WASTE STREAM 9J23 Bunker Waste

SITE	Hunterston A
SITE OWNER	Nuclear Decommissioning Authority
WASTE CUSTODIAN	Magnox Limited
WASTE TYPE	ILW

WASTE VOLUMES

		Reported
Stocks:	At 1.4.2019.....	595.4 m³
Total future arisings:		0 m³
Total waste volume:		595.4 m³

Comment on volumes: There will be no future arisings of this stream; the bunker is nominally full. The total waste volume is made up of the sum of FED Magnox 563.7m3, FED graphite 4m3, MCI 26.7m3, FED Fuel Channel Components 0.15m3 and MAC 0.8m3.

Uncertainty factors on volumes:

Stock (upper):	x 1.2	Arisings (upper)	x
Stock (lower):	x 0.7	Arisings (lower)	x

WASTE SOURCE FED Magnox - Fuel element debris, from the removal of Magnox splitters and buttons from discharged fuel elements.FED Graphite - Fuel element debris from the removal of graphite sleeves from discharged fuel elements plus reflector sleeves from each fuel channel.FED Fuel Channel components - The waste consists of components from reactor fuel assemblies.MAC - The source of the waste is miscellaneous activated in-core components.MCI - The source of the waste is redundant contaminated equipment and materials.

PHYSICAL CHARACTERISTICS

General description: FED Magnox - The waste consists of splitters and buttons from discharged fuel elements. Each fuel element comprises a Magnox can with 4 splitter blades. These blades are sheared off. Each piece of Magnox is generally small (75 mm long) with an average mass of 0.1125 kg which includes a percentage of the braces (i.e. mass of Magnox per fuel element is 0.45 kg). Magnox buttons (one per element) each weigh 1.7g. No items require special handling. During initial station operation the desplittering process involved baling Magnox into 150 mm diameter bales.FED Graphite - Each fuel channel comprised 10 fuel elements (with associated graphite sleeves) and a disposable bottom reflector graphite sleeve. The fuel element sleeve and the reflector have been removed from the fuel and reduced in size in a cracking unit. The resultant graphite pieces have a maximum size of 300 mm and weight of 5.5 kg. Dust from the cracking operation has been accumulated in polythene bags or bottles. There are no large items that may require special handling.FED Fuel Channel Components - Fuel channel components are metallic and consist of one cast iron support member and ten zirconium `D' bars per fuel channel. There are no large items that may require special handling..MAC - The waste consists of thermocouple cables, control rod wires, BCD clips, and contact assemblies. There are no large items that may require special handling.MCI - The waste consists mainly of redundant pond fuel handling equipment, filters, filter dust bags, general metallic waste and incinerator ash bags and some 20-litre cans of sludge. Items must have a dimension less than 1.3 metres to pass through a bunker loading hole. Wastes may be in polythene bags or 180-litre drums. No large items have been identified apart from pond skips which have a volume of 1.2 m3 and weigh 350 kg.

Physical components (%wt): FED Magnox (94.68%) - Splitter blades (99.9 wt%), Magnox buttons (<0.1 wt%). By volume, there is 95% of solid and 5% powder.FED Graphite (0.67%) - Fuel element sleeves (99 wt%), reflector sleeves (1 wt%), polythene bags and bottles (trace wt%).FED Fuel Channel Components (0.03%) - Support members (~44% wt), D-bars (~56% wt).MAC (0.13%) - Thermocouple cables (~94% wt), control rod wire (~4% wt), other items (~2% wt).MCI (4.48%) - Percentage breakdown of physical constituents by weight is as follows, filters (~14%), filter dust bags (~28%), sludge (~4%), incinerator ash (~20%), general waste (~29%), pond skips (~5%). By volume, the solid and powders are 50% each.

Sealed sources: -

Bulk density (t/m³): 0.27

Comment on density: Mean bulk density is 0.25 t/m3. This assumes a packing fraction of 1/7 (= 0.143).

CHEMICAL COMPOSITION

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General description and components (%wt): FED Magnox - The waste is comprised of (~100%) Magnox AL80 alloy. The Magnox may be contaminated by fission products and actinides. Some corrosion product, magnesium hydroxide, may be present (<0.3 wt %).FED Graphite - Graphite (100%), graphite impurities. The waste consists almost entirely of graphite with only trace amounts of activated impurities, fission product and, actinide contaminants and metals. Also trace quantities of polythene.FED Fuel Channel Components - The waste consists of cast iron and zirconium metal. Cast iron (~44%), zirconium (~56%).MAC - The waste consists principally of stainless steel, with other unspecified metals.MCI - The waste consists of metals such as stainless steel, mild steel and aluminium alloys, entrapped graphite dust and other dust, and ceramic material and incinerator ash. Some sludge and ion exchange resin is also present (~4% wt), this contains organic materials including polymers and cellulose (~5 wt%).

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 or organic compounds.
C-14: Carbon 14 will be present as graphite.
Cl-36: Chlorine 36 incorporated in the Magnox may be associated with barium impurity (barium chloride). Other chlorine 36 may be associated with surface contamination.
Se-79: The chemical form of selenium has not been determined.
Tc-99: The chemical form of technetium has not been determined.
Ra: Radium isotope content is insignificant.
Th: The thorium isotope content is insignificant.
U: Chemical form of uranium isotopes may be uranium oxides.
Np: The chemical form of neptunium has not been determined.
Pu: Chemical form of plutonium isotopes may be plutonium oxides.

Metals and alloys (%wt): FED Magnox - No bulk metal items present.FED Graphite - No sheet or bulk metal present in this waste stream.FED Fuel Channel Components - Support members (~44% wt) are 200 mm length x 150 mm diameter.MAC - Waste is neither in sheet form nor in bulk.MCI - No sheet metal is expected. Bunker contains 2 pond skips each with an envelope volume 1.2 m3 and mass 350 kg.

Stainless steel	0	
Other ferrous metals	~1.5	MAC - The waste contains steel and other metals. Alloying proportions of tin, nickel, niobium and molybdenum may be present.
Iron		
Aluminium		
Beryllium	<0.03	
Cobalt		
Copper	0	
Lead	0	
Magnox/Magnesium	~94.0	FED Magnox - Magnox AL80, which includes 0.8 wt% aluminium as an alloying constituent. There will be impurities, generally at trace levels, incorporated in the Magnox.
Nickel		
Titanium		
Uranium		
Zinc	TR	
Zircaloy/Zirconium	~0.01	FED Fuel Channel Components: Zirconium D Bars
Other metals	0	No "other" metals have been identified.

Organics (%wt): Some polythene wrappings present. Trace amounts of polythene will be present. Graphite dust was placed in the bunkers using polythene bags or bottles. Filters and waste bags contain organic materials. The relative amounts of organic materials have not been established. There are no halogenated plastics or rubbers present in the majority of the

waste. Halogenated plastics are expected to be present in the MCI, however no detailed information exists. Halogenated rubbers may be present in the MCI.

Total cellulosics	0.09
Paper, cotton	~0.09
Wood	0
Halogenated plastics	0
Total non-halogenated plastics	0.18
Condensation polymers	~0.18
Others	TR
Organic ion exchange materials	~0.18
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	TR

Other materials (%wt): Traces of graphite may be present on the FED Magnox, FED Fuel Channel Components, MAC and MCI.

Inorganic ion exchange materials.	0
Inorganic sludges and flocs	~0.90
Soil	0
Brick/Stone/Rubble	0
Cementitious material	0
Sand	
Glass/Ceramics	0
Graphite	~1.9
Desiccants/Catalysts	
Asbestos	TR
Non/low friable	
Moderately friable	
Highly friable	
Free aqueous liquids	TR
Free non-aqueous liquids	0
Powder/Ash	TR

Inorganic anions (%wt): None expected at greater than trace concentrations for the majority of the waste.The sludge and ion exchange resin within the MCI may contain inorganic anions.

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Fluoride	TR
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 certain conditions. Other hazardous materials have not been fully assessed; however they are only likely to be present in trace quantities.

Combustible metals	~94.0
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	~94.0
Active particles	
Soluble solids as bulk chemical compounds	

Hazardous substances / non hazardous pollutants: -

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): Yes

EDTA.....

DPTA.....

NTA.....

Polycarboxylic acids……

Other organic complexants.....

Total complexing agents..... TR

PACKAGING AND CONDITIONING

Conditioning method: The solid will be encapsulated in a 3m3 box. It is not expected that the waste will be tamped or compacted. Any powdered waste is expected to be encapsulated separately and packaged in 3m3 Drum as 9J62.

Plant Name: SILWR

Location: Hunterston A Decommissioning Site

Plant startup date: -

Total capacity (m³/y incoming waste): ~500.0

Target start date for packaging this stream: -

Throughput for this stream (m³/y incoming waste): ~113.0

Other information: All solid wastes in the bunker would be encapsulated together in a BFS/OPC matrix and packaged in 3m3 Stainless Steel Box. There is no intention to first supercompact the waste. Any powdered waste is expected to be encapsulated separately in a 9:1 BFS/OPC matrix and would be packaged in 3m3 Drum as 9J62.

Likely container type:

Container	Waste packaged (%vol)	Waste loading (m³)	Payload (m³)	Number of packages
3m³ box (round corners)	100.0	2.84	2.7	210

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Likely container type comment:	The loading assumes that the waste will revert to a similar volume as the original volume in the vault. It is not expected that the waste will be tamped or compacted.
Range in container waste volume:	No significant variability is expected.
Other information on containers:	The 3m3 box is expected to be made from stainless steel.
Likely conditioning matrix:	Blast Furnace Slag / Ordinary Portland Cement
Other information:	-
Conditioned density (t/m³):	~2.0
Conditioned density comment:	The density of the conditioned waste will probably be about 2 t/m3.
Other information on conditioning:	The proposed method has changed from dissolution to encapsulation in BFS/OPC, in a 3m3 box. The wastes in the bunker will probably be encapsulated together, but possibly excluding any ash and dusts (9J62). The waste is a mixture of historic waste streams 9J18, 9J26, 9J35 and 9J40 in addition to 9J23. Any of the Magnox waste that has degraded from metal to powder will be encapsulated in a 3m3 drum with a conditioning factor of about 3 as 9J62.
Opportunities for alternative disposal routing:	

Treatment	Stream volume (%)	Comment
-	-	-

RADIOACTIVITY

Source:	Predominantly activation products with possible contamination by fission products and actinides.
Uncertainty:	The values quoted are indicative of 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:	Activities have been estimated from activation calculations with assumptions for contamination.
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	2.01E-02	C C 2			Gd 153		8		
Be 10	1.15E-07	C C 2			Ho 163		8		
C 14	1.67E-04	C C 2			Ho 166m		8		
Na 22		8			Tm 170		8		
Al 26	5.59E-05	C C 2			Tm 171		8		
Cl 36		8			Lu 174		8		
Ar 39		8			Lu 176		8		
Ar 42		8			Hf 178n		8		
K 40		8			Hf 182		8		
Ca 41	1.91E-05	C C 2			Pt 193		8		
Mn 53		8			Tl 204		8		
Mn 54		8			Pb 205		8		
Fe 55	1.52E-04	C C 2			Pb 210		8		
Co 60	1.09E-03	C C 2			Bi 208		8		
Ni 59	7.37E-05	C C 2			Bi 210m		8		
Ni 63	5.71E-03	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	7.88E-04	C C 2			Th 227		8		
Zr 93	2.58E-06	C C 2			Th 228		8		
Nb 91		8			Th 229		8		
Nb 92		8			Th 230		8		
Nb 93m	1.99E-06	C C 2			Th 232		8		
Nb 94	7.90E-08	C C 2			Th 234	7.98E-08	C C 2		
Mo 93	2.52E-06	C C 2			Pa 231		8		
Tc 97		8			Pa 233	5.71E-09	C C 2		
Tc 99	8.28E-07	C C 2			U 232		8		
Ru 106		8			U 233		8		
Pd 107		8			U 234	7.07E-08	C C 2		
Ag 108m	3.48E-06	C C 2			U 235	1.89E-09	C C 2		
Ag 110m		8			U 236	6.53E-09	C C 2		
Cd 109		8			U 238	7.98E-08	C C 2		
Cd 113m	3.63E-05	C C 2			Np 237	5.71E-09	C C 2		
Sn 119m		8			Pu 236		8		
Sn 121m	1.77E-04	C C 2			Pu 238	1.63E-05	C C 2		
Sn 123		8			Pu 239	2.34E-05	C C 2		
Sn 126	4.83E-09	C C 2			Pu 240	2.79E-05	C C 2		
Sb 125	3.95E-07	C C 2			Pu 241	2.72E-04	C C 2		
Sb 126		8			Pu 242	1.02E-08	C C 2		
Te 125m	9.89E-08	C C 2			Am 241	4.62E-05	C C 2		
Te 127m		8			Am 242m	7.49E-08	C C 2		
I 129		8			Am 243	2.10E-08	C C 2		
Cs 134	2.08E-09	C C 2			Cm 242	6.18E-08	C C 2		
Cs 135	1.02E-08	C C 2			Cm 243	1.27E-08	C C 2		
Cs 137	7.94E-04	C C 2			Cm 244	1.22E-07	C C 2		
Ba 133	2.62E-05	C C 2			Cm 245		8		
La 137	3.79E-06	C C 2			Cm 246		8		
La 138		8			Cm 248		8		
Ce 144		8			Cf 249		8		
Pm 145	5.42E-07	C C 2			Cf 250		8		
Pm 147	3.51E-05	C C 2			Cf 251		8		
Sm 147		8			Cf 252		8		
Sm 151	5.37E-06	C C 2			Other a				
Eu 152	3.26E-05	C C 2			Other b/g				
Eu 154	1.24E-04	C C 2			**Total a**	**1.14E-04**	**C C 2**	**0**	
Eu 155	8.86E-07	C C 2			**Total b/g**	**2.97E-02**	**C C 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