

|                     |             |                     |
|---------------------|-------------|---------------------|
| <b>WASTE STREAM</b> | <b>9A34</b> | <b>FED Graphite</b> |
|---------------------|-------------|---------------------|

**SITE** Berkeley

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** ILW

**WASTE VOLUMES**

|         |                  |                                  |
|---------|------------------|----------------------------------|
| Stocks: | At 1.4.2019..... | Reported<br>156.1 m <sup>3</sup> |
|---------|------------------|----------------------------------|

Total future arisings: 0 m<sup>3</sup>

Total waste volume: 156.1 m<sup>3</sup>

Comment on volumes: Station operation ceased in March 1989. This waste stream was accumulated between October 1982 and May 1991. The volume quoted is the estimated bulk volume of the waste if separated from other wastes with which it is mixed.

Uncertainty factors on volumes: Stock (upper): x 1.1 Arisings (upper) x  
Stock (lower): x 0.9 Arisings (lower) x

**WASTE SOURCE**

The source of the waste is the removal of graphite struts from fuel elements prior to dispatch of the elements to Sellafield. There may be a few stabilising wedges and support frames.

**PHYSICAL CHARACTERISTICS**

General description: This waste comprises Graphite struts. It was generated during the destrutting operations performed on the cooled fuel elements. The struts (two per element) were each originally 575mm x 25mm x 27mm and weighed 556g. The two graphite support struts are often fractured in more than one place, resulting in a number of different lengths of graphite debris. A pair of struts often remain connected by stainless steel or zirconium bridge pieces. The graphite strut was broken during the destrutting operation. It is therefore unlikely that there will be any large items which will require special handling. The waste is loose in the vaults.

Physical components (%vol): Graphite struts (100 vol%).

Sealed sources: -

Bulk density (t/m<sup>3</sup>): 0.57

Comment on density: The bulk density of 0.57 t/m<sup>3</sup> assumes a packing factor to give an overall volume of about three times the displacement volume of the waste. The packing factor will be variable and the bulk density can be up to 1.7 t/m<sup>3</sup>.

**CHEMICAL COMPOSITION**

General description and components (%wt): Graphite will account for all of the waste. The graphite will be contaminated with fission products and actinides and there may be activation of impurities within the graphite.

Chemical state: Neutral

Chemical form of radionuclides: H-3: Some tritium may be chemically bound with the graphite. Other tritium may be present as water.  
C-14: Carbon 14 will probably be present as graphite.  
Cl-36: Chlorine 36 will probably be chemically bound to the graphite. Some may be linked chemically with impurities within the graphite.  
Se-79: The selenium content is insignificant.  
Tc-99: The technetium content is insignificant.  
Ra: Radium isotope content is insignificant.  
Th: The thorium isotope content is insignificant.  
U: Chemical form of uranium isotopes has not been determined but may be uranium oxides.  
Np: The neptunium content is insignificant.  
Pu: Chemical form of plutonium isotopes has not been determined but may be plutonium oxides.

Metals and alloys (%wt): There are no metallic items present.

**WASTE STREAM****9A34****FED Graphite**

Stainless steel..... 0  
 Other ferrous metals..... 0  
 Iron.....  
 Aluminium..... 0  
 Beryllium..... TR  
 Cobalt.....  
 Copper..... 0  
 Lead..... 0  
 Magnox/Magnesium..... 0  
 Nickel.....  
 Titanium.....  
 Uranium.....  
 Zinc..... 0  
 Zircaloy/Zirconium..... 0  
 Other metals..... 0

There are no "other" metals.

## Organics (%wt):

The graphite may be contaminated with trace quantities of organic material.

Total cellulosics..... 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..... TR

## Other materials (%wt):

Principally graphite.

Inorganic ion exchange materials. 0  
 Inorganic sludges and flocs..... 0  
 Soil..... 0  
 Brick/Stone/Rubble..... 0  
 Cementitious material..... 0  
 Sand.....  
 Glass/Ceramics..... 0

**WASTE STREAM****9A34****FED Graphite**

|  |  |       |
|--|--|-------|
|  | Graphite.....  | >99.0 |
|  | Desiccants/Catalysts.....  |       |
|  | Asbestos.....  | 0     |
|  | Non/low friable.....   |       |
|  | Moderately friable.....  |       |
|  | Highly friable.....  |       |
|  | Free aqueous liquids.....  | TR    |
|  | Free non-aqueous liquids.....  | 0     |
|  | Powder/Ash.....  | P     |
| Inorganic anions (%wt):                              | None of the inorganic anions listed in the table is expected to be present at greater than trace concentration.  |       |
|  | Fluoride.....  | TR    |
|  | Chloride.....  | TR    |
|  | Iodide.....  | 0     |
|  | Cyanide.....   | 0     |
|  | Carbonate.....   | TR    |
|  | Nitrate.....   | TR    |
|  | Nitrite.....   | TR    |
|  | Phosphate.....   | TR    |
|  | Sulphate.....  | TR    |
|  | Sulphide.....  | 0     |
| Materials of interest for waste acceptance criteria: | The risk of a graphite dust explosion is very low as the dust is mixed with other materials which will inhibit an explosion. Graphite blocks, although very difficult to ignite, will burn in air. |       |
|  | Combustible metals.....  | 0     |
|  | Low flash point liquids.....   | 0     |
|  | Explosive materials.....   | 0     |
|  | Phosphorus.....  | 0     |
|  | Hydrides.....  | 0     |
|  | Biological etc. materials.....   | 0     |
|  | Biodegradable materials.....   |       |
|  | Putrescible wastes.....  | 0     |
|  | Non-putrescible wastes.....  |       |
|  | Corrosive materials.....   | 0     |
|  | Pyrophoric materials.....  | 0     |
|  | Generating toxic gases.....  | 0     |
|  | Reacting with water.....   | 0     |
|  | Active particles.....  |       |
|  | Soluble solids as bulk chemical compounds.....   |       |
| Hazardous substances / non hazardous pollutants:     | None expected.   |       |
|  | Acrylamide.....  |       |
|  | Benzene.....   |       |

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Chlorinated solvents.....  
 Formaldehyde.....  
 Organometallics.....  
 Phenol.....  
 Styrene.....  
 Tri-butyl phosphate.....  
 Other organophosphates.....  
 Vinyl chloride.....  
 Arsenic.....  
 Barium.....  
 Boron.....  
 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.....

Complexing agents (%wt):

Yes  
 EDTA.....  
 DPTA.....  
 NTA.....  
 Polycarboxylic acids.....  
 Other organic complexants.....  
 Total complexing agents..... TR

**PACKAGING AND CONDITIONING**

Conditioning method: This stream is to be co-packaged with 9A63, 9A64, 9A83, 9A84, 9A33, 9A35, 9A41, 9A42, 9A43, 9A49, 9A50, 9A51, 9A54, 9A55, 9A56, 9A74. Packages are assigned to 9A33, 9A34, 9A74.

Plant Name:

-

Location:

Berkeley Site

Plant startup date:

-

Total capacity

-

(m<sup>3</sup>/y incoming waste):

|                     |             |                     |
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Target start date for packaging this stream: -

Throughput for this stream (m<sup>3</sup>/y incoming waste): -

Other information: -

|                        |                                   |                       |                                 |                           |                    |
|------------------------|-----------------------------------|-----------------------|---------------------------------|---------------------------|--------------------|
| Likely container type: | Container                         | Waste packaged (%vol) | Waste loading (m <sup>3</sup> ) | Payload (m <sup>3</sup> ) | Number of packages |
|                        | 6m <sup>3</sup> concrete box (SD) | 100.0                 | ~2.262                          | 5.8                       | 69                 |

Likely container type comment: -

Range in container waste volume: -

Other information on containers: -

Likely conditioning matrix: Other information: -

Conditioned density (t/m<sup>3</sup>): -

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing:

| Treatment | Stream volume (%) | Comment |
|-----------|-------------------|---------|
| -         | -                 | -       |

**RADIOACTIVITY**

Source: Activation, when the associated fuel elements were irradiated, of nuclides incorporated into the graphite. Contamination by fission products and actinides when the fuel elements were in the fuel pond.

Uncertainty: The values quoted are indicative of the activities that might be expected.

Definition of total alpha and total beta/gamma: Where totals are shown on the table of radionuclide activities they are the sums of the listed alpha or beta/gamma emitting radionuclides plus 'other alpha' or 'other beta/gamma'.

Measurement of radioactivities: Specific activity is a function of Station operating history. Estimates were derived from theoretical assessments of activation product activity and from experimental measurements of the contamination of Magnox.

Other information: -

**WASTE STREAM 9A34 FED Graphite**

| Nuclide | Mean radioactivity, TBq/m <sup>3</sup> |                |                 |                | Nuclide          | Mean radioactivity, TBq/m <sup>3</sup> |                |                 |                |
|---------|--|----------------|-----------------|----------------|------------------|--|----------------|-----------------|----------------|
|         | Waste at 1.4.2019                      | Bands and Code | Future arisings | Bands and Code |                  | Waste at 1.4.2019                      | Bands and Code | Future arisings | Bands and Code |
| H 3     | 1.02E-01                               | CC 2           |                 |                | Gd 153           |  | 8              |                 |                |
| Be 10   | 2E-09                                  | CC 2           |                 |                | Ho 163           |  | 8              |                 |                |
| C 14    | 3.00E-03                               | CC 2           |                 |                | Ho 166m          | 9.92E-06                               | CC 2           |                 |                |
| Na 22   |  | 8              |                 |                | Tm 170           |  | 8              |                 |                |
| Al 26   | 2E-09                                  | CC 2           |                 |                | Tm 171           |  | 8              |                 |                |
| Cl 36   | 4E-05                                  | 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   | 2E-05                                  | CC 2           |                 |                | Pt 193           |  | 8              |                 |                |
| Mn 53   |  | 8              |                 |                | Tl 204           |  | 8              |                 |                |
| Mn 54   |  | 8              |                 |                | Pb 205           |  | 8              |                 |                |
| Fe 55   | 2.34E-06                               | CC 2           |                 |                | Pb 210           |  | 8              |                 |                |
| Co 60   | 1.03E-03                               | CC 2           |                 |                | Bi 208           |  | 8              |                 |                |
| Ni 59   | 2E-07                                  | CC 2           |                 |                | Bi 210m          |  | 8              |                 |                |
| Ni 63   | 2.76E-05                               | 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   | 5.26E-05                               | CC 2           |                 |                | Th 227           |  | 8              |                 |                |
| Zr 93   |  | 8              |                 |                | Th 228           |  | 8              |                 |                |
| Nb 91   |  | 8              |                 |                | Th 229           |  | 8              |                 |                |
| Nb 92   |  | 8              |                 |                | Th 230           |  | 8              |                 |                |
| Nb 93m  | 2.97E-08                               | CC 2           |                 |                | Th 232           |  | 8              |                 |                |
| Nb 94   | 1.00E-06                               | CC 2           |                 |                | Th 234           | 5E-08                                  | CC 2           |                 |                |
| Mo 93   | 3.00E-08                               | CC 2           |                 |                | Pa 231           |  | 8              |                 |                |
| Tc 97   |  | 8              |                 |                | Pa 233           | 6.18E-09                               | CC 2           |                 |                |
| Tc 99   | 6E-09                                  | CC 2           |                 |                | U 232            |  | 8              |                 |                |
| Ru 106  |  | 8              |                 |                | U 233            |  | 8              |                 |                |
| Pd 107  |  | 8              |                 |                | U 234            | 5.08E-08                               | CC 2           |                 |                |
| Ag 108m | 5.88E-06                               | CC 2           |                 |                | U 235            | 1E-09                                  | CC 2           |                 |                |
| Ag 110m |  | 8              |                 |                | U 236            | 7.00E-09                               | CC 2           |                 |                |
| Cd 109  |  | 8              |                 |                | U 238            | 5E-08                                  | CC 2           |                 |                |
| Cd 113m | 1.65E-06                               | CC 2           |                 |                | Np 237           | 6.18E-09                               | CC 2           |                 |                |
| Sn 119m |  | 8              |                 |                | Pu 236           |  | 8              |                 |                |
| Sn 121m | 4.27E-07                               | CC 2           |                 |                | Pu 238           | 1.82E-05                               | CC 2           |                 |                |
| Sn 123  |  | 8              |                 |                | Pu 239           | 2E-05                                  | CC 2           |                 |                |
| Sn 126  |  | 8              |                 |                | Pu 240           | 3.00E-05                               | CC 2           |                 |                |
| Sb 125  | 1.93E-09                               | CC 2           |                 |                | Pu 241           | 3.93E-04                               | CC 2           |                 |                |
| Sb 126  |  | 8              |                 |                | Pu 242           | 2E-08                                  | CC 2           |                 |                |
| Te 125m |  | 8              |                 |                | Am 241           | 4.93E-05                               | CC 2           |                 |                |
| Te 127m |  | 8              |                 |                | Am 242m          | 1.88E-07                               | CC 2           |                 |                |
| I 129   |  | 8              |                 |                | Am 243           | 5.00E-08                               | CC 2           |                 |                |
| Cs 134  | 7.12E-09                               | CC 2           |                 |                | Cm 242           | 1.55E-07                               | CC 2           |                 |                |
| Cs 135  |  | 8              |                 |                | Cm 243           | 4.55E-08                               | CC 2           |                 |                |
| Cs 137  | 5.30E-05                               | CC 2           |                 |                | Cm 244           | 3.17E-07                               | CC 2           |                 |                |
| Ba 133  | 9.12E-07                               | CC 2           |                 |                | Cm 245           |  | 8              |                 |                |
| La 137  |  | 8              |                 |                | Cm 246           |  | 8              |                 |                |
| La 138  |  | 8              |                 |                | Cm 248           |  | 8              |                 |                |
| Ce 144  |  | 8              |                 |                | Cf 249           |  | 8              |                 |                |
| Pm 145  | 1.88E-06                               | CC 2           |                 |                | Cf 250           |  | 8              |                 |                |
| Pm 147  | 8.42E-08                               | CC 2           |                 |                | Cf 251           |  | 8              |                 |                |
| Sm 147  |  | 8              |                 |                | Cf 252           |  | 8              |                 |                |
| Sm 151  | 1.82E-05                               | CC 2           |                 |                | Other a          |  |                |                 |                |
| Eu 152  | 1.62E-04                               | CC 2           |                 |                | Other b/g        |  |                |                 |                |
| Eu 154  | 1.91E-04                               | CC 2           |                 |                | <b>Total a</b>   | <b>1.18E-04</b>                        | <b>CC 2</b>    | <b>0</b>        |                |
| Eu 155  | 5.51E-06                               | CC 2           |                 |                | <b>Total b/g</b> | <b>1.07E-01</b>                        | <b>CC 2</b>    | <b>0</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