

<b>WASTE STREAM</b>	<b>5B26</b>	<b>LLLETP Sludge</b>
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**SITE** Dounreay  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Dounreay Site Restoration Limited  
**WASTE TYPE** LLW

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2019.....	16.0 m <sup>3</sup>
Future arisings -	1.4.2019 - 31.3.2027.....	~8.0 m <sup>3</sup>
Total future arisings:		8.0 m <sup>3</sup>
Total waste volume:		24.0 m <sup>3</sup>

Comment on volumes: It has been assumed that the sludge will arise at about 1 m<sup>3</sup>/year. Operational experience suggests that arisings will be around 1 m<sup>3</sup> per year.

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

**WASTE SOURCE** This waste stream consists of sludges which will be produced as a result of operations in the Low Level Liquid Effluent Treatment Plant (LLLETP) at Dounreay. The sludges themselves will consist of a mixture of ferric and aluminium hydroxides.

**PHYSICAL CHARACTERISTICS**

General description: The waste is a watery sludge.  
 Physical components (%vol): The waste consists of ferric/aluminium hydroxide sludge.  
 Sealed sources: -  
 Bulk density (t/m<sup>3</sup>): ~1.2  
 Comment on density: The density is based on scoping studies.

**CHEMICAL COMPOSITION**

General description and components (%wt): The waste consists of ferric/aluminium hydroxide sludge.

Chemical state: Alkali  
 Chemical form of radionuclides: H-3: Not thought to be present.  
 C-14: Not thought to be present.  
 Cl-36: Not thought to be present.  
 Se-79: Not thought to be present.  
 Tc-99: Not thought to be present.  
 I-129: Not thought to be present.  
 Ra: May be present as particulate.  
 Th: May be present as particulate.  
 U: Likely to be present as particulate.  
 Np: Possible present in low concentrations.  
 Pu: Not identified by analysis to date.

Metals and alloys (%wt): -  
 Stainless steel..... 0  
 Other ferrous metals..... 0  
 Iron.....  
 Aluminium.....  
 Beryllium.....  
 Cobalt..... 0  
 Copper.....  
 Lead..... 0  
 Magnox/Magnesium..... 0  
 Nickel.....

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**LLLETP Sludge**

	Titanium.....	
	Uranium.....	
	Zinc.....	0
	Zircaloy/Zirconium.....	0
	Other metals.....	0
Organics (%wt):	-	
	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):	-	
	Inorganic ion exchange materials.	0
	Inorganic sludges and flocs.....	100.0
	Soil.....	0
	Brick/Stone/Rubble.....	0
	Cementitious material.....	0
	Sand.....	
	Glass/Ceramics.....	
	Graphite.....	0
	Desiccants/Catalysts.....	
	Asbestos.....	0
	Non/low friable.....	
	Moderately friable.....	
	Highly friable.....	
	Free aqueous liquids.....	P
	Free non-aqueous liquids.....	0
	Powder/Ash.....	0
Inorganic anions (%wt):	-	

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

Materials of interest for  
waste acceptance criteria:

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

Hazardous substances /  
non hazardous pollutants:

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

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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):

No  
 EDTA.....  
 DPTA.....  
 NTA.....  
 Polycarboxylic acids.....  
 Other organic complexants.....  
 Total complexing agents..... 0

**TREATMENT, PACKAGING AND DISPOSAL**

Planned on-site / off-site treatment(s):

Treatment	On-site / Off site	Stream volume %
Low force compaction Supercompaction (HFC) Incineration Solidification Decontamination Metal treatment Size reduction Decay storage Recycling / reuse Other / various None	On-site	100.0

Comment on planned treatments:

LLLETP sludge is expected to be produced at a sludge concentration of up to 50g/l. This is expected to be dewatered to a sludge concentration of around 300g/l. Sludge is cemented into 200 litre lost paddle product drums using 3:1 PFA/OPC grout and approx. 40% volume sludge loading.

**WASTE STREAM****5B26****LLLETP Sludge****Disposal Routes:**

Disposal Route	Stream volume %
Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known	100.0

**Upcoming (2019/20-2021/22) Waste Routing (if expected to change from above):**

Disposal Route	Stream volume %		
	2019/20	2020/21	2021/22
Expected to be consigned to the LLW Repository Expected to be consigned to a Landfill Facility Expected to be consigned to an On-Site Disposal Facility Expected to be consigned to an Incineration Facility Expected to be consigned to a Metal Treatment Facility Expected to be consigned as Out of Scope Expected to be recycled / reused Disposal route not known			

**Waste Packaging for Disposal:**

Container	Stream volume %	Waste loading m <sup>3</sup>	Number of packages
1/3 Height IP-1 ISO 2/3 Height IP-2 ISO 1/2 Height WAMAC IP-2 ISO 1/2 Height IP-2 Disposal/Re-usable ISO 2m box (no shielding) 4m box (no shielding) Other	100.0	10	3

**Other information:**

The waste will consist of 200 litre drums of cemented sludge. DSRL is investigating the feasibility of alternative LLW Container.

**Waste Planned for Disposal at the LLW Repository:** (Not applicable to this waste stream)**Container voidage:**

-

**Waste Characterisation Form (WCH):**

The waste does not meet the LLWR's Waste Acceptance Criteria (WAC).

Will be disposed in the LLW Disposal Facility at Dounreay and once conditioned, will meet is Waste Acceptance Criteria.

**Waste consigned for disposal to LLWR in year of generation:**

No. The waste is held in a storage tank before being immobilised in cement.

**Potential for the waste to contain discrete items:**

-

**Non-Containerised Waste for In-Vault Grouting:** (Not applicable to this waste stream)**Stream volume (%):**

-

**Waste stream variation:**

-

**Bounding cuboidal volume:****Inaccessible voidage:**

-

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Other information:

-

**RADIOACTIVITY**

Source:

The activity originates from a variety of operations on the Dounreay site.

Uncertainty:

The information is accurate to within a factor of ten

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 beta/gamma emitting radionuclides were estimated from sludge composition studies. Total alpha and beta/gamma values were derived from consignor records.

Other information:

Specific Activities have been re-evaluated since 2016: based on consignor's records.

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**LLLETP Sludge**

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					Gd 153				
Be 10					Ho 163				
C 14					Ho 166m				
Na 22					Tm 170				
Al 26					Tm 171				
Cl 36					Lu 174				
Ar 39					Lu 176				
Ar 42					Hf 178n				
K 40					Hf 182				
Ca 41					Pt 193				
Mn 53					Tl 204				
Mn 54					Pb 205				
Fe 55					Pb 210				
Co 60	6.36E-06	CC 2	6.36E-06	CC 2	Bi 208				
Ni 59					Bi 210m				
Ni 63					Po 210				
Zn 65					Ra 223				
Se 79					Ra 225				
Kr 81					Ra 226				
Kr 85					Ra 228				
Rb 87					Ac 227				
Sr 90	1.32E-04	CC 2	1.32E-04	BB 2	Th 227				
Zr 93					Th 228				
Nb 91					Th 229				
Nb 92					Th 230				
Nb 93m					Th 232				
Nb 94					Th 234				
Mo 93					Pa 231				
Tc 97					Pa 233				
Tc 99					U 232				
Ru 106					U 233				
Pd 107					U 234	1.75E-06	CC 2	1.75E-06	CC 2
Ag 108m					U 235	5.47E-08	CC 2	5.47E-08	CC 2
Ag 110m					U 236	5.47E-08	CC 2	5.47E-08	CC 2
Cd 109					U 238	9.57E-08	CC 2	9.57E-08	CC 2
Cd 113m					Np 237				
Sn 119m					Pu 236				
Sn 121m					Pu 238	4.49E-05	CC 2	4.49E-05	CC 2
Sn 123					Pu 239	2.92E-05	CC 2	2.92E-05	CC 2
Sn 126					Pu 240	2.15E-05	CC 2	2.15E-05	CC 2
Sb 125					Pu 241	4.51E-04	CC 2	4.51E-04	CC 2
Sb 126					Pu 242				
Te 125m					Am 241	4.53E-05	CC 2	4.53E-05	CC 2
Te 127m					Am 242m				
I 129					Am 243				
Cs 134					Cm 242				
Cs 135					Cm 243				
Cs 137	8.50E-05	CC 2	8.50E-05	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	1.58E-06	CC 2	1.58E-06	CC 2	Cf 251				
Sm 147					Cf 252				
Sm 151					Other a				
Eu 152					Other b/g				
Eu 154	2.75E-06	CC 2	2.75E-06	CC 2	<b>Total a</b>	<b>1.43E-04</b>	<b>CC 2</b>	<b>1.43E-04</b>	<b>CC 2</b>
Eu 155	1.57E-06	CC 2	1.57E-06	CC 2	<b>Total b/g</b>	<b>6.80E-04</b>	<b>CC 2</b>	<b>6.80E-04</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