Site Restoration Programme

Winfrith End State Project:

Supporting Document to the Winfrith Deposit for Recovery Permit Application

Project report – ES(24)P407 Issue 1, December 2024

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1 INTRODUCTION

This document provides information in support of the Deposit for Recovery (DfR) permit application for the Winfrith End State (Ref. 1). The permit application is required to enable the construction of two on-site deposits at the Steam Generating Heavy Water Reactor (SGHWR) and the Dragon reactor to take place as part of the wider decommissioning and restoration of the Winfrith site.

In parallel to the DfR permit application, an application to vary the Winfrith sites Radiological Substances Regulation (RSR) permit is being submitted. Permission through the RSR-C5 application is being sought to dispose in-situ the below ground structures and in-scope materials from the SGHWR and Dragon reactors.

The DfR application is being made to seek to deposit:

- Demolition arisings already stockpiled on the Winfrith site that are Out of Scope of Radioactive Substances Regulation (RSR); and
- Demolition arisings from the above ground structures of SGHWR and Dragon reactors that are Out of Scope of RSR.

2 PROJECT VISION

Why our work matters

At Nuclear Restoration Services (NRS), we are dedicated to the safe, secure, and sustainable decommissioning and restoration of nuclear sites. Our mission extends beyond merely dismantling reactors; we aim to create a positive legacy for future generations and bolster resilient local economies.

Transforming Winfrith for the future

The decommissioning and restoration of the Winfrith site is set to be the first of its kind in the UK. Our approach not only considers the technical challenges but also places a strong emphasis on the community and environment. By restoring the site to heathland, we're creating valuable habitats for local wildlife and providing amenity value for the local community. The decommissioning and restoration of the site will be a world leading example in sustainable decommissioning that is built on the views of the local community. Restoration of the site will support development of valuable and rare habitats that are unique to Dorset.

The End State for the site, that delivers heathland with public access, has been defined to include:

- On-site disposals of radioactive wastes at SGWHR and Dragon, including the sub-surface structures in-situ and backfilling with radioactive and non-radioactive wastes. This additionally included the construction of engineered caps and landscaping to provide a surface finish suitable for the next planned land use;
- Decommissioning and demolition of all other above ground structures on the site, with removal of wastes for off-site management;
- Assessment of land quality on the site and remediation of contamination to meet suitable risk criteria;
- Removal of subsurface structures to 1 meter below ground level, to allow for reestablishment of habitats;
- Decommissioning of the site drainage infrastructure to reinstate a natural hydrograph;

- Creation of a mire habitat to manage the water balance on site after removal of drains;
- Removal of roads;
- Removal of the fence and any other infrastructure.

After completion of decommissioning, implementation of disposals and reinstatement of the site surface finish, public access to the site will be permitted. This is identified as the Interim End Point (IEP).

NRS will continue to manage the site, through a stewardship phase which includes validation monitoring, until such a time as the site achieves the Site Reference State and the environmental permits can be surrendered.

A significant body of work has been completed to demonstrate that the proposed deposits are safe. This work is summarised within the Winfrith Environmental Setting and Site Description Report (Ref. 2) and Site-Wide Environmental Safety Case (SWESC) (Ref. 3) that accompany the application.

3 PURPOSE AND SCOPE

The purpose of this document is to provide further information in support of that supplied within the part A, B2 and F1 environmental permit application forms to enable the proposed deposits at SGHWR and Dragon.

4 APPLICATION OVERVIEW

4.1 Proposed Applications

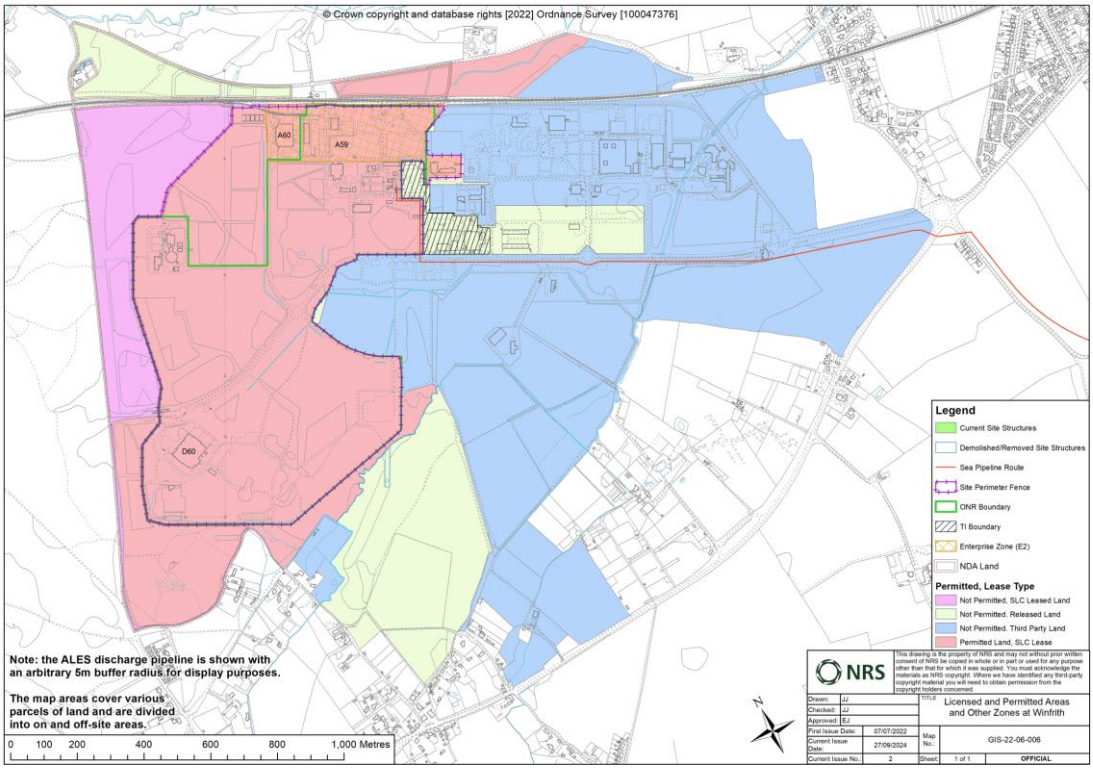
To enable the proposed on-site deposit/disposals NRS is applying for:

- A Deposit for Recovery (DfR) permit, to enable the directive waste currently stockpiled at D630, and newly derived demolition arisings (Out of Scope (OoS) of RSR) from SGHWR and Dragon reactors to be recovered so that it can be used for the purpose of filling the below ground voids;
- A variation to the site's RSR permit, for the disposal of the low-level radioactive waste on-site arising from within the above and below ground structures of SGHWR and Dragon;
- Planning permission for the waste activities and the change of use for the site.

4.2 Deposit Locations

The SGHWR and Dragon reactors are located towards the western boundary of the Winfrith site as shown in Figure 1. The B78 fuel storage building containing the Dragon reactor mortuary tubes lies north-northeast of the Dragon reactor.

Figure 1 - The Winfrith Site and its surroundings including current and demolished Site structures



4.3 Local environment, pathways and receptors

The Hydrogeological Interpretation (Ref. 4) presents an assessment of the occurrence and movement of groundwater at the Winfrith Site under current and predicted future conditions (Ref. 4). It includes details of the present-day topography, meteorology, geology, hydrology, hydrogeology, below ground structures (including drainage) and groundwater quality.

In summary, on the Winfrith site:

- The ground elevations lie between 20 m and 50 m above ordnance datum (AOD), with ground sloping towards the Rivers Win and Frome from the summit of Blacknoll Hill;
- There is an average annual rainfall of 840.5 mm with higher monthly rainfall recorded in winter months;
- Natural surface hydrology, Ignoring the impact of site-drainage, the site can be split into two catchments ;
  - A larger (northern) catchment that drains the majority of the site towards Flume 1 and the Frome channel;
  - A smaller (southern) catchment that drains to the River Win.
- Rainwater runoff is currently managed through a network of surface water and land drainage systems. This drainage works to efficiently move surface water from the site to one of the two receiving rivers, the River Frome to the north, and the River Win to the south.

During preparations for the end state, NRS will return the site to a more natural hydrological function which is in-line with establishing a habitat suitable for heathland development. This will be achieved by removing or blocking the site drainage system and introducing a passive water management system that will beneficially encourage both, a wet-heathland habitat and protect neighbouring areas from flooding (Ref. 18).

Poole and London Clay formations directly underlie the site. In addition, developed parts of site are underlain by made ground and head/river terrace deposits are present across much of the site (up to 4 m thick). Further details of the geology of the site are provided within Ref. 4.

A description of the local environment, and, the source, pathway, receptor model is provided within the site's Conceptual Site Model (CSM) (Ref. 5), which outlines:

- How contaminants will migrate through the SGHWR and Dragon structures;
- The saturated and unsaturated pathway through the geosphere, including how dissolved contaminants will attenuate through the geosphere pathway via dilution, dispersion, biodegradation and sorption/desorption;
- How alkalinity will attenuate in the environment.

The CSM (Ref. 5) also describes the different receptors relevant to the proposed deposits, these are:

- Groundwater (as a receptor);
- Water dependant terrestrial ecosystems (wet heath, acid mire);
- Surface water (rivers Win and Frome).

5 NON-RADIOLOGICAL ASSESSMENT

The Winfrith Hydrogeological Risk Assessment (HRA) (Ref. 6) presents a tiered hydrogeological risk assessment of the proposed SGHWR and Dragon Reactor Complex end states. The HRA is based on a Non-Radiological Inventory (NRI) which sets out the anticipated chemical components that will make up the completed SGHWR and Dragon end states. The NRI, and therefore the HRA, account for and assess the non-radiological risk from the completed end state for SGHWR and Dragon including the sub-surface structures in-situ, the radioactive waste to be deposited and the non-radioactive wastes proposed for recovery.

The model is simulated to run for 20,000 years from the end state allowing for the peak concentration to be realised at the model compliance point. The modelled degradation of the cap and the concrete boundary structures are set for 1,000 years as a cautious assumption of when degradation of these structures will be complete (Ref. 6).

5.1 Tier 1 assessment

Tier 1 qualitative risk screening was carried out on all chemical components of the end states of the SGHWR and Dragon Reactor Complex that may form contaminants in the environment. Potential releases of the following contaminants from the end state were identified as acceptable (Ref. 6) and these need no further assessment:

- Contaminants bound within concrete in reinforced concrete structures, concrete blocks and the Dragon reactor mortuary hole structure. The Dragon mortuary hole structures retained in-situ will be infilled with cementitious grout to for a concrete monolith;
- Contaminants bound within steel in concrete structures and blocks;
- Contaminants bound within paint and fibreglass;
- Hydrocarbon fractions in oil staining of structures: <C10 aromatic compounds and >C16 aliphatic compounds;
- Arsenic and mercury in demolition arisings;
- Emplaced non-waste materials that will be used in the Dragon reactor mortuary holes and the structures of the deposits.

The specific justifications supporting these screening decisions are presented in the HRA (Ref. 6).

5.2 Tier 2 assessment

For the Tier 2 Generic Quantitative Risk Assessment (GQRA), porewater concentrations of contaminants in the demolition arisings were calculated and compared with compliance criteria selected from relevant water quality standards that are protective of groundwater and surface water[1]. The calculated porewater concentration of the following contaminants was lower than the selected compliance criteria for the following: antimony, barium, cadmium, chloride, fluoride, molybdenum, nickel, selenium and sulphate. The GQRA demonstrated that there are no unacceptable inputs to groundwater from these contaminants and these contaminants therefore need no further risk assessment. The Tier 2 GQRA was insufficient to demonstrate an acceptable risk from alkalinity and several inorganic and organic contaminants as summarised in the HRA (Ref. 6). Contaminants requiring a Tier 3 risk assessment are presented in Table 1.

Further details supporting the Tier 2 assessment outcomes are presented in the HRA (Ref. 6).

Table 1 - Summary of contaminants requiring Detailed Quantitative Risk Assessment

Component in the SGHWR and Dragon reactor complexes	Contaminants
Concrete blocks	Alkalinity (pH)
Demolition arisings	Alkalinity (pH)
	Chromium (as Cr(III) and Cr(IV)), copper, lead and zinc
	PCB-28, PCB-52, PCB-101, PCB-118, PCB-138, PCB-153 and PCB-180
Oil-stained concrete (SGHWR Regions 1 and 2 only)	TPH-CWG[2] >C10-C12, >C12-C16 and >C16-C21 aromatic fractions

5.3 Tier 3 assessment

Modelling of contaminants in Table 1 (screened as requiring a Detailed Quantitative Risk Assessment was undertaken for the Tier 3 assessment. Inputted chemical concentrations have used a reference scenario which is a cautious estimate of the predicted evolution of the end state. The modelling of the reference scenario demonstrated that the risk for all modelled contaminants at the SGHWR and Dragon reactors are well below compliance levels, despite the conservative assumptions made (Ref. 6). Table 2 shows the contaminants and features for which the peak concentrations were closest to their compliance limits, and the times of their peaks.

Table 2 - Contaminants for which the peak concentrations in the Tier 3 Detailed Quantitative Risk Assessment were closest to the respective compliance limits

[1] Compliance limits and compliance points (the point along the groundwater flow pathway where the defined compliance limit must not be exceeded) are set on a case-by-case basis as part of the HRA and may be different for hazardous substances and non-hazardous pollutants. At Winfrith, the default values are surface water environmental quality standards, but these have been "sense-checked" against a range of other standards and a judgement made for each contaminant (Ref. 6).

[2] Total Petroleum Hydrocarbon Criteria Working Group.

Type	Contaminant	Feature	Compliance limit / Peak concentration	Time of peak (years after deposit)
Metals	Chromium (VI)	SGHWR	2.8	1218
TPH	C10-C12 Aromatics	SGHWR	163	764
PCB	PCB-101	Dragon	11.3	1251

The assessment of the risk to groundwater from alkalinity has been undertaken using a PHAST model. PHAST simulates reactive solute transport in a 3-dimensional groundwater flow system; this alongside embedded geochemical calculations highlights the suitability of the software to model alkalinity release, and attenuation in the Poole Formation (Ref. 6).

The PHAST modelling results demonstrate that the maximum pH in groundwater is significantly lower than the compliance criterion, even with the use of conservative assumptions.

An assessment of cumulative effects was also undertaken because groundwater flow modelling has shown that, under some circumstances, groundwater flows from the SGHWR deposit to beneath the Dragon deposit. The Tier 3 assessment concluded that cumulative impacts will not cause an unacceptable risk to groundwater.

The parameter uncertainties were addressed through a number of variant and alternative scenarios. These demonstrated an acceptable risk to groundwater for all modelled contaminants, thereby providing confidence that the outcomes of the reference scenario are robust.

Based on the three tiers of risk assessment it is concluded that the non-radiological hydrogeological risk from the envisaged SGHWR and Dragon Reactor end states to controlled waters is acceptable.

6 MANAGEMENT OF THE DEPOSITS

6.1 Operator Competency

The operation of the deposit, including the construction, waste emplacement, capping and aftercare will be undertaken in accordance with the Chartered Institution of Wastes Management Operato Competency Schemes (WAMITAB) management arrangements.

The implementation of the WAMITAB certification scheme will be prior to implementation of disposals, owing to the prolonged project start up timescales. As such NRS has agreed for the implementation and provision of WAMITAB certified and Technically Competent Managers to be a pre-commencement condition of the permit.

6.2 Structure of the Deposits

The basal engineering requirements of the deposits are to be met using the existing below ground structures from the reactors.

6.2.1 Steam Generating Heavy Water Reactor

The SGHWR building comprises 10 levels, three of which are below the level of the surrounding ground surface (below ground). Above ground, the structure is a steel-clad metal frame with masonry (brick) and concrete internal structures. Below ground, the structure is mainly reinforced concrete. Although SGHWR comprises many rooms, the below ground level

elements of the SGHWR can be simplified into four regions based on the elevation of the top of the base slab in each region:

- Region 1: The reactor bioshield, primary containment and immediate surrounds;
- Region 2: The steam labyrinth to the west of the primary containment, the delay tank room, and turbine hall;
- The South Annexe, including the pump pit to the north of the turbine hall; and
- The North Annexe.

A summary of the floor slab elevation and thickness of the floor in each region of the SGHWR is presented in Table 3.

Table 3 - Summary of Floor Slab Elevation and Thickness of Each Region of the SGHWR

Component	**Top of Floor Slab Elevation (m AOD)**	**Floor Slab Thickness / Description**
SGHWR Region 1	28.8	2.74 m thick reinforced concrete
SGHWR Region 2	30.6 to 35.4	Turbine hall - 2.74 m reinforced concrete Delay tank room - 0.91 m reinforced concrete Steam labyrinth 0.69 m reinforced concrete
SGHWR North Annexe	37.8	Typically, 0.33 m reinforced concrete
SGHWR South Annexe	35.4 to 36.6	Variable – between 0.23 m and 0.53 m reinforced concrete

In preparation for the End State, the concept design is for SGHWR to be demolished to 1 m below ground level (m bgl). Most internal walls in the subsurface structure will remain in-situ unless they need to be removed to gain access for deposition of the infill material. Accessible non-structural metal elements will be removed. The SGHWR void will be backfilled to 1 m bgl.

A plan and cross section view of SGHWR is presented in

Figure **2** and Figure 3.

Figure 2 - Plan showing the four regions of the SGHWR building.

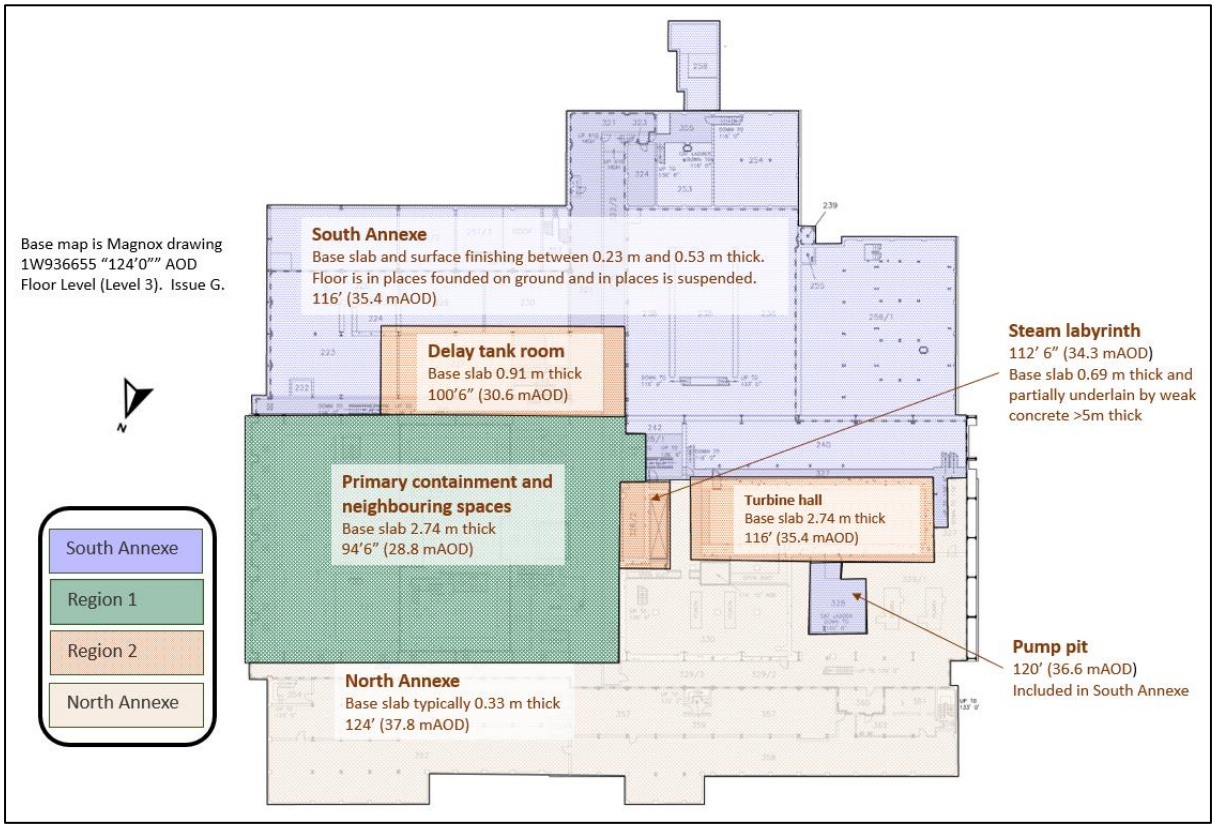
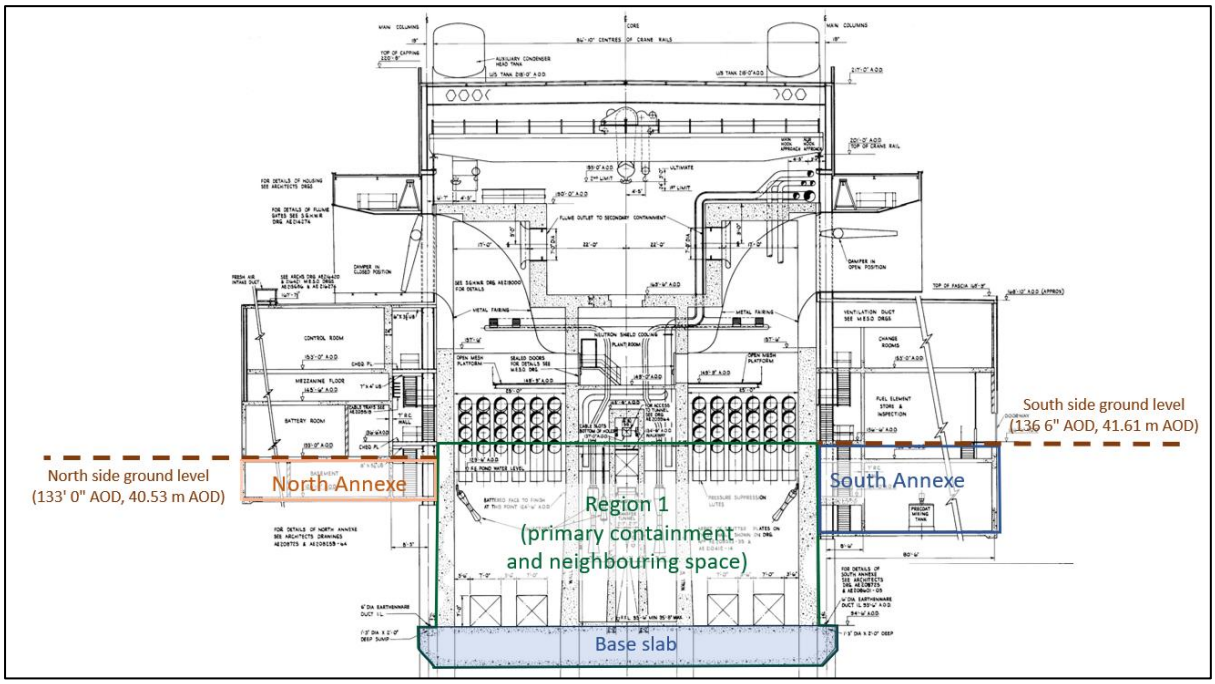


Figure 3 - Cross section through the SGHWR building



6.2.2 Dragon

The elevation of the top of the floor slab of the Dragon reactor is 27.34 m AOD and its base slab is typically 3.7 m thick reinforced concrete.

The Dragon reactor is shown in plan in Figure 4 and in section in Figure 5. The Dragon reactor is circular in plan-view and has four concentric concrete walls referred to sequentially from the outside in as Wall A, Wall B, Wall C and Wall D. The aggregate in the concrete was observed to be flint during a WSP site visit on 27 July 2023. The reactor reinforced concrete bioshield is referred to as Wall D. A steel shell is located within a void between Wall B and Wall C. Wall B includes brick-filled apertures and Wall A has many penetrations into the services duct approximately 1 m above the -25' (27.43 m AOD) floor level.

Figure 4 - Plan view of the Dragon Reactor

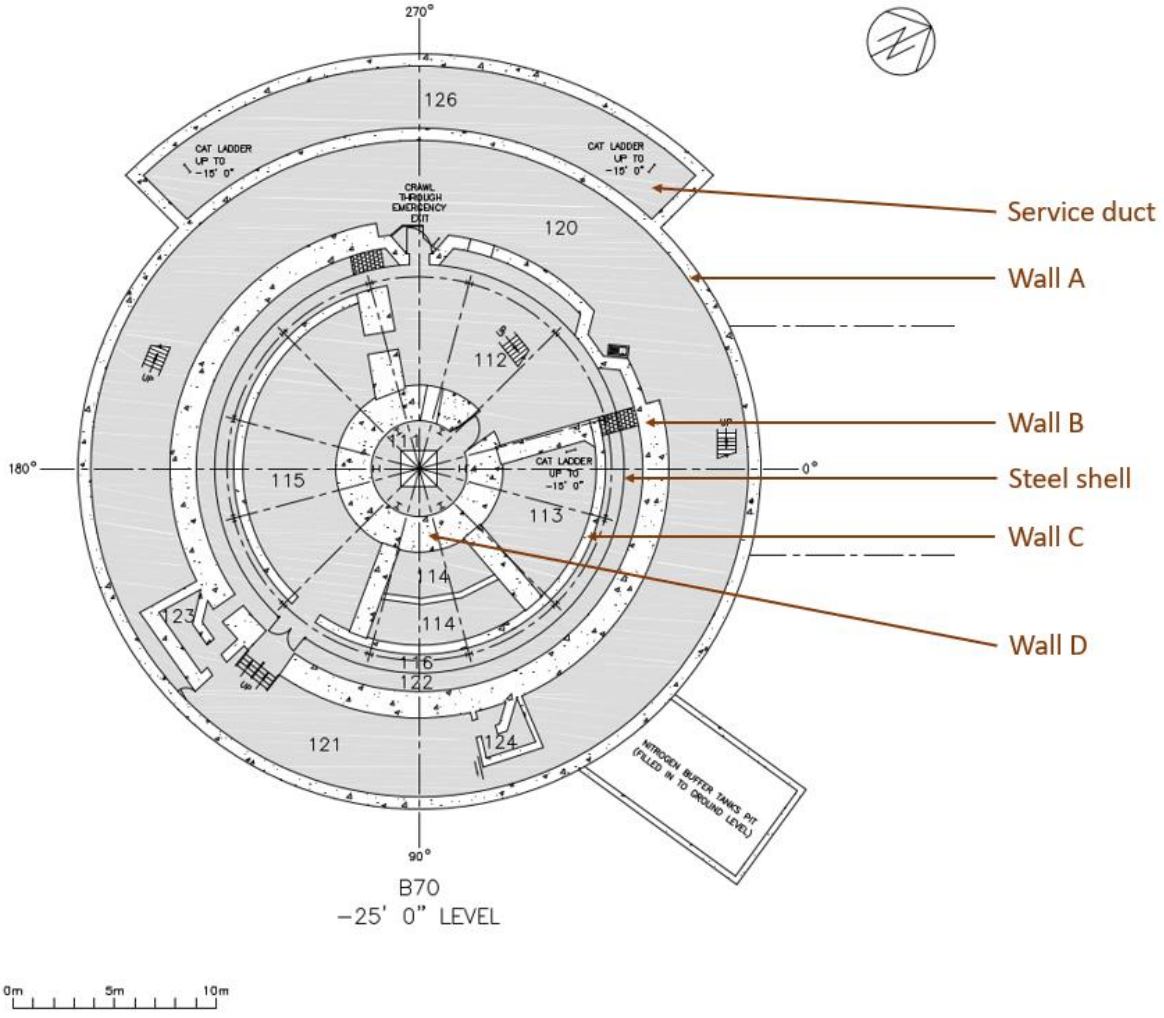
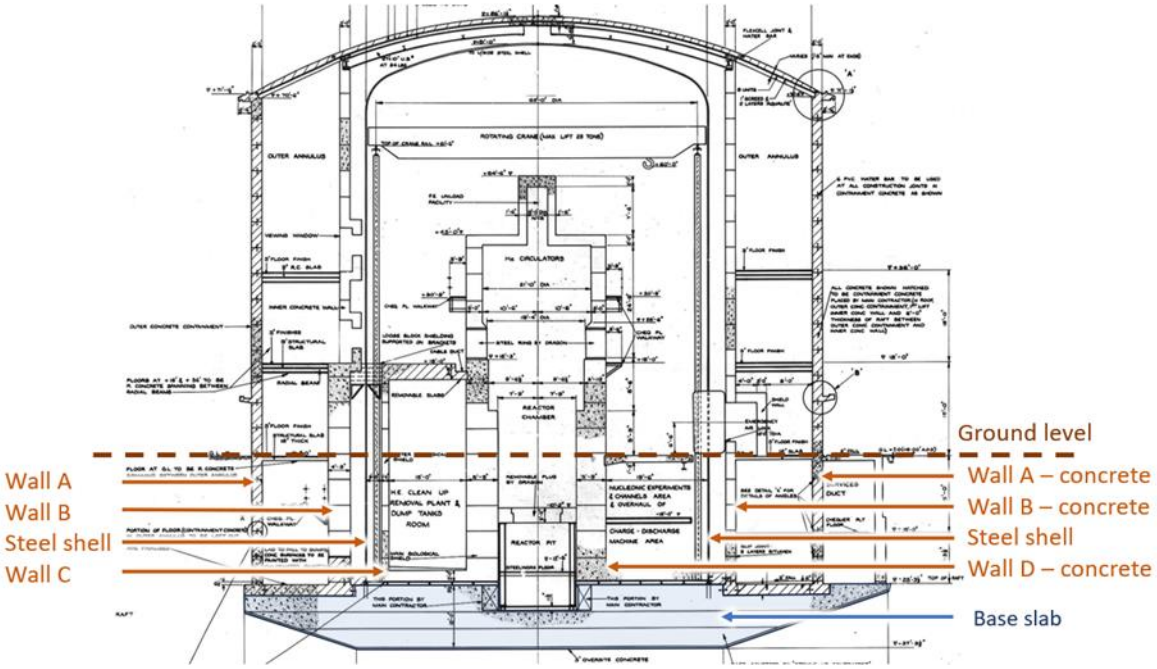


Figure 5 - Cross Section through the Dragon Reactor



Alongside the B70 Dragon reactor structure, the disposal/deposit covers the B78 foundation slab and mortuary holes. The Dragon mortuary holes are located to the north of Dragon. The mortuary holes comprise a pit excavated below ground level and infilled with concrete, within which were housed galvanised mild steel holes for storing spent fuel. The basal elevation is approximately 30.3 m AOD. The primary mortuary holes system comprises 50 vertical mild steel storage holes, with external diameter 0.27 m, wall thickness 13 mm and depth 4.2 m.

6.2.3 SGHWR and Dragon end state concept designs

The end state concept designs have been developed for the SGHWR and Dragon deposits. Internal walls in the subsurface structure will remain in-situ unless they need to be removed to gain access for deposition of the infill material.

Demolition of the primary containment will use wireline cutting and to place concrete blocks within the below ground voids. The above ground external building envelope will be demolished using a high reach machine. Arisings will be placed within the below ground voids. Stockpiled material will be used as a supplement for the filling of the below ground voids.

The concept designs have been developed in accordance with the Design Management manual (Ref. 7) and are detailed within the Design Substantiation Report (DSR) (Ref. 8).

The DSR is underpinned by the following engineering assessments and studies:

- SGHWR structural assessment and demolition study (Ref. 9) – which developed credible demolition and backfilling sequences and completed a preliminary structural assessment of the building during demolition and backfilling;
- Engineering appraisal and concept design (Ref. 10) – which developed and assessed credible options for the design of the demolition and the engineered cap. These options were then assessed and preferred designs identified;
- SGHWR and Dragon reactor basement structural integrity assessment (Ref. 11) - a significant investigation into the structural integrity of SGHWR and the Dragon recator through the expected demolition sequence;

- Consideration of concrete permeability (Ref. 12) – a review of concrete degradation rates assumed for the concrete barriers of near surface disposals both within the UK and internationally to determine the most appropriate rates to use within the risk assessments for the proposed Winfrith disposals;
- Evidence for in-leakage of groundwater (Ref. 13) – reviews evidence of water ingress into SGHWR to identify potential weaknesses in the structure;
- Review of construction joints and water bars (Ref.14) – determines the integrity of construction joints and water bars in preventing potential direct discharges to groundwater from SGHWR;
- Review of penetrations in the structures (Ref.15).

A further output of the completed engineering assessment is a set of functional requirements for the deposits. The purpose of which is to underpin the initial concept designs of the disposals/deposits and set the bounding constraints for the detailed design. A detailed summary of the engineering assessments and the functional requirements is presented within the DSR (Ref. 8).

6.3 Backfill of the Deposits

The deposits are proposed to consist of existing demolition arisings at the Site (currently stored at D630); and those to be generated through demolition of the above ground reactor structures that are OoS of RSR.

The material disposed of will predominantly be broken concrete and brick (associated with demolition activities), however, the DfR permit will seek to permit waste codes EWC 17 01 01 (concrete), 17 01 02 (brick), 17 01 03 (tiles and ceramics) and 17 01 07 (concrete, bricks, tiles and ceramics in mixtures.

The material stockpiled at D630 has been characterised and this identifies it as being OoS of RSR. Further characterisation will be performed prior to emplacement within the deposits to ensure that the material meets the Emplacement Acceptance Criteria (EAC) (Ref. 16).

The EAC provides the physical and chemical properties that the recovered waste must conform to in order to be deemed as suitable for emplacement. Characterisation at the point of source and at the point of emplacement will be used to evidence the suitability of these materials for emplacement.

NRS will endeavour to remove all recyclable and hazardous materials prior to commencing demolition activities although complete removal will not be possible as some materials will be embedded within the structure (concrete) or are otherwise inaccessible. Where hazardous materials cannot be removed due to inaccessibility or being embedded within the structure, NRS will seek demonstrate the approach is safe and optimised.

Table 4 presents the void spaces and the volumes of backfill required to infill these voids. The current volume estimates for the proposed backfill following the concept design are presented. The volume required from D630 is required to meet the difference in volume between in-situ generated demolition arisings and blocks and the respective void spaces. It should be noted that a portion of the volume of the demolition arisings generated in-situ will be permissioned through the RSR permit variation, and a portion through this DfR permit. These volumes will be established through detailed design and further characterisation.

Table 4 - Voids and material volumes for SGHWR and Dragon

	Volume (m^3)					
Component	**Void**	**Blocks**	**Available for Demolition Arisings (m^3)**	**Available for Demolition Arisings (SGHWR + Dragon reactor)**	**Demolition Arisings Generated In Situ (m^3)**	**Void to be Filled using the D630 Stockpiles (m^3)**
SGHWR Region 1	11,649	6,300	5,349	23,439	5,840	17,599
SGHWR Region 2	3,425	None	3,425			
SGHWR North Annexe	4,164		4,164			
SGHWR South Annexe	10,501		10,501			
Dragon reactor – within Wall C	1,891	400	1,491	6,144	4,891	1,253
Dragon reactor –outside of Wall C	4,653	None	4,653			

Table 4 presents the total voidage within the SGHWR and Dragon deposits, with these being subdivided into a number of discrete components as outlined in Section 6.2.

The backfill for SGHWR and Dragon that this application is seeking permission for is presented in Tables 5 and 6.

Table 5 - SGHWR Deposit for Recovery Backfill

Waste Code	**Description**	**Volume**
17 01 01	Non Hazardous Concrete	Up to a maximum volume of 23,439 m^3. Total void volume of SGHWR is 29,739m^3 with 6,300m^3 of concrete blocks being permissioned under a GRR permit variation.
17 01 02	Non Hazardous Bricks	
17 01 03	Non Hazardous Tiles and Ceramics	
17 01 07	Non Hazardous mixtures of Concrete, Bricks, Tiles and Ceramics	

Table 6 - Dragon Deposit for Recovery Backfill

Waste Code	**Description**	**Volume**
17 01 01	Non Hazardous Concrete	Up to a maximum volume of 6,144 m^3. Total void volume of SGHWR is 6,544 m^3 with 400m^3 of concrete blocks being permissioned under a GRR permit variation.
17 01 02	Non Hazardous Bricks	
17 01 03	Non Hazardous Tiles and Ceramics	

17 01 07	Non Hazardous mixtures of Concrete, Bricks, Tiles and Ceramics	

6.4 Capping of the Deposits

The deposits at SGHWR and Dragon are to be capped with an engineered cap. The cap will protect the deposits from water ingress and discourage intrusion from deep rooted plants or burrowing animals and inadvertent human intrusion. The Construction Quality Assurance Plan (CQAP) (Ref. 17) outlines the measures that the cap will include to protect the deposits.

The caps will be finished by a layer of approximately 1 m thick of site derived soils to promote vegetation growth. The use of site derived soils will create a habitat suitable for the natural colonisation of heathland vegetation. The outlines of the restoration for the Winfrith site, including the capping of the deposits is presented in the Restoration Management Plan (Ref. 18).

The capping design will be optimised through the detailed design of the demolition and construction activities.

7 MANAGEMENT OF NON-RADIOLOGICAL HAZARDS

NRS describes its management of non-radiological hazards in the SWESC (Ref. 3). NRS has assessed, and will continue to review, the risks posed by non-radiological hazards present on the Winfrith site such that people and the environment are protected during the period of, and after release from, RSR and the DfR Permit. This will be undertaken by showing consistency with the level of protection provided by relevant national standards.

For the proposed deposits, qualitative arguments and quantitative assessment are used to confirm the acceptability of risks from current and future non-radiological hazards. This includes a HRA (Ref. 6), which considered the potential impacts to groundwater, and associated receptors. Following regulatory guidance on groundwater risk assessment, a tiered approach to risk assessment has been employed. The hydrogeological risk assessment will be kept up to date alongside the detailed design process where additional characterisation data becomes available following the progression of decommissioning and new access arises.

8 ENVIRONMENTAL MONITORING

8.1 Ground Gas Monitoring

There is no ground gas monitoring proposed for the deposits. Details of the justification for this is presented in the ESSD (Ref. 2).

8.2 Surface Water Monitoring

There is no surface water monitoring proposed for the deposits. Details of the justification for this are presented in the ESSD (Ref. 2).

8.3 Groundwater Monitoring Procedures

The Environmental Monitoring Plan (EMP) sets out the scope of environmental monitoring planned to validate the performance of the Dragon and SGHWR deposits (Ref. 19). This is restricted to groundwater monitoring from boreholes located in positions where contaminants emanating from the two deposits are most likely to be detected.

The NRS procedure for undertaking and reviewing an EMP is defined within S-045 (Ref. 20). All NRS sites are expected to apply the sampling and analysis methods described within S-045.

Groundwater monitoring at Winfrith is conducted within a Quality Assurance framework that is compliant with BS ISO 5667-14-2006 and the 'Nuclear Industry Code of Practice for Routine Water Quality Monitoring' (Ref. 21).

The field procedures, sample collection, storage and despatch are managed by a set of Data Quality Objectives, indicators and assessment criteria.

Laboratory data quality is assured through using BS EN ISO/IEC 17025:2017 (UKAS) accredited laboratories for all analysis.

The monitoring is performed by groundwater specialists in accordance with a contract specification. This specification details how:

- The depth to groundwater, free product and to the base of each monitoring well is measured;
- Groundwater is purged from the monitoring well prior to monitoring being completed;
- Well head parameters are measured;
- Groundwater is sampled.

Laboratory analysis is completed for a range of radiological and non-radiological determinants defined within the contract specification.

Field and laboratory data will be assessed by suitably qualified and experienced personnel (SQEP) individuals for appropriate quality checks ('data validation') prior to being used, to identify errors and inconsistencies the checking will, where possible, be undertaken in sufficient time to afford an opportunity to re-run laboratory analysis within sample holding times.

Field and laboratory results will be recorded within IMAGES data capture templates and uploaded to the IMAGES database as is currently undertaken as part of the routine monitoring of groundwater and surface water at the site.

IMAGES is used for collating and compiling technical information and data associated with decommissioning, site characterisation, land quality management and site end state programmes. All documents relating to the on-site disposal permit or DfR applications will be held on IMAGES. It is expected that records that are required to support maintenance of the permits and the eventual permit surrender application will also be held in IMAGES.

8.4 During Construction Groundwater Monitoring Programme.

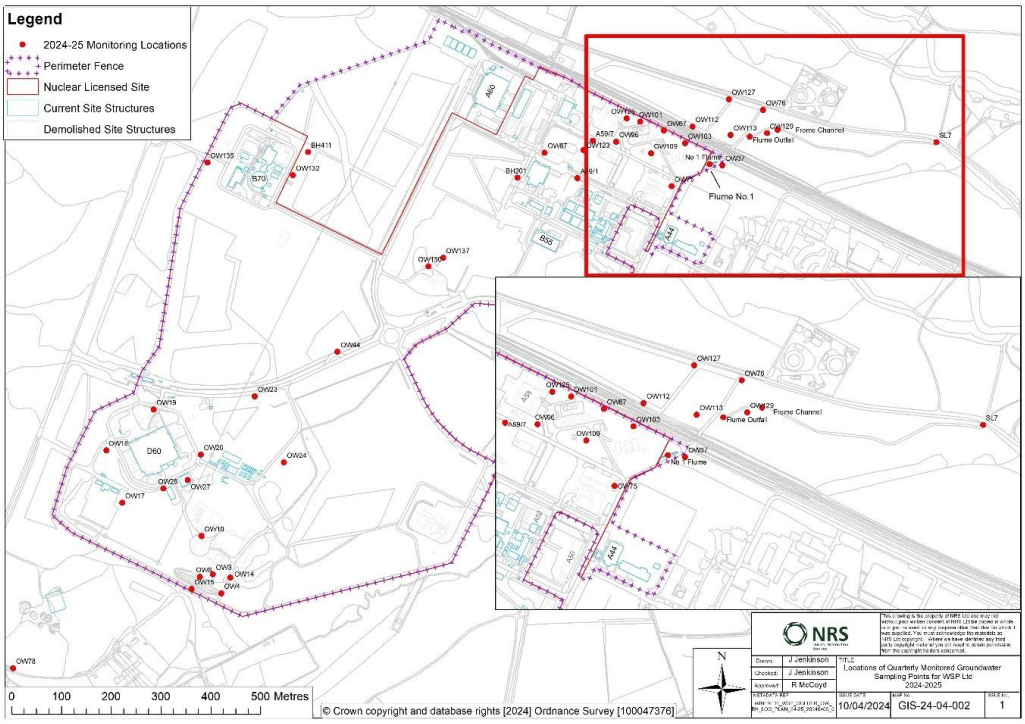
The environmental monitoring to be undertaken through the construction of the deposits is presented in the Environmental Site Setting and Description report (Ref. 2). The purpose of this monitoring is to validate the absence of contamination through construction.

Groundwater monitoring through construction will be undertaken through quarterly sampling of 44 boreholes to support site restoration. The locations are identified in Figure 6.

The analysis requirements for these samples is presented below:

- Chemical Species: metals, Volatile Organic Compounds (VOCs), Monitored Natural Attenuation (MNA) Suite, Major Ions, pH and Total Petroleum Hydrocarbons (TPH-CWG);
- Radioactive Species: Gross Alpha, Gross Beta and Tritium.

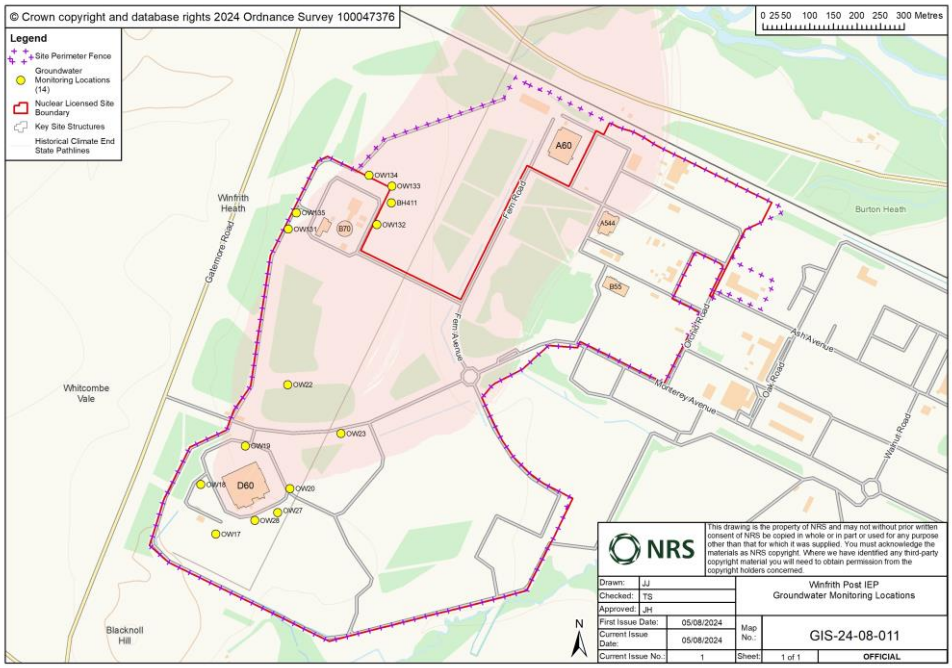
Figure 6 - Locations of existing groundwater monitoring locations at the Winfrith Site



8.5 Post-Construction Groundwater Monitoring Programme.

The Environmental Monitoring Plan (Ref. 19) describes the scope of monitoring to be completed to validate the performance of the deposits. In summary, this includes groundwater monitoring in the locations identified in Figure 7.

Figure 7: Locations of validation monitoring boreholes for the proposed SGHWR and Dragon deposits



The monitoring will be completed as follows:

- Continuous measurements of groundwater flow will be taken at OW133 (down gradient of Dragon) and at OW19 (downgradient of SGHWR) from one year before and one year after the deposits. This is to identify if the deposits have an impact on groundwater flow;
- Groundwater will be measured quarterly to ensure that any impact on groundwater quality from seasonal changes in rainfall can be determined.

The selected determinands for analysis of groundwater samples are:

- Gross alpha;
- Gross beta;
- Tritium;
- Gamma spectrometry;
- Metals (dissolved): As, Ba, Cd, Cr (total and Cr(VI), Cu, Hg, Mo, Ni, Pb, Sb, Se and Zn; and
- Major ions: Ca, Na, K, Mg, Cl, F, SO_4, NO_3, total alkalinity.

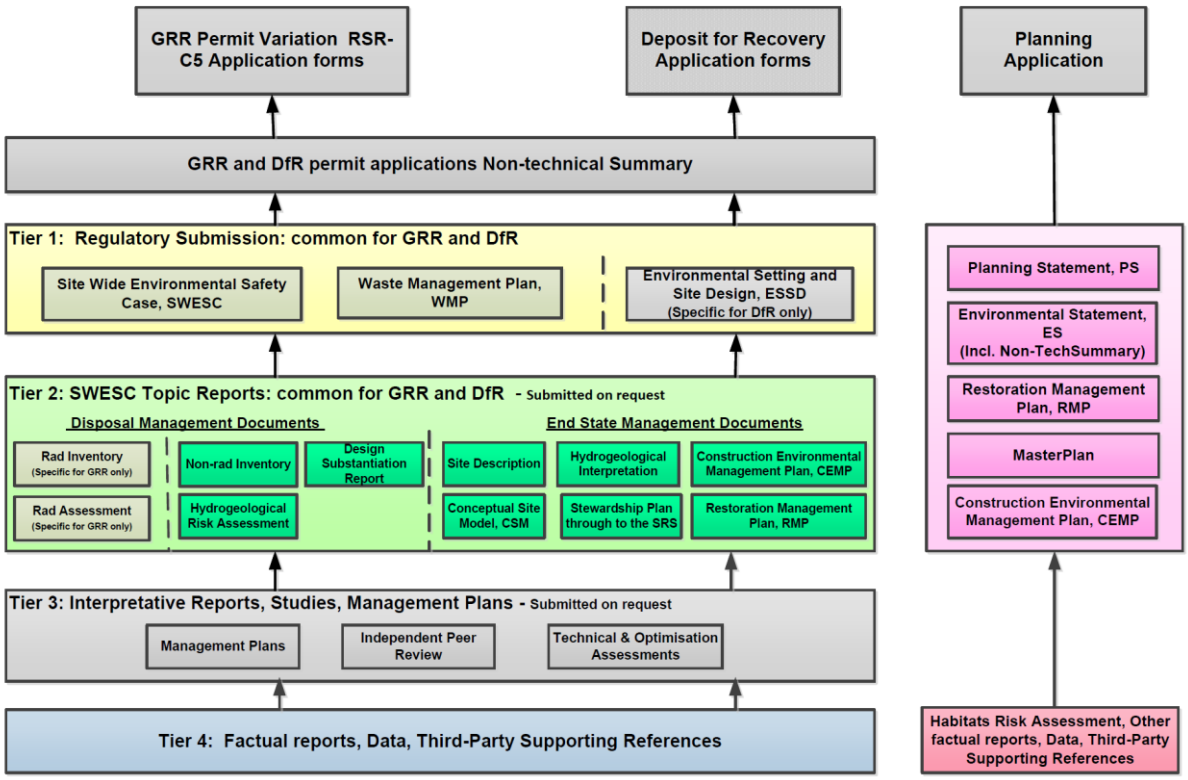
Whilst radiological determinands are not required to be monitored under DfR permit conditions, they have been retained for completeness since they are monitored for under GRR.

9 DOCUMENT STRUCTURE

This section will provide a list of documents that have been produced that together form the technical underpinning for the Winfrith DfR application.

These documents have been produced in collaboration with the application to vary the radiological substances regulation permit for the NRS Winfrith site, and are organised according to their position in the application's document hierarchy.

Figure 8 - Document hierarchy within GRR, DfR and Planning Applications



The DfR documents are listed in separate tables according to their position within the document hierarchy.

Table 7 - Tier 1 Documents - Regulatory Submission

No	Ref	Title
1	ES(24)P405	Non-technical summary, NTS
2	ES(24)P390	Site Wide Environmental Safety Case, SWESC
3	ES(24)P406	Environmental Setting and Site Description Report, ESSD

Table 8 - Tier 2 Documents - Topic Reports

No	Ref	Title
1	ES(18)P196	Winfrith Site Description
2	ES(18)P227	Soil and Groundwater Radiological and Chemical Background Values for the Winfrith Site
3	ES(22)P367	Non-radioactive inventory
4	ES(21)P322	Conceptual Site Model, CSM
5	ES(21)P331	Hydrogeological Interpretation

No	Ref	Title
6	ES(22)P361	Hydrogeological Risk Assessment, HRA
7	ES(23)P387	Design Substantiation Report, DSR
8	ES(18)P235	Stewardship Plan
9	ES(21)P333	Climate change report
10	ES(20)P329	Groundwater compliance report.

Table 9 - Tier 3 documents – Interpretive reports, studies and management plans

No	Ref	Title
1	ES(24)P404	Construction Environmental Management Plan, CEMP
2	ES(24)P389	Environmental Monitoring Plan, EMP
3	ES(24)P398	Structural Integrity Assessment
4	ES(19)P324	Site Wide Materials Management Plan, SWMMP
5	ES(18)P191	Emplacement Acceptance Criteria, EAC

10 REFERENCES

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2. Environmental Setting and Site Description Report, ES(24)P406, Issue 1, December 2024.
3. Site Wide Environmental Safety Case, ES(24)P390, Issue 1, December 2024.
4. Winfrith Site: Interpretation of Present and Future Hydrogeological Conditions, ES(21)P331, Issue 2, December 2024.
5. Winfrith Site: Conceptual Site Model to Underpin a Hydrogeological Risk Assessment and Radiological Performance Assessment of the SGHWR and Dragon Reactor (and Mortuary Tubes) End States, ES(21)P332, Issue1, December 2024.
6. Hydrogeological Risk Assessment of the SGHWR and Dragon Reactors at the Winfrith site, ES(22)P361, Issue 1, December 2024.
7. NRS Design Management Manual, MAN 0004, Issue 12, February 2024.
8. Winfrith End State: Design Substantiation Report (Concept Stage) – SGHWR and the Dragon Reactor, ES(23)P387, Issue 1, October 2024.
9. SGHWR structural assessment and demolition study, 5161206-212-005, Issue 2, August 2018.
10. Engineering appraisal and concept design, ES(19)P282, Issue 3, July 2019.
11. Winfrith Structural Integrity Assessment- Structural Integrity Report, ES(24)P398, Issue 1, November 24
12. Winfrith End State: Concept of Concrete Degradation and its Representation in Numerical Models, WSP Report No: 20146580.618/A.2, November 2023.
13. Water Ingress Arisings at SGHWR, RET 2664, Issue 1, August 2023.
14. Winfrith End State: SGHWR Concrete Joints, SGHMX1852, Issue 1, August 2023.
15. Winfrith End State: SGHWR South Annexe Water Ingress and Penetrations, RET2421, Issue 1, February 2022.
16. Emplacement Acceptance Criteria to support Winfrith End State, ES(18)P191, Issue 2, August 2024.
17. Construction Quality Assurance Plan for the SGHWR and Dragon Reactor End States, ES(24)P409, Issue 1, December 2024.
18. Winfrith End State Restoration Management Plan, 70089718-003. ES(24)P399, Issue 1, December 2024.
19. Winfrith End State Environmental Monitoring Plan, ES(24)P389, Issue 1, December 2024.
20. Environmental monitoring Programme, S-045, Issue 5, April 2022.
21. Nuclear Industry Code of Practice for Routine Water Quality Monitoring, Version 1, February 2015.

Appendix A – Deposit for Recovery Compliance Schedule

The EA provides regulation for recovery operations of land. The EA operates Deposit for Recovery (DfR) applications as two types of permits: Standard Rules and Bespoke Rules Permits. The EA's standard rules have been applied, as appropriate, in the Winfrith Deposit for Recovery application. The applicable parts of these conditions are set out below. Where arguments are presented below, these are respective arguments presented in the SWESC (Ref. 3)

ID	Requirement / Guidance	Where Addressed
DFR-1	… operators shall manage and operate the activities: in accordance with a written management system that identifies and minimises risks of pollution, including those arising from operations, maintenance, accidents, incidents, non-conformances and those drawn to the attention of the operator as a result of complaints and using sufficient competent persons and resources.	NRS has a culture that places EHSS&Q considerations at the heart of its plans and practices. This culture is evident in the development of the decommissioning strategy for Winfrith. NRS has a set of generic process documents regarding items such as planning, developing safety cases, waste management and record keeping that are implemented in site-specific procedures. The Winfrith Site Manual summarises, and sign-posts to the relevant procedures for works undertaken on the site *See:* Arguments M.1 to M.12 *Key References:* A5 – A21
DFR-2	… operators shall: Comply with the requirements of an approved competence scheme	NRS is operating the DfR programme under the WAMITAB competence scheme. *See:* Arguments M.1 and U.1 *Key References:* A17
DFR-3	The operator is only authorised to carry out the activities specified	NRS has a clear Site Wide Materials Management Plan detailing sources and origin of materials to be deposited. EAC have been prepared for Winfrith and issued in tandem with this SWESC. *See:* Arguments M.1 and M.11 *Key References:* A14, A18
DFR-4	…operators shall: Not deviate from the approved waste recovery plan without prior written approval from the Environment Agency.	NRS has a clear strategy for waste recovery. Whilst ongoing characterisation and optimisation is undertaken throughout decommissioning and demolition, any deviations will only occur following written agreement from the EA and confirmed updates to the Winfrith EAC. *See:* Arguments M.1, U.1 and M.11

ID	Requirement / Guidance	Where Addressed
		Key References: A14, A15, A18, A19
DFR-5	…the activities shall: Not extend beyond the site.	NRS will only place material for recovery into the two reactor basements. *See:* Arguments M.1 to M.12, D.3 and D.7 *Key References:* A10, A14, A18, A19, A22, A23
DFR-6	Wastes shall only be accepted if it is a type listed in Table 2.5 of the standard rules, it meets the additional restrictions in that table; and (a) it is inert waste, with the exception of topsoil, peat, soil from cleaning and washing beet and road planings; and (b) appropriate measures have been taken to ensure that the waste is free from contamination; and (c) it has been identified as a suitable waste in the approved waste recovery plan; and (d) its chemical, physical and biological characteristics make it suitable for its intended use on the site.	NRS has an ongoing process to appropriately characterise the D630 stockpile and determine the suitability of use as backfill. In addition, EAC have been issued in tandem to this SWESC detailing the physical, chemical, and biological properties of wastes that are to be emplaced. *See:* Arguments M.11, M.13, D.2 and D.6 *Key References:* A14, A20
DFR-7	Any waste that does not comply with all of the conditions of the EAC or fit the description of the waste recorded in EAC shall be rejected and shall be: (a) Removed from the site; or (b) Moved to a designated quarantine area pending removal.	NRS has developed Emplacement Acceptance Criteria (EAC) detailing the biological, chemical and physical characteristics of the demolition material that is acceptance for use in filling the below-ground voids. Any waste that does not meet these criteria will be segregated and disposed of off-site. Stockpiled materials such as D630 will undergo a sort and segregate process to remove non-compliant materials. *See:* Arguments M.11 *Key References:* A10, A14, A19

A1 Scottish Environment Protection Agency, Environment Agency and Natural Resources Wales, *Management of radioactive waste from decommissioning of nuclear sites: Guidance on Requirements for Release from Radioactive Substances Regulation*, 24 July 2018.

A2 NRS, *Winfrith End State Project: Waste Management Plan*, Appendix A: WMP Spreadsheet, Nuclear Restoration Services Ltd, ES(23)P378 Spreadsheet, Draft B, February 2023.

A3 NRS, *Winfrith End State Project: Waste Management Plan*, Nuclear Restoration Services Ltd, ES(23)P378 Issue 1, DRAFT 4, January 2024.

A4 Winfrith Site End State Engagement: Statement of Community Involvement, 70089718-SEN, Issue 1, July 2023.

A5 Site Restoration Programme: The Winfrith End State Stewardship Plan, ES9”3)P386, issue 1, November 2024.

A6 Winfrith End State Project: Winfrith End Point Specification and Definition, ES(16)P117, Issue 3, December 2023.

A7 Winfrith Site: Land Quality Plan, ES/19/P257, Issue 2, April 2019.

A8 Winfrith End State Environmental Monitoring Plan, ES(24)P389, Issue 1, November 2024.

A9 Winfrith End State Zone Close Out Process and Requirements, ES(17)P183, Issue 1 Draft B.

A10 Hydrogeological Risk Assessment of the SGHWR and Dragon Reactor (and Mortuary Tubes) End States. 20146580.611/A.0, Issue 1 Revision 2. 30 January 2024.

A11 Winfrith Site: End State Radiological Performance Assessment 2024, ES(23)P388, Issue 1 Draft 3, November 2024.

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A13 Site Restoration: Winfrith End State: Waste Management Plan, ES(23)P378, issue 1, October 2024.

A14 Emplacement Acceptance Criteria to support Winfrith End State, ES(18)P191, Issue 2, August 2024.

A15 Site Restoration programme: Winfrith End State Project: Accompanying report to the Non-Radiological inventory of SGHWR, Dragon Reactor Complex and Backfill, ES(21)P335, Issue 4, May 2024.

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A19 Winfrith End State Project: Waste Recovery Plan, ES(19)P285, Formal Draft 3, March 2021.

A20 Summary of 2018 Characterisation of the D630 Rubble Stockpile, ES/18/NFR/035, Issue 1, February 2019.

A21 Harwell/Winfrith Sites Manual, MAN 0001, Issue 16, 24 January 2023.

A22 Winfrith End State: Design Substantiation Report (Concept Stage) – SGHWR and the Dragon Reactor, ES(23)P387, Issue 1, October 2024.

A23 Winfrith End State: SGHWR & Dragon End State Engineering Concept Designs: Preliminary Below Ground Void Backfill Optimisation, ES(22)P384, Issue 1 Draft B, June 2024.

A24 Winfrith Site: Interpretation of Present and Future Hydrogeological Conditions, ES(21)P331, Issue 1, April 2023.

A25 Winfrith Site: Environmental Statement, Draft

A26 Winfrith Site: Restoration Management Plan, WSP Ref: 70089718-003. ES(24)P399, Issue 1, November 2024.

A27 Winfrith End State: Assessment of the effect of Climate Change on groundwater levels, ES(21)P333, Draft 2, 29 March 2021.