

| WASTE STREAM | 5B01 | PFR Raffinate |
|--------------|------|---------------|
|--------------|------|---------------|

**SITE** Dounreay

**SITE OWNER** Nuclear Decommissioning Authority

**WASTE CUSTODIAN** Nuclear Restoration Services Ltd (NRS)

**WASTE TYPE** ILW

#### WASTE VOLUMES

|                        | Reported (m <sup>3</sup> ) | OR | Conditioned (m <sup>3</sup> ) | Packaged (m <sup>3</sup> ) |
|------------------------|----------------------------|----|-------------------------------|----------------------------|
| Stocks:                | At 1.4.2025                |    |                               |                            |
| Future arisings:       |                            |    |                               |                            |
| Total future arisings: |                            |    |                               |                            |
| Total waste volume:    |                            |    |                               |                            |

Number of waste packages in stock: At 1.4.2025..... - packages

Comment on arising rates: Programme is based on NRS Dounreay's LTP24 as at December 2023. There will be no further arisings of this waste stream. Stocks will reduce as the waste is conditioned. This will increase waste in 5B01/C.

Additional information on quantities: Stocks uncertainty related only to tank level monitoring equipment error margin. There will be no future arisings. Tank washouts will be undertaken but have not been quantified as yet.

Uncertainty factors on volumes: Stock (upper): x 1.05 Arisings (upper): x -  
Stock (lower): x 0.95 Arisings (lower): x -

**WASTE SOURCE** The source of this waste is from the reprocessing of Prototype Fast Reactor (PFR) fuel.

#### PHYSICAL CHARACTERISTICS

General description: The waste is a raffinate from fuel reprocessing. There are no large items in the waste.

Changes since waste generated: Some of the raffinate has been evaporated to reduce its volume.

Bulk density (t/m<sup>3</sup>): = 1.3

Comment on density: The density of the raffinate has historically been measured at about 1.27 t/m<sup>3</sup>. Based on ILoC.

#### CHEMICAL COMPOSITION

General description and components (%wt): The raffinate is a nitric acid solution containing fission products and trace quantities of uranium and plutonium. Nitric acid (96.6%) and metals in solution (copper, sodium, iron, cadmium, nickel and zinc) (3.4%).

Chemical state: Acid

Sheet metal proportion / thickness: -

Metals and alloys (%wt):

|                           | (%wt) | Type(s) / Grades(s) with proportions                                                           | % of total C14 activity |
|---------------------------|-------|------------------------------------------------------------------------------------------------|-------------------------|
| Stainless steel.....      | = 0   | -                                                                                              |                         |
| Other ferrous metals..... | P     | -                                                                                              |                         |
| Iron.....                 | P     | -                                                                                              |                         |
| Aluminium.....            | = 0   | -                                                                                              |                         |
| Beryllium.....            | = 0   | -                                                                                              |                         |
| Cobalt.....               | = 0   | -                                                                                              |                         |
| Copper.....               | P     | -                                                                                              |                         |
| Lead.....                 | = 0   | -                                                                                              |                         |
| Magnox/Magnesium.....     | = 0   | -                                                                                              |                         |
| Nickel.....               | P     | -                                                                                              |                         |
| Titanium.....             | = 0   | -                                                                                              |                         |
| Uranium.....              | = 0   | -                                                                                              |                         |
| Zinc.....                 | P     | -                                                                                              |                         |
| Zircaloy/Zirconium.....   | = 0   | -                                                                                              |                         |
| Other metals.....         | = 3.4 | Covers a range of metallic species which are in solution including sodium, cadmium and nickel. |                         |

Organics (%wt):

|                                     | (%wt) | Type(s) and comment | % of total C14 activity |
|-------------------------------------|-------|---------------------|-------------------------|
| Total cellulotics.....              | = 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.....                   | = 0   | -                   |                         |
| Oil or grease.....                  | = 0   | -                   |                         |
| Fuel.....                           | = 0   | -                   |                         |
| Asphalt/Tarmac (cont.coal tar)..... | = 0   | -                   |                         |
| Asphalt/Tarmac (no coal tar).....   | = 0   | -                   |                         |
| Bitumen.....                        | = 0   | -                   |                         |
| Others.....                         | = 0   | -                   |                         |
| Other organics.....                 | = 0   | -                   |                         |

Other materials (%wt):

|                                       | (%wt)  | Type(s) and comment                            | % of total C14 activity |
|---------------------------------------|--------|------------------------------------------------|-------------------------|
| Inorganic ion exchange materials..... | = 0    | -                                              |                         |
| Inorganic sludges and flocs.....      | = 0    | -                                              |                         |
| Soil.....                             | = 0    | -                                              |                         |
| Brick/Stone/Rubble.....               | = 0    | -                                              |                         |
| Cementitious material.....            | = 0    | -                                              |                         |
| Sand.....                             | = 0    | -                                              |                         |
| Glass/Ceramics.....                   | = 0    | -                                              |                         |
| Graphite.....                         | = 0    | -                                              |                         |
| Desiccants/Catalysts.....             | = 0    | -                                              |                         |
| Asbestos.....                         | = 0    | -                                              |                         |
| Non/low friable.....                  | = 0    | -                                              |                         |
| Moderately friable.....               | = 0    | -                                              |                         |
| Highly friable.....                   | = 0    | -                                              |                         |
| Free aqueous liquids.....             | = 96.6 | Plutonium Nitrate (~0.3% by vol) + Nitric Acid |                         |
| Free non-aqueous liquids.....         | = 0    | -                                              |                         |
| Powder/Ash.....                       | = 0    | -                                              |                         |

#### COMPONENTS OF MATERIALS, WASTE PROPERTIES, MATERIALS NOT CONTRIBUTING TO MASS

Inorganic anions (%wt):

|                | (%wt)  | Type(s) and comment |
|----------------|--------|---------------------|
| Fluoride.....  | = 0    | -                   |
| Chloride.....  | P      | -                   |
| Iodide.....    | = 0    | -                   |
| Cyanide.....   | = 0    | -                   |
| Carbonate..... | = 0    | -                   |
| Nitrate.....   | = 30.0 | -                   |
| Nitrite.....   | = 0    | -                   |
| Phosphate..... | TR     | -                   |
| Sulphate.....  | P      | -                   |
| Sulphide.....  | = 0    | -                   |

Materials of interest for waste acceptance criteria:

|                                                | (%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.....                   | = 0    | -                   |
| Putrescible wastes.....                        | = 0    | -                   |
| Non-putrescible wastes.....                    | = 0    | -                   |
| Corrosive materials.....                       | = 96.6 | -                   |
| Pyrophoric materials.....                      | = 0    | -                   |
| Generating toxic gases.....                    | = 96.6 | -                   |
| Reacting with water.....                       | P      | Sodium              |
| Higher activity particles.....                 | = 0    | -                   |
| Soluble solids as bulk chemical compounds..... | = 0    | -                   |

Hazardous substances / non hazardous pollutants:

|                             | (%wt) | Type(s) and comment |
|-----------------------------|-------|---------------------|
| Acrylamide.....             | NE    | -                   |
| Benzene.....                | = 0   | -                   |
| Chlorinated solvents.....   | = 0   | -                   |
| Formaldehyde.....           | = 0   | -                   |
| Organometallics.....        | = 0   | -                   |
| Phenol.....                 | = 0   | -                   |
| Styrene.....                | = 0   | -                   |
| Tri-butyl phosphate.....    | TR    | -                   |
| Other organophosphates..... | = 0   | -                   |
| Vinyl chloride.....         | = 0   | -                   |
| Arsenic.....                | = 0   | -                   |
| Barium.....                 | = 0   | -                   |
| Boron.....                  | = 0   | -                   |
| Boron (in Boral).....       | = 0   | -                   |
| Boron (non-Boral).....      | = 0   | -                   |
| Cadmium.....                | P     | -                   |
| Caesium.....                | = 0   | -                   |
| Selenium.....               | = 0   | -                   |
| Chromium.....               | = 0   | -                   |
| Molybdenum.....             | = 0   | -                   |
| Thallium.....               | = 0   | -                   |
| Tin.....                    | = 0   | -                   |
| Vanadium.....               | = 0   | -                   |
| Mercury compounds.....      | = 0   | -                   |
| Others.....                 | = 0   | -                   |

Complexing agents (%wt):

| Yes                            |       |                                                                     |
|--------------------------------|-------|---------------------------------------------------------------------|
|                                | (%wt) | Type(s) and comment                                                 |
| EDTA.....                      | = 0   | -                                                                   |
| DPTA.....                      | = 0   | -                                                                   |
| NTA.....                       | = 0   | -                                                                   |
| Polycarboxylic acids.....      | = 0   | -                                                                   |
| Other organic complexants..... | TR    | Traces of organic complexing agents (MDP, DBP, TBP) may be present. |
| Total complexing agents.....   | TR    | -                                                                   |

Physical components:

|                                         | Number | Type(s) and comment |
|-----------------------------------------|--------|---------------------|
| Sources.....                            | = 0    | -                   |
| Electronic & Electrical Equipment (EEE) |        |                     |
| EEE Type 1.....                         | = 0    | -                   |
| EEE Type 2.....                         | = 0    | -                   |
| EEE Type 3.....                         | = 0    | -                   |
| EEE Type 4.....                         | = 0    | -                   |
| EEE Type 5.....                         | = 0    | -                   |

## TREATMENT, PACKAGING AND DISPOSAL

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

| Treatment                                                  | On-site / Off-site | Stream volume % |
|------------------------------------------------------------|--------------------|-----------------|
| Size reduction                                             |                    |                 |
| Decay storage                                              |                    |                 |
| Low force compaction                                       |                    |                 |
| Supercompaction (HFC)                                      |                    |                 |
| Incineration                                               |                    |                 |
| Drying/dewatering/liquid separation                        |                    |                 |
| Tie down/fixatives/strippable coating/painting application |                    |                 |
| Decontamination                                            |                    |                 |
| Metal treatment                                            |                    |                 |
| Recycling / reuse                                          |                    |                 |
| Thermal treatment, including vitrification                 |                    |                 |
| Encapsulation                                              | On-site            | = 100.0         |
| Polymer encapsulation                                      |                    |                 |
| Other physical treatment                                   |                    |                 |
| Other chemical treatment                                   | On-site            | = 100.0         |
| Containerisation                                           |                    |                 |
| Treatment not yet determined                               |                    |                 |
| None                                                       |                    |                 |

Comments on planned treatments:

The current strategy is neutralisation of the PFR raffinate using NaOH followed by immobilisation with cement into 500 L drums in the Dounreay Cementation Plant.

Conditioning method:

The current strategy is neutralisation of the PFR raffinate using NaOH followed by immobilisation with cement into 500 L drums in the Dounreay Cementation Plant.

Conditioning plants:

| Plant Name                 | Location |
|----------------------------|----------|
| Dounreay Cementation Plant | Dounreay |

Likely conditioning matrix:

Non-standard

Further information on the conditioning matrix:

The raffinate will probably be incorporated into a cement based lattice using a 1:2 PFA/OPC formulation, with an average of 228 litres of raffinate being incorporated into each drum. The waste will undergo a neutralisation process using sodium hydroxide.

#### Waste Packaging:

| Likely container type: | Container           | Waste packaged (vol%) | Waste loading (m³) | Payload (m³) | Number of packages | Estimated start date for packaging |
|------------------------|---------------------|-----------------------|--------------------|--------------|--------------------|------------------------------------|
|                        | 500 l drum (paddle) | 100.0                 | 0.23               | 0.50         | 729                | 2026                               |

Range in container waste loading: The target loading is 0.228 m³ of raw raffinate per drum, but is dependent on composition of the raffinate in the tank. A final volume of 328 l of neutralised liquor will be dispensed to each drum.

Other information on packaging and conditioning:

-

Conditioned density (t/m³):

~ 1.8

Conditioned density comment:

The density of the conditioned waste will probably be about 1.8 t/m³.

#### Management Routes:

| Disposal Route                                                                     | Stream volume % | Raw density t/m³ | Start date |
|------------------------------------------------------------------------------------|-----------------|------------------|------------|
| Expected to be consigned to a Near Site, Near Surface Disposal Facility (Scotland) | = 100.0         |                  |            |
| Expected to be Non-NSD HAW managed under Scottish Government's policy              |                 |                  |            |
| Expected to be disposed to LLW Vaults NRS Dounreay                                 |                 |                  |            |
| Expected to be consigned to the Geological Disposal Facility                       |                 |                  |            |
| Expected to be consigned to a Near Surface Disposal Facility                       |                 |                  |            |
| Expected to be consigned to the LLW Repository                                     |                 |                  |            |
| Expected to be consigned to a Landfill Facility                                    |                 |                  |            |
| Expected to be disposed On-Site                                                    |                 |                  |            |
| Expected to be managed by In-Situ Disposal                                         |                 |                  |            |
| Expected to be consigned to an Incineration Facility                               |                 |                  |            |
| Expected to be consigned to a Metal Treatment Facility                             |                 |                  |            |
| Expected to be Out of Scope                                                        |                 |                  |            |
| Expected to be recycled / reused                                                   |                 |                  |            |
| Disposal route not known                                                           |                 |                  |            |

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

Opportunities for alternative disposal routing: No

| Baseline Management Route | Opportunity Management Route | Stream volume (%) | Opportunity Confidence | Comment |
|---------------------------|------------------------------|-------------------|------------------------|---------|
| -                         | -                            | -                 | -                      | -       |

#### RADIOACTIVITY

Source:

Activity arises mainly from the fission products separated from the irradiated Prototype Fast Reactor fuel at reprocessing

Uncertainty:

The activity accuracy is within a factor of 3

Measurement of radioactivities:

Samples were taken from the tanks and subsequently analysed. These results gave specific activities for the principle radionuclides. Other specific activities were estimated from earlier results and Fispin calculations.

Chemical form of radionuclides:

H-3: Likely to be present as water.  
 C-14: Unknown - possibly present as traces of dissolved solvent.  
 Cl-36: Likely to be present, form unknown.  
 Se-79: Likely to be present, form unknown.  
 Tc-99: Likely to be present, form unknown.  
 I-129: Likely to be present, form unknown.  
 Ra: Likely to be present as nitrate.  
 Th: Present as nitrate.  
 U: Present as nitrate.  
 Np: Likely to be present, form unknown.  
 Pu: Present as nitrate.

| WASTE STREAM |                            |                   | 5B01            |                   | PFR Raffinate |                            |                   |                 |                   |
|--------------|----------------------------|-------------------|-----------------|-------------------|---------------|----------------------------|-------------------|-----------------|-------------------|
| Nuclide      | Mean radioactivity, TBq/m³ |                   |                 |                   | Nuclide       | Mean radioactivity, TBq/m³ |                   |                 |                   |
|              | Waste at<br>1.4.2025       | Bands and<br>Code | Future Arisings | Bands and<br>Code |               | Waste at<br>1.4.2025       | Bands and<br>Code | Future Arisings | Bands and<br>Code |
| H 3          | = 5.95E-03                 | B B 1             |                 |                   | Gd 153        | = 4.57E-19                 | B B 2             |                 |                   |
| Be 10        | = 2.37E-09                 | B B 2             |                 |                   | Ho 163        | = 7.04E-10                 | B B 2             |                 |                   |
| C 14         | = 9.72E-05                 | B B 2             |                 |                   | Ho 166m       | = 7.47E-08                 | B B 2             |                 |                   |
| Na 22        |                            |                   |                 |                   | Tm 170        | = 1.41E-29                 | B B 2             |                 |                   |
| Al 26        |                            |                   |                 |                   | Tm 171        | = 3.13E-09                 | B B 2             |                 |                   |
| Cl 36        | = 4.83E-09                 | B B 2             |                 |                   | Lu 174        | = 2.18E-09                 | B B 2             |                 |                   |
| Ar 39        |                            |                   |                 |                   | Lu 176        | = 3.26E-14                 | B B 2             |                 |                   |
| Ar 42        |                            |                   |                 |                   | Hf 178n       | = 4.76E-07                 | B B 2             |                 |                   |
| K 40         | = 3.56E-10                 | B B 2             |                 |                   | Hf 182        | = 6.07E-13                 | B B 2             |                 |                   |
| Ca 41        | = 4.01E-07                 | B B 2             |                 |                   | Pt 193        |                            |                   |                 |                   |
| Mn 53        | = 3.06E-09                 | B B 2             |                 |                   | Tl 204        | = 8.24E-06                 | B B 2             |                 |                   |
| Mn 54        | = 1.64E-11                 | B B 2             |                 |                   | Pb 205        | = 1.76E-10                 | B B 2             |                 |                   |
| Fe 55        | = 7.17E-04                 | B B 2             |                 |                   | Pb 210        | = 8.92E-11                 | B B 2             |                 |                   |
| Co 60        | = 1.17E-02                 | B B 2             |                 |                   | Bi 208        | = 1.31E-10                 | B B 2             |                 |                   |
| Ni 59        | = 7.22E-04                 | B B 2             |                 |                   | Bi 210m       | = 4.45E-11                 | B B 2             |                 |                   |
| Ni 63        | = 3.03E-02                 | B B 2             |                 |                   | Po 210        | = 8.68E-11                 | B B 2             |                 |                   |
| Zn 65        | = 1.62E-15                 | B B 2             |                 |                   | Ra 223        | = 2.65E-09                 | B B 2             |                 |                   |
| Se 79        | = 1.28E-03                 | B B 2             |                 |                   | Ra 225        | = 3.24E-06                 | B B 2             |                 |                   |
| Kr 81        |                            |                   |                 |                   | Ra 226        | = 2.24E-10                 | B B 2             |                 |                   |
| Kr 85        |                            |                   |                 |                   | Ra 228        | = 5.96E-08                 | B B 2             |                 |                   |
| Rb 87        | = 4.48E-08                 | B B 2             |                 |                   | Ac 227        | = 2.67E-09                 | B B 2             |                 |                   |
| Sr 90        | = 6.30E+01                 | B B 2             |                 |                   | Th 227        | = 2.62E-09                 | B B 2             |                 |                   |
| Zr 93        | = 4.82E-03                 | B B 2             |                 |                   | Th 228        | = 2.47E-07                 | B B 2             |                 |                   |
| Nb 91        |                            |                   |                 |                   | Th 229        | = 3.24E-06                 | B B 2             |                 |                   |
| Nb 92        | = 1.77E-10                 | B B 2             |                 |                   | Th 230        | = 1.40E-08                 | B B 2             |                 |                   |
| Nb 93m       | = 5.52E-03                 | B B 2             |                 |                   | Th 232        | = 6.55E-08                 | B B 2             |                 |                   |
| Nb 94        | = 5.70E-05                 | B B 2             |                 |                   | Th 234        | = 4.49E-06                 | B B 2             |                 |                   |
| Mo 93        | = 4.21E-04                 | B B 2             |                 |                   | Pa 231        | = 5.69E-09                 | B B 2             |                 |                   |
| Tc 97        |                            |                   |                 |                   | Pa 233        | = 4.67E-04                 | B B 2             |                 |                   |
| Tc 99        | = 5.06E-02                 | B B 2             |                 |                   | U 232         | = 1.85E-07                 | B B 2             |                 |                   |
| Ru 106       | = 2.03E-06                 | B B 2             |                 |                   | U 233         | = 7.55E-08                 | B B 2             |                 |                   |
| Pd 107       | = 1.11E-03                 | B B 2             |                 |                   | U 234         | = 1.15E-04                 | B B 2             |                 |                   |
| Ag 108m      |                            |                   |                 |                   | U 235         | = 1.76E-07                 | B B 2             |                 |                   |
| Ag 110m      | = 8.20E-14                 | B B 2             |                 |                   | U 236         | = 4.87E-07                 | B B 2             |                 |                   |
| Cd 109       | = 1.73E-10                 | B B 2             |                 |                   | U 238         | = 4.50E-06                 | B B 2             |                 |                   |
| Cd 113m      | = 5.28E-03                 | B B 2             |                 |                   | Np 237        | = 4.68E-04                 | B B 2             |                 |                   |
| Sn 119m      | = 1.78E-13                 | B B 2             |                 |                   | Pu 236        | = 2.82E-10                 | B B 2             |                 |                   |
| Sn 121m      | = 1.58E-01                 | B B 2             |                 |                   | Pu 238        | = 1.34E+00                 | B B 2             |                 |                   |
| Sn 123       | = 3.35E-26                 | B B 2             |                 |                   | Pu 239        | = 1.59E-01                 | B B 2             |                 |                   |
| Sn 126       | = 4.44E-03                 | B B 2             |                 |                   | Pu 240        | = 1.76E-01                 | B B 2             |                 |                   |
| Sb 125       | = 2.05E-02                 | B B 2             |                 |                   | Pu 241        | = 1.67E+00                 | B B 2             |                 |                   |
| Sb 126       | = 4.44E-03                 | B B 2             |                 |                   | Pu 242        | = 1.34E-04                 | B B 2             |                 |                   |
| Te 125m      | = 4.85E-03                 | B B 2             |                 |                   | Am 241        | = 2.79E+01                 | B B 2             |                 |                   |
| Te 127m      | = 6.65E-33                 | B B 2             |                 |                   | Am 242m       | = 7.74E-01                 | B B 2             |                 |                   |
| I 129        | = 1.28E-04                 | B B 2             |                 |                   | Am 243        | = 5.16E-02                 | B B 2             |                 |                   |
| Cs 134       | = 1.53E-03                 | B B 2             |                 |                   | Cm 242        | = 6.46E-01                 | B B 2             |                 |                   |
| Cs 135       | = 6.23E-03                 | B B 2             |                 |                   | Cm 243        | = 1.33E-01                 | B B 2             |                 |                   |
| Cs 137       | = 1.84E+02                 | B B 2             |                 |                   | Cm 244        | = 1.06E+00                 | B B 2             |                 |                   |
| Ba 133       | = 1.84E-05                 | B B 2             |                 |                   | Cm 245        | = 1.39E-04                 | B B 2             |                 |                   |
| La 137       |                            |                   |                 |                   | Cm 246        | = 5.49E-06                 | B B 2             |                 |                   |
| La 138       | = 2.14E-13                 | B B 2             |                 |                   | Cm 248        | = 3.31E-20                 | B B 2             |                 |                   |
| Ce 144       | = 2.75E-09                 | B B 2             |                 |                   | Cf 249        | = 1.48E-10                 | B B 2             |                 |                   |
| Pm 145       |                            |                   |                 |                   | Cf 250        | = 3.98E-11                 | B B 2             |                 |                   |
| Pm 147       | = 2.32E-01                 | B B 2             |                 |                   | Cf 251        | = 2.73E-14                 | B B 2             |                 |                   |
| Sm 147       | = 1.13E-09                 | B B 2             |                 |                   | Cf 252        | = 2.34E-17                 | B B 2             |                 |                   |
| Sm 151       | = 1.06E+01                 | B B 2             |                 |                   | Unsp a        |                            |                   |                 |                   |
| Eu 152       | = 5.53E-05                 | B B 2             |                 |                   | Unsp b/g      |                            |                   |                 |                   |
| Eu 154       | = 7.23E-01                 | B B 2             |                 |                   | Total a       | 3.14E+01                   | *                 | 0               | *                 |
| Eu 155       | = 2.96E-01                 | B B 2             |                 |                   | Total b/g     | 2.62E+02                   | *                 | 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 the 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  
\* Total calculated from the 114 declared radionuclides