

<b>WASTE STREAM</b>	<b>9B86/C</b>	<b>Sludge</b>
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**SITE** Bradwell

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Magnox Limited

**WASTE TYPE** ILW

Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Conditioned	Packaged
Stocks:	At 1.4.2022.....	0.5 m <sup>3</sup>	7.9 m <sup>3</sup>
Total future arisings:		0 m <sup>3</sup>	0 m <sup>3</sup>
Total waste volume:		0.5 m <sup>3</sup>	7.9 m <sup>3</sup>
Number of waste packages in stock:	At 1.4.2022.....	6 package(s)	

Comment on volumes: Volume calculated using known waste mass per package and density from characterisation campaigns (WD/CALC/1472 Issue 1).

Uncertainty factors on volumes:

Stock (upper):	x 1.2	Arisings (upper)	x
Stock (lower):	x 0.8	Arisings (lower)	x

**WASTE SOURCE** The sludge originates from routine filtration of liquid effluents and cooling pond water and from special clean-up operations on cooling ponds.

**PHYSICAL CHARACTERISTICS**

General description: The waste consists of debris washed from persons, floors and clothing, corrosion products such as magnesium hydroxide and carbonate detached from fuel elements and materials such as flakes of paint. Also there is some oil and grease. Sludge particles may be up to millimetre size. Bulk sludge was retrieved from mules from where it was pumped to a buffer tank that was used to fill the three 400 litre barrels attached to the processing plant. These were filled in several stages with periods of in-vessel drying between fillings. This sequence was repeated until the packages were filled to the required level. The barrels were then transferred to MOSAIK® EIs creating the disposable package. More watery sludge (mainly supernatant and flush water) was also transferred and conditioned into 3 MOSAIK® T-ISAR. These form the origin for this waste stream.

Physical components (%wt): Sludge, and bound water (100 wt%) not removed by drying. No other constituents anticipated.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): 1.18

Comment on density: The bulk density is taken from WD/CALC/1472.

**CHEMICAL COMPOSITION**

General description and components (%wt): Siliceous materials (sand and cementitious particles), corrosion products (magnesium hydroxides, carbonate, iron oxy-hydroxides), ion exchange material and miscellaneous organic materials dominated by oil/paints.

Chemical state: Alkali

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.

U: The chemical form of uranium isotopes has not been determined but uranium oxides are present as corrosion products.

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.

Metals and alloys (%wt): -

<b>WASTE STREAM</b>	<b>9B86/C</b>	<b>Sludge</b>
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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	NE		
Other ferrous metals.....	NE		
Iron.....	5.5		
Aluminium.....	1.1		
Beryllium.....	TR		
Cobalt.....	0.01		
Copper.....	0.06		
Lead.....	TR		
Magnox/Magnesium.....	5.3	Unreacted Magnox is expected.	
Nickel.....	0.02		
Titanium.....			
Uranium.....			
Zinc.....	0.45		
Zircaloy/Zirconium.....	NE		
Other metals.....	1.6	0.04wt% chromium, 0.25wt% potassium, 0.05wt% manganese, 1.3wt% sodium.	

Organics (%wt): Oil and grease are present.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics.....	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.....	6.1		
Oil or grease .....			
Fuel.....			
Asphalt/Tarmac (cont.coal tar)...			
Asphalt/Tarmac (no coal tar)....			
Bitumen.....			
Others.....	6.1	Organic carbon, of which 49.6wt% is hexane soluble oil.	
Other organics.....	NE		

Other materials (%wt): -

<b>WASTE STREAM</b>	<b>9B86/C</b>	<b>Sludge</b>
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	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	0		
Inorganic sludges and flocs.....	79.9		
Soil.....	0		
Brick/Stone/Rubble.....	TR		
Cementitious material.....	NE		
Sand.....			
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		

Inorganic anions (%wt):           Chemical analysis of samples shows only the inorganic anions indicated.

	(%wt)	Type(s) and comment
Fluoride.....	0	
Chloride.....	0.28	
Iodide.....	0	
Cyanide.....	0	
Carbonate.....	29.1	
Nitrate.....	0	
Nitrite.....	0	
Phosphate.....	0	
Sulphate.....	0	
Sulphide.....	0	

Materials of interest for waste acceptance criteria:           The waste is unlikely to present a fire hazard due to the high water content. <2% of the waste is oil and grease.

	(%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.....		

<b>WASTE STREAM</b>	<b>9B86/C</b>	<b>Sludge</b>
---------------------	---------------	---------------

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

Hazardous substances / 0.04wt% Chromium  
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.....	0	
Boron (in Boral).....		
Boron (non-Boral).....		
Cadmium.....		
Caesium.....		
Selenium.....		
Chromium.....	0.04	
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.....  
Total complexing agents..... TR

Potential for the waste to contain discrete items: No. In & of itself not a DI; assumed not likely to contain any "rogue" items that could be.

**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 RS drum (0mm Pb)	100.0	0.075	0.0754	6

Container type comment: The waste has been packaged into 3 MOSAIK II-15 T ISAR and 3 MOSAIK II-15 EI DCICs.

Range in container waste volume: -

Other information on containers: -

Conditioned density (t/m<sup>3</sup>): ~1.18

Conditioned density comment: From WD/CALC/1472

Other information on conditioning: -

**RADIOACTIVITY**

Source: Contaminated sludge. Contamination by fission products, actinides and activation products.

Uncertainty: Specific activity is a function of Station operating history. 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 activities were calculated using mass of waste, density of waste, and fingerprints obtained from 2013 characterisation. Workings in WD/MISC/5895 Issue 1 and characterisation from WD/CALC/1472.

Other information: -

**WASTE STREAM 9B86/C Sludge**

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	2.53E-03	BB 2			Gd 153	1.76E-04	BB 2		
Be 10	1.37E-07	BB 2			Ho 163		8		
C 14	7.79E-04	BB 2			Ho 166m	1.41E-05	BB 2		
Na 22		8			Tm 170	1.48E-05	BB 2		
Al 26		8			Tm 171		8		
Cl 36	1.97E-06	BB 2			Lu 174		8		
Ar 39	7.69E-04	BB 2			Lu 176		8		
Ar 42	1.73E-09	BB 2			Hf 178n		8		
K 40	4.56E-09	BB 2			Hf 182	2.06E-05	BB 2		
Ca 41	2.02E-05	BB 2			Pt 193		8		
Mn 53		8			Tl 204	1.79E-07	BB 2		
Mn 54		8			Pb 205	7.97E-07	BB 2		
Fe 55	3.79E-03	BB 2			Pb 210		8		
Co 60	6.56E-03	BB 2			Bi 208		8		
Ni 59	2.02E-05	BB 2			Bi 210m		8		
Ni 63	1.55E-04	BB 2			Po 210		8		
Zn 65		8			Ra 223	6.86E-08	BB 2		
Se 79	4.72E-08	BB 2			Ra 225		8		
Kr 81	5.00E-09	BB 2			Ra 226		8		
Kr 85	1.06E-03	BB 2			Ra 228		8		
Rb 87		8			Ac 227	1.27E-08	BB 2		
Sr 90	1.48E-02	BB 2			Th 227		8		
Zr 93	2.02E-06	BB 2			Th 228	1.80E-05	BB 2		
Nb 91		8			Th 229	1.56E-09	BB 2		
Nb 92		8			Th 230	1.85E-06	BB 2		
Nb 93m	3.96E-06	BB 2			Th 232	6.67E-08	BB 2		
Nb 94	4.29E-05	BB 2			Th 234		8		
Mo 93	1.01E-05	BB 2			Pa 231	1.53E-07	BB 2		
Tc 97		8			Pa 233		8		
Tc 99	1.31E-05	BB 2			U 232	2.38E-05	BB 2		
Ru 106		8			U 233	9.89E-07	BB 2		
Pd 107	9.16E-08	BB 2			U 234	3.66E-06	BB 2		
Ag 108m	4.92E-08	BB 2			U 235	1.80E-05	BB 2		
Ag 110m		8			U 236	1.86E-06	BB 2		
Cd 109		8			U 238		8		
Cd 113m	2.16E-07	BB 2			Np 237	8.26E-03	BB 2		
Sn 119m		8			Pu 236	1.39E-02	BB 2		
Sn 121m	5.76E-03	BB 2			Pu 238	1.38E-02	BB 2		
Sn 123		8			Pu 239	1.85E-09	BB 2		
Sn 126	1.99E-07	BB 2			Pu 240	3.59E-06	BB 2		
Sb 125	2.08E-09	BB 2			Pu 241		8		
Sb 126	2.79E-08	BB 2			Pu 242	5.93E-02	BB 2		
Te 125m		8			Am 241		8		
Te 127m		8			Am 242m		8		
I 129	2.38E-08	BB 2			Am 243	1.24E-05	BB 2		
Cs 134	9.52E-06	BB 2			Cm 242		8		
Cs 135	1.37E-08	BB 2			Cm 243	4.86E-06	BB 2		
Cs 137	5.55E-02	BB 2			Cm 244	5.99E-05	BB 2		
Ba 133	3.54E-05	BB 2			Cm 245	5.27E-09	BB 2		
La 137	1.42E-09	BB 2			Cm 246		8		
La 138		8			Cm 248		8		
Ce 144		8			Cf 249		8		
Pm 145		8			Cf 250		8		
Pm 147	4.23E-05	BB 2			Cf 251		8		
Sm 147		8			Cf 252		8		
Sm 151		8			Other a				
Eu 152	9.19E-04	BB 2			Other b/g				
Eu 154	1.16E-06	BB 2			<b>Total a</b>	<b>9.55E-02</b>	<b>BB 2</b>	<b>0</b>	
Eu 155	1.03E-03	BB 2			<b>Total b/g</b>	<b>9.41E-02</b>	<b>BB 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