WASTE STREAM 9R102 Berkeley Centre Decommissioning : Primary LLW

SITE	Berkeley
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 m³
Future arisings -	1.4.2022 - 31.3.2034.....	184.3 m³
Total future arisings:		184.3 m³
Total waste volume:		184.3 m³
Comment on volumes:	-	
Uncertainty factors on volumes:	Stock (upper): x	Arisings (upper) x 1.2
	Stock (lower): x	Arisings (lower) x 0.8

WASTE SOURCE

General LLW waste arisings from initial decommissioning of the Berkeley Centre. The main source of the waste is from glove boxes, caves and cells used for post irradiation examination (PIE) of fuel, reactor graphite and steel from Magnox and Advance Gas Reactor (AGR) power stations throughout the UK. Following PIE and analysis, items were sent to the Berkeley Centre ILW store. Following de licence of the Berkeley Centre the site boundaries were changed, and the Shielded Area arisings were included in these waste streams along with some waste from the ILW store.

PHYSICAL CHARACTERISTICS

General description:	Contaminated structural material (e.g. concrete and pond scabblings), fixtures, fittings and equipment comprised of mostly metals and plastics and associated secondary waste from decommissioning. Items include ladders, tooling, scaffolding, cabling, ventilation equipment. Laboratory waste from PIE and analysis of fuels, graphite and steels (i.e. consumable laboratory items) along with waste from remote inspection activities at the Littlebrook site. The predominant materials are metal, plastics and rubber. Redundant equipment utilised in PIE and analysis of fuel, graphite and steels. The predominant material is metal, with small quantities of plastics and rubble. Items include cave cans, pipework, tooling. Waste from contamination control procedures applied during the extraction of primary decommissioning waste at the Berkeley Centre, including paper, cotton and plastics.
Physical components (%wt):	Metal (87%), Concrete/Rubble (2%), Biodegradable (non-putrescibles) (4%), Plastics (Halogenated) (1%), Plastics (non-halogenated) (2%), Rubber (1%), Wood (2%), Others (1%).
Sealed sources:	The waste does not contain sealed sources.
Bulk density (t/m³):	~4.42
Comment on density:	Derived from WCH mass / volume (1MXN-1BNL-0-WCH-0-4683 V4)

CHEMICAL COMPOSITION

General description and components (%wt):	A variety of materials including Metal (87%), Concrete/Rubble (2%), Biodegradable (non-putrescible) (4%), Plastics (Halogenated) (1%), Plastics (non-halogenated) (2%), Rubber (1%), Wood (2%), Others (1%).
Chemical state:	Neutral
Chemical form of radionuclides:	H-3: The chemical form of tritium has not been assessed. C-14: The chemical form of carbon 14 has not been assessed. Cl-36: The chemical form of chlorine 36 has not been assessed. Ra: The radium isotope content is expected to be insignificant. Th: Thethorium isotope content is expected to be insignificant. U: The chemical form of uranium isotopes has not been assessed. Pu: The chemical form of plutonium isotopes has not been assessed.
Metals and alloys (%wt):	Some items may have been cut for packaging but an assessment of item dimensions has not been made.

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	(%wt)	Type(s) / Grade(s) with proportions	% of total C14 activity
Stainless steel	~37.7	Assorted stainless steel including: Pipework, tooling, fixtures, fittings, beams, cave-cans, and other miscellaneous plant items and equipment	
Other ferrous metals	~25.1	Drums, Pipework, tooling, fixtures, fittings, beams, cave-cans, and other miscellaneous plant items and equipment.	
Iron			
Aluminium	~2.0	Ladders, scaffolding, HEPA filters and miscellaneous items and equipment	
Beryllium			
Cobalt			
Copper	~2.4	Copper cabling	
Lead	~19.7	Lead shielding blocks	
Magnox/Magnesium			
Nickel			
Titanium			
Uranium			
Zinc	~0.04	Miscellaneous galvanised items, HEPA filters	
Zircaloy/Zirconium			
Other metals	NE		

Organics (%wt): Some organic materials may be present.

	(%wt)	Type(s) and comment	% of total C14 activity
Total cellulosics	~2.0		
Paper, cotton	~0		
Wood	~2.0		
Halogenated plastics	~1.0	Plastic sheeting, tents, bags, packaging, PPE	
Total non-halogenated plastics	~2.0		
Condensation polymers	~1.0	Plastic wrap, tents, bags, packaging, containers, PPE	
Others	~1.0	Plastic wrap, tents, bags, packaging, containers, PPE	
Organic ion exchange materials	0		
Total rubber	~1.0		
Halogenated rubber	~1.0		
Non-halogenated rubber	NE		
Hydrocarbons			
Oil or grease			
Fuel			
Asphalt/Tarmac (cont.coal tar)			
Asphalt/Tarmac (no coal tar)			
Bitumen			

Others.....			
Other organics.....	NE		

Other materials (%wt): -

	(%wt)	Type(s) and comment	% of total C14 activity
Inorganic ion exchange materials..	0		
Inorganic sludges and flocs.....	0		
Soil.....	NE		
Brick/Stone/Rubble.....	NE		
Cementitious material.....	~2.0	Of which circa 0.02% is encapsulated sludge	
Sand.....			
Glass/Ceramics.....	~0.14	Lagging	
Graphite.....	NE		
Desiccants/Catalysts.....			
Asbestos.....	~0.81		
Non/low friable.....	~0.27	Equal portions of white/brown/blue asbestos assumed. Lagging / Contaminated clothing / Insulation Board	
Moderately friable.....	~0.27	Equal portions of white/brown/blue asbestos assumed. Lagging / Contaminated clothing / Insulation Board	
Highly friable.....	~0.27	Equal portions of white/brown/blue asbestos assumed. Lagging / Contaminated clothing / Insulation Board	
Free aqueous liquids.....	0		
Free non-aqueous liquids.....	0		
Powder/Ash.....	0		

Inorganic anions (%wt): Not fully assessed.

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

Materials of interest for waste acceptance criteria: Less than 1% by weight asbestos is present

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	(%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.....	P	
Putrescible wastes.....	0	
Non-putrescible wastes.....	P	
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: Approximately 1% by weight asbestos is present. Trace amounts of barium and bromine in lamps <1m3.

	(%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.....		
Molybdenum.....		
Thallium.....		
Tin.....		
Vanadium.....		

Mercury compounds.....		
Others.....		
Electronic Electrical Equipment (EEE)		
EEE Type 1.....		
EEE Type 2.....		
EEE Type 3.....		
EEE Type 4.....	P	100 off flourescent light tubes @ 0.24 kg each = 24.00 kg
EEE Type 5.....		

Complexing agents (%wt): Yes

	(%wt)	Type(s) and comment
EDTA.....		
DPTA.....		
NTA.....		
Polycarboxylic acids…….		
Other organic complexants.....	TR	Citrates from Decon90
Total complexing agents.....	TR	

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)

TREATMENT, PACKAGING AND DISPOSAL

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

Treatment	On-site / Off site	Stream volume %
Low force compaction	On-site	4.0
Supercompaction (HFC)	Off-site	4.0
Incineration	Off-site	46.0
Solidification		
Decontamination		
Metal treatment	Off-site	34.0
Size reduction		
Decay storage		
Recyling / reuse		
Other / various		
None		16.0

Comment on planned treatments: ~15% of this waste stream is expected to be sent to Landfill as VLLW .

Disposal Routes:

Disposal Route	Stream volume %	Disposal density t/m3
Expected to be consigned to the LLW Repository	5.0	4.4
Expected to be consigned to a Landfill Facility	15.0	4.4
Expected to be consigned to an On-Site Disposal Facility		
Expected to be consigned to an Incineration Facility	46.0	0.40
Expected to be consigned to a Metal Treatment Facility	34.0	1.4
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 01 01, 17 06 01*

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

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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			

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	~4.0	43.2	< 1
1/2 Height IP-2 Disposal/Re-usable ISO	~1.0	10	< 1
2m box (no shielding)			
4m box (no shielding)			
Other			

Other information: It is likely that this waste will be placed in a container with other LLW. 43.2m3 loading volume for WAMAC 1/2 height ISO is calculated based on the fact that you can low force compact two times the normal volume of waste into a 200 litre/0.2m3 drum (400 litres/0.4m3), you can then fit 36 drums (14.4m3) into a ½ height ISO, each drum can be super-compacted to a 1/3 of its original volume so therefore we can get 3 x the amount of un-compacted drums into the final disposal container (43.2m3).

Waste Planned for Disposal at the LLW Repository:

Container voidage: No significant inaccessible voidage is expected to be present.

Waste Characterisation Form (WCH): The waste meets the LLWR's Waste Acceptance Criteria (WAC).
The waste has a current WCH.
Inventory information is consistent with the 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

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Source:	Contamination of the materials.
Uncertainty:	Only approximate estimates have been made of specific activities from measured activity on waste drums and the use of fingerprints.
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:	Data based on 1MXN-1BNL-0-WCH-0-4683 V4 decayed by two years from April 2020 to April 2022 to the start date of arisings. The fingerprint for Berkeley 9R102 was originally derived from five sources; Magnox and AGR Graphite, AGR Fuel Waste, General Magnox Trash Steel. The waste inventory was derived from fingerprints based on multiple swab samples and bulk samples.
Other information:	No radionuclides other than those listed as possibly being present are expected to be significant.

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Nuclide	Mean radioactivity, TBq/m³				Nuclide	Mean radioactivity, TBq/m³			
	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			1.48E-06	C C 2	Gd 153				8
Be 10				8	Ho 163				8
C 14			2.39E-07	C C 2	Ho 166m				8
Na 22				8	Tm 170				8
Al 26				8	Tm 171				8
Cl 36			5.8E-07	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				8	Pt 193				8
Mn 53				8	Tl 204				8
Mn 54				8	Pb 205				8
Fe 55			1.44E-07	C C 2	Pb 210				8
Co 60			3.46E-07	C C 2	Bi 208				8
Ni 59				8	Bi 210m				8
Ni 63			6.74E-06	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			1.13E-04	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			7.56E-08	C C 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			1.4E-07	C C 2	U 235				8
Ag 110m				8	U 236				8
Cd 109				8	U 238				8
Cd 113m				8	Np 237				8
Sn 119m				8	Pu 236				8
Sn 121m				8	Pu 238			3.46E-06	C C 2
Sn 123				8	Pu 239			1.21E-06	C C 2
Sn 126				8	Pu 240			1.59E-06	C C 2
Sb 125			1.92E-08	C C 2	Pu 241			4.83E-05	C C 2
Sb 126				8	Pu 242				8
Te 125m			4.82E-09	C C 2	Am 241			6.07E-06	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			1.6E-08	C C 2
Cs 137			1.18E-04	C C 2	Cm 244			7.72E-07	C C 2
Ba 133			3.95E-08	C C 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			2.41E-07	C C 2	Cf 251				8
Sm 147				8	Cf 252				8
Sm 151				8	Other a				
Eu 152			1.86E-07	C C 2	Other b/g				
Eu 154			5.67E-07	C C 2	**Total a**	**0**		**1.31E-05**	**C C 2**
Eu 155			7.66E-08	C C 2	**Total b/g**	**0**		**2.89E-04**	**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