

<b>WASTE STREAM</b>	<b>2D26</b>	<b>Ion Exchange Material (Clinoptilolite) and Sand</b>
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**SITE** Sellafield  
**SITE OWNER** Nuclear Decommissioning Authority  
**WASTE CUSTODIAN** Sellafield Limited  
**WASTE TYPE** ILW  
 Is the waste subject to Scottish Policy: No

**WASTE VOLUMES**

		Reported
Stocks:	At 1.4.2022.....	1445.0 m <sup>3</sup>
Future arisings -	1.4.2022 - 31.3.2023.....	40.0 m <sup>3</sup>
	1.4.2023 - 31.3.2024.....	40.0 m <sup>3</sup>
	1.4.2024 - 31.3.2025.....	40.0 m <sup>3</sup>
	1.4.2025 - 31.3.2026.....	40.0 m <sup>3</sup>
	1.4.2026 - 31.3.2027.....	40.0 m <sup>3</sup>
	1.4.2027 - 31.3.2028.....	40.0 m <sup>3</sup>
	1.4.2028 - 31.3.2029.....	40.0 m <sup>3</sup>
	1.4.2029 - 31.3.2030.....	40.0 m <sup>3</sup>
	1.4.2030 - 31.3.2031.....	40.0 m <sup>3</sup>
	1.4.2031 - 31.3.2032.....	40.0 m <sup>3</sup>
	1.4.2032 - 31.3.2033.....	40.0 m <sup>3</sup>
	1.4.2033 - 31.3.2034.....	40.0 m <sup>3</sup>
	1.4.2034 - 31.3.2035.....	40.0 m <sup>3</sup>
	1.4.2035 - 31.3.2036.....	40.0 m <sup>3</sup>
	1.4.2036 - 31.3.2037.....	40.0 m <sup>3</sup>
	1.4.2037 - 31.3.2038.....	40.0 m <sup>3</sup>
	1.4.2038 - 31.3.2039.....	40.0 m <sup>3</sup>
	1.4.2039 - 31.3.2040.....	40.0 m <sup>3</sup>
	1.4.2040 - 31.3.2041.....	40.0 m <sup>3</sup>
	1.4.2041 - 31.3.2042.....	40.0 m <sup>3</sup>
	1.4.2042 - 31.3.2043.....	40.0 m <sup>3</sup>
	1.4.2043 - 31.3.2044.....	40.0 m <sup>3</sup>
	1.4.2044 - 31.3.2045.....	40.0 m <sup>3</sup>
	1.4.2045 - 31.3.2046.....	40.0 m <sup>3</sup>
	1.4.2046 - 31.3.2047.....	40.0 m <sup>3</sup>
	1.4.2047 - 31.3.2048.....	40.0 m <sup>3</sup>
	1.4.2048 - 31.3.2049.....	40.0 m <sup>3</sup>
	1.4.2049 - 31.3.2050.....	40.0 m <sup>3</sup>
	1.4.2050 - 31.3.2051.....	40.0 m <sup>3</sup>
	1.4.2051 - 31.3.2052.....	40.0 m <sup>3</sup>
	1.4.2052 - 31.3.2053.....	40.0 m <sup>3</sup>
	1.4.2053 - 31.3.2054.....	40.0 m <sup>3</sup>
	1.4.2054 - 31.3.2055.....	40.0 m <sup>3</sup>
	1.4.2055 - 31.3.2056.....	40.0 m <sup>3</sup>
	1.4.2056 - 31.3.2057.....	40.0 m <sup>3</sup>
	1.4.2057 - 31.3.2058.....	40.0 m <sup>3</sup>
	1.4.2058 - 31.3.2059.....	40.0 m <sup>3</sup>
	1.4.2059 - 31.3.2060.....	40.0 m <sup>3</sup>
Total future arisings:		1520.0 m <sup>3</sup>
Total waste volume:		2965.0 m <sup>3</sup>

Comment on volumes: SIXEP to continue generating spent sand and ion exchange material at an assumed rate of 40 m<sup>3</sup>/yr (5 IX bed changes). Current storage volume based upon SONAR scan of BST 13 in August 2021 and SIXOP3 record of BST 14 and MASWEP A waste volumes. Uncertainty in arisings is linked to the forecast frequency of sand bed or ion exchange resin changes and the duration of plant operations in SIXEP.

Uncertainty factors on volumes: Stock (upper): x 1.2 Arisings (upper) x 1.43  
 Stock (lower): x 0.8 Arisings (lower) x 0.88

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**WASTE SOURCE** Waste arises from operation of SIXEP.

**PHYSICAL CHARACTERISTICS**

General description: Waste is a granular material - spent ion exchanger (clinoptilolite) and sand, stored under water. There are no large items requiring special handling. The waste will have settled and consolidated over time.

Physical components (%wt): Current stocks are approx. ion exchange material (60%wt), sand (4%wt) and water (36%wt). The stock by 31/12/2060 is estimated to be of generally similar composition.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m<sup>3</sup>): ~1.5

Comment on density: The density (about 1.5 t/m<sup>3</sup>) is based on the densities of the two constituents (clinoptilolite and sand). Settling and consolidation of the material takes place over time.

**CHEMICAL COMPOSITION**

General description and components (%wt): Current stocks are approx. ion exchange material (60%wt), sand (4%wt) and water (36%wt). The stock by 31/12/2060 is estimated to be of generally similar composition. Spent pre-treated clinoptilolite would probably have a different composition of adsorbed cations compared to natural clinoptilolite.

Chemical state: Neutral

Chemical form of radionuclides: Cl-36: Unknown.  
I-129: Unknown.  
U: Present as metal and oxides.  
Np: Unknown.  
Pu: Present as metal and oxides.

Metals and alloys (%wt): -

	(%wt)	Type(s) / Grade(s) with proportions	%		of total C14 activity
Stainless steel.....	0				
Other ferrous metals.....	0				
Iron.....	0				
Aluminium.....	0				
Beryllium.....	NE				
Cobalt.....	0				
Copper.....	0				
Lead.....	0				
Magnox/Magnesium.....	TR	Very small quantities of Magnox metal may be present, but the quantity is unknown.			
Nickel.....	0				
Titanium.....	0				
Uranium.....	TR	Small quantities of uranium may be present, but the quantity is unknown.			
Zinc.....	0				
Zircaloy/Zirconium.....	0				
Other metals.....	0				

**Organics (%wt):** There are no organics present. Only inorganic ion exchange material is present.

	(%wt)	Type(s) and comment	%		of total C14 activity
Total cellulose.....	0				
Paper, cotton.....	0				
Wood.....	0				
Halogenated plastics .....	0				

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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 .....	0
Fuel.....	0
Asphalt/Tarmac (cont.coal tar)...	0
Asphalt/Tarmac (no coal tar)....	0
Bitumen.....	0
Others.....	0
Other organics.....	0

Other materials (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	~60.0		
Inorganic sludges and flocs.....	0		
Soil.....	0		
Brick/Stone/Rubble.....	0		
Cementitious material.....	0		
Sand.....	~4.0		
Glass/Ceramics.....	0		
Graphite.....	0		
Desiccants/Catalysts.....	0		
Asbestos.....	0		
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....	~36.0		
Free non-aqueous liquids.....	0		
Powder/Ash.....	0		

Inorganic anions (%wt): The waste contains silicates and trace amounts of carbonates. 1996 sample data indicated high levels of chloride which may be erroneous. Other anions given below are unlikely to be present except in trace quantities.

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	(%wt)	Type(s) and comment
Fluoride.....	TR	
Chloride.....	~1.3	Based on 1996 sample results - may be erroneous.
Iodide.....	TR	
Cyanide.....	0	
Carbonate.....	TR	
Nitrate.....	TR	
Nitrite.....	TR	
Phosphate.....	TR	
Sulphate.....	TR	
Sulphide.....	TR	

Materials of interest for waste acceptance criteria: -

	(%wt)	Type(s) and comment
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.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	0	
Higher activity particles.....	P	Sand (4% wt.) and clinoptilolite (60% wt.) particles have activity associated with them.
Soluble solids as bulk chemical compounds.....	0	

Hazardous substances / non hazardous pollutants: None

	(%wt)	Type(s) and comment
Acrylamide.....	0	
Benzene.....	0	
Chlorinated solvents.....	0	
Formaldehyde.....	0	
Organometallics.....	0	
Phenol.....	0	
Styrene.....	0	
Tri-butyl phosphate.....	0	

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Other organophosphates.....	0
Vinyl chloride.....	0
Arsenic.....	0
Barium.....	0
Boron.....	0
Boron (in Boral).....	0
Boron (non-Boral).....	0
Cadmium.....	0
Caesium.....	0
Selenium.....	0
Chromium.....	0
Molybdenum.....	0
Thallium.....	0
Tin.....	0
Vanadium.....	0
Mercury compounds.....	0
Others.....	0
Electronic Electrical Equipment (EEE)	
EEE Type 1.....	0
EEE Type 2.....	0
EEE Type 3.....	0
EEE Type 4.....	0
EEE Type 5.....	0

Complexing agents (%wt):      No

	(%wt)	Type(s) and comment
EDTA.....	0	
DPTA.....	0	
NTA.....	0	
Polycarboxylic acids.....	0	
Other organic complexants.....	0	There are no organic complexing agents present.
Total complexing agents.....	0	

Potential for the waste to contain discrete items:      No. Waste itself not considered as a Discrete Item. This may alter depending on waste packaging arrangements.

**PACKAGING AND CONDITIONING**

Conditioning method:      To be confirmed.  
Plant Name:      To be confirmed.  
Location:      Sellafield.  
Plant startup date:      To be confirmed.  
Total capacity (m³/y incoming waste):      -  
Target start date for packaging this stream:      -

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Throughput for this stream (m<sup>3</sup>/y incoming waste): -

Other information: The strategy for retrieval and packaging of waste from the SIXEP Bulk Storage Tanks is currently undergoing review.

Likely container type:	Container	Waste packaged (%vol)	Waste loading (m <sup>3</sup> )	Payload (m <sup>3</sup> )	Number of packages
	3m <sup>3</sup> box (square corners)	100.0	1.92	2.8	1545

Likely container type comment: 3m<sup>3</sup> box considered as a baseline. Waste materials could also be placed into 500 litre drums.

Range in container waste volume: Container waste loading provided on the basis of raw ion-exchange material being loaded into a 3m<sup>3</sup> box. Note: maximum waste loading is 2.52m<sup>3</sup> but volume reduction factor of 1.31 applies to this waste, yielding 1.92m<sup>3</sup>. Waste loading will vary based on conditioning requirements.

Other information on containers: -

Likely conditioning matrix: Not Specified

Other information: Material may be thermally treated beforehand which may change encapsulant. Encapsulating raw waste may also be required.

Conditioned density (t/m<sup>3</sup>): ~1.5

Conditioned density comment: Density above provided on unconditioned waste.

Other information on conditioning: Two potential conditioning options are: thermal treatment to minimise waste volume, or encapsulation to stabilise the waste. This may significantly change the number of waste package numbers required for these wastes (-66%,+40%)

Opportunities for alternative disposal routing: Yes

Baseline Management Route	Opportunity Management Route	Stream volume (%)	Estimated Date that Opportunity will be realised	Opportunity Confidence	Comment
Disposal at a Geological Disposal Facility	Disposal at a Geological Disposal Facility	NE	NE	Low	Potential opportunity for Thermal Treatment

**RADIOACTIVITY**

Source: The main activity sources are Cs-134, Cs-137, Sr-90 and various alpha species, which are associated with the clinoptilolite and sand. These species would also be present in the water associated with these waste materials.

Uncertainty: Specific activity data is based on limited sample data collected in 1996. Hence, there is a significant degree of uncertainty regarding the accuracy of the data. The data may also not be representative of current operations.

Definition of total alpha and total beta/gamma: Constituents of total alpha activity not known. Total beta was not measured during the 1996 sampling campaign (Beta 5 was measured), and the activities of all relevant beta emitters are unknown.

Measurement of radioactivities: Major radionuclides were measured by analysis of samples taken from storage tanks.

Other information: The activity data has not been decayed because fresh arisings have continued to be fed to the storage tanks since 1996. Activity in older material would have decayed since consignment to the tanks, but it is not currently possible to quantify the effect of this. The activity present in future arisings has not been assessed.

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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					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		6		6	Pb 205				
Fe 55					Pb 210				
Co 60		6		6	Bi 208				
Ni 59					Bi 210m				
Ni 63					Po 210				
Zn 65		6		6	Ra 223				
Se 79					Ra 225				
Kr 81					Ra 226				
Kr 85					Ra 228				
Rb 87					Ac 227				
Sr 90		6		6	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		6		6
Tc 99					U 232				
Ru 106		6		6	U 233				
Pd 107					U 234		6		6
Ag 108m					U 235		6		6
Ag 110m		6		6	U 236		6		6
Cd 109					U 238		6		6
Cd 113m					Np 237				
Sn 119m					Pu 236				
Sn 121m					Pu 238		6		6
Sn 123					Pu 239		6		6
Sn 126					Pu 240		6		6
Sb 125		6		6	Pu 241		6		6
Sb 126					Pu 242		6		6
Te 125m					Am 241				
Te 127m					Am 242m				
I 129					Am 243				
Cs 134		6		6	Cm 242				
Cs 135					Cm 243				
Cs 137		6		6	Cm 244				
Ba 133					Cm 245				
La 137					Cm 246				
La 138					Cm 248				
Ce 144		6		6	Cf 249				
Pm 145					Cf 250				
Pm 147					Cf 251				
Sm 147					Cf 252				
Sm 151					Other a				
Eu 152		6		6	Other b/g				
Eu 154		6		6	<b>Total a</b>	<b>NE</b>	<b>6</b>	<b>NE</b>	<b>6</b>
Eu 155		6		6	<b>Total b/g</b>	<b>NE</b>	<b>6</b>	<b>NE</b>	<b>6</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