WASTE STREAM 5G303 DRAGON Reactor Decommissioning LLW

SITE	Winfrith
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.....	0 m^3
Future arisings -	1.4.2022 - 31.3.2027.....	585.5 m^3
Total future arisings:		585.5 m^3
Total waste volume:		585.5 m^3

Comment on volumes: Decommissioning and deplanting of buildings prior to demolition and clearance of structures. Volume updated for 2016 RWI to reflect SMART Inventory review.

Uncertainty factors on volumes:

Stock (upper):	x	Arisings (upper)	x 1.5
Stock (lower):	x	Arisings (lower)	x 0.5

WASTE SOURCE The waste consists of all arisings from the Dragon reactor decommissioning.

PHYSICAL CHARACTERISTICS

General description: The waste is primarily formed of metallics wastes, concrete, grout and soft wastes such as PPE.

Physical components (%wt): Concrete and brick from building structures 70%, Pressure vessel, Main Shield Plug and Associated metalwork 23%, mixed waste including waste in IP2 drums, plastic from various fittings 7%.

Sealed sources: The waste does not contain sealed sources.

Bulk density (t/m^3): ~2.44

Comment on density: Waste stream mass divided by volume taken from draft WCH

CHEMICAL COMPOSITION

General description and components (%wt): Concrete and brick ~70%, metalwork ~23%, mixed waste 7%

Chemical state: Neutral

Chemical form of radionuclides:
H-3: Radionuclides are present as trace elements in the activated materials. Present through contamination.
C-14: Radionuclides are present as trace elements in the activated materials. Present through contamination.
Cl-36: Radionuclides are present as trace elements in the activated materials.
Se-79: Radionuclides are present as trace elements in the activated materials.
Tc-99: Radionuclides are present as trace elements in the activated materials.
I-129: Radionuclides are present as trace elements in the activated materials.
Ra: Radionuclides are present as trace elements in the activated materials. Possible presence through contamination.
Th: Radionuclides are present as trace elements in the activated materials. Possible presence through contamination.
U: Radionuclides are present as trace elements in the activated materials. Present through contamination.
Np: Radionuclides are present as trace elements in the activated materials. Possible presence through contamination.
Pu: Radionuclides are present as trace elements in the activated materials. Present through contamination.

Metals and alloys (%wt): Plate thicknesses are 1" for the thermal shield plates, ~2" for the pressure vessel. Other material will be present from non-core items. It should be noted that the material will be sized reduced to allow it to be packed into the containers.

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel	~0.14	Items from Dragon facility	
Other ferrous metals	17.5	Variety of items from Dragon facility	
Iron			
Aluminium			
Beryllium	0		
Cobalt			
Copper	~0.01	Copper items from Dragon facility	
Lead	~0.07	Solid (chevrons etc.) / lead shot	
Magnox/Magnesium	~0.05	Magnesium Oxide (within pyro cable)	
Nickel			
Titanium			
Uranium			
Zinc			
Zircaloy/Zirconium	0		
Other metals	5.3	Undefined from WCH data	

Organics (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics	1.0		
Paper, cotton	0		
Wood	1.0		
Halogenated plastics	~0.01	Solid - PPE, PVC etc.	
Total non-halogenated plastics	~0.46	Solid - PPE, Containers etc.	
Condensation polymers	~0.23		
Others	~0.23		
Organic ion exchange materials	0		
Total rubber	1.0		
Halogenated rubber	0.50		
Non-halogenated rubber	0.50		
Hydrocarbons	~0.01		
Oil or grease	~0.01		
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.....	0		
Soil.....	0		
Brick/Stone/Rubble.....	70.0		
Cementitious material.....	P		
Sand.....			
Glass/Ceramics.....	~0.08	Man Made Mineral Fibres mainly within cement	
Graphite.....	P		
Desiccants/Catalysts.....			
Asbestos.....	~0.13		
Non/low friable.....			
Moderately friable.....			
Highly friable.....	~0.13	Chrysotile and Amosite	
Free aqueous liquids.....	0		
Free non-aqueous liquids.....	0		
Powder/Ash.....	P		

Inorganic anions (%wt): ~0.02% is thermal insulation (Newtherm), a, calcium silicate

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

Materials of interest for waste acceptance criteria: ~1.8 m3 asbestos in IP2 containers was identified in the SMART review.

	(%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.....	1.0	
Putrescible wastes.....	0	
Non-putrescible wastes.....	1.0	

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

Hazardous substances / non hazardous pollutants: Some lead will be present. Powders are likely to result from cutting during removal and size reduction. Asbestos present.

	(%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.....	0.01	Alloy within steel
Molybdenum.....		
Thallium.....		
Tin.....		
Vanadium.....		
Mercury compounds.....		
Others.....	1.0	plasterboard
Electronic Electrical Equipment (EEE)		
EEE Type 1.....	P	250 off Stripped down circuit boards
EEE Type 2.....		
EEE Type 3.....	P	150 items
EEE Type 4.....		
EEE Type 5.....	P	10 off Rechargeable batteries

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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: Not yet determined. In & of itself not a DI; waste stream may include DIs (notably any stainless steel components)Large Concrete Items (LCIs) may be DIs; drummed (ungrouted)/"rubbleised" wastes assumed not DIs

TREATMENT, PACKAGING AND DISPOSAL

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

Treatment	On-site / Off site	Stream volume %
Low force compaction		
Supercompaction (HFC)		
Incineration	Off-site	0.01
Solidification		
Decontamination		
Metal treatment		
Size reduction		
Decay storage		
Recyling / reuse		
Other / various		
None		100.0

Comment on planned treatments: 97.75% of the stream is expected to be disposed of as VLLW to landfill.

Disposal Routes:

Disposal Route	Stream volume %	Disposal density t/m3
Expected to be consigned to the LLW Repository	2.2	2.4
Expected to be consigned to a Landfill Facility	97.8	2.4
Expected to be consigned to an On-Site Disposal Facility		
Expected to be consigned to an Incineration Facility	0.01	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: 17 04 07, 17 05 03*/04

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 m³	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	2.2	~10	2

Other information: Stream volume and disposal routing information has been updated in line with new draft WCH currently under assessment. Physical composition and fingerprint remain aligned with current approved/extended version of the WCH (1MXN-2WIN-0-WCH-0-4353 V1).

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 has a current WCH.
Differences exist between Inventory information and current WCH.

Waste consigned for disposal to LLWR in year of generation: Yes.

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: Neutron induced activity of structural components. Fuel/ fission product contamination not yet assessed, but believed to be negligible in core components. Contamination levels in non-core plant are significant and will be quantified in the future.

Uncertainty: The radionuclide inventory has been derived from activation modelling of the core LLW components only. Therefore the radionuclides present are those theoretically predicted to arise by the model from neutron activation. The data therefore requires caution in two respects: (i) it will generally (except in the case of fission product contamination e.g. Cs137) be a very conservative upper limit. (ii) the radionuclides are theoretically predicted to arise from activation of trace elements in reactor components but may not actually be present. The strategy to address these issues is further sampling and analysis to produce fingerprints as the decommissioning work proceeds.

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: A reactor activation study was carried out based on a 3-D Monte Carlo neutron transport code to determine energy dependent neutron flux spectra, and on the EASY/FISPACT neutron activation code. This addresses core components only (see above comments).

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	The majority of wastes will actually be contaminated components. Activity data based on WCH: 1MXN-2WIN-0-WCH-0-4353 V1 and decayed by five years.
Other information:	-

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Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code	Nuclide	Mean radioactivity, TBq/m³ Waste at 1.4.2022	Bands and Code	Future arisings	Bands and Code
H 3			5.88E-05	C C 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			1.22E-06	C C 2	Ho 166m				8
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			1.37E-08	C C 2	Lu 174				8
Ar 39				8	Lu 176				8
Ar 42				8	Hf 178n				8
K 40				8	Hf 182				8
Ca 41			3.37E-07	C C 2	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55			3.77E-07	C C 2	Pb 210				8
Co 60			4.63E-06	C C 2	Bi 208				8
Ni 59			2.42E-07	C C 2	Bi 210m				8
Ni 63			1.63E-05	C C 2	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			2.68E-06	C C 2	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			1.73E-08	C C 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			1.41E-08	C C 2
Ag 108m				8	U 235			2.28E-09	C C 2
Ag 110m				8	U 236				8
Cd 109				8	U 238			1.73E-08	C C 2
Cd 113m				8	Np 237				8
Sn 119m				8	Pu 236				8
Sn 121m				8	Pu 238			1.49E-08	C C 2
Sn 123				8	Pu 239			1.22E-09	C C 2
Sn 126				8	Pu 240			1.22E-09	C C 2
Sb 125				8	Pu 241			6.5E-08	C C 2
Sb 126				8	Pu 242				8
Te 125m				8	Am 241			2.99E-08	C C 2
Te 127m				8	Am 242m				8
I 129				8	Am 243				8
Cs 134				8	Cm 242				8
Cs 135				8	Cm 243			1.16E-09	C C 2
Cs 137			9.63E-06	C C 2	Cm 244			1.07E-09	C C 2
Ba 133				8	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				8	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151				8	Other a				
Eu 152			3.61E-06	C C 2	Other b/g				
Eu 154			1.42E-07	C C 2	**Total a**	**0**		**8.32E-08**	**C C 2**
Eu 155				8	**Total b/g**	**0**		**9.81E-05**	**C C 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