

<b>WASTE STREAM</b>	<b>5B34</b>	<b>DFR Breeder Fuel Removal Waste</b>
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**SITE** Dounreay  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Dounreay Site Restoration Limited  
**WASTE TYPE** ILW

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2019.....	8.2 m <sup>3</sup>
Future arisings -	1.4.2019 - 31.3.2028.....	3.8 m <sup>3</sup>
Total future arisings:		3.8 m <sup>3</sup>
Total waste volume:		12.0 m <sup>3</sup>

Comment on volumes: The waste will arise as a result of breeder fuel retrieval operations. It should be noted that the DSRL site programme is under revision and that arisings dates are subject to change.

Uncertainty factors on volumes: Stock (upper): x 1.02 Arisings (upper) x 1.2  
 Stock (lower): x 0.98 Arisings (lower) x 0.8

**WASTE SOURCE** The waste will consist of breeder fuel cladding and associated operational wastes.

**PHYSICAL CHARACTERISTICS**

General description: The waste mostly comprises stainless steel and breeder fuel cladding.  
 Physical components (%vol): Aluminium (0.19%), Ceramics (0.10%), Copper (3.93%), Glass (0.19%), Plastic (9.29%), Stainless steel (86.30%),  
 Sealed sources: The waste does not contain sealed sources.  
 Bulk density (t/m<sup>3</sup>): 2.265  
 Comment on density: Bulk Density was taken from LoC

**CHEMICAL COMPOSITION**

General description and components (%wt): Aluminium (0.07%), Ceramics (0.05%), Copper (4.86%), Glass (0.07%), Plastic (1.18%), Stainless steel (93.77%),

Chemical state: Neutral

Chemical form of radionuclides: H-3: Present  
 C-14: Present  
 Cl-36: Present  
 Se-79: Present  
 Tc-99: Present  
 I-129: Present  
 Ra: Present  
 Th: Present  
 U: Present  
 Np: Present  
 Pu: Present

Metals and alloys (%wt): Stainless steel present as drums, thin tubing and bulk end fittings.  
 Stainless steel..... 93.8 Assumed to be M316.  
 Other ferrous metals.....  
 Iron.....  
 Aluminium..... 0.07  
 Beryllium..... NE  
 Cobalt..... 0  
 Copper..... 4.9  
 Lead..... 0  
 Magnox/Magnesium..... 0  
 Nickel..... 0

**WASTE STREAM**

**5B34**

**DFR Breeder Fuel Removal Waste**

	Titanium.....	
	Uranium.....	TR
	Zinc.....	0
	Zircaloy/Zirconium.....	0
	Other metals.....	Antimony, Uranium
Organics (%wt):	-	
	Total cellulose.....	0
	Paper, cotton.....	0
	Wood.....	0
	Halogenated plastics .....	1.2
	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):	-	
	Inorganic ion exchange materials.	0
	Inorganic sludges and flocs.....	0
	Soil.....	0
	Brick/Stone/Rubble.....	0
	Cementitious material.....	0
	Sand.....	0
	Glass/Ceramics.....	0.12
	Graphite.....	0
	Desiccants/Catalysts.....	0
	Asbestos.....	0
	Non/low friable.....	
	Moderately friable.....	
	Highly friable.....	
	Free aqueous liquids.....	0
	Free non-aqueous liquids.....	0
	Powder/Ash.....	0
Inorganic anions (%wt):	No inorganic anions are present in the waste.	

**WASTE STREAM**

**5B34**

**DFR Breeder Fuel Removal Waste**

Fluoride.....	0
Chloride.....	0
Iodide.....	0
Cyanide.....	0
Carbonate.....	0
Nitrate.....	0
Nitrite.....	0
Phosphate.....	0
Sulphate.....	0
Sulphide.....	0

Materials of interest for waste acceptance criteria:

Uranium metal is present.

Combustible metals.....	P	=0.5%
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	
Corrosive materials.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	P	=0.5%
Active particles.....	NE	
Soluble solids as bulk chemical compounds.....	0	

Hazardous substances / non hazardous pollutants:

There are no toxic metals present in the waste.

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

**WASTE STREAM****5B34****DFR Breeder Fuel Removal Waste**

Cadmium..... NE  
 Caesium.....  
 Selenium..... NE  
 Chromium..... NE  
 Molybdenum..... NE  
 Thallium.....  
 Tin..... NE  
 Vanadium..... NE  
 Mercury compounds.....  
 Others..... NE  
 Electronic Electrical Equipment (EEE)  
   EEE Type 1.....  
   EEE Type 2.....  
   EEE Type 3.....  
   EEE Type 4.....  
   EEE Type 5.....

Complexing agents (%wt): No  
 EDTA.....  
 DPTA.....  
 NTA.....  
 Polycarboxylic acids.....  
 Other organic complexants.....  
 Total complexing agents..... 0

**PACKAGING AND CONDITIONING**

Conditioning method: The waste will be packaged into 160 l crates inside Z6033 200 litre drums. The drums will be packaged into 500 litre drums in the future.  
 Plant Name: TBC  
 Location: Dounreay  
 Plant startup date: TBC  
 Total capacity (m<sup>3</sup>/y incoming waste): NE  
 Target start date for packaging this stream: -  
 Throughput for this stream (m<sup>3</sup>/y incoming waste): NE  
 Other information: -

Likely 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	0.133	0.5	90

<b>WASTE STREAM</b>	<b>5B34</b>	<b>DFR Breeder Fuel Removal Waste</b>
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Likely container type comment: -

Range in container waste volume: For RHILW assumes 1 Z6033 drum per 500L drum.

Other information on containers: Likely to be 316 stainless steel.

Likely conditioning matrix: Cement

Other information: 3:1 PFA/OPC

Conditioned density (t/m<sup>3</sup>): ~2.2

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: No

Treatment	Stream volume (%)	Comment
-	-	-

**RADIOACTIVITY**

Source: The main source of activity is the activated cladding and minor contamination from irradiated breeder fuel debris.

Uncertainty: Specific activities are best estimates on computer modelling. Both stocks and arisings data taken from LoC. Specific activities calculated using separate stocks and arisings volumes.

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: Data taken from LoC

Other information: Main radionuclides only are quantified. Radionuclide specific activities have been re-evaluated since 2016

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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	2.55E-04	CC 2	3.77E-04	CC 2	Gd 153				
Be 10					Ho 163				
C 14	7.01E-04	CC 2	7.02E-04	CC 2	Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36	6.62E-08	CC 2	6.62E-08	CC 2	Lu 174				
Ar 39	1.39E-04	CC 2	1.42E-04	CC 2	Lu 176				
Ar 42	3.06E-09	CC 2	3.55E-09	CC 2	Hf 178n				
K 40					Hf 182				
Ca 41	5.11E-06	CC 2	5.11E-06	CC 2	Pt 193				
Mn 53					Tl 204				
Mn 54					Pb 205	4.06E-10	CC 2	4.06E-10	CC 2
Fe 55					Pb 210				
Co 60	2.59E-04	CC 2	6.49E-04	CC 2	Bi 208	3.44E-10	CC 2	3.44E-10	CC 2
Ni 59	2.32E-03	CC 2	2.32E-03	CC 2	Bi 210m	5.69E-10	CC 2	5.69E-10	CC 2
Ni 63	7.35E-02	CC 2	7.71E-02	CC 2	Po 210				
Zn 65					Ra 223				
Se 79	7.92E-08	CC 2	7.92E-08	CC 2	Ra 225				
Kr 81	1.60E-08	CC 2	1.60E-08	CC 2	Ra 226				
Kr 85	7.83E-06	CC 2	1.23E-05	CC 2	Ra 228				
Rb 87					Ac 227	1.96E-09	CC 2	2.45E-09	CC 2
Sr 90	2.99E-04	CC 2	3.54E-04	CC 2	Th 227				
Zr 93					Th 228				
Nb 91					Th 229				
Nb 92	9.31E-10	CC 2	9.31E-10	CC 2	Th 230				
Nb 93m					Th 232				
Nb 94	8.89E-03	CC 2	8.89E-03	CC 2	Th 234				
Mo 93	6.56E-04	CC 2	6.57E-04	CC 2	Pa 231				
Tc 97					Pa 233				
Tc 99	5.11E-05	CC 2	5.11E-05	CC 2	U 232	5.02E-08	CC 2	5.38E-08	CC 2
Ru 106					U 233	6.20E-07	CC 2	6.20E-07	CC 2
Pd 107					U 234	3.15E-07	CC 2	3.15E-07	CC 2
Ag 108m					U 235	1.33E-08	CC 2	1.33E-08	CC 2
Ag 110m					U 236				
Cd 109					U 238	3.13E-07	CC 2	3.13E-07	CC 2
Cd 113m	5.17E-05	CC 2	7.29E-05	CC 2	Np 237				
Sn 119m					Pu 236				
Sn 121m					Pu 238	4.23E-06	CC 2	4.47E-06	CC 2
Sn 123					Pu 239	4.94E-04	CC 2	4.94E-04	CC 2
Sn 126					Pu 240	1.94E-05	CC 2	1.95E-05	CC 2
Sb 125					Pu 241	2.73E-06	CC 2	3.83E-06	CC 2
Sb 126					Pu 242				
Te 125m					Am 241	2.78E-06	CC 2	2.78E-06	CC 2
Te 127m					Am 242m				
I 129	9.52E-10	CC 2	9.52E-10	CC 2	Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	4.83E-04	CC 2	5.68E-04	CC 2	Cm 244				
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144					Cf 249				
Pm 145					Cf 250				
Pm 147					Cf 251				
Sm 147					Cf 252				
Sm 151					Other a				
Eu 152					Other b/g				
Eu 154					<b>Total a</b>	<b>5.22E-04</b>	<b>CC 2</b>	<b>5.22E-04</b>	<b>CC 2</b>
Eu 155					<b>Total b/g</b>	<b>8.76E-02</b>	<b>CC 2</b>	<b>9.19E-02</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