WASTE STREAM 5B33 PFR Mixer Breeder Sections

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

		Reported
Stocks:	At 1.4.2022.....	5.4 m^3
Future arisings -	1.4.2030 - 31.3.2031.....	0.2 m^3
Total future arisings:		0.2 m^3
Total waste volume:		5.6 m^3

Comment on volumes: It should be noted that the DSRL are using a provisional Site Progrmme and that arisings dates are subject to change.

Uncertainty factors on volumes:

Stock (upper):	x 1.02	Arisings (upper)	x 1.02
Stock (lower):	x 0.98	Arisings (lower)	x 0.98

WASTE SOURCE Mixer breeder elements irradiated in PFR.

PHYSICAL CHARACTERISTICS

General description: The PFR mixer breeders are the top sections of fuel sub-assemblies that were irradiated in the PFR core. The mixer breeder sections contained mixer breeder pins that were held in place above the fuel pins by hexagonal grids and were surrounded by a stainless steel wrapper. Above the upper grid are stainless steel pipes that helped mix the circulating sodium.

Physical components (%vol): Stainless steel (68%), uranium dioxide (32%)

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m^3): 2.02

Comment on density: -

CHEMICAL COMPOSITION

General description and components (%wt): Stainless steel (68%), uranium dioxide (32%)

Chemical state: Neutral

Chemical form of radionuclides: U: Present as nat/dep UO2.

Metals and alloys (%wt): Pin cladding is M316, wrappers and other structures were made from various steels including En58B, Fv548, HL548, 12R72HV, P316, PE16, FV607 and FV448.

	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	68.0		
Other ferrous metals.....			
Iron.....			
Aluminium.....			
Beryllium.....	P		
Cobalt.....			
Copper.....			
Lead.....			
Magnox/Magnesium.....			
Nickel.....			

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Titanium.....		
Uranium.....	32.0	Uranium Dioxide
Zinc.....		
Zircaloy/Zirconium.....		
Other metals.....		

Organics (%wt): -

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

Other materials (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..			
Inorganic sludges and flocs.....			
Soil.....			
Brick/Stone/Rubble.....			
Cementitious material.....			
Sand.....			
Glass/Ceramics.....			
Graphite.....			
Desiccants/Catalysts.....			
Asbestos.....			
Non/low friable.....			
Moderately friable.....			
Highly friable.....			

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Free aqueous liquids.....

Free non-aqueous liquids.....

Powder/Ash.....

Inorganic anions (%wt): -

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

Materials of interest for waste acceptance criteria: -

	(%wt)	Type(s) and comment
Combustible metals.....		
Low flash point liquids.....		
Explosive materials.....		
Phosphorus.....		
Hydrides.....		
Biological etc. materials.....		
Biodegradable materials.....		
Putrescible wastes.....		
Non-putrescible wastes.....		
Corrosive materials.....		
Pyrophoric materials.....		
Generating toxic gases.....		
Reacting with water.....		
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.....

Complexing agents (%wt):

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

Potential for the waste to contain discrete items: Not yet determined.

PACKAGING AND CONDITIONING

Conditioning method:	The waste will initially be stored in 160 litre crates within 200 litre drums. It will be repackaged in 500 litre drums for long term storage.
Plant Name:	RHILW Repackaging Facility
Location:	Dounreay
Plant startup date:	2028
Total capacity (m^3/y incoming waste):	0.2

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Target start date for packaging this stream: 2031

Throughput for this stream (m^3/y incoming waste): 0.2

Other information: RHILW Repackaging Facility is currently in design phase.

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
500 l drum	100.0	0.199	0.5	29

Likely container type comment: -

Range in container waste volume: Assumption is that there will be 1 x 200 l drum inside a 500 l drum.

Other information on containers: -

Likely conditioning matrix: Pulverised fuel ash/Ordinary Portland cement mixture

Other information: Three to one ratio.

Conditioned density (t/m^3): ~2.3

Conditioned density comment: -

Other information on conditioning: -

Opportunities for alternative disposal routing: No

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

RADIOACTIVITY

Source: Irradiation of mixer breeder sections in PFR.

Uncertainty: -

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: The plutonium inventory of the mixer breeders was calculated using the COSMOS program POWHIST. The POWHIST code was run at the end of each PFR Run and additionally a sister program, POWSTART, was also run at the beginning of each reactor run. Aligns to DSRL nuclear accountancy data.

Other information: Specific activity uses 2019 UKRWI data decayed to 2022

WASTE STREAM 5B33 PFR Mixer Breeder Sections

Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3	4.06E-02	A A 2	5.62E-02	A A 2	Gd 153	8.66E-15	A A 2	8.99E-14	A A 2
Be 10	8.75E-08	A A 2	8.75E-08	A A 2	Ho 163	3.74E-11	A A 2	3.75E-11	A A 2
C 14	1.89E-02	A A 2	1.89E-02	A A 2	Ho 166m	2.19E-07	A A 2	2.20E-07	A A 2
Na 22					Tm 170				
Al 26					Tm 171	9.06E-09	A A 2	6.38E-08	A A 2
Cl 36	2.42E-26	A A 2	2.42E-26	A A 2	Lu 174	3.76E-18	A A 2	1.18E-17	A A 2
Ar 39					Lu 176	2.55E-24	A A 2	2.55E-24	A A 2
Ar 42					Hf 178n				
K 40					Hf 182	3.45E-15	A A 2	3.45E-15	A A 2
Ca 41	3.65E-20	A A 2	3.65E-20	A A 2	Pt 193				
Mn 53	1.21E-12	A A 2	1.21E-12	A A 2	Tl 204	1.81E-23	A A 2	5.14E-23	A A 2
Mn 54	6.73E-10	A A 2	1.03E-08	A A 2	Pb 205	2.53E-23	A A 2	2.53E-23	A A 2
Fe 55	1.36E-01	A A 2	5.70E-01	A A 2	Pb 210	3.67E-11	A A 2	1.82E-11	A A 2
Co 60	2.17E+02	A A 2	4.62E+02	A A 2	Bi 208	3.04E-21	A A 2	3.04E-21	A A 2
Ni 59	1.22E+00	A A 2	1.22E+00	A A 2	Bi 210m				
Ni 63	1.68E-07	A A 2	1.75E-07	A A 2	Po 210	3.66E-11	A A 2	1.82E-11	A A 2
Zn 65					Ra 223	3.33E-08	A A 2	5.34E-09	A A 2
Se 79					Ra 225	2.75E-10	A A 2	2.18E-10	A A 2
Kr 81	7.15E-11	A A 2	7.15E-11	A A 2	Ra 226	4.29E-11	A A 2	1.66E-11	A A 2
Kr 85	5.90E-01	A A 2	8.57E-01	A A 2	Ra 228	1.02E-13	A A 2	8.43E-14	A A 2
Rb 87	3.38E-21	A A 2	3.38E-21	A A 2	Ac 227	3.35E-08	A A 2	5.56E-09	A A 2
Sr 90	1.39E+00	A A 2	1.6E+00	A A 2	Th 227	3.29E-08	A A 2	5.35E-09	A A 2
Zr 93	9.25E-04	A A 2	9.25E-04	A A 2	Th 228	1.57E-05	A A 2	1.24E-05	A A 2
Nb 91	2.58E-06	A A 2	2.59E-06	A A 2	Th 229	2.76E-10	A A 2	2.18E-10	A A 2
Nb 92	3.69E-09	A A 2	3.69E-09	A A 2	Th 230	3.86E-09	A A 2	2.72E-09	A A 2
Nb 93m	7.02E-04	A A 2	6.41E-04	A A 2	Th 232	1.30E-13	A A 2	1.07E-13	A A 2
Nb 94	5.35E-02	A A 2	5.35E-02	A A 2	Th 234	3.59E-03	A A 2	3.58E-03	A A 2
Mo 93	5.89E-21	A A 2	5.90E-21	A A 2	Pa 231	7.32E-08	A A 2	6.35E-08	A A 2
Tc 97	1.28E-13	A A 2	1.28E-13	A A 2	Pa 233	2.02E-04	A A 2	2.01E-04	A A 2
Tc 99	3.42E-03	A A 2	3.42E-03	A A 2	U 232	1.6E-05	A A 2	1.69E-05	A A 2
Ru 106	1.11E-06	A A 2	1.84E-05	A A 2	U 233	1.07E-07	A A 2	1.02E-07	A A 2
Pd 107	8.45E-05	A A 2	8.45E-05	A A 2	U 234	2.25E-05	A A 2	1.93E-05	A A 2
Ag 108m	9.56E-09	A A 2	9.65E-09	A A 2	U 235	7.91E-05	A A 2	7.90E-05	A A 2
Ag 110m	4.59E-13	A A 2	5.16E-12	A A 2	U 236	8.37E-05	A A 2	8.36E-05	A A 2
Cd 109	4.63E-14	A A 2	6.31E-13	A A 2	U 238	3.59E-03	A A 2	3.59E-03	A A 2
Cd 113m	3.65E-03	A A 2	4.88E-03	A A 2	Np 237	2.02E-04	A A 2	2.01E-04	A A 2
Sn 119m	8.60E-13	A A 2	1.24E-11	A A 2	Pu 236	1.93E-07	A A 2	7.39E-07	A A 2
Sn 121m	1.11E-02	A A 2	1.19E-02	A A 2	Pu 238	1.87E-01	A A 2	1.95E-01	A A 2
Sn 123					Pu 239	8.75E+00	A A 2	8.75E+00	A A 2
Sn 126	8.52E-05	A A 2	8.52E-05	A A 2	Pu 240	8.19E-01	A A 2	8.20E-01	A A 2
Sb 125	3.63E-03	A A 2	1.50E-02	A A 2	Pu 241	1.83E+00	A A 2	2.42E+00	A A 2
Sb 126	1.19E-05	A A 2	8.52E-05	A A 2	Pu 242	4.02E-06	A A 2	4.02E-06	A A 2
Te 125m	9.00E-04	A A 2	3.54E-03	A A 2	Am 241	2.22E-01	A A 2	2.05E-01	A A 2
Te 127m					Am 242m	5.17E-04	A A 2	5.32E-04	A A 2
I 129	1.7E-05	A A 2	1.7E-05	A A 2	Am 243	1.89E-06	A A 2	1.89E-06	A A 2
Cs 134	3.99E-04	A A	2.50E-03	A A 2	Cm 242	4.25E-04	A A 2	4.40E-04	A A 2
Cs 135	8.1E-04	A A 2	8.1E-04	A A 2	Cm 243	1.45E-05	A A 2	1.66E-05	A A 2
Cs 137	2.68E+01	A A 2	3.06E+01	A A 2	Cm 244	6.03E-06	A A 2	7.53E-06	A A 2
Ba 133	6.46E-10	A A 2	9.44E-10	A A 2	Cm 245	3.25E-10	A A 2	3.25E-10	A A 2
La 137	2.1E-09	A A 2	2.1E-09	A A 2	Cm 246	2.33E-12	A A 2	2.33E-12	A A 2
La 138	1.36E-13	A A 2	1.36E-13	A A 2	Cm 248	2.73E-19	A A 2	2.73E-19	A A 2
Ce 144	1.80E-08	A A 2	2.52E-07	A A 2	Cf 249	9.58E-19	A A 2	9.69E-19	A A 2
Pm 145	5.35E-10	A A 2	6.71E-10	A A 2	Cf 250	6.06E-20	A A 2	8.23E-20	A A 2
Pm 147	4.30E-02	A A 2	1.89E-01	A A 2	Cf 251	2.49E-23	A A 2	2.50E-23	A A 2
Sm 147	6.06E-09	A A 2	6.06E-09	A A 2	Cf 252	9.99E-27	A A 2	4.33E-26	A A 2
Sm 151	1.60E+00	A A 2	1.67E+00	A A 2	Other a			4.49E-05	A A 2
Eu 152	3.59E-03	A A 2	4.84E-03	A A 2	Other b/g	9.52E+00	A A 2	4.00E+01	A A 2
Eu 154	5.82E-02	A A 2	9.26E-02	A A 2	**Total a**	**9.98E+00**	**A A 2**	**9.97E+00**	**A A 2**
Eu 155	6.75E-02	A A 2	1.52E-01	A A 2	**Total b/g**	**2.60E+02**	**A A 2**	**5.41E+02**	**A A 2**

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