more clearly

Contents

1 Introduction 7
1.1 Report context 7
1.2 Background 7
1.3 Regulatory context 8
2 Objectives 9
3 Scope 9
4 Report Structure 10
5 Responsibilities 10
6 EAC For SGHWR and Dragon reactor building structures 11
6.1 EAC 1: Physical characteristics of the building structures 11
6.2 EAC 2: Chemical characteristics of the building structures 12
6.3 EAC 3: Biological characteristics of the building structures 12
6.4 EAC 4: Radiological characteristics of the building 12
7 EAC for Engineering materials used in the SGHWR and Dragon reactors 13
7.1 EAC 5: Engineering materials 13
8 EAC for D630 stockpiles 13
8.1 EAC 6: Physical properties of demolition rubble 13
8.2 EAC 7: Chemical properties of demolition rubble 14
8.3 EAC 8: Biological characteristics of demolition rubble 14
8.4 EAC 9: Radiological characteristics of demolition rubble 14
9 Further work 15
10 References 16

Tables

Table 1: Physical characteristics of materials forming part of the End State 11

Annexes

Annexe 1: Non-radiological characteristics of the material 17
Annexe 2: Chemical concentration limits for rubble stockpiles 20

GLOSSARY

Activity: Expressed in Becquerels (Bq), means the number of spontaneous nuclear transformations occurring in a period of one second.

Chelating agents: An inorganic complex in which a ligand is coordinated to a metal ion at two (or more) points, so that there is a ring of atoms including the metal.

Chemically complexing: Either a chelating agent or a monodentate organic ligand.

Decay products: A stable or radioactive nuclide formed by the radioactive decay of another nucleus.

Free Liquid: Any liquid which is present as a separate phase including liquid which is physically adsorbed onto a solid matrix rather than chemically combined. This can include water, oil and/or solvents.

Groundwater: All water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.

Groundwater Activity: The discharge of a pollutant that results in the direct input of that pollutant to groundwater, or, the discharge of a pollutant in circumstances that might lead to an indirect input of that pollutant to groundwater, or, any other discharge that might lead to the direct or indirect input of a pollutant to groundwater.

Hazardous material: a material that has hazardous properties and has been assigned a hazard statement code, as defined in the EA guide Waste Classification: Guidance on the Classification and Assessment of Waste (Ref. 16).

Hazard properties: The following properties of waste, which render them hazardous in accordance with the Hazardous Waste (England and Wales) Regulations 2005 'as amended':

- HP 1 "Explosive": waste which is capable by chemical reaction of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic waste, explosive organic peroxide waste and explosive self-reactive waste is included.
- HP 2 "Oxidising": waste which may, generally by providing oxygen, cause or contribute to the combustion of other materials.
- HP 3 "Flammable":
  - Flammable liquid waste: liquid having a flash point below 60^{o}C or waste gas oil, diesel and light heating oils having a flash point >55^{o}C and ≤75^{o}C;
  - Flammable pyrophoric liquid and solid waste: solid or liquid waste which, even in small quantities, is liable to ignite within five minutes after coming into contact with air;
  - Flammable solid waste: solid waste which is readily combustible or may cause or contribute to fire through friction;
  - Flammable gaseous waste: gaseous waste which is flammable in air at 20^{o}C and a standard pressure of 101.3kPa; water reactive waste: waste which, in contact with water, emits flammable gases in dangerous quantities; and
  - Other flammable waste: flammable aerosols, flammable self-heating waste, flammable organic peroxides and flammable self-reactive waste.
- HP 4 "Irritant": waste which on application can cause skin irritation or damage to the eye.

- HP 5 “Specific Target Organ Toxicity”: waste which can cause specific target organ toxicity either from a single or repeated exposure, or which cause acute toxic effects following aspiration.
- HP 6 “Acute Toxicity”: waste which can cause acute toxic effects following oral or dermal administration, or inhalation exposure.
- HP 7 “Carcinogenic”: waste which induces cancer or increase its incidence.
- HP 8 “Corrosive”: waste which on application can cause skin corrosion.
- HP 9 “Infectious”: waste containing viable microorganisms or their toxins which are known or reliably believed to cause disease in man or other living organisms.
- HP 10 “Toxic for reproduction”: waste which has adverse effects on sexual function and fertility in adult males and females, as well as developmental toxicity in the offspring.
- HP 11 “Mutagenic”: waste which may cause a mutation, that is a permanent change in the amount or structure of the genetic material in a cell.
- HP 12 “Release of an acute toxic gas”: waste which releases acute toxic gases (Acute Tox. 1, 2 or 3 in contact with water or an acid.
- HP 13 ‘Sensitising’: waste which contains one or more substances known to cause sensitising effects to the skin or the respiratory organs.
- HP 14 “Ecotoxic”: waste which presents or may present immediate or delayed risks for one or more sectors of the environment.
- HP 15 “waste capable of exhibiting a hazardous property listed above not directly displayed by the original waste”: waste capable of exhibiting a hazardous property listed above not directly displayed by the original waste.

Hazardous substance (in relation to groundwater): is any substance or group of substances that are toxic, persistent and liable to bio-accumulate, or that give rise to an equivalent level of concern. This definition is the same as that described within EPR Schedule 22 (Ref. 1).

Inert: Materials that do not undergo any significant physical, chemical or biological transformations. Inert material will not dissolve, burn or otherwise physically or chemically react, biodegrade or adversely affect other matter with which it comes into contact in a way likely to give rise to environmental pollution or harm to human health. The total leachability and pollutant content of the material and ecotoxicity of the leachate must be insignificant, and in particular not endanger the quality of surface water and/or groundwater.

Ion exchange material: Any material, whether synthetic or naturally occurring, that has the capability of interchanging ions from one substance to another by means of a reversible chemical or physical process.

Non-hazardous pollutant (in relation to groundwater): any pollutant other than a hazardous substance.

Out of Scope: refers to materials or wastes that have arisen from nuclear operations or decommissioning process where the concentrations of radionuclides are so low that they are not subject to specific environmental regulations, meaning they are not legally considered radioactive material or waste, as defined within EPR Schedule 23.

Recovery: Any operation the principal result of which is waste serving a useful purpose by replacing other materials which would otherwise have been used to fulfil a particular function, or waste being prepared to fulfil that function, in the plant or in the wider economy. Annex II sets out a non-exhaustive list of recovery operations.

Soluble solids: Solid substances which are described as soluble or slightly soluble in cold water (inorganic compounds) and water (organic compounds) in the solubility column of the latest edition of the CRC “Handbook of Chemistry and Physics”.

1 INTRODUCTION

1.1 Report context

The Site End State for the Winfrith site includes disposals of radioactive wastes and deposits of non-radioactive wastes at the Steam Generating Heavy Water Reactor (SGHWR) and Dragon reactors. The disposal and deposit of wastes to form the End State will be permissioned through appropriate Environmental Permits, issued under Schedule 22 and 23 of the Environmental Permitting Regulations.

This document defines the Emplacement Acceptance Criteria (EAC) for material that will form the End States for the SGHWR and Dragon reactors. Materials and wastes used to form the End States must meet the EAC to be compliant with the risk assessments and overarching Site Wide Environmental Safety Case (SWESC) that support the Environmental Permit applications. Compliance with this EAC, and a number other documents e.g. the Construction Quality Assurance Plan, will ensure compliance with the risk assessments, SWESC, environmental permit applications and other regulatory requirements.

1.2 Background

The Winfrith site was established to undertake research and development of new nuclear reactor designs alongside analysis of existing reactor designs elsewhere in the UK and across the world. A total of nine experimental reactors were developed and operated at the site, as well as five laboratory facilities and associated support structures. The site operated between 1957 and 1995. Of the nine original reactors, only the SGHWR and Dragon reactor structures remain.

The site is now being decommissioned to deliver the next planned land use of 'heathland with public access'. The preferred approach for decommissioning and waste management (Ref. 3) for the SGHWR and Dragon reactors is to leave the below ground structures in situ as set out in a Site Wide Environmental Safety Case (SWESC) (Ref. 4). This would be permissioned as a Radioactive Substances Activity, under the GRR, as a variation to the site's current environmental permit.

The remaining below ground void space at the SGHWR and Dragon reactors will need to be backfilled to create a surface level suitable to allow the next planned land use of heathland with public access. The End State (Ref. 4) includes using radioactive wastes from demolition of the SGHWR and Dragon above ground structures for the purpose of backfilling some of the remaining below ground void.

It has been identified in the Site Wide Materials Management Plan (SWMMP) (Ref. 5) that infilling of the remaining SGHWR and Dragon reactor voids will be completed using demolition material generated elsewhere on the Winfrith site. This will include a combination of radioactive and non-radioactive wastes.

As the relative presence of radiologically in-scope and Out of Scope (OoS) waste cannot be fully assessed at current, the risk assessments and Environmental Permit applications make cautious assumptions.

The radiological and non-radiological aspects of disposals and deposits, respectively, are governed through different legislative regimes:

- The Environment Agencies' '*Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulation*' (known as the GRR) (Ref. 1) allows operators to consider on-site management of radioactive wastes, subject to meeting the requirements set out in the guidance and a suitable Permit being granted. Optimisation assessments have shown that the preferred

approach for some structures at Winfrith includes managing radiologically contaminated structures in situ and using demolition arisings from the structures in backfilling as part of delivering the site end state;

- The Deposit for Recovery (DfR) (Ref. 2) permit application seeks to use Out of Scope (OoS) demolition arisings for the purpose of backfilling remaining sub-surface void space to support delivery of the End State and the next planned land use. The demolition arisings will be sourced from the above ground building structures of the SGHWR and Dragon reactor, and demolition arisings from the D630 stockpiles.

1.3 Regulatory context

1.3.1 Radioactive (in scope) waste

The aim of the GRR is for operators to demonstrate that waste management is optimised and that a site can eventually complete all activities involving radioactive substances, thereby achieving the Site Reference State (SRS) and exiting Radioactive Substances Regulation (RSR).

In situ disposal and disposal for a purpose of radioactive wastes (collectively called on site disposal) can be permissioned under GRR on the basis that they can be demonstrated as optimised and safe. The SWESC and supporting assessments have been produced based on a proposed End State for the reactor structures. Any radioactive wastes remaining as part of the End State at the SGHWR and Dragon reactors must be demonstrated to be consistent with the SWESC and supporting assessments.

The criteria in this EAC are based on the SWESC and risk assessments to ensure that the disposals are compliant with the Environmental Permit.

Optimisation is an important aspect of the GRR, whereby the preferred approach for managing wastes must be assessed using a range of attributes to identify the preferred approach on balance. The EAC reflects the currently optimised approach for SGHWR and the Dragon reactor.

1.3.2 Out of Scope (OoS) waste

It is anticipated that a significant fraction of the demolition material from Winfrith's decommissioning work will be OoS of RSR. Where such material is classed as an OoS waste for on-site use, this will be regulated by the Environmental Permitting Regulations (England and Wales) 2016 (EPR) which transposes the requirements of the Waste Framework Directive (WFD) (Ref. 6) in Schedule 9 – Waste Operations (Ref. 7).

The SWMMP (Ref. 5) identifies that suitable OoS material from demolition of the SGHWR and Dragon reactors and the D630 stockpiles will be used for the purpose off backfilling the reactor voids. This will be permissioned through a Deposit for Recovery (DfR) Environmental Permit (Ref. 8).

The application for a DfR permit includes detailed risk assessments for the chemical components of the radioactive wastes, OoS wastes and OoS structure in-situ that will form the End States for the reactor structures. The risk assessments have demonstrated that the proposed End States are compliant with regulatory requirements.

Compliance with this EAC will ensure compliance with the risk assessments, and therefore the associated environmental permits.

OoS structures connected to the ground are exempt from the WFD, and not defined as a waste and therefore do not require environmental permitting. However they form part of the end state and so will be assessed against the EAC to ensure a consistent approach.

1.3.3 Groundwater legislation

The SGHWR and Dragon reactor End States must be consistent with all relevant regulatory requirements. The end states have the potential to be in contact with groundwater, therefore the legal requirements to protect groundwater are enacted through this EAC and the engineering design.

In some locations, additional engineering works will be required to prevent direct discharges from wastes in the reactor voids (in scope and OoS) to groundwater. Any new materials used in engineering of structures that may be in contact with groundwater will also be need to be compliant with groundwater protection legislation.

Compliance with this EAC, the detailed design for the reactor End States and the Construction Quality Assurance Plan, will ensure compliance with the Environmental Permits and regulatory requirements in relation to groundwater protection.

2 OBJECTIVES

The key objective of this EAC document is to provide guidance to the decommissioning project(s) on how to undertake decommissioning and manage wastes to ensure it is suitable for to form part of the End State for the SGHWR and Dragon reactor.

Adherence to the EAC will ensure all materials comprising the SGHWR and Dragon reactor End States are consistent with the supporting risk assessments, the SWESC and Environmental Permit applications, ensuring overall compliance.

3 SCOPE

The EAC in this document are applicable to any materials included in the End State for the SGHWR and Dragon reactors. The scope of EAC includes waste or materials associated with:

- The below ground structures to be left in situ;
- Any existing or new demolition material that will be used to infill the below ground voids;
- Any engineering materials used to enable implementation of the end state, including grouts or sealants.

The only demolition arisings intended for use at the SGHWR and Dragon disposals/deposits are demolition arisings from their above ground structures at SGHWR and Dragon reactors and demolition arisings already held on the site in the D630 stockpiles.

The EAC are not applicable to, and should not be used to screen, the following materials:

- Soil/spoil;
- Virgin Clay used within the cap;
- Primary aggregates used in the cap;
- Geotextiles used in the cap.

These engineering materials may be considered for emplacement, subject to suitable screening and their suitability of use.

The EAC does not override health and safety legislation in protecting workers (though it is written in mind of such requirements). Materials which meet all the EAC in this document are subject to health and safety legislation and therefore additional controls may be required before work can commence. For example, worker dose constraints, regulated under the Ionising Radiations Regulations 2017 (Ref. 9) and controls on worker asbestos exposure, regulated under The Control of Asbestos Regulations 2012 (Ref. 10) will need additional consideration.

4 REPORT STRUCTURE

This report presents the EAC for non-radiological characteristics within separate annexes. Details of these acceptance criteria are presented in Annexe 1 and Annexe 2. The permit applications for both DfR and GRR reference both this overarching document, and the two annexes for non-radiological compliance criteria for any disposed or deposited material.

5 RESPONSIBILITIES

The End State team and Site Restoration programme is responsible for maintaining this EAC document and ensuring the criteria remain valid and in line with site specific risk assessments.

The SGHWR and Dragon reactor projects seeking to leave structures in place and reuse site-won materials for infilling, in accordance with the SWMMP, are responsible for:

- Adhering to the EAC whilst carrying out deplanting, demolition and infilling work;
- Characterisation at a suitable level to demonstrate compliance with this EAC, including any testing of materials which may be required to ensure compliance.

In the event that a specific material or type of material does not meet the entirety of the EAC, further assessment can be undertaken to determine the preferred approach to management with reference to the risk assessments and the SWESC. In all cases, should materials not meet the requirements set out here, decommissioning teams should contact the End State team in the first instance.

6 EAC FOR SGHWR AND DRAGON REACTOR BUILDING STRUCTURES

The End State for SGHWR and Dragon reactors includes below ground structures remaining in situ and above ground structures being used to backfill below ground voids. To ensure the long term safety of the End States, building structures that will remain in situ, or be used for filling below ground voids will need to meet the EAC. Below ground structures that are to be left in situ and above ground structures that are to be used in backfilling voids are collectively be referred to as “material” in the following EAC.

A single set of EAC are presented for ease of use, however it is important to recognise that the differing regulatory requirements may need to be considered depending on if a waste is in scope or OoS.

Any material not meeting the EAC must be removed, unless otherwise assessed and agreed with the End State team. Where it may not be feasible / practical to remove or decontaminate non-compliant materials, discussions with the End State team will be required.

6.1 EAC 1: Physical characteristics of the building structures

This section of the EAC provides details of the physical characteristics of the SGHWR and Dragon reactor structures that can be retained as part of the End State, either in-situ or for use in backfilling voids.

In-situ structures and future demolition arisings to be produced as part of implementing the SGHWR and Dragon reactor End States will consist of concrete, bricks, tiles and ceramics, including mixtures of these, which would be assigned waste codes 17-01-01, 17-01-02, 17-01-03 or 17-01-07 once demolished. These materials will not include hazardous substances. Any materials not meeting the EAC should be removed as part of decommissioning operations prior to implementation of the End State.

Radioactive (in-scope) wastes (Ref. 1) should consist of the same physical materials (concrete, brick, tiles and ceramics, or mixtures thereof) and meet the other specifications set out in this document.

Table 1: Physical characteristics of materials forming part of the End State

EAC ID	Description
EAC 1.1 – Bulk Materials	Concrete, brick, ceramics and tiles, or mixtures thereof, can remain as part of the end state. For OoS materials that are demolished as part implementing the end state wastes would be consistent with EWC codes 17-01-01, 17-01-02, 17-01-03 or 17-01-07. This includes structural and non-structural concrete, brick, and ceramic within the SGHWR and Dragon reactor structures.
EAC 1.2 – Structural steel	Steel rebar, structural support and sleeves at penetration points in concrete walls can remain as part of the end state.
EAC 1.3 – Encast asbestos	Asbestos bound into the building structures, either encast, painted or otherwise inaccessible can remain as part of the end state.
EAC 1.4 – Oil contamination	Oil contamination of structural concrete and brick can remain in place where decontamination is not feasible.

The following materials are not compliant with the EAC and must be removed from the structure, prior to implementation of the End State:

- Plasterboard;
- Wood and other organic material;
- Non-structural metals, such as ventilation ducting and staircases;
- Electrical and electronic wastes;
- Bitumen liners of above ground tank rooms;
- Visible chemical contamination that can be readily decontaminated;
- Accessible and easily removable asbestos / asbestos contamination must be removed.

Any materials that cannot be removed should be identified and discussed with the End State team.

The required geotechnical characteristics (material size and shape) of the demolition arisings to be generated from the SGHWR and Dragon reactor have yet to be defined. These properties will be defined in the Detailed Design phase and incorporated into the EAC as appropriate.

Should decommissioning projects produce wastes for retention as part of the End State prior to detailed design being available, these should be discussed with the End State team. As general guidance concrete blocks and demolition arisings up to a size up to 150 mm are consistent with the concept design (Ref. 18).

6.2 EAC 2: Chemical characteristics of the building structures

All wastes and materials forming part of the End State must not contain hazardous properties (Annexe 1), except those specific substances and locations where it is appropriately risk assessed and / or demonstrated as the optimised approach.

The presence of any hazardous properties, as classified in Annexe 1, will require additional review and assessment.

When undertaking detailed chemical analysis, results should be reviewed by the End State team.

6.3 EAC 3: Biological characteristics of the building structures

Material shall not contain biological wastes, including pathogenic or infectious materials as listed within Hazard Groups 2, 3 or 4 in the Approved List of biological agents produced by The Advisory Committee on Dangerous Pathogens (Ref. 6).

If any potential biological contaminants are identified, contact the industrial safety engineer in the first instance.

6.4 EAC 4: Radiological characteristics of the building

The following radiological EAC applies to in-scope material only. Naturally Occurring Radioactive Material (NORM) contamination is excluded from the scope.

The potential amounts of radioactivity for disposal at the SGHWR and Dragon reactor are set out in the radiological inventory, which is a cautious assessment of the potential inventory remaining as part of the End State. The risks to people and the environment have been assessed and shown to be acceptable (Ref. 11 and 12). Actual disposals will be compared to the radiological inventory to ensure the risk assessments are bounding.

In the event that characterisation indicates that the total activity of the disposals, or localised specific activities, exceed the stated EAC the End State team should be notified in the first instance. Further risk assessment and review of the optimisation cases may be appropriate.

<u>EAC 4.1: Optimisation.</u>

The management approach for wastes must be demonstrated as optimised, with doses to people and the environment demonstrated as being As Low As Reasonable Achievable

(ALARA). The requirement for optimisation includes whether a waste is managed on-site, and how any on-site disposals are implement (Requirement R13 of the GRR (Ref. 1)).

Should total or specific activities exceed those specified in the current optimisation and risk assessments, the assessments will need to be reviewed to determine whether a waste can remain as part of the End State.

EAC 4.2: Average specific activity limits.

The specific activity must be ALARA and in any case should not exceed 200 Bq/g averaged over an appropriate volume based on Data Quality Objectives (DQO). The 200 Bq/g specific activity limit is only applicable to fingerprints currently approved for SGHWR and Dragon reactors (at publication date). Any new radionuclide fingerprints should be shared with the End State team prior to use in on-site disposals.

In assessing radioactivity levels against these limits, the activity of decay products with half-lives of less than three months shall be excluded. The sentencing volume should reflect the level of homogeneity or heterogeneity of the waste through the characterisation approach. The DQO should address both surface contamination and bulk contamination.

Any materials with an average specific activity greater than the 200 Bq/g limit will be subject to additional optimisation before consideration for retention or emplacement and may necessitate a review of the associated risk assessments and SWESC.

EAC 4.3: Dilution of radioactivity.

In-scope radioactive wastes cannot be deliberately mixed with lower activity or OoS wastes to purposely reduce the specific activity. Wherever possible, waste form characterisation should be completed in-situ to assess the total activity and specific activities present (Ref. 5).

7 EAC FOR ENGINEERING MATERIALS USED IN THE SGHWR AND DRAGON REACTORS

The final decommissioning of the reactors, and implementation of the end state is likely to require additional engineering to ensure safety and compliance with regulatory requirements. This section describes the EAC that will control the use of materials required to support this work.

7.1 EAC 5: Engineering materials

Any materials used for engineering purposes shall be compliant with the UK Government list of prohibited substances (Ref. 16).

8 EAC FOR D630 STOCKPILES

The demolition arisings at D630 will be used for the purpose of backfilling any remaining void space at the SGHWR and Dragon reactor to produce a surface level suitable the next planned land use.

Initial characterisation has been undertaken and risk assessments completed based on the data obtained. Prior to use in infilling of voids, further characterisation and screening will be required to demonstrate the demolition arisings meet the EAC.

8.1 EAC 6: Physical properties of demolition rubble

The rubble used for emplacement shall consist of concrete, brick, ceramic and tiles, or mixtures thereof, consistent with the EWC codes 17-01-01, 17-01-02, 17-01-03 or 17-01-07.

The following materials are not compliant with the EAC and must be removed, prior being used in the End State:

- Plasterboard;
- Wood and other organic material;
- Metal(s) including rebar and cabling;
- Electrical and electronic wastes;
- Visible chemical contamination of the rubble;
- Asbestos and potentially asbestos containing materials.

8.2 EAC 7: Chemical properties of demolition rubble

Details of the acceptance criteria for chemical properties of the material are presented in Annexe 1 and Annexe 2.

When undertaking detailed chemical analysis, results should be reviewed by the End State team.

8.3 EAC 8: Biological characteristics of demolition rubble

Material shall not contain biological wastes, including pathogenic or infectious materials as listed within Hazard Groups 2, 3 or 4 in the Approved List of biological agents produced by The Advisory Committee on Dangerous Pathogens (Ref. 6).

If any potential biological contaminants are identified, contact the industrial safety engineer in the first instance.

8.4 EAC 9: Radiological characteristics of demolition rubble

The following radiological EAC applies to in-scope material only. Naturally Occurring Radioactive Material (NORM) contamination is excluded from the scope.

From history, provenance and characterisation, there is no indication of radioactivity present in the D630 rubble stockpiles at levels that would be considered in-scope of RSR. However, only a small proportion of the stockpiles has been re-characterised and further assessment will be required prior to use in filling the SGHWR and Dragon reactor voids. The amount of radioactivity present, even when below OoS levels, will need to be assessed prior to emplacement.

The potential amounts of radioactivity present in the D630 rubble stockpiles are set out in the radiological inventory, which is a cautious assessment of the potential inventory remaining as part of the End State. The risks to people and the environment have been assessed (Ref. 11 and 12) and are shown to be acceptable.

Actual disposals will be compared to the radiological inventory to ensure the risk assessments are bounding. In the event that the characterisation indicates that the total activity of the disposals, or localised specific activities exceed values in the radiological inventory, further review will be required. Any material with activities greater than those specified should contact the End State team to discuss further optimisation.

<u>EAC 9.1: Average specific activity limits of demolition rubble</u>

The specific radioactivity must be ALARA and in any case should not exceed 200 Bq/g averaged over a proportionate volume based on DQO, noting that existing characterisation data indicates activity levels are very low.

In accounting for activity against these limits, the activity of decay products with half-lives of less than three months shall be excluded. The sentencing volume should reflect the level of homogeneity or heterogeneity through the characterisation planning.

Any materials with an average specific activity greater than the 200 Bq/g limit shall be excluded from the disposal and disposed off-site.

9 FURTHER WORK

The EAC will be updated where required to allow for additional material characteristics upon the completion of further work.

Engineering assessment work is required at the detailed design stage to inform the acceptable geotechnical nature of the material for emplacement. The EAC covering the physical characteristics of the material will be updated once this is complete.

Further additional work that may prompt a change to the EAC includes:

- Characterisation of SGHWR and Dragon as decommissioning progresses;
- Work required as a result of requests for further justification through the determination period.

10 REFERENCES

1. Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radiological Substances Regulation. Version 1.0. 24 July 2018.
2. Standard rules SR2015 No. 39. The Environmental Permitting (England & Wales) Regulations 2016. Use of waste in a deposit for recovery operation (Construction, reclamation, restoration or improvement of land other than by mobile plant). SR205 No. 39 v2. Version 2. 03 April 2019.
3. Winfrith Site: SGHWR End State BAT Assessment: Report on the Stakeholder Workshop. ES(17)P160. Issue 1. May 2017.
4. Winfrith End State: Site Wide Environmental Safety Case 2024. ES(24)P390. Issue 1. December 2024.
5. Winfrith End State Project: Site Wide Material Management Plan. ES(19)P324. Issue 4. August 2024 .
6. European Commission. Directive 2008/98/EC on Waste (Waste Framework Directive). 2008.
7. The Environmental Permitting (England and Wales) Regulations 2016.
8. Winfrith End State Project: Waste Recovery Plan. ES(19)P285. Issue 3. October 2020.
9. The Ionising Radiations Regulations 2017.
10. The Control of Asbestos Regulations 2012.
11. Winfrith Site: End State Radiological Performance Assessment 2024. ES(23)P388. Issue 1. December 2024.
12. Winfrith Site: End State Radiological Inventory. ES(19)P281. Version 2. December 2024.
13. Winfrith Site: Hydrogeological Risk Assessment of the SGHWR and Dragon Reactor (and Mortuary Tubes) End States. ES(22)P361. Issue 1. December 2024.
14. European Commission. Directive 2006/118/EC on the protection of groundwater against pollution and deterioration (the Groundwater Daughter Directive). 2006.
15. Winfrith End State Project: Conceptual site model to underpin an hydrogeological risk assessment and a radiological performance assessment of the steam generating heavy water reactor and dragon reactor complex end states. ES(21)P332. Issue 1. December 2024.
16. Groundwater hazardous substances standards, Water Framework Directive UKTAG, January 2018.
17. Guidance on the classification and assessment of waste (1st Edition v.1.2.GB) Technical Guidance WM3, Environment Agencies. Edition 1. October 2021.
18. Winfrith End State: Design Substantiation Report (Concept Stage) – SGHWR and the Dragon Reactor. ES(23)P387. Issue 1. August 2024.

Annexe 1: Non-radiological characteristics of the material

This Annexe sets out the EAC for the chemical properties of the material for the SGHWR and Dragon reactor building structures and the D630 rubble stockpiles.

The criteria set out below apply to both the below ground material retained in situ and the demolition infill material to be placed in voids as a disposal for a purpose (radioactive waste) or deposit for recovery (OoS waste).

Hazardous materials.

Wastes classified as hazardous must be excluded or treated and made safe wherever practicable. For a material to be made safe, the hazards are removed or reduced to such a level that the material no longer contains that hazard. A hazardous material is a material that has hazardous properties and has been assigned a hazard statement code, as defined in the EA guide “Waste Classification: Guidance on the Classification and Assessment of Waste” (WM3) (Ref. 17).

Materials with hazardous properties are not permitted for use in a recovery operation, and therefore are excluded for use in DfR operations (Ref. 2).

Radioactive wastes containing hazardous properties may be permitted for retention / emplacement under GRR, subject to optimisation. Therefore, if any hazardous properties are identified, further discussion with the End States team will be required.

This relates to Requirement R15 of the GRR (Ref. 1) – “Protection Against Non-Radiological Hazards”.

Explosive substances

Materials must not contain substances which are capable, by chemical reaction, of producing gas at such a temperature and pressure and at such a speed as to cause damage to the surroundings. Pyrotechnic waste, explosive organic peroxide waste and explosive self-reactive waste is included.

Strong oxidising agents

Strong oxidising agents (e.g. peroxides, chlorates, nitrates) are to be excluded wherever practicable and, in any case, should not be in close contact with easily oxidised material (see Hazardous Property HP 2) (Ref. 17).

Flammable substances

Materials must not contain highly flammable or flammable substances (see Hazardous Property HP 3) (Ref. 17).

Toxic substances

Materials must not contain substances which are toxic at concentrations greater than their toxic thresholds (see Hazardous Property HP 5 and HP 6) (Ref. 17). However, structures with lead paint may be considered for emplacement under GRR subject to an optimisation assessment.

Corrosive substances

Materials must have contain corrosive properties (see Hazardous Property HP 8) (Ref. 17).

Chemically complexing and chelating agents

Materials must not contain strong chemically complexing or chelating agents, unless treated and stabilised.

Harmful gasses

Materials must not contain, or be capable of spontaneously generating, quantities of toxic gases, vapours or fumes harmful to persons (see Hazardous Property HP 12) (Ref. 17).

Soluble solids

Material containing readily soluble solid materials (this does not include concrete) should not be used without prior conditioning, i.e. the readily soluble solid waste must be fixed in a solid matrix (e.g. cement) that will not readily release that component when contacted with water. The definition of a soluble solid is provided in the Glossary.

Ion exchange materials

Materials must not contain any ion exchange materials.

Liquids

No free liquid is permitted within the material and no liquids with flashpoint less than 21 °C should be adsorbed to the solid material. This includes water, oil and solvents. No assessment of these materials through optimisation may take place. However, the use of grout is exempted.

Unknown substances

Materials must not contain chemical substances arising from research and development, such as laboratory residues, which are not identified or which are new and whose effects on man or the environment are not known.

Asbestos

Materials must contain less than 0.1 wt% of asbestos fibres.

Any materials which contain any asbestos containing materials which are visible to the naked eye will be dual classified as 17 01 07 AND 17 06 05* (for the visible asbestos element). Dual classification of the waste will result in classification of inert and non-hazardous components at 17 01 07 and the hazardous asbestos at 17 06 05*.

An optimisation under the terms of GRR has been completed for asbestos bound into the structure of SGHWR that shows the preferred approach of management in situ. This asbestos is also below the 0.1 wt% threshold.

Materials containing ≥ 0.1% w/w of asbestos fibres are classified as hazardous waste (Ref. 17). These materials should be segregated and disposed of at an appropriately licensed off-site facility.

Bitumen

Bitumen mixtures must not contain coal tar in concentrations above 0.1%.

Coal tar concentrations above 0.1% would render the material a hazardous waste (HP 7 carcinogenic) (Ref. 16). No hazardous materials are permitted to be used for recovery under the DfR guidance (Ref. 2). Concentrations of demolition arisings with bitumen or coal tar concentrations greater than 0.1% result in the material being classified as hazardous, with mirror EWC codes of 17 01 06* and 17 01 07. These materials should be segregated and disposed of at an appropriately licensed off-site facility.

The use of hazardous materials is not permitted under DfR (Ref. 2 and 8) and therefore no optimisation assessment has been undertaken for wastes containing greater than 0.1% bitumen (coal tar).

Leachable substances in inert materials

The maximum concentrations have been assessed with a liquid/solid ratio of 10 l/kg (Ref. 17), in accordance with the batch leaching test BS EN 12457-3:2002. Leachable substances must meet the requirements of EWC waste codes 17-01-01, 17-01-02 and 17-01-03.

Organic Contents.

Materials must not contain organic matter greater than 1% weight.

Annexe 2: Chemical concentration limits for rubble stockpiles

The analytical limits are based on the Detailed Quantitative Risk Assessment (DQRA) (Ref. 13) to support Environmental Permit applications.

Where chemical testing is undertaken, the following acceptance criteria apply.

Table A2.1 – Leachable concentrations limits for metals (mg/kg) (Ref. 15, Table 606/25)

Contaminant	Leachable concentration (mg/kg) at a liquid to solid ratio of 10 l/kg
Chromium (III)	0.38
Chromium (VI)	0.38
Copper	0.10
Lead	0.02
Zinc	0.32

Table A2.2 – Leach test limits for PCB's (µg/kg) (Ref. 15, Table 606/24)

Contaminant	Total concentration for PCB's (µg/kg)	Maximum concentration (µg/kg) for individual congeners
PCB-28	1000	14
PCB-52		26
PCB-101		260
PCB-118		180
PCB-138		50
PCB-153		240
PCB-180		170

Samples analysed must be representative of the waste form and due account should be taken of any aggregate present in the samples/wastes that may not be subject to analysis.