

| WASTE STREAM | 9B15/C | Sludge |
|--------------|--------|--------|
|--------------|--------|--------|

**SITE** Bradwell

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Nuclear Restoration Services Ltd (NRS)

**WASTE TYPE** ILW

#### WASTE VOLUMES

|                        | At 1.4.2025 | Reported (m <sup>3</sup> ) | OR | Conditioned (m <sup>3</sup> ) | Packaged (m <sup>3</sup> ) |
|------------------------|-------------|----------------------------|----|-------------------------------|----------------------------|
| Stocks:                |             |                            |    | = 12.6                        | 43.5                       |
| Future arisings:       |             |                            |    |                               | 0.0                        |
| Total future arisings: |             |                            |    | 0.0                           | 0.0                        |
| Total waste volume:    |             |                            |    | 12.6                          | 43.5                       |

Number of waste packages in stock: At 1.4.2025..... 8 packages

Comment on arising rates: -

Additional information on quantities: -

Uncertainty factors on volumes:

|                |        |                   |     |
|----------------|--------|-------------------|-----|
| Stock (upper): | x 1.00 | Arisings (upper): | x - |
| Stock (lower): | x 1.00 | Arisings (lower): | x - |

**WASTE SOURCE** Sludge heel arose from operation of Pond Water Treatment Plant (PWTP) and Active Effluent Treatment Plan (AETP) as well as decommissioning operations such as pond wall scabbling and pond skip decontamination. Some ADAP sludge, originating from the operation of the Aqueous Discharge Abatement Plant (ADAP) present, as well as sand from filter units used to treat effluent and gravel from the interface of FED storage vaults.

#### PHYSICAL CHARACTERISTICS

General description: Sludge heel was consolidated and conditioned using Advanced Vacuum Drying System (AVDS), where possible the sludge was co-packaged with gravel, sand, ADAP sludge and other miscellaneous contaminated items (MCI).

Changes since waste generated: -

Bulk density (t/m<sup>3</sup>): = 0.91

Comment on density: The bulk density of the sludge was calculated using the total wastestream mass and total wastestream volume from package records.

#### CHEMICAL COMPOSITION

General description and components (%wt): Sludge heel consisting of magnesium hydroxide, magnesium carbonate, ion exchange material as well as sand and concrete dust. Some organic materials present in form of oils, paint and soap. Gravel interface from FED vaults. Sludge (56 wt%), Sand (16 wt%), Gravel (28 wt%).

Chemical state: Alkali

Sheet metal proportion / thickness: -

Metals and alloys (%wt):

|                           | (%wt) | Type(s) / Grades(s) with proportions     | % of total C14 activity |
|---------------------------|-------|------------------------------------------|-------------------------|
| Stainless steel.....      | NE    | -                                        |                         |
| Other ferrous metals..... | NE    | -                                        |                         |
| Iron.....                 |       | -                                        |                         |
| Aluminium.....            | NE    | -                                        |                         |
| Beryllium.....            | TR    | -                                        |                         |
| Cobalt.....               |       | -                                        |                         |
| Copper.....               | NE    | -                                        |                         |
| Lead.....                 | TR    | -                                        |                         |
| Magnox/Magnesium.....     | P     | Corroded Magnox within the sludge.       |                         |
| Nickel.....               |       | -                                        |                         |
| Titanium.....             |       | -                                        |                         |
| Uranium.....              |       | -                                        |                         |
| Zinc.....                 | NE    | -                                        |                         |
| Zircaloy/Zirconium.....   | NE    | -                                        |                         |
| Other metals.....         | NE    | "Other" metals have not been identified. |                         |

Organics (%wt):

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

Other materials (%wt):

|                                       | (%wt)  | Type(s) and comment                            | % of total C14 activity |
|---------------------------------------|--------|------------------------------------------------|-------------------------|
| Inorganic ion exchange materials..... | TR 0   | -                                              |                         |
| Inorganic sludges and flocs.....      | = 56.4 | Majority 61V sludge, some ADAP sludge present. |                         |
| Soil.....                             | = 0    | -                                              |                         |
| Brick/Stone/Rubble.....               | = 27.7 | Gravel from the 8B Interface of FED Vaults     |                         |
| Cementitious material.....            | NE     | -                                              |                         |
| Sand.....                             | = 15.9 | Contaminated sand co-packaged with sludge.     |                         |
| Glass/Ceramics.....                   | = 0    | -                                              |                         |
| Graphite.....                         | TR     | -                                              |                         |
| Desiccants/Catalysts.....             | -      | -                                              |                         |
| Asbestos.....                         | = 0    | -                                              |                         |
| Non/low friable.....                  | -      | -                                              |                         |
| Moderately friable.....               | -      | -                                              |                         |
| Highly friable.....                   | -      | -                                              |                         |
| Free aqueous liquids.....             | P      | -                                              |                         |
| Free non-aqueous liquids.....         | P      | -                                              |                         |
| Powder/Ash.....                       | = 0    | -                                              |                         |

#### COMPONENTS OF MATERIALS, WASTE PROPERTIES, MATERIALS NOT CONTRIBUTING TO MASS

Inorganic anions (%wt):

|                | (%wt)   | Type(s) and comment                                     |
|----------------|---------|---------------------------------------------------------|
| Fluoride.....  | = 0     | -                                                       |
| Chloride.....  | TR 0.01 | -                                                       |
| Iodide.....    | = 0     | -                                                       |
| Cyanide.....   | = 0     | -                                                       |
| Carbonate..... | ~ 6.0   | Chemical analysis shows carbonate contents of 4-8wt(%). |
| Nitrate.....   | = 0     | -                                                       |
| Nitrite.....   | = 0     | -                                                       |
| Phosphate..... | = 0     | -                                                       |
| Sulphate.....  | = 0.80  | -                                                       |
| Sulphide.....  | = 0     | -                                                       |

Materials of interest for waste acceptance criteria:

|                                                | (%wt) | Type(s) and comment |
|------------------------------------------------|-------|---------------------|
| Combustible metals.....                        | < 0   | -                   |
| Low flash point liquids.....                   | = 0   | -                   |
| Explosive materials.....                       | = 0   | -                   |
| Phosphorus.....                                | = 0   | -                   |
| Hydrides.....                                  | = 0   | -                   |
| Biological etc. materials.....                 | TR    | -                   |
| Biodegradable materials.....                   | 0     | -                   |
| Putrescible wastes.....                        | = 0   | -                   |
| Non-putrescible wastes.....                    | -     | -                   |
| Corrosive materials.....                       | = 0   | -                   |
| Pyrophoric materials.....                      | = 0   | -                   |
| Generating toxic gases.....                    | NE    | -                   |
| Reacting with water.....                       | -     | -                   |
| Higher activity particles.....                 | -     | -                   |
| Soluble solids as bulk chemical compounds..... | -     | -                   |

Hazardous substances / non hazardous pollutants:

|                             | (%wt) | Type(s) and comment |
|-----------------------------|-------|---------------------|
| Acrylamide.....             | 0     | -                   |
| 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.....                 |       | -                   |

Complexing agents (%wt):

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

Physical components:

|                                         | Number | Type(s) and comment |
|-----------------------------------------|--------|---------------------|
| Sources.....                            |        | -                   |
| Electronic & Electrical Equipment (EEE) |        | -                   |
| EEE Type 1.....                         |        | -                   |
| EEE Type 2.....                         |        | -                   |
| EEE Type 3.....                         |        | -                   |
| EEE Type 4.....                         |        | -                   |
| EEE Type 5.....                         |        | -                   |

## TREATMENT, PACKAGING AND DISPOSAL

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

| Treatment                                                  | On-site / Off-site | Stream volume % |
|------------------------------------------------------------|--------------------|-----------------|
| Size reduction                                             |                    |                 |
| Decay storage                                              |                    |                 |
| Low force compaction                                       |                    |                 |
| Supercompaction (HFC)                                      |                    |                 |
| Incineration                                               |                    |                 |
| Drying/dewatering/liquid separation                        |                    |                 |
| Tie down/fixatives/strippable coating/painting application |                    |                 |
| Decontamination                                            |                    |                 |
| Metal treatment                                            |                    |                 |
| Recycling / reuse                                          |                    |                 |
| Thermal treatment, including vitrification                 |                    |                 |
| Encapsulation                                              |                    |                 |
| Polymer encapsulation                                      |                    |                 |
| Other physical treatment                                   |                    |                 |
| Other chemical treatment                                   |                    |                 |
| Containerisation                                           |                    |                 |
| Treatment not yet determined                               |                    |                 |
| None                                                       |                    |                 |

Comments on planned treatments:

-

Conditioning method:

The waste has been conditioned using AVDS and packaged in 8 Type VI DCICs.

Conditioning plants:

| Plant Name | Location |
|------------|----------|
|            |          |

Likely conditioning matrix:

-

Further information on the conditioning matrix:

-

**Waste Packaging:**

| Likely container type: | Container   | Waste packaged (vol%) | Waste loading (m³) | Payload (m³) | Number of packages | Estimated start date for packaging |
|------------------------|-------------|-----------------------|--------------------|--------------|--------------------|------------------------------------|
|                        | 3 m³ RS box | 100.0                 | 1.6                | 1.6          | 8                  | -                                  |

Range in container waste loading: -

Other information on packaging and conditioning: -

Conditioned density (t/m³): ~ 0.91

Conditioned density comment: Calculated using total waste volume and mass from package records

**Management Routes:**

| Disposal Route                                                                     | Stream volume % | Raw density t/m³ | Start date |
|------------------------------------------------------------------------------------|-----------------|------------------|------------|
| Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland) | 100.0           |                  |            |
| Expected to be Non-NSD HAW managed under Scottish Government's policy              |                 |                  |            |
| Expected to be disposed to LLW Vaults NRS Dounreay                                 |                 |                  |            |
| Expected to be consigned to the Geological Disposal Facility                       |                 |                  |            |
| Expected to be consigned to a Near Surface Disposal Facility                       |                 |                  |            |
| Expected to be consigned to the LLW Repository                                     |                 |                  |            |
| Expected to be consigned to a Landfill Facility                                    |                 |                  |            |
| Expected to be disposed On-Site                                                    |                 |                  |            |
| Expected to be managed by In-Situ Disposal                                         |                 |                  |            |
| Expected to be consigned to an Incineration Facility                               |                 |                  |            |
| Expected to be consigned to a Metal Treatment Facility                             |                 |                  |            |
| Expected to be Out of Scope                                                        |                 |                  |            |
| Expected to be recycled / reused                                                   |                 |                  |            |
| Disposal route not known                                                           |                 |                  |            |

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

Opportunities for alternative disposal routing: No

| Baseline Management Route | Opportunity Management Route | Stream volume (%) | Opportunity Confidence | Comment |
|---------------------------|------------------------------|-------------------|------------------------|---------|
| -                         | -                            | -                 | -                      | -       |

**RADIOACTIVITY**

Source: Contaminated sludge, gravel, sand and other miscellaneous contaminated items. Contamination by fission products, actinides and activation products.

Uncertainty: Specific activities of all 8 waste packages were determined using gamma spectroscopy and fingerprints. The above values (Tbq/m³) are calculated by summing individual package activities. The presence of ADAP sludge introduces some uncertainty due to method used to calculate reference date of fingerprint. Decayed to 01/04/2025.

Measurement of radioactivities: Specific activities of all 8 waste packages were measured and derived using gamma spectroscopy and the application of fingerprints.

Chemical form of radionuclides: H-3: Most tritium is expected to be present as water but some may be present in the form of other inorganic compounds or as organic compounds.  
C-14: Carbon 14 may be present as graphite.  
Cl-36: The chemical form of chlorine 36 has not been assessed.  
Se-79: The chemical form of selenium has not been determined.  
Tc-99: The chemical form of technetium has not been determined.  
I-129: -  
Ra: -  
Th: -  
U: The chemical form of uranium isotopes has not been determined but may be uranium oxides.  
Np: The chemical form of neptunium has not been determined.  
Pu: The chemical form of plutonium isotopes has not been determined but may be plutonium oxides.

| WASTE STREAM |                            | 9B15/C            |                 | Sludge            |           |                            |                   |                 |                   |
|--------------|----------------------------|-------------------|-----------------|-------------------|-----------|----------------------------|-------------------|-----------------|-------------------|
| Nuclide      | Mean radioactivity, TBq/m³ |                   |                 |                   | Nuclide   | Mean radioactivity, TBq/m³ |                   |                 |                   |
|              | Waste at<br>1.4.2025       | Bands and<br>Code | Future Arisings | Bands and<br>Code |           | Waste at<br>1.4.2025       | Bands and<br>Code | Future Arisings | Bands and<br>Code |
| H 3          | 2.16E-02                   | C C 2             |                 |                   | Gd 153    |                            | 8                 |                 |                   |
| Be 10        |                            |                   |                 |                   | Ho 163    | 1.42E-08                   | C C 2             |                 |                   |
| C 14         | 1.20E-03                   | C C 2             |                 |                   | Ho 166m   | 7.84E-06                   | C C 2             |                 |                   |
| Na 22        |                            |                   |                 |                   | Tm 170    |                            | 8                 |                 |                   |
| Al 26        |                            |                   |                 |                   | Tm 171    |                            | 8                 |                 |                   |
| Cl 36        | 5.97E-07                   | C C 2             |                 |                   | Lu 174    |                            | 8                 |                 |                   |
| Ar 39        | 7.65E-06                   | C C 2             |                 |                   | Lu 176    |                            | 8                 |                 |                   |
| Ar 42        |                            |                   |                 |                   | Hf 178n   | 9.32E-06                   | C C 2             |                 |                   |
| K 40         | 3.48E-09                   | C C 2             |                 |                   | Hf 182    |                            | 8                 |                 |                   |
| Ca 41        | 1.09E-04                   | C C 2             |                 |                   | Pt 193    | 1.39E-04                   | C C 2             |                 |                   |
| Mn 53        |                            |                   |                 |                   | Tl 204    | 1.37E-07                   | C C 2             |                 |                   |
| Mn 54        |                            |                   |                 |                   | Pb 205    |                            | 8                 |                 |                   |
| Fe 55        | 3.54E-04                   | C C 2             |                 |                   | Pb 210    |                            | 8                 |                 |                   |
| Co 60        | 1.14E-03                   | C C 2             |                 |                   | Bi 208    |                            | 8                 |                 |                   |
| Ni 59        | 7.87E-05                   | C C 2             |                 |                   | Bi 210m   |                            | 8                 |                 |                   |
| Ni 63        | 9.28E-03                   | C C 2             |                 |                   | Po 210    |                            | 8                 |                 |                   |
| Zn 65        |                            |                   |                 |                   | Ra 223    |                            | 8                 |                 |                   |
| Se 79        | 2.67E-08                   | C C 2             |                 |                   | Ra 225    |                            | 8                 |                 |                   |
| Kr 81        | 1.35E-09                   | C C 2             |                 |                   | Ra 226    |                            | 8                 |                 |                   |
| Kr 85        | 1.89E-04                   | C C 2             |                 |                   | Ra 228    |                            | 8                 |                 |                   |
| Rb 87        |                            |                   |                 |                   | Ac 227    |                            | 8                 |                 |                   |
| Sr 90        | 8.05E-03                   | C C 2             |                 |                   | Th 227    |                            | 8                 |                 |                   |
| Zr 93        | 5.52E-06                   | C C 2             |                 |                   | Th 228    | 9.34E-09                   | C C 2             |                 |                   |
| Nb 91        |                            |                   |                 |                   | Th 229    |                            | 8                 |                 |                   |
| Nb 92        |                            |                   |                 |                   | Th 230    | 1.72E-09                   | C C 2             |                 |                   |
| Nb 93m       | 6.91E-06                   | C C 2             |                 |                   | Th 232    |                            | 8                 |                 |                   |
| Nb 94        | 5.25E-07                   | C C 2             |                 |                   | Th 234    | 1.47E-06                   | C C 2             |                 |                   |
| Mo 93        | 1.96E-08                   | C C 2             |                 |                   | Pa 231    |                            | 8                 |                 |                   |
| Tc 97        |                            |                   |                 |                   | Pa 233    | 2.66E-07                   | C C 2             |                 |                   |
| Tc 99        | 5.71E-06                   | C C 2             |                 |                   | U 232     | 9.08E-09                   | C C 2             |                 |                   |
| Ru 106       |                            |                   |                 |                   | U 233     | 2.19E-08                   | C C 2             |                 |                   |
| Pd 107       | 6.52E-08                   | C C 2             |                 |                   | U 234     | 1.96E-06                   | C C 2             |                 |                   |
| Ag 108m      | 3.61E-05                   | C C 2             |                 |                   | U 235     | 5.46E-08                   | C C 2             |                 |                   |
| Ag 110m      |                            |                   |                 |                   | U 236     | 2.02E-07                   | C C 2             |                 |                   |
| Cd 109       |                            |                   |                 |                   | U 238     | 1.47E-06                   | C C 2             |                 |                   |
| Cd 113m      | 1.45E-06                   | C C 2             |                 |                   | Np 237    | 2.66E-07                   | C C 2             |                 |                   |
| Sn 119m      |                            |                   |                 |                   | Pu 236    |                            | 8                 |                 |                   |
| Sn 121m      | 2.57E-06                   | C C 2             |                 |                   | Pu 238    | 4.93E-04                   | C C 2             |                 |                   |
| Sn 123       |                            |                   |                 |                   | Pu 239    | 1.00E-03                   | C C 2             |                 |                   |
| Sn 126       | 2.43E-07                   | C C 2             |                 |                   | Pu 240    | 9.94E-04                   | C C 2             |                 |                   |
| Sb 125       | 1.60E-07                   | C C 2             |                 |                   | Pu 241    | 9.21E-03                   | C C 2             |                 |                   |
| Sb 126       | 3.40E-08                   | C C 2             |                 |                   | Pu 242    | 9.45E-07                   | C C 2             |                 |                   |
| Te 125m      | 3.99E-08                   | C C 2             |                 |                   | Am 241    | 5.22E-03                   | C C 2             |                 |                   |
| Te 127m      |                            |                   |                 |                   | Am 242m   | 5.46E-06                   | C C 2             |                 |                   |
| I 129        | 9.70E-07                   | C C 2             |                 |                   | Am 243    | 1.77E-06                   | C C 2             |                 |                   |
| Cs 134       | 1.26E-07                   | C C 2             |                 |                   | Cm 242    | 4.51E-06                   | C C 2             |                 |                   |
| Cs 135       | 4.88E-07                   | C C 2             |                 |                   | Cm 243    | 1.88E-06                   | C C 2             |                 |                   |
| Cs 137       | 1.24E-02                   | C C 2             |                 |                   | Cm 244    | 2.06E-05                   | C C 2             |                 |                   |
| Ba 133       | 2.50E-05                   | C C 2             |                 |                   | Cm 245    |                            | 8                 |                 |                   |
| La 137       | 1.38E-09                   | C C 2             |                 |                   | Cm 246    |                            | 8                 |                 |                   |
| La 138       |                            |                   |                 |                   | Cm 248    |                            | 8                 |                 |                   |
| Ce 144       |                            |                   |                 |                   | Cf 249    |                            | 8                 |                 |                   |
| Pm 145       |                            |                   |                 |                   | Cf 250    |                            | 8                 |                 |                   |
| Pm 147       | 4.42E-06                   | C C 2             |                 |                   | Cf 251    |                            | 8                 |                 |                   |
| Sm 147       |                            |                   |                 |                   | Cf 252    |                            | 8                 |                 |                   |
| Sm 151       | 2.66E-04                   | C C 2             |                 |                   | Unsp a    |                            |                   |                 |                   |
| Eu 152       | 1.63E-06                   | C C 2             |                 |                   | Unsp b/g  |                            |                   |                 |                   |
| Eu 154       | 4.71E-05                   | C C 2             |                 |                   | Total a   | 7.74E-03                   | *                 | 0               | *                 |
| Eu 155       | 4.94E-06                   | C C 2             |                 |                   | Total b/g | 6.42E-02                   | *                 | 0               | *                 |

#### 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 the 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  
\* Total calculated from the 114 declared radionuclides