WASTE STREAM 5B22 ADU Floc

SITE	Dounreay
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Dounreay Site Restoration Limited
WASTE TYPE	ILW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	164.0 m³
Future arisings -	1.4.2020 - 31.3.2022.....	16.0 m³
Total future arisings:		16.0 m³
Total waste volume:		180.0 m³

Comment on volumes: Future arisings consist of nitric acid tank washings. Stocks uncertainty related only to tank level monitoring equipment error margin. The 16 m³ of future arisings is an allowance for Nitric Acid Tank Washings

Uncertainty factors on volumes:

Stock (upper):	x 1.05	Arisings (upper)	x 1.2
Stock (lower):	x 0.95	Arisings (lower)	x 0.8

WASTE SOURCE The floc results from the decontamination of high alpha MA/LA liquors from the PFR fuel reprocessing plant.

PHYSICAL CHARACTERISTICS

General description: The waste is an alpha and beta/gamma contaminated ammonium diuranate (ADU) floc. There are no large items present.

Physical components (%vol): ADU floc (63%), water (37%).

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 1.26

Comment on density: Density based on analysis of samples in 1990/91 and the inclusion of the supernate.

CHEMICAL COMPOSITION

General description and components (%wt): Major species present are uranium (11.28% UO2), nitrate (6.29) ammonium ions (2.43%), ammonia (1.17%) sulphate ions (2.53%), phosphate ions (2.73%), hydroxide (1.77%) iron (0.38%), sodium (0.38%) and plutonium (0.007%). The remainder of the waste is water (70.99) and minor species.

Chemical state: Alkali

Chemical form of radionuclides:
Ra: Trace quantities present.
Th: Trace quantities present.
U: Present as ammonium diuranate and UO2.
Np: Trace quantities present.
Pu: Trace quantities present as PuO2.

Metals and alloys (%wt): The waste contains only metal ions in solution.

Stainless steel.....	0
Other ferrous metals.....	0.40
Iron.....	0
Aluminium.....	~0.02
Beryllium.....	0
Cobalt.....	0
Copper.....	
Lead.....	0
Magnox/Magnesium.....	0
Nickel.....	
Titanium.....	
Uranium.....	~9.9

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	Zinc	0	
	Zircaloy/Zirconium	0	
	Other metals	0.40	Other metals include sodium (0.4%), plutonium (0.006%) and minor species (0.04%).
Organics (%wt):	Trace quantities of organic solvent are present (MBP, DBP, TBP, OK). Quantities undetermined but total phosphate is < 1% by weight.		
	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	0	
	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	~52.3	
	Soil	0	
	Brick/Stone/Rubble	0	
	Cementitious material	0	
	Sand	0	
	Glass/Ceramics	0	
	Graphite	0	
	Desiccants/Catalysts		
	Asbestos	0	
	Non/low friable		
	Moderately friable		
	Highly friable		
	Free aqueous liquids	37.0	
	Free non-aqueous liquids	TR	
	Powder/Ash	0	
Inorganic anions (%wt):	In addition to thoses below, hydroxide (1.77%).		

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Fluoride	0
Chloride	0
Iodide	0
Cyanide	0
Carbonate	0
Nitrate	~6.3
Nitrite	0
Phosphate	~2.7
Sulphate	~2.5
Sulphide	0

Materials of interest for waste acceptance criteria: Sulphuric acid is present. There are also traces of solvents.

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

Hazardous substances / non hazardous pollutants: The waste contains a small amount of cadmium (<0.001%).

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

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	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):	Yes		
	EDTA.....		
	DPTA.....		
	NTA.....		
	Polycarboxylic acids……		
	Other organic complexants.....	TR	The waste contains small amounts of degraded TBP, DBP, MBP and kerosene.
	Total complexing agents.....	TR	

PACKAGING AND CONDITIONING

Conditioning method:	Once removed the waste will be treated to result in an acceptable product. ADU Floc may have to be dissolved in nitric acid to allow transfer of the Floc to a reaction vessel where it will be conditioned with sodium hydroxide. Current strategy indicates that the waste will then transferred to a temporary cementation plant for cementation into 500L drums.
Plant Name:	Temporary Cementation Plant
Location:	Dounreay
Plant startup date:	2022
Total capacity (m^3/y incoming waste):	120.0
Target start date for packaging this stream:	2022
Throughput for this stream (m^3/y incoming waste):	120.0
Other information:	-

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
500 l drum	100.0	0.25	0.5	720

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Likely container type comment:	The conditioning factor is expected to be about 2.0.
Range in container waste volume:	-
Other information on containers:	Stainless Steel. The container is likely to be manufactured from 316 stainless steel.
Likely conditioning matrix:	Cement
Other information:	The dissolved ADU floc would then be added to NaOH, producing NaDU slurry which would be cemented into 500 litre drums.
Conditioned density (t/m³):	~1.7
Conditioned density comment:	Density is likely to be around 1.7 t/m³ once conditioned and cemented.
Other information on conditioning:	-
Opportunities for alternative disposal routing:	No

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source:	Main source of radioactivity is fission products with Am-241, Cm-243 and plutonium (alpha).
Uncertainty:	Accuracy of tank analysis to 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:	The specific activities of the principal radionuclides were measured by sampling followed by radiochemical analysis in 2006 and 2011 and adjusted to align with Nuclear Material Accountancy records. Other specific activities were estimated using a rigorous approach involving back calculation from the PFR raffinate inventory.
Other information:	-

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Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2019	Bands and Code	Future arisings	Bands and Code
H 3	1.03E-05	B B 1	1.15E-05	B B 1	Gd 153	3.21E-20	B B 2	2.59E-19	B B 2
Be 10	2.95E-13	B B 2	2.95E-13	B B 2	Ho 163	8.77E-14	B B 2	8.76E-14	B B 2
C 14	2.42E-08	B B 2	2.42E-08	B B 2	Ho 166m	9.31E-12	B B 2	9.33E-12	B B 2
Na 22					Tm 170				
Al 26					Tm 171	3.43E-12	B B 2	7.07E-12	B B 2
Cl 36	6E-13	B B 2	6E-13	B B 2	Lu 174	8.65E-13	B B 2	1.28E-12	B B 2
Ar 39					Lu 176				
Ar 42					Hf 178n	6.78E-11	B B 2	7.09E-11	B B 2
K 40	4.43E-14	B B 2	4.43E-14	B B 2	Hf 182				
Ca 41	4.98E-11	B B 2	4.98E-11	B B 2	Pt 193	5.93E-10	B B 2	6.1E-10	B B 2
Mn 53	<3.8E-13	C 3	<3.8E-13	C 3	Tl 204	3.07E-09	B B 2	4.42E-09	B B 2
Mn 54	<2.69E-13	C 3	<1.35E-12	C 3	Pb 205	2.19E-14	B B 2	2.19E-14	B B 2
Fe 55	<4.06E-07	C 3	<6.74E-07	C 3	Pb 210	6.05E-10	B B 2	3.88E-10	B B 2
Co 60	3.19E-06	B B 1	4.15E-06	B B 1	Bi 208	1.63E-14	B B 2	1.63E-14	B B 2
Ni 59	8.96E-08	B B 2	8.96E-08	B B 2	Bi 210m				
Ni 63	3.92E-06	B B 2	3.97E-06	B B 2	Po 210	5.41E-10	B B 2	3.4E-10	B B 2
Zn 65	1.04E-16	B B 2	8.13E-16	B B 2	Ra 223	3.33E-09	B B 2	2.49E-09	B B 2
Se 79	1.59E-07	B B 2	1.59E-07	B B 2	Ra 225	1.76E-08	B B 2	1.51E-08	B B 2
Kr 81					Ra 226	4.69E-09	B B 2	3.44E-09	B B 2
Kr 85					Ra 228	4.47E-14	B B 2	3.49E-14	B B 2
Rb 87	5.55E-12	B B 2	5.55E-12	B B 2	Ac 227	3.39E-09	B B 2	2.54E-09	B B 2
Sr 90	9.01E-03	B B 2	9.45E-03	B B 2	Th 227	3.31E-09	B B 2	2.47E-09	B B 2
Zr 93	5.96E-06	B B 2	5.96E-06	B B 2	Th 228	6.88E-05	B B 2	6.96E-05	B B 2
Nb 91	1.35E-08	B B 2	1.35E-08	B B 2	Th 229	1.77E-08	B B 2	1.52E-08	B B 2
Nb 92	4.4E-13	B B 2	4.4E-13	B B 2	Th 230	1.55E-06	B B 2	1.33E-06	B B 2
Nb 93m	1.10E-05	B B 2	1.14E-05	B B 2	Th 232	8.63E-14	B B 2	7.4E-14	B B 2
Nb 94	1.41E-07	B B 2	1.41E-07	B B 2	Th 234	1.54E-03	B B 2	1.54E-03	B B 2
Mo 93	5.23E-08	B B 2	5.23E-08	B B 2	Pa 231	1.76E-08	B B 2	1.5E-08	B B 2
Tc 97	8.54E-12	B B 2	8.54E-12	B B 2	Pa 233	2.47E-04	B B 2	2.47E-04	B B 2
Tc 99	1.25E-01	B B 2	1.25E-01	B B 2	U 232	6.74E-05	B B 2	6.87E-05	B B 2
Ru 106	<8.91E-07	C 3	<3.5E-06	C 3	U 233	1.34E-05	B B 2	1.34E-05	B B 2
Pd 107	2.74E-07	B B 2	2.74E-07	B B 2	U 234	1.21E-02	B B 1	1.21E-02	B B 1
Ag 108m	4.55E-10	B B 2	4.56E-10	B B 2	U 235	5.91E-05	B B 1	5.91E-05	B B 1
Ag 110m	4.52E-15	B B 2	3.38E-14	B B 2	U 236	1.25E-04	B B 1	1.25E-04	B B 1
Cd 109	5.72E-13	B B 2	1.7E-12	B B 2	U 238	1.54E-03	B B 1	1.54E-03	B B 1
Cd 113m	8.57E-07	B B 2	9.48E-07	B B 2	Np 237	2.47E-04	B B 2	2.47E-04	B B 2
Sn 119m	3.99E-15	B B 2	2.22E-14	B B 2	Pu 236	2.23E-09	B B 2	3.6E-09	B B 2
Sn 121m	2.11E-05	B B 2	2.16E-05	B B 2	Pu 238	2.15E+00	B B 2	2.18E+00	B B 2
Sn 123	5.66E-25	B B 2	2.67E-23	B B 2	Pu 239	1.55E-01	B B 2	1.55E-01	B B 2
Sn 126	5.49E-07	B B 2	5.49E-07	B B 2	Pu 240	1.57E-01	B B 1	1.57E-01	B B 1
Sb 125	1.15E-05	B C 3	1.89E-05	B C 3	Pu 241	1.86E+00	B B 1	2.05E+00	B B 1
Sb 126	7.69E-08	B B 2	7.69E-08	B B 2	Pu 242	1.26E-04	B B 1	1.26E-04	B B 1
Te 125m	<2.87E-06	C 3	<4.73E-06	C 3	Am 241	9.34E-02	B B 2	8.75E-02	B B 2
Te 127m					Am 242m	9.80E-05	B B 2	9.9E-05	B B 2
I 129	3.17E-04	B B 2	3.17E-04	B B 2	Am 243	6.39E-06	B B 2	6.39E-06	B B 2
Cs 134	1.42E-06	B C 3	2.78E-06	B C 3	Cm 242	8.09E-05	B B 2	8.17E-05	B B 2
Cs 135	7.68E-07	B B 2	7.68E-07	B B 2	Cm 243	1.89E-05	B B 1	1.98E-05	B B 1
Cs 137	2.62E-02	B B 2	2.75E-02	B B 2	Cm 244	1.65E-04	B B 2	1.78E-04	B B 2
Ba 133	3.41E-09	B B 2	3.89E-09	B B 2	Cm 245	1.73E-08	B B 2	1.73E-08	B B 2
La 137	5.55E-12	B B 2	5.55E-12	B B 2	Cm 246	6.82E-10	B B 2	6.82E-10	B B 2
La 138					Cm 248				
Ce 144	<7.11E-11	C 3	<4.14E-10	C 3	Cf 249	1.85E-14	B B 2	1.86E-14	B B 2
Pm 145	4.83E-11	B B 2	5.22E-11	B B 2	Cf 250	6.81E-15	B B 2	7.57E-15	B B 2
Pm 147	1.4E-04	B B 2	2.37E-04	B B 2	Cf 251				
Sm 147	4.10E-12	B B 2	4.1E-12	B B 2	Cf 252				
Sm 151	1.38E-03	B B 2	1.4E-03	B B 2	Other a				
Eu 152	9.26E-07	B B 2	1.03E-06	B B 2	Other b/g				
Eu 154	1.45E-02	B B 1	1.71E-02	B B 1	**Total a**	**2.57E+00**	**B B 2**	**2.60E+00**	**B B 2**
Eu 155	9.12E-03	B B 2	1.22E-02	B B 2	**Total b/g**	**2.05E+00**	**B B 2**	**2.24E+00**	**B B 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