

|                     |              |  |
|---------------------|--------------|--|
| <b>WASTE STREAM</b> | <b>2A307</b> | <b>Final Dismantling &amp; Site Clearance Concrete (Reactor &amp; Non-Reactor) LLW</b> |
|---------------------|--------------|--|

**SITE** Calder Hall  
**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Sellafield Limited

**WASTE TYPE** LLW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

|                        |                           | Reported                |
|------------------------|---------------------------|-------------------------|
| Stocks:                | At 1.4.2022.....          | 0 m <sup>3</sup>        |
| Future arisings -      | 1.4.2022 - 31.3.2023..... | 0 m <sup>3</sup>        |
|                        | 1.4.2023 - 31.3.2024..... | 0 m <sup>3</sup>        |
|                        | 1.4.2024 - 31.3.2025..... | 0 m <sup>3</sup>        |
|                        | 1.4.2025 - 31.3.2107..... | 0 m <sup>3</sup>        |
|                        | 1.4.2107 - 31.3.2111..... | ~16604.0 m <sup>3</sup> |
| Total future arisings: |                           | 16604.0 m <sup>3</sup>  |
| Total waste volume:    |                           | 16604.0 m <sup>3</sup>  |

**Comment on volumes:** For inventory purposes the arisings are assumed to arise at a uniform rate. Final Dismantling & Site Clearance is assumed to commence in 2104, with reactor dismantling commencing in 2107, and lasting for ten years. Volumes and radioactivity have been calculated for 100 years after reactor shutdown, i.e. 2103, but the volume in this stream would not change for decommissioning in 2107.

**Uncertainty factors on volumes:**  
 Stock (upper): x Arisings (upper) x 5.0  
 Stock (lower): x Arisings (lower) x 0.2

**WASTE SOURCE** Concrete wastes from dismantling of reactors and associated plant.

**PHYSICAL CHARACTERISTICS**

**General description:** A wide variety of concrete and reinforced concrete items (reinforcing steel is described in waste stream 2A306).  
**Physical components (%vol):** Concrete and reinforced concrete from reactor bioshield (~97% vol) and other structures (3%vol).  
**Sealed sources:** The waste does not contain sealed sources.  
**Bulk density (t/m<sup>3</sup>):** 1.4  
**Comment on density:** The density is of the waste as cut for packaging assuming 20% in blocks and 80% as rubble.

**CHEMICAL COMPOSITION**

**General description and components (%wt):** Concrete (100%). Some of the concrete may include iron shot.  
**Chemical state:** Alkali  
**Chemical form of radionuclides:**  
 H-3: The tritium is incorporated in the concrete.  
 C-14: The carbon 14 content is insignificant.  
 Cl-36: The chemical form of chlorine has not been determined.  
 Se-79: The selenium content is insignificant.  
 Tc-99: The technetium content is insignificant.  
 I-129: The iodine content is insignificant.  
 Ra: The radium content is insignificant.  
 Th: The thorium content is insignificant.  
 U: The uranium content is insignificant.  
 Np: The neptunium content is insignificant.  
 Pu: The plutonium content is insignificant.  
**Metals and alloys (%wt):** There are no large or bulk metal items.

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|                           | (%wt) | Type(s) / Grade(s) with proportions | % of total C14 activity |
|---------------------------|-------|-------------------------------------|-------------------------|
| Stainless steel.....      | 0     |                                     |                         |
| Other ferrous metals..... | NE    |                                     |                         |
| Iron.....                 |       |                                     |                         |
| Aluminium.....            | 0     |                                     |                         |
| Beryllium.....            | 0     |                                     |                         |
| Cobalt.....               | 0     |                                     |                         |
| Copper.....               | 0     |                                     |                         |
| Lead.....                 | 0     |                                     |                         |
| Magnox/Magnesium.....     | 0     |                                     |                         |
| Nickel.....               | 0     |                                     |                         |
| Titanium.....             |       |                                     |                         |
| Uranium.....              | 0     |                                     |                         |
| Zinc.....                 | 0     |                                     |                         |
| Zircaloy/Zirconium.....   | 0     |                                     |                         |
| Other metals.....         | 0     |                                     |                         |

Organics (%wt):                      None expected. No halogenated plastics or rubbers are expected to be present.

|                                     | (%wt) | Type(s) and comment | % of total C14 activity |
|-------------------------------------|-------|---------------------|-------------------------|
| Total cellulose.....                | 0     |                     |                         |
| Paper, cotton.....                  | 0     |                     |                         |
| Wood.....                           | 0     |                     |                         |
| Halogenated plastics .....          | 0     |                     |                         |
| Total non-halogenated plastics..... | 0     |                     |                         |
| Condensation polymers.....          | 0     |                     |                         |
| Others.....                         | 0     |                     |                         |
| Organic ion exchange materials....  | 0     |                     |                         |
| Total rubber.....                   | 0     |                     |                         |
| Halogenated rubber .....            | 0     |                     |                         |
| Non-halogenated rubber.....         | 0     |                     |                         |
| Hydrocarbons.....                   |       |                     |                         |
| Oil or grease .....                 |       |                     |                         |
| Fuel.....                           |       |                     |                         |
| Asphalt/Tarmac (cont.coal tar)...   |       |                     |                         |
| Asphalt/Tarmac (no coal tar)....    |       |                     |                         |
| Bitumen.....                        |       |                     |                         |
| Others.....                         |       |                     |                         |
| Other organics.....                 | 0     |                     |                         |

Other materials (%wt):                      -

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|                                    | (%wt)  | Type(s) and comment | % of total C14 activity |
|------------------------------------|--------|---------------------|-------------------------|
| Inorganic ion exchange materials.. | 0      |                     |                         |
| Inorganic sludges and flocs.....   | 0      |                     |                         |
| Soil.....                          | 0      |                     |                         |
| Brick/Stone/Rubble.....            | 0      |                     |                         |
| Cementitious material.....         | ~100.0 |                     |                         |
| Sand.....                          |        |                     |                         |
| Glass/Ceramics.....                | 0      |                     |                         |
| Graphite.....                      | TR     |                     |                         |
| Desiccants/Catalysts.....          |        |                     |                         |
| Asbestos.....                      | 0      |                     |                         |
| Non/low friable.....               |        |                     |                         |
| Moderately friable.....            |        |                     |                         |
| Highly friable.....                |        |                     |                         |
| Free aqueous liquids.....          | 0      |                     |                         |
| Free non-aqueous liquids.....      | 0      |                     |                         |
| Powder/Ash.....                    | 0      |                     |                         |

Inorganic anions (%wt):      Principal anions will be silicates and aluminates in various anionic forms. Carbonates could be up to 20% if limestone was used as an aggregate.

|                | (%wt) | Type(s) and comment |
|----------------|-------|---------------------|
| Fluoride.....  | <1.0  |                     |
| Chloride.....  | <1.0  |                     |
| Iodide.....    | <1.0  |                     |
| Cyanide.....   | 0     |                     |
| Carbonate..... | <2.0  |                     |
| Nitrate.....   | <1.0  |                     |
| Nitrite.....   | <1.0  |                     |
| Phosphate..... | <1.0  |                     |
| Sulphate.....  | ~2.0  |                     |
| Sulphide.....  | <1.0  |                     |

Materials of interest for waste acceptance criteria:      No materials likely to pose a fire or other non-radiological hazard have been identified.

|                                | (%wt) | Type(s) and comment |
|--------------------------------|-------|---------------------|
| Combustible metals.....        | 0     |                     |
| Low flash point liquids.....   | 0     |                     |
| Explosive materials.....       | 0     |                     |
| Phosphorus.....                | 0     |                     |
| Hydrides.....                  | 0     |                     |
| Biological etc. materials..... | 0     |                     |
| Biodegradable materials.....   | 0     |                     |
| Putrescible wastes.....        | 0     |                     |

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Non-putrescible wastes.....  
 Corrosive materials..... 0  
 Pyrophoric materials..... 0  
 Generating toxic gases..... 0  
 Reacting with water..... 0  
 Higher activity particles.....  
 Soluble solids as bulk chemical  
 compounds.....

Hazardous substances /  
 non hazardous pollutants: -

(%wt) Type(s) and comment

Acrylamide.....  
 Benzene.....  
 Chlorinated solvents.....  
 Formaldehyde.....  
 Organometallics.....  
 Phenol.....  
 Styrene.....  
 Tri-butyl phosphate.....  
 Other organophosphates.....  
 Vinyl chloride.....  
 Arsenic.....  
 Barium.....  
 Boron.....  
     Boron (in Boral).....  
     Boron (non-Boral).....  
 Cadmium.....  
 Caesium.....  
 Selenium.....  
 Chromium.....  
 Molybdenum.....  
 Thallium.....  
 Tin.....  
 Vanadium.....  
 Mercury compounds.....  
 Others.....  
 Electronic Electrical Equipment (EEE)  
     EEE Type 1.....  
     EEE Type 2.....  
     EEE Type 3.....  
     EEE Type 4.....  
     EEE Type 5.....

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Complexing agents (%wt): No

|                                | (%wt) | Type(s) and comment |
|--------------------------------|-------|---------------------|
| EDTA.....                      |       |                     |
| DPTA.....                      |       |                     |
| NTA.....                       |       |                     |
| Polycarboxylic acids.....      |       |                     |
| Other organic complexants..... |       |                     |
| Total complexing agents.....   | 0     |                     |

Potential for the waste to contain discrete items: Yes. Iron Shot may be present in some rubble.

**TREATMENT, PACKAGING AND DISPOSAL**

Planned on-site / off-site treatment(s):

| Treatment  | On-site / Off site | Stream volume % |
|--|--------------------|-----------------|
| Low force compaction<br>Supercompaction (HFC)<br>Incineration<br>Solidification<br>Decontamination<br>Metal treatment<br>Size reduction<br>Decay storage<br>Recycling / reuse<br>Other / various<br>None |                    | 100.0           |

Comment on planned treatments:

It has been assumed for the 2022 UK RWI that no further treatment will be carried out prior to disposal and that the LLW will be non-compactable waste to be consigned to LLWR for disposal.

**Disposal Routes:**

| Disposal Route   | Stream volume % | Disposal density t/m3 |
|--|-----------------|-----------------------|
| Expected to be consigned to the LLW Repository           | 10.0            | 1.2                   |
| Expected to be consigned to a Landfill Facility          | 90.0            | 1.5                   |
| Expected to be consigned to an On-Site Disposal Facility |                 |                       |
| Expected to be consigned to an Incineration Facility     |                 |                       |
| Expected to be consigned to a Metal Treatment Facility   |                 |                       |
| Expected to be consigned as Out of Scope                 |                 |                       |
| Expected to be recycled / reused                         |                 |                       |
| Disposal route not known                                 |                 |                       |

Classification codes for waste expected to be consigned to a landfill facility: -

**Upcoming (2022/23-2024/25) Waste Routing (if expected to change from above):**

| Disposal Route   | Stream volume % |         |         |
|--|-----------------|---------|---------|
|  | 2022/23         | 2023/24 | 2024/25 |
| Expected to be consigned to the LLW Repository           |                 |         |         |
| Expected to be consigned to a Landfill Facility          |                 |         |         |
| Expected to be consigned to an On-Site Disposal Facility |                 |         |         |
| Expected to be consigned to an Incineration Facility     |                 |         |         |
| Expected to be consigned to a Metal Treatment Facility   |                 |         |         |
| Expected to be consigned as Out of Scope                 |                 |         |         |
| Expected to be recycled / reused                         |                 |         |         |
| Disposal route not known                                 |                 |         |         |

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**Opportunities for alternative disposal routing:** Not yet determined

| Baseline Management Route | Opportunity Management Route | Stream volume (%) | Estimated Date that Opportunity will be realised | Opportunity Confidence | Comment |
|---------------------------|------------------------------|-------------------|--|------------------------|---------|
| -                         | -                            | -                 | -  | -                      | -       |

**Waste Packaging for Disposal:**

| Container  | Stream volume % | Waste loading m <sup>3</sup> | Number of packages |
|--|-----------------|------------------------------|--------------------|
| 1/3 Height IP-1 ISO<br>2/3 Height IP-2 ISO<br>1/2 Height WAMAC IP-2 ISO<br>1/2 Height IP-2 Disposal/Re-usable ISO<br>2m box (no shielding)<br>4m box (no shielding)<br>Other | 10.0            | 10                           | 167                |

Other information: -

**Waste Planned for Disposal at the LLW Repository:**

Container voidage: -

Waste Characterisation Form (WCH): It is not yet determined if the waste meets LLWR's Waste Acceptance Criteria (WAC).

Waste consigned for disposal to LLWR in year of generation: Not yet determined.

**Non-Containerised Waste for In-Vault Grouting:** (Not applicable to this waste stream)

Stream volume (%): -

Waste stream variation: -

Bounding cuboidal volume:

Inaccessible voidage: -

Other information: -

**RADIOACTIVITY**

Source: Activation of the concrete and impurities. There may be some contamination.

Uncertainty: The values quoted were derived by calculation from available material specifications and are indicative of the activities that are expected. The major source of uncertainty is the impurity levels. The calculations only apply to the Reactor Waste (97% of total) and Non-Reactor waste is assumed to have the same specific activity.

Definition of total alpha and total beta/gamma: Total beta/gamma is defined as the sum of the listed activities of all nuclides other than alpha emitters. All alpha emitters are insignificant and the total is therefore given as <1E-9 TBq/m<sup>3</sup>.

Measurement of radioactivities: The specific activities have been estimated using a neutron activation calculation.

Other information: The activities quoted are those at 100 years after reactor shutdown, i.e. in 2103. There may be some contamination by Cs137.

**WASTE STREAM 2A307 Final Dismantling & Site Clearance Concrete (Reactor & Non-Reactor) LLW**

| Nuclide | Mean radioactivity, TBq/m <sup>3</sup> |                |                 |                | Nuclide          | Mean radioactivity, TBq/m <sup>3</sup> |                     |                 |                |
|---------|--|----------------|-----------------|----------------|------------------|--|---------------------|-----------------|----------------|
|         | Waste at 1.4.2022                      | Bands and Code | Future arisings | Bands and Code |                  | Waste at 1.4.2022                      | Bands and Code      | Future arisings | Bands and Code |
| H 3     |  |                | 2.00E-05        | CC 2           | Gd 153           |  |                     |                 | 8              |
| Be 10   |  |                |                 | 8              | Ho 163           |  |                     | 3.00E-09        | CC 2           |
| C 14    |  |                |                 | 8              | Ho 166m          |  |                     | 6.00E-09        | CC 2           |
| Na 22   |  |                |                 |                | Tm 170           |  |                     |                 | 8              |
| Al 26   |  |                |                 |                | Tm 171           |  |                     |                 | 8              |
| Cl 36   |  |                | 9.00E-07        | CC 2           | Lu 174           |  |                     |                 | 8              |
| Ar 39   |  |                |                 | 8              | Lu 176           |  |                     |                 | 8              |
| Ar 42   |  |                |                 | 8              | Hf 178n          |  |                     |                 | 8              |
| K 40    |  |                |                 | 8              | Hf 182           |  |                     |                 | 8              |
| Ca 41   |  |                | 1.00E-05        | CC 2           | Pt 193           |  |                     |                 | 8              |
| Mn 53   |  |                |                 | 8              | Tl 204           |  |                     |                 | 8              |
| Mn 54   |  |                |                 | 8              | Pb 205           |  |                     |                 | 8              |
| Fe 55   |  |                |                 | 8              | Pb 210           |  |                     |                 | 8              |
| Co 60   |  |                |                 | 8              | Bi 208           |  |                     |                 | 8              |
| Ni 59   |  |                | 2.00E-08        | CC 2           | Bi 210m          |  |                     |                 | 8              |
| Ni 63   |  |                | 1.00E-06        | CC 2           | Po 210           |  |                     |                 | 8              |
| Zn 65   |  |                |                 | 8              | Ra 223           |  |                     |                 | 8              |
| Se 79   |  |                |                 | 8              | Ra 225           |  |                     |                 | 8              |
| Kr 81   |  |                |                 | 8              | Ra 226           |  |                     |                 | 8              |
| Kr 85   |  |                |                 | 8              | Ra 228           |  |                     |                 | 8              |
| Rb 87   |  |                |                 | 8              | Ac 227           |  |                     |                 | 8              |
| Sr 90   |  |                |                 | 8              | Th 227           |  |                     |                 | 8              |
| Zr 93   |  |                |                 | 8              | Th 228           |  |                     |                 | 8              |
| Nb 91   |  |                |                 | 8              | Th 229           |  |                     |                 | 8              |
| Nb 92   |  |                |                 | 8              | Th 230           |  |                     |                 | 8              |
| Nb 93m  |  |                |                 | 8              | Th 232           |  |                     |                 | 8              |
| Nb 94   |  |                | 2.00E-08        | CC 2           | Th 234           |  |                     |                 | 8              |
| Mo 93   |  |                |                 | 8              | Pa 231           |  |                     |                 | 8              |
| Tc 97   |  |                |                 | 8              | Pa 233           |  |                     |                 | 8              |
| Tc 99   |  |                |                 | 8              | U 232            |  |                     |                 | 8              |
| Ru 106  |  |                |                 | 8              | U 233            |  |                     |                 | 8              |
| Pd 107  |  |                |                 | 8              | U 234            |  |                     |                 | 8              |
| Ag 108m |  |                | 4.00E-08        | CC 2           | U 235            |  |                     |                 | 8              |
| Ag 110m |  |                |                 | 8              | U 236            |  |                     |                 | 8              |
| Cd 109  |  |                |                 | 8              | U 238            |  |                     |                 | 8              |
| Cd 113m |  |                |                 | 8              | Np 237           |  |                     |                 | 8              |
| Sn 119m |  |                |                 | 8              | Pu 236           |  |                     |                 | 8              |
| Sn 121m |  |                |                 | 8              | Pu 238           |  |                     |                 | 8              |
| Sn 123  |  |                |                 | 8              | Pu 239           |  |                     |                 | 8              |
| Sn 126  |  |                |                 | 8              | Pu 240           |  |                     |                 | 8              |
| Sb 125  |  |                |                 | 8              | Pu 241           |  |                     |                 | 8              |
| Sb 126  |  |                |                 | 8              | Pu 242           |  |                     |                 | 8              |
| Te 125m |  |                |                 | 8              | Am 241           |  |                     |                 | 8              |
| Te 127m |  |                |                 | 8              | Am 242m          |  |                     |                 | 8              |
| I 129   |  |                |                 | 8              | Am 243           |  |                     |                 | 8              |
| Cs 134  |  |                |                 | 8              | Cm 242           |  |                     |                 | 8              |
| Cs 135  |  |                |                 | 8              | Cm 243           |  |                     |                 | 8              |
| Cs 137  |  |                |                 | 6              | Cm 244           |  |                     |                 | 8              |
| Ba 133  |  |                |                 | 8              | Cm 245           |  |                     |                 | 8              |
| La 137  |  |                |                 | 8              | Cm 246           |  |                     |                 | 8              |
| La 138  |  |                |                 | 8              | Cm 248           |  |                     |                 | 8              |
| Ce 144  |  |                |                 | 8              | Cf 249           |  |                     |                 | 8              |
| Pm 145  |  |                |                 | 8              | Cf 250           |  |                     |                 | 8              |
| Pm 147  |  |                |                 | 8              | Cf 251           |  |                     |                 | 8              |
| Sm 147  |  |                |                 | 8              | Cf 252           |  |                     |                 | 8              |
| Sm 151  |  |                | 6.00E-07        | CC 2           | Other a          |  |                     |                 | 8              |
| Eu 152  |  |                | 2.00E-06        | CC 2           | Other b/g        |  |                     |                 | 8              |
| Eu 154  |  |                | 5.00E-09        | CC 2           | <b>Total a</b>   | <b>0</b>                               | <b>&lt;1.00E-09</b> | <b>C 3</b>      |                |
| Eu 155  |  |                |                 | 8              | <b>Total b/g</b> | <b>0</b>                               | <b>3.46E-05</b>     | <b>CC 2</b>     |                |

**Bands (Upper and Lower)**

- A a factor of 1.5
- B a factor of 3
- C a factor of 10
- D a factor of 100
- E a factor of 1000

Note: Bands quantify uncertainty in mean radioactivity.

**Code**

- 1 Measured activity
- 2 Derived activity (best estimate)
- 3 Derived activity (upper limit)
- 4 Not present
- 5 Present but not significant
- 6 Likely to be present but not assessed
- 7 Present in significant quantities but not determined
- 8 Not expected to be present in significant quantity