WASTE STREAM 5C302 BEPO Reactor Decommissioning ILW

SITE	Harwell
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Magnox Limited
WASTE TYPE	ILW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	0 m³
Future arisings -	1.4.2019 - 31.3.2025.....	561.0 m³
Total future arisings:		561.0 m³
Total waste volume:		561.0 m³

Comment on volumes: Volume updated for 2016 RWI to reflect SMART Inventory Review.

Uncertainty factors on volumes:

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

WASTE SOURCE Reactor decommissioning of 6.5 MW(T) reactor with graphite moderator and air cooling.

PHYSICAL CHARACTERISTICS

General description:	Graphite bricks (740 x 185 x 185mm) moderator, and reflector, some of which have been in contact with the fuel elements. Mild steel plate 5/8" thick.
Physical components (%wt):	Graphite blocks, moderator and reflector (9.6%) and steel plates (0.4%). Small amounts of stainless steel and boron carbide. Trace amounts of aluminium and potentially bismuth.
Sealed sources:	-
Bulk density (t/m³):	2.3
Comment on density:	This is based on the theoretical densities of: Graphite = 1.64 t/m³; Steel = 7.9 t/m³.

CHEMICAL COMPOSITION

General description and components (%wt):	Graphite (98%) and steel (2%).
Chemical state:	Neutral
Chemical form of radionuclides:	H-3: Present in graphite. C-14: Present in graphite. Cl-36: Present from the activation of trace imputities in the graphite.
Metals and alloys (%wt):	The mild steel plates are 5/8" thick.

Stainless steel.....	TR	
Other ferrous metals.....	2.0	Mild steel
Iron.....		
Aluminium.....	TR	
Beryllium.....	0	
Cobalt.....		
Copper.....	0	
Lead.....	0	
Magnox/Magnesium.....	0	
Nickel.....		
Titanium.....		
Uranium.....	0	
Zinc.....	0	
Zircaloy/Zirconium.....	0	
Other metals.....	TR	The thermal column may contain small amounts of cadmium and

bismuth.

Organics (%wt):	No organics are present.	
	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	
	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	0
	Soil	0
	Brick/Stone/Rubble	0
	Cementitious material	0
	Sand	
	Glass/Ceramics	0
	Graphite	98.0
	Desiccants/Catalysts	
	Asbestos	0
	Non/low friable	
	Moderately friable	
	Highly friable	
	Free aqueous liquids	0
	Free non-aqueous liquids	0
	Powder/Ash	0
Inorganic anions (%wt):	None present.	

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: There is a possibility of stored Wigner energy in the graphite.

Combustible metals..... 0

Low flash point liquids..... 0

Explosive materials..... 0

Phosphorus..... 0

Hydrides..... 0

Biological etc. materials..... 0

Biodegradable materials.....

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: None expected.

Acrylamide.....

Benzene.....

Chlorinated solvents.....

Formaldehyde.....

Organometallics.....

Phenol.....

Styrene.....

Tri-butyl phosphate.....

Other organophosphates.....

Vinyl chloride.....

Arsenic.....

Barium.....

Boron.....

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

PACKAGING AND CONDITIONING

Conditioning method:	The graphite will be annealed to release the Wigner energy prior to packaging in to 6m3 boxes for long-term storage in the Harwell ILW Store.
Plant Name:	BEP0 waste packaging plant
Location:	Harwell
Plant startup date:	2019
Total capacity (m^3/y incoming waste):	-
Target start date for packaging this stream:	2019
Throughput for this stream (m^3/y incoming waste):	-
Other information:	-

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m^3)	Payload (m^3)	Number of packages
6m^3 concrete box (SD)	100.0	2.895	5.8	194

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Likely container type comment:	-
Range in container waste volume:	The waste loadings and payload factor given are for an average graphite package, which will form the majority of packages. Metals will be segregated and packaged separately, and will have a lower waste loading of ~2m3.
Other information on containers:	-
Likely conditioning matrix:	Pulverised Fly Ash / Ordinary Portland Cement
Other information:	-
Conditioned density (t/m³):	~2.3
Conditioned density comment:	Conditioned mass divided by payload volume for average graphite package. Density will be in the range 1.8 to 2.4 for other packages.
Other information on conditioning:	-
Opportunities for alternative disposal routing:	

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source:	Activation of graphite and steel. There may be spot contamination of fission products.
Uncertainty:	Alpha activity associated with the wastes is minimal as no fuel was damaged.
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:	Specific activities are based on a sampling campaign and calculations based on the operational life of the reactor, given in 2013 conceptual LoC submission 2013. Decay corrected to date of arising.
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			1.11E-02	B B 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			1.96E-02	B B 2	Ho 166m				8
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			3.96E-05	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			1.31E-05	C C 2	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55			1.93E-05	C C 2	Pb 210				8
Co 60			4.29E-04	B B 2	Bi 208				8
Ni 59			1.05E-04	D D 2	Bi 210m				8
Ni 63			8.83E-03	D D 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				8	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			2.41E-06	D D 2	Th 234				8
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				8
Ag 108m				8	U 235				8
Ag 110m				8	U 236				8
Cd 109				8	U 238				8
Cd 113m			1.56E-07	D D 2	Np 237				8
Sn 119m				8	Pu 236				8
Sn 121m				8	Pu 238				8
Sn 123				8	Pu 239				8
Sn 126				8	Pu 240				8
Sb 125				8	Pu 241				8
Sb 126				8	Pu 242				8
Te 125m				8	Am 241				8
Te 127m				8	Am 242m				8
I 129				8	Am 243				8
Cs 134				8	Cm 242				8
Cs 135				8	Cm 243				8
Cs 137				8	Cm 244				8
Ba 133			4.14E-07	D D 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				8	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151			7.87E-07	D D 2	Other a				
Eu 152			8.59E-04	B B 2	Other b/g				
Eu 154			3.07E-04	B B 2	**Total a**	**0**		**0**	
Eu 155			3.77E-07	D D 2	**Total b/g**	**0**		**4.13E-02**	**D D 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