

<b>WASTE STREAM</b>	<b>5B01/C</b>	<b>Cemented PFR Raffinate</b>
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**SITE** Dounreay  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Dounreay Site Restoration Limited

**WASTE TYPE** ILW

Is the waste subject to Scottish Policy: Yes

**WASTE VOLUMES**

		Conditioned	Packaged
Stocks:	At 1.4.2022.....	62.5 m <sup>3</sup>	71.4 m <sup>3</sup>
Future arisings -	1.4.2023 - 31.3.2024.....	182.2 m <sup>3</sup>	208.1 m <sup>3</sup>
	1.4.2024 - 31.3.2025.....	182.2 m <sup>3</sup>	208.1 m <sup>3</sup>
Total future arisings:		364.5 m <sup>3</sup>	416.2 m <sup>3</sup>
Total waste volume:		427.0 m <sup>3</sup>	487.6 m <sup>3</sup>
Number of waste packages in stock:	At 1.4.2022.....	125 package(s)	

Comment on volumes: Programme is from DSRL's provisional LTP. Arisings reflects that of 5B01 but is a conditioned volume, rather than raw Waste. Tank washouts will be undertaken but have not been quantified as yet. This may produce more arisings.

Uncertainty factors on volumes: Stock (upper): x 1.0 Arisings (upper) x 1.05  
Stock (lower): x 1.0 Arisings (lower) x 0.95

**WASTE SOURCE** The source of this waste is from the reprocessing of Prototype Fast Reactor (PFR) fuel.

**PHYSICAL CHARACTERISTICS**

General description: The waste is a raffinate from fuel reprocessing immobilised in a 1:2 PFA:OPC grout matrix within 500L drums. There are no large items in the waste. The waste has been cemented into 500 litre drums.

Physical components (%vol): Cemented Aqueous liquor (100%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): ~1.77

Comment on density: The density of the conditioned raffinate is about 1.77 t/m<sup>3</sup>.

**CHEMICAL COMPOSITION**

General description and components (%wt): The raffinate is a nitric acid solution containing fission products and trace quantities of uranium and plutonium. Nitric acid (96.6%) and metals in solution (copper, sodium, iron, cadmium, nickel and zinc) (3.4%). This has since been neutralised with caustic soda (NaOH) and immobilised in a cemented matrix

Chemical state: Alkali

Chemical form of radionuclides: H-3: Likely to be present as water.  
C-14: Unknown - possibly present as traces of dissolved solvent.  
Cl-36: Likely to be present, form unknown.  
Se-79: Likely to be present, form unknown.  
Tc-99: Likely to be present, form unknown.  
I-129: Likely to be present, form unknown.  
Ra: Likely to be present as nitrate.  
Th: Present as nitrate.  
U: Present as nitrate.  
Np: Likely to be present, form unknown.  
Pu: Present as nitrate.

Metals and alloys (%wt): -

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	0		
Other ferrous metals.....	0		
Iron.....			
Aluminium.....			
Beryllium.....	0		
Cobalt.....	0		
Copper.....	0		
Lead.....	0		
Magnox/Magnesium.....	0		
Nickel.....			
Titanium.....	0		
Uranium.....	0		
Zinc.....	0		
Zircaloy/Zirconium.....	0		
Other metals.....	3.4	Covers a range of metallic species which are in the immobilised solution including sodium, cadmium and nickel.	

Organics (%wt):                      The only organic materials present in the waste are trace quantities of complexing agents.

	(%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.....	96.6		
Sand.....	0		
Glass/Ceramics.....	0		
Graphite.....	0		
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):           The waste contains nitrate and traces of sulphates, phosphates and chlorides.

	(%wt)	Type(s) and comment
Fluoride.....	0	
Chloride.....	TR	
Iodide.....	0	
Cyanide.....	0	
Carbonate.....	0	
Nitrate.....	30.0	
Nitrite.....	0	
Phosphate.....	TR	
Sulphate.....	TR	
Sulphide.....	0	

Materials of interest for waste acceptance criteria:           The waste contains nitric acid.

	(%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	
Non-putrescible wastes.....	0	

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

Hazardous substances / non hazardous pollutants: Cadmium is present in solution in small quantities. Nitric acid (96.6%).

	(%wt)	Type(s) and comment
Acrylamide.....		
Benzene.....		
Chlorinated solvents.....		
Formaldehyde.....		
Organometallics.....		
Phenol.....		
Styrene.....		
Tri-butyl phosphate.....	TR	
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): Yes

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids.....		
Other organic complexants.....	TR	Traces of organic complexing agents (MDP, DBP, TBP) may be present.
Total complexing agents.....	TR	

Potential for the waste to contain discrete items: No.

**PACKAGING AND CONDITIONING**

Container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	500 l drum	100.0	0.5	0.5	854

Container type comment: The loading will vary slightly , depending upon the chemical composition of the raffinate in that tank.

Range in container waste volume: The target loading is 0.228 m<sup>3</sup> of raw raffinate per drum, but is dependent on composition of the raffinate in the tank. A final volume of 328 l of neutralised liquor will be dispensed to each drum.

Other information on containers: Stainless Steel. The container will be manufactured from 316 stainless steel.

Conditioned density (t/m<sup>3</sup>): ~1.77

Conditioned density comment: The density of the conditioned waste will probably be about 1.8 t/m<sup>3</sup>.

Other information on conditioning: -

**RADIOACTIVITY**

Source: Activity arises mainly from the fission products separated from the irradiated Prototype Fast Reactor fuel at reprocessing

Uncertainty: The activity accuracy is within a factor of 3.

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: Samples were taken from the tanks and subsequently analysed. These results gave specific activities for the principle radionuclides. Other specific activities were estimated from earlier results and Fispin calculations.

Other information: Activities are based on a combination of analysis and FISPIN data. The total activities of stocks are for partially evaporated liquor; there will be no further arisings. The range in activity levels are based on samples of the PFR raffinate tanks in November 2003. Alpha 11 - 99 TBq/m<sup>3</sup>, beta/gamma 150 - 1,300 TBq/m<sup>3</sup>. The intention is to blend liquors from each of the four tanks to provide a consistent feedstock for processing. The LoC describes a methodology that will better underpin how the final waste package inventory will be assigned to the conditioned waste.

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**5B01/C**

**Cemented PFR Raffinate**

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	3.14E-03	BB 1	3.71E-03	BB 1	Gd 153	1.66E-19	BB 2	1.23E-16	BB 2
Be 10	1.06E-09	BB 2	1.06E-09	BB 2	Ho 163	3.14E-10	BB 2	3.14E-10	BB 2
C 14	4.34E-05	BB 2	4.34E-05	BB 2	Ho 166m	3.34E-08	BB 2	3.34E-08	BB 2
Na 22					Tm 170	2.31E-27	BB 2	8.48E-25	BB 2
Al 26					Tm 171	4.17E-09	BB 2	1.23E-08	BB 2
Cl 36	2.16E-09	BB 2	2.16E-09	BB 2	Lu 174	1.48E-09	BB 2	2.66E-09	BB 2
Ar 39					Lu 176	1.45E-14	BB 2	1.45E-14	BB 2
Ar 42					Hf 178n	5.20E-08	BB 2	5.56E-08	BB 2
K 40	1.59E-10	BB 2	1.59E-10	BB 2	Hf 182	2.71E-13	BB 2	2.71E-13	BB 2
Ca 41	1.79E-07	BB 2	1.79E-07	BB 2	Pt 193	2.04E-06	BB 2	2.13E-06	BB 2
Mn 53	1.36E-09	BB 2	1.36E-09	BB 2	Tl 204	6.32E-06	BB 2	1.09E-05	BB 2
Mn 54	8.50E-11	BB 2	9.67E-10	BB 2	Pb 205	7.84E-11	BB 2	7.84E-11	BB 2
Fe 55	6.61E-04	BB 2	1.41E-03	BB 2	Pb 210	9.45E-11	BB 2	7.62E-11	BB 2
Co 60	7.72E-03	BB 1	1.14E-02	BB 2	Bi 208	5.88E-11	BB 2	5.88E-11	BB 2
Ni 59	3.22E-04	BB 2	3.22E-04	BB 2	Bi 210m	1.98E-11	BB 2	1.98E-11	BB 2
Ni 63	1.38E-02	BB 2	1.41E-02	BB 2	Po 210	9.10E-11	BB 2	7.3E-11	BB 2
Zn 65	1.63E-14	BB 2	3.65E-13	BB 2	Ra 223	1.45E-09	BB 2	1.35E-09	BB 2
Se 79	9.85E-05	BB 2	9.85E-05	BB 2	Ra 225	6.57E-11	BB 2	5.79E-11	BB 2
Kr 81					Ra 226	3.07E-10	BB 2	2.64E-10	BB 2
Kr 85					Ra 228	2.62E-12	BB 2	2.58E-12	BB 2
Rb 87	2.00E-08	BB 2	2E-08	BB 2	Ac 227	1.46E-09	BB 2	1.35E-09	BB 2
Sr 90	3.03E+01	BB 1	3.26E+01	BB 2	Th 227	1.43E-09	BB 2	1.33E-09	BB 2
Zr 93	2.15E-03	BB 2	2.15E-03	BB 2	Th 228	9.02E-08	BB 2	9.85E-08	BB 2
Nb 91	2.43E-06	BB 2	2.44E-06	BB 2	Th 229	6.59E-11	BB 2	5.79E-11	BB 2
Nb 92	7.89E-11	BB 2	7.89E-11	BB 2	Th 230	3.41E-08	BB 2	3.29E-08	BB 2
Nb 93m	2.47E-03	BB 2	2.5E-03	BB 2	Th 232	2.69E-12	BB 2	2.69E-12	BB 2
Nb 94	2.54E-05	BB 2	2.54E-05	BB 2	Th 234	2.01E-06	BB 2	2.01E-06	BB 2
Mo 93	1.87E-04	BB 2	1.87E-04	BB 2	Th 231	2.54E-09	BB 2	2.53E-09	BB 2
Tc 97	1.54E-12	BB 2	1.54E-12	BB 2	Pa 233	1.97E-04	BB 2	1.85E-04	BB 2
Tc 99	2.26E-02	BB 2	2.26E-02	BB 2	U 232	8.50E-08	BB 2	8.76E-08	BB 2
Ru 106	6.09E-06	BB 2	4.79E-05	BB 2	U 233	2.93E-08	BB 2	2.69E-08	BB 2
Pd 107	4.92E-04	BB 2	4.92E-04	BB 2	U 234	4.56E-05	BB 1	4.06E-05	BB 2
Ag 108m	1.60E-06	BB 2	1.61E-06	BB 2	U 235	7.82E-08	BB 1	7.8E-08	BB 2
Ag 110m	7.72E-13	BB 2	1.61E-11	BB 2	U 236	2.08E-07	BB 1	2.02E-07	BB 2
Cd 109	4.05E-10	BB 2	2.09E-09	BB 2	U 238	2.01E-06	BB 1	2.01E-06	BB 2
Cd 113m	2.68E-03	BB 2	3.12E-03	BB 2	Np 237	1.97E-04	BB 2	1.85E-04	BB 2
Sn 119m	1.07E-12	BB 2	1.42E-11	BB 2	Pu 236	2.72E-10	BB 2	5.56E-10	BB 2
Sn 121m	7.29E-02	BB 2	7.57E-02	BB 2	Pu 238	5.90E-01	BB 1	5.97E-01	BB 2
Sn 123	5.35E-24	BB 2	1.91E-21	BB 2	Pu 239	6.79E-02	BB 1	6.79E-02	BB 2
Sn 126	8.62E-04	BB 2	8.62E-04	BB 2	Pu 240	7.45E-02	BB 1	7.43E-02	BB 2
Sb 125	1.93E-02	BB 2	4.1E-02	BB 2	Pu 241	8.21E-01	BB 1	9.48E-01	BB 2
Sb 126	1.21E-04	BB 2	1.21E-04	BB 2	Pu 242	5.69E-05	BB 1	5.65E-05	BB 2
Te 125m	4.83E-03	BB 2	1.03E-02	BB 2	Am 241	1.25E+01	BB 1	1.26E+01	BB 2
Te 127m	3.16E-30	BB 2	3.36E-27	BB 2	Am 242m	3.51E-01	BB 2	3.57E-01	BB 2
I 129	5.7E-05	BB 2	5.7E-05	BB 2	Am 243	2.31E-02	BB 2	2.31E-02	BB 2
Cs 134	1.85E-03	BB 1	5.06E-03	BB 1	Cm 242	2.90E-01	BB 2	2.94E-01	BB 2
Cs 135	2.78E-03	BB 2	2.78E-03	BB 2	Cm 243	6.34E-02	BB 2	6.79E-02	BB 2
Cs 137	8.81E+01	BB 1	9.44E+01	BB 1	Cm 244	5.28E-01	BB 2	5.93E-01	BB 2
Ba 133	1.01E-05	BB 2	1.23E-05	BB 2	Cm 245	6.2E-05	BB 2	6.2E-05	BB 2
La 137	2.00E-08	BB 2	2E-08	BB 2	Cm 246	2.46E-06	BB 2	2.46E-06	BB 2
La 138	9.58E-14	BB 2	9.58E-14	BB 2	Cm 248	8.71E-12	BB 2	8.71E-12	BB 2
Ce 144	1.74E-08	BB 2	2.5E-07	BB 2	Cf 249	6.62E-11	BB 2	6.66E-11	BB 2
Pm 145	1.54E-07	BB 2	1.74E-07	BB 2	Cf 250	2.09E-11	BB 2	2.45E-11	BB 2
Pm 147	2.27E-01	BB 2	5.02E-01	BB 2	Cf 251	1.22E-14	BB 2	1.23E-14	BB 2
Sm 147	1.48E-08	BB 2	1.48E-08	BB 2	Cf 252	2.29E-17	BB 2	5.02E-17	BB 2
Sm 151	4.86E+00	BB 2	4.97E+00	BB 2	Other a				BB 2
Eu 152	2.85E-05	BB 2	3.32E-05		Other b/g				
Eu 154	4.15E-01	BB 1	5.29E-01	BB 1	<b>Total a</b>	<b>1.42E+01</b>	<b>BB 2</b>	<b>1.43E+01</b>	<b>BB 2</b>
Eu 155	2.23E-01	BB 1	3.42E-01	BB 1	<b>Total b/g</b>	<b>1.25E+02</b>	<b>BB 2</b>	<b>1.35E+02</b>	<b>BB 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