

WASTE STREAM	9B21	FED Magnox, Gravel and Interface
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SITE Bradwell

SITE OWNER Nuclear Decommissioning Authority

WASTE CUSTODIAN Magnox Limited

WASTE TYPE LLW

Is the waste subject to Scottish Policy: No

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2022.....	274.0m ³
Total future arisings:		0 m ³
Total waste volume:		274.0m ³
Comment on volumes:	The current stock held at Tradebe awaiting supercompaction and onward disposal is based on a known quantity of drums so uncertainty is low.	
Uncertainty factors on volumes:	Stock (upper): x 1.1	Arisings (upper) x
	Stock (lower): x 0.9	Arisings (lower) x

WASTE SOURCE The stream covers a mixture of Gravel, Oxide and Fuel Element Debris (FED) retrieved from the Active Waste Compound Vaults 0B, 1A, 1B, 2A, 2B, 4A, 4B & 5A; and Gravels/Oxide retrieved from Vaults 7A, 7B & 8A.

PHYSICAL CHARACTERISTICS

General description: FED, gravel and interface. As the materials were retrieved from the vaults, they were sorted into either FED, Gravel or Interface drums. The interface drums arose when the project could no longer separate the FED from the Gravel and so each interface drum consists of a mixture of both FED, Gravel along with some oxides. Best efforts have been made to ensure that the drums do not contain High Dose Rate Items (HDRI), such as nimonic springs or fuel.

Physical components (%vol): Metal (86%), gravel (12%), plastics (1%) and a notional 1% has been included to account for the secondary PPE and filter waste from supercompaction.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m³): 0.63

Comment on density: The bulk density is based on the stock of 172.8te with a raw volume of 274m³ taken from the draft WCH for disposal. Following supercompaction this will increase to 1.62t/m³

CHEMICAL COMPOSITION

General description and components (%wt): Magnox metal (type ZR55) (>60%), fission product and actinide contamination. The potential corrosion products present are detailed in the section above. The quantities/ratios of each potential corrosion product is currently unknown. The chemical composition of the chippings is not known. It is likely that either silica or limestone has been used. Fission products, actinides and other activation products will be present as contaminants.

Chemical state: Neutral

Chemical form of radionuclides: H-3: Tritium is expected to be present as surface contamination possibly as water but perhaps in the form of other inorganic compounds or as organic compounds.
 C-14: Carbon 14 will probably be present as graphite.
 Cl-36: Chlorine 36 incorporated in the Magnox may be associated with barium impurity (BaCl₂). Other chlorine 36 may be associated with surface contamination.
 U: Chemical form of U isotopes has not been determined but may be oxides.
 Np: The chemical form of neptunium has not been determined.
 Pu: Chemical form of Pu isotopes has not been determined but may be oxides.

Metals and alloys (%wt): The thickness of some of the waste will be of the order of a mm or less.

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel.....	0		
Other ferrous metals.....	15.4	FED Drum / filter body	
Iron.....	0.33	FED Alloy	
Aluminium.....	0.45	FED Alloy	
Beryllium.....	0		
Cobalt.....	TR	FED Alloy	
Copper.....	0.01	FED Alloy	
Lead.....	0.05	FED Alloy	
Magnox/Magnesium.....	70.1	FED Alloy	
Nickel.....	0.01	FED Alloy	
Titanium.....	TR	FED Alloy	
Uranium.....			
Zinc.....	0.02	FED Alloy	
Zircaloy/Zirconium.....	0.03	FED Alloy	
Other metals.....	0		
Organics (%wt):	-		
	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulose.....	0		
Paper, cotton.....	0		
Wood.....	0		
Halogenated plastics	0		
Total non-halogenated plastics.....	0.58		
Condensation polymers.....	0.58	Plastic wrapping / PPE	
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.....			
Other materials (%wt):	-		

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	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	0		
Inorganic sludges and flocs.....	NE		
Soil.....	0		
Brick/Stone/Rubble.....	12.0	Gravel	
Cementitious material.....	0		
Sand.....			
Glass/Ceramics.....	0		
Graphite.....	TR		
Desiccants/Catalysts.....			
Asbestos.....	0		
Non/low friable.....			
Moderately friable.....			
Highly friable.....			
Free aqueous liquids.....			
Free non-aqueous liquids.....	0		
Powder/Ash.....			

Inorganic anions (%wt): The inorganic anion content of the gravel has not been fully assessed.

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

Materials of interest for waste acceptance criteria: Magnox will ignite under appropriate conditions.

	(%wt)	Type(s) and comment
Combustible metals.....		
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.....		

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Corrosive materials.....	0	
Pyrophoric materials.....	0	
Generating toxic gases.....	0	
Reacting with water.....	P	1491.8m2
Higher activity particles.....		
Soluble solids as bulk chemical compounds.....		

Hazardous substances / non hazardous pollutants: Polyurathane foam contained within mild steel FED drum filters (0.03%), Also included in the FED alloy - calcium (0.28%), manganese (0.01%), neodymium (0.10%), silicon (0.02%).

	(%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.....	TR	FED Alloy
Caesium.....		
Selenium.....		
Chromium.....	0.01	FED Alloy
Molybdenum.....		
Thallium.....		
Tin.....		
Vanadium.....		
Mercury compounds.....		
Others.....	0.44	Polyurathane foam contained within mild steel FED drum filters (0.03%), Also included in the FED alloy - calcium (0.28%), manganese (0.01%), neodymium (0.10%), silicon (0.02%)
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): No

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids.....		
Other organic complexants.....		
Total complexing agents.....	0	

Potential for the waste to contain discrete items: No. In & of itself not a DI - un-grouted, compacted drums assumed to not be DIs

TREATMENT, PACKAGING AND DISPOSAL

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

Treatment	On-site / Off site	Stream volume %
Low force compaction		
Supercompaction (HFC)	Off-site	96.2
Incineration	Off-site	3.8
Solidification		
Decontamination		
Metal treatment		
Size reduction		
Decay storage		
Recycling / reuse		
Other / various		
None		100.0

Comment on planned treatments:

The waste will be supercompacted prior to disposal to increase the packing efficiency in the disposal container.

Disposal Routes:

Disposal Route	Stream volume %	Disposal density t/m3
Expected to be consigned to the LLW Repository	96.2	1.6
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	3.8	0.40
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		

Classification codes for waste expected to be consigned to a landfill facility: -

Upcoming (2022/23-2024/25) Waste Routing (if expected to change from above):

Disposal Route	Stream volume %		
	2022/23	2023/24	2024/25
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			

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Opportunities for alternative disposal routing: -

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

Waste Packaging for Disposal:

Container	Stream volume %	Waste loading m ³	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	96.2	25.7	11

Other information: Raw waste volume is assumed to reduce by factor of 0.39 upon supercompaction. Assuming standard 10m³ per HHISO for disposal of compacted waste this equates to 25.7m³ of raw waste volume per container.

Waste Planned for Disposal at the LLW Repository:

Container voidage: -

Waste Characterisation Form (WCH): The waste meets the LLWR's Waste Acceptance Criteria (WAC). The waste does not have a current WCH.

Waste consigned for disposal to LLWR in year of generation: No. Waste was consigned from Bradwell site in 2018 to be supercompacted and disposed of to LLWR and as a result was not included in RWI 2019. Delays with the supercompaction and disposal from the treatment site mean that it is to be included again in the 2022 RWI whilst this work completes.

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

Stream volume (%): -

Waste stream variation: -

Bounding cuboidal volume:

Inaccessible voidage: -

Other information: -

RADIOACTIVITY

Source: The source of the waste is the removal of splitters from fuel elements prior to dispatch of the elements for reprocessing. Activation of trace elements in the Magnox and contamination by fission products and actinides will be the main sources of activity.

Uncertainty: 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: Values were derived from measurements, calculations of induced activity and estimates of likely contamination. A campaign of sampling was undertaken during the retrieval of the material. Values above are based on WCH for LLWR ref 1MXN-3BRA-0-WCH-L-3775 V13 decayed 6 years for RWI 2022

Other information: -

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Nuclide	Mean radioactivity, TBq/m ³				Nuclide	Mean radioactivity, TBq/m ³			
	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	3.40E-03	CC 1			Gd 153		8		
Be 10		8			Ho 163		8		
C 14	8.17E-05	CC 1			Ho 166m		8		
Na 22		8			Tm 170		8		
Al 26		8			Tm 171		8		
Cl 36	8E-06	CC 2			Lu 174		8		
Ar 39		8			Lu 176		8		
Ar 42		8			Hf 178n		8		
K 40		8			Hf 182		8		
Ca 41		8			Pt 193		8		
Mn 53		8			Tl 204		8		
Mn 54		8			Pb 205		8		
Fe 55	2.29E-05	CC 1			Pb 210		8		
Co 60	8.01E-05	CC 2			Bi 208		8		
Ni 59		8			Bi 210m		8		
Ni 63	8.64E-04	CC 1			Po 210		8		
Zn 65		8			Ra 223		8		
Se 79		8			Ra 225		8		
Kr 81		8			Ra 226		8		
Kr 85		8			Ra 228		8		
Rb 87		8			Ac 227		8		
Sr 90	3.73E-04	CC 1			Th 227		8		
Zr 93		8			Th 228		8		
Nb 91		8			Th 229		8		
Nb 92		8			Th 230		8		
Nb 93m		8			Th 232		8		
Nb 94		8			Th 234	1.46E-09	CC 2		
Mo 93		8			Pa 231		8		
Tc 97		8			Pa 233		8		
Tc 99		8			U 232		8		
Ru 106		8			U 233		8		
Pd 107		8			U 234	2.06E-09	CC 2		
Ag 108m	9.07E-05	CC 2			U 235		8		
Ag 110m		8			U 236		8		
Cd 109		8			U 238	1.46E-09	CC 2		
Cd 113m		8			Np 237		8		
Sn 119m		8			Pu 236		8		
Sn 121m		8			Pu 238	4.28E-05	CC 1		
Sn 123		8			Pu 239	8.44E-05	CC 1		
Sn 126		8			Pu 240	8.75E-05	CC 1		
Sb 125		8			Pu 241	6.62E-04	CC 1		
Sb 126		8			Pu 242		8		
Te 125m		8			Am 241	3.47E-04	CC 1		
Te 127m		8			Am 242m		8		
I 129		8			Am 243		8		
Cs 134		8			Cm 242		8		
Cs 135		8			Cm 243	2.29E-07	CC 1		
Cs 137	4.16E-05	CC 2			Cm 244	1.69E-07	CC 1		
Ba 133	1.1E-06	CC 2			Cm 245		8		
La 137		8			Cm 246		8		
La 138		8			Cm 248		8		
Ce 144		8			Cf 249		8		
Pm 145		8			Cf 250		8		
Pm 147	1E-07	CC 1			Cf 251		8		
Sm 147		8			Cf 252		8		
Sm 151	2.35E-06	CC 2			Other a				
Eu 152	2.4E-07	CC 2			Other b/g				
Eu 154	2.25E-06	CC 2			Total a	5.62E-04	CC 2	0	
Eu 155	9.42E-07	CC 2			Total b/g	5.63E-03	CC 2	0	

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