Estimated Releases of Radioactivity to the Environment: Justification and the Uncertainty Related to the Estimates

2010

Dounreay Site Restoration Ltd

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1.1		Comments from DEC and numerical data check incorporated	September 2009
1.2		Updated to changes since September 2009	March 2010

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1 Introduction

The Dounreay site is undergoing a programme of decommissioning, which by 2025 will see the demolition of all radioactive structures and the build of new facilities to store the higher activity wastes and conditioned fuels. The application for the disposal of radioactive wastes, supported by this document is written to cover the scope of the decommissioning programme, the Dounreay Lifetime Plan (LTP), and the information within are the estimates of radioactive waste discharges to air and water up to the 2025 date.

1.1 The application, to which this paper relates, assumes all operations are carried out concurrently in line with the programme of work to decommission the site. Unlike previous applications the scope of the work now includes using techniques and tools for the dismantling of plant and buildings.

1.2 The sections 2 to 5 set out the estimated discharges to air and water of radioactive wastes arising from the decommissioning of the Dounreay facilities and infrastructure. This information supporting the estimates of radioactive gaseous and liquid discharges up to 2025 and informing the level of proposed limits, based on the highest estimates in the years 2010 to 2025.

1.3 For each of the parts of the site an estimate of the future discharge to air and water has been made. These estimates are further broken down to either the facility or decommissioning project taking account of;

- historical discharges and the future programme where no new process is proposed; or
- estimates from the radioactivity inventory and the proposed treatments, taking account of facility BPM studies.

1.4 Section 6 sets out the basis for the proposed limits over any 12 month (year) period and summarises those limits. The proposed limits on discharges take account of the process, current or new, adding a contingency allowance that will allow for the uncertainties in the estimates.

2 Estimates of Discharges from the Dounreay Fast Reactor (DFR)

2.1 In addition to general operations the decommissioning of the DFR, in the time period of the application, will have four major components:

- Care and Maintenance operations and Pond Water disposal
- NaK disposal operations
- Breeder Fuel Removal operations
- Primary Circuit Decontamination

2.2 The Care and Maintenance operations and Pond water disposal have previous data to which future disposals can be extrapolated with reasonable accuracy. However, for gaseous discharges, the weekly sample papers are returning results at or just marginally above the minimum detectable activity with consequent uncertainty of the order of 75% to 100%.

2.3 The NaK disposal operations are new to DFR, although active commissioning of the NaK Disposal Plant and the associated Ion Exchange Plant has provided information on the gaseous and liquid discharges that can be expected in the operational phase of these plants.

2.3.1 Worker dose models derived for the nuclear safety case for the NaK Disposal Plant were used to calculate discharges to atmosphere.

2.3.2 Estimates of the radioactive liquid waste activity are calculated using sample results from the primary circuit NaK. The results of the sampling and analysis of the NaK batches during active commissioning has shown that the radiological inventory of the NaK is within the bounding case radiological inventory used to support NDP BPM cases, with the exception of Sr-90.

2.3.3 The level of Cs-137 activity in the NaK is relatively consistent (+/- 15%) and aligns very closely with the predicted 1.3 TBq/batch and a total Cs-137 inventory of 460TBq.

2.3.4 The total Sr-90 inventory of 126 GBq is approximately an order of magnitude greater than previously estimated (16.5 GBq). The gaseous beta discharges and liquid Sr90 discharges show that Sr-90 is being minimised to close to or below analysis minimum detectable levels.

2.3.5 Similarly, the use of a bounding case for Tritium inventory of 2.52TBq of the NaK, based on PFR Sodium Disposal Plant sodium inventory estimates, has been shown to be very pessimistic with an overestimate by two orders of magnitude. The total NaK inventory now assessed as 24 GBq.

2.4 The Breeder Fuel Removal operation is a new process for DFR involving the removal of the breeder elements from the DFR reactor vessel, de-cladding the pins and ensuring the clad and fuel pellets are free of any liquid metal coolant.

2.4.1 The estimates of release of radionuclides to the liquid stream from the cleaning process include:

- An allowance for residual NaK contamination;
- Surface strip during the cleaning process (an effect observed during similar operations in France); and
- FISPIN model calculation of nuclide content of the breeder fuel.

2.4.2 The estimates of release to atmosphere are based on assumptions from French experience and application of release fractions within safety assessment models.

2.5 The Primary Circuit Decontamination consists of:

- the removal of NaK residues contaminated with
    - oxide and hydride compounds; and
    - fuel residue due to the nature of operation of the DFR reactor.

This particular project will benefit from the experiences gained by carrying out the NDP and BFR projects.

2.6 The uncertainties within the estimates are not transparent. The processes to be progressed during DFR decommissioning are new processes. Assumptions used in calculating these estimates may be pessimistic in some cases but may equally be underestimated by virtue of the type of samples taken and analysed. Programme changes may also result in variation to the amount discharged in any one year.

2.7 For the gaseous discharge, as the DFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the krypton is left as estimated;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	1.52E+05	3.00E+05
Beta (Excluding Tritium and Krypton-85)	3.41E+08	7.00E+08
Tritium	1.36E+12	2.70E+12
Krypton-85	3.00E+12	3.00E+12

2.8 For the liquid discharge, as the DFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the caesium and strontium are doubled;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	2.00E+08	4.00E+08
Beta (Excluding Tritium)	6.30E+11	1.26E+12
Tritium	1.19E+12	2.40E+12
Strontium-90	7.33E+10	1.47E+11
Caesium-137	2.81E+11	5.60E+11

DFR T1 – ESTIMATES OF GASEOUS DISCHARGES FROM THE DOUNREAY FAST REACTOR PROJECT

DFR Gaseous Discharges Predicted future 12 month discharges in Bq																	
FACILITY	Nuclide	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
DFR NDP	alpha	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03											
	beta	1.15E+05	1.05E+05	1.05E+05	1.05E+05	1.05E+05											
	H-3	1.03E+12	9.18E+11	9.18E+11	9.18E+11	9.18E+11											
DFR POND	alpha	2.00E+03	2.00E+04	1.00E+05	1.00E+05	1.00E+05											
	beta	6.80E+06	6.80E+07	3.40E+08	3.40E+08	3.40E+08											
	H-3	7.08E+09	7.08E+09	7.08E+09	7.08E+09	7.08E+09											
DFR BFR	alpha			2.00E+03	2.00E+03	4.56E+04	4.56E+04	4.56E+04	4.56E+04								
	beta			1.00E+04	1.00E+04	4.08E+05	4.08E+05	4.08E+05	4.08E+05								
	H-3			2.20E+10	2.20E+10	4.32E+11	4.32E+11	4.32E+11	4.32E+11								
	Kr-85			1.50E+11	1.50E+11	3.00E+12	3.00E+12	3.00E+12	3.00E+12								
DFR RNR	alpha									1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03	1.80E+03		
	beta									1.73E+04	1.73E+04	1.73E+04	1.73E+04	1.73E+04	1.73E+04		
	H-3									1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11		
DFR Ops	alpha	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.18E+03	5.18E+03	5.18E+03	5.18E+03
	beta	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.17E+04	5.17E+04	5.17E+04	5.17E+04
	H3	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.65E+10	1.65E+10	1.65E+10	1.65E+10
	Kr-85	1.80E+08	1.80E+08	1.80E+08	1.80E+08	3.60E+08	3.60E+08	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07	3.60E+07
TOTALS	**alpha**	**8.80E+03**	**2.68E+04**	**1.09E+05**	**1.09E+05**	**1.52E+05**	**5.06E+04**	**5.06E+04**	**5.06E+04**	**6.80E+03**	**6.80E+03**	**6.80E+03**	**6.80E+03**	**6.98E+03**	**6.98E+03**	**5.18E+03**	**5.18E+03**
	beta	**6.97E+06**	**6.82E+07**	**3.40E+08**	**3.40E+08**	**3.41E+08**	**4.58E+05**	**4.58E+05**	**4.58E+05**	**6.73E+04**	**6.73E+04**	**6.73E+04**	**6.73E+04**	**6.90E+04**	**6.90E+04**	**5.17E+04**	**5.17E+04**
	H-3	**1.04E+12**	**9.26E+11**	**9.48E+11**	**9.48E+11**	**1.36E+12**	**4.33E+11**	**4.33E+11**	**4.33E+11**	**1.56E+11**	**1.56E+11**	**1.56E+11**	**1.56E+11**	**1.72E+11**	**1.72E+11**	**1.65E+10**	**1.65E+10**
	Kr-85	**1.80E+08**	**1.80E+08**	**1.50E+11**	**1.50E+11**	**3.00E+12**	**3.00E+12**	**3.00E+12**	**3.00E+12**	**3.60E+07**	**3.60E+07**	**3.60E+07**	**3.60E+07**	**3.60E+07**	**3.60E+07**	**3.60E+07**	**3.60E+07**

DFR T2 – ESTIMATES OF LIQUID DISCHARGES FROM THE DOUNREAY FAST REACTOR PROJECT

DFR Liquid Discharges Predicted future 12 month discharge in Bq

FACILITY	Nuclide	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
DFR NDP	alpha	6.62E+05	5.94E+05	5.94E+05	5.94E+05	5.94E+05											
	beta	1.41E+10	1.27E+10	1.27E+10	1.27E+10	1.27E+10											
	H-3	1.03E+12	9.18E+11	9.18E+11	9.18E+11	9.18E+11											
	Sr-90	1.35E+09	1.21E+09	1.21E+09	1.21E+09	1.21E+09											
	Cs-137	1.91E+11	1.71E+11	1.71E+11	1.71E+11	1.71E+11											
DFR POND	alpha	2.00E+07		2.00E+07	2.00E+07												
	beta	1.45E+10		2.90E+10	2.90E+10												
	H-3	5.52E+10		1.56E+10	6.38E+10												
	Sr90	4.50E+08		3.15E+08	3.15E+08												
	Cs137	3.00E+07	1.50E+06	6.49E+08	4.75E+07												
DFR BFR	alpha			1.01E+07		1.98E+08	1.98E+08	1.98E+08	1.98E+08								
	beta			1.54E+06		1.63E+11	1.63E+11	1.63E+11	1.63E+11								
	H-3			1.32E+08		2.59E+09	2.59E+09	2.59E+09	2.59E+09								
	Sr-90			3.63E+10		7.11E+10	7.11E+10	7.11E+10	7.11E+10								
	Cs-137			4.59E+09		8.97E+10	8.97E+10	8.97E+10	8.97E+10								
DFR RNR	alpha									1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00		
	beta									2.14E+09	2.14E+09	2.14E+09	2.14E+09	2.14E+09	2.14E+09		
	H-3									1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11	1.55E+11		
	Sr-90									2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08		
	Cs-137									2.88E+10	2.88E+10	2.88E+10	2.88E+10	2.88E+10	2.88E+10		
DFR Ops	alpha	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06
	beta	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11
	H-3	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11	1.00E+11
	Sr-90	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09
	Cs-137	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10
TOTALS	**alpha**	**2.27E+07**	**2.59E+06**	**3.27E+07**	**2.26E+07**	**2.01E+08**	**2.00E+08**	**2.00E+08**	**2.00E+08**	**2.00E+06**	**2.00E+06**	**2.00E+06**	**2.00E+06**	**2.00E+06**	**2.00E+06**	**2.00E+06**	**2.00E+06**
	beta	**3.42E+11**	**3.06E+11**	**3.77E+11**	**3.35E+11**	**6.30E+11**	**4.45E+11**	**4.45E+11**	**4.45E+11**	**1.52E+11**	**1.52E+11**	**1.52E+11**	**1.52E+11**	**1.52E+11**	**1.52E+11**	**1.21E+11**	**1.21E+11**
	H-3	**1.19E+12**	**1.02E+12**	**1.03E+12**	**1.08E+12**	**1.02E+12**	**1.03E+11**	**1.03E+11**	**1.03E+11**	**2.55E+11**	**2.55E+11**	**2.55E+11**	**2.55E+11**	**2.55E+11**	**2.55E+11**	**1.00E+11**	**1.00E+11**
	Sr-90	**2.80E+09**	**2.21E+09**	**3.89E+10**	**2.53E+09**	**7.33E+10**	**7.21E+10**	**7.21E+10**	**7.21E+10**	**1.20E+09**	**1.20E+09**	**1.20E+09**	**1.20E+09**	**1.20E+09**	**1.20E+09**	**1.00E+09**	**1.00E+09**
	Cs-137	**2.11E+11**	**1.91E+11**	**1.96E+11**	**1.91E+11**	**2.81E+11**	**1.10E+11**	**1.10E+11**	**1.10E+11**	**4.88E+10**	**4.88E+10**	**4.88E+10**	**4.88E+10**	**4.88E+10**	**4.88E+10**	**2.00E+10**	**2.00E+10**

3 Estimates of Discharges from the Prototype Fast Reactor (PFR)

3.1 The decommissioning of the PFR in the time period will encompass the following types of operations:

- Sodium residue removal – Reactor Vessel, SCTL, PCTL, IFC
- Disposal of 100Te sodium metal from KNK Germany
- Irradiated Fuel Cell (IFC) POCO operations
- Irradiated Fuel Buffer Store (IFBS) operations
- IFBS Pond water disposal
- Primary Sodium Pump and Intermediate Heat Exchanger cleaning
- Alkali Metals Laboratory operations
- Dismantling and steam clean of approximately 900 Boron Carbide (B_4C) control rod pins
- Decontamination of reactor and IFC equipment and tools.

3.2 An extensive search and review of the documentation on PFR decommissioning has been carried out leading to a best estimate of radioactive waste inventory[1]. This best estimate considers the gaseous and liquid routes of disposal, allocating discharge to each media for each of the decommissioning activities.

3.3 One activity not captured by this review is the cleaning and disposal of the B_4C control rods in the Irradiated Fuel Cell (IFC) steam clean facility. The control rods are to be broken down into cladding and B_4C pellets. The cladding and pellets will then be steam cleaned to remove any residual sodium and stored as solid radioactive waste. These operations will result in an estimated release of 450 TBq of tritium at approximately 150 TBq/yr over a 3 year programme[2].

- *The tritium inventory was based on the n2alpha reaction data quoted in the Brian Kelly[3] report on FR absorbers.*
- *Calculations were based on the irradiation history (i.e. effective full power days in PFR) to give the amount of tritium generated.*
- *The Kelly paper indicates that only about 30% of the tritium is retained in the boron carbide. The bulk would have found its way to the pellet surfaces via diffusion. As irradiation proceeds, the boron carbide pellets begin to crack and the fragments then progressively sub-divide due to internal mechanical stresses. The latter is due to the poor thermal conductivity of the boron carbide coupled with, to a lesser extent, tritium generation in the intersticies of the boron carbide molecular structure. Thus, as irradiation proceeds the surface area of the boron carbide pellets increases and this, coupled with a high operating temperature allows gas diffusion to proceed at pace and tritium is released to the gas plenum and then the reactor coolant.*
- *In terms of operating temperature, it is worth noting that at reactor full power the centreline temperature of the boron carbide (i.e. ~1 cm diameter) is about 2500 degrees centigrade and outer temperature is about 700 degrees centigrade.*

[1] An Assessment of PFR Radionuclides at Decommissioning, PFR(05)P008

[2] Internal e:mail communication, B Munro to A Potts

[3] B T Kelly, Fast Reactor Systems Data and Conventions Manual: Materials Data for Neutron Absorbers, TRG Report 4000/5(S), FRDC/MWP(76)P244, FRASG(76)P44 - Rev

- *On the basis of (3rd bullet) above, it is suggested that the inventory is circa 500Tbq of Tritium*

3.4 Tritium discharges will be to both gaseous and liquid routes for which it is assumed the proportion to each will similar to that experienced for the PFR Secondary Sodium Cells decommissioning. Therefore 100% of the inventory is assumed to be discharged by the gaseous route whilst at the same time 10% of the inventory is discharged by the liquid route.

3.5 The krypton discharge, as ascribed to the Buffer Store, is declared at half the inventory held in the irradiated subassemblies currently stored in the Buffer Store Pond. The release arises from the storage cans being opened up to check the integrity of the containers. This operation could be carried out either within the Buffer Store or in the IFC. The release also assumes that up to half the containers have failed resulting in corrosion breach of the fuels primary containment resulting in a release of the krypton gas.

3.6 Uncertainty in the estimates of discharges results from;

- the lack of precision in the waste inventories;
- the assumptions made on the tritium inventory of B_4C pins; and
- the potential worst case assumption on the failure rate of Buffer Store containment cans.

3.7 For the gaseous discharge, as the PFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium is times 1.5 and the krypton is left as estimated;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	6.40E+04	1.28E+05
Beta (Excluding tritium and krypton-85)	3.87E+08	7.80E+08
Tritium	5.00E+13	7.50E+13
Krypton-85	5.69E+14	5.69E+14

3.8 For the liquid discharge, as the PFR decommissioning project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimates are doubled and the caesium and sodium are doubled;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	4.10E+07	8.20E+07
Beta (ex H-3)	6.70E+11	1.34E+12
H-3	5.00E+13	1.00E+14
Cs-137	3.05E+11	6.10E+11
Na-22	6.61E+09	1.32E+10

PFR T1 – ESTIMATES OF GASEOUS DISCHARGES FROM THE PROTOTYPE FAST REACTOR PROJECT

Predicted future 12 month discharge (Bq)																		
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tank Farm	trit		1.00E+07	1.00E+07														
SCTL	trit				5.00E+13	5.00E+13				-								
DDT	trit						-	-	3.75E+10	3.75E+10								
PCTL	alpha																	
	beta																	
	trit							8.49E+11	8.49E+11	8.49E+11								
SID	trit		8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09						
IFC residue	alpha																	
	beta																	
	trit			7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09	7.82E+09						
Reactor residue	alpha																	
	beta				3.86E+08	3.86E+08	3.86E+08	3.86E+08	3.86E+08									
	trit		-	-	2.89E+10	2.89E+10	2.89E+10	2.89E+10	2.89E+10									
IFC POCO	alpha																	
	beta																	
	trit		-					3.00E+11	3.00E+11	3.00E+11								
IFBS Operations	alpha		4.00E+03	4.00E+03	4.00E+03	4.00E+03	4.00E+03	4.00E+03										
	beta		6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04										
	Kr-85		5.69E+14	5.69E+14	5.69E+14	5.69E+14	5.69E+14	5.69E+14										
AML	alpha		6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04	6.00E+04										
	beta		5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05										
	trit		1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09								
TOTALS	alpha		6.40E+04	6.40E+04	6.40E+04	6.40E+04	6.40E+04	6.40E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	beta		5.60E+05	5.60E+05	3.87E+08	3.87E+08	3.87E+08	3.87E+08	3.86E+08	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	trit		9.14E+09	1.70E+10	5.00E+13	5.00E+13	4.59E+10	1.19E+12	1.23E+12	1.20E+12	1.60E+10	1.60E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Kr-85		5.69E+14	5.69E+14	5.69E+14	5.69E+14	5.69E+14	5.69E+14	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

PFR T2 – ESTIMATES OF LIQUID DISCHARGES FROM THE PROTOTYPE FAST REACTOR PROJECT

Predicted future 12 month discharge (Bq)																		
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Tank Farm	trit		2.80E+07	2.80E+07														
SCTL	trit				5.00E+13	5.00E+13				-								
DDT	trit						-	-	3.75E+10	3.75E+10								
PCTL	alpha							1.76E+04	1.76E+04	1.76E+04								
	beta(ex H3)							1.25E+11	1.25E+11	1.25E+11								
	trit							8.49E+11	8.49E+11	8.49E+11								
	Cs-137							1.08E+11	1.08E+11	1.08E+11								
	Na-22							3.70E+06	3.70E+06	3.70E+06								
SID	trit		8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09	8.13E+09						
IFBS operations	alpha		5.40E+04	5.40E+04	5.40E+04	5.40E+04	5.40E+04	5.40E+04										
	beta(ex H3)		3.96E+08	3.96E+08	3.96E+08	3.96E+08	3.96E+08	3.96E+08										
	Trit																	
	Cs-137																	
IFC residue	alpha			1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05	1.76E+05						
	beta			7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07	7.20E+07						
	trit			8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09	8.60E+09						
Reactor residue	alpha						3.52E+06	3.52E+06	3.52E+06									
	beta(ex H3)						1.88E+11	1.90E+11	1.90E+11									
	trit						8.84E+11	8.84E+11	8.84E+11									
	Cs-137						1.54E+11	1.54E+11	1.54E+11									
	Na-22		-	-	-	-	6.61E+09	6.61E+09	6.61E+09									
IFC POCO	alpha							3.10E+06	3.10E+06	3.10E+06	3.10E+06							
	beta(ex H3)							6.36E+08	6.36E+08	6.36E+08	6.36E+08							
	trit							3.00E+11	3.00E+11	3.00E+11								
Old LAET	alpha		1.52E+07	1.52E+07														
	beta		7.60E+08	7.60E+08														
	Cs-137		1.41E+07	1.41E+07														

BS Pond Water	alpha												4.10E+07					
	beta												2.54E+09					
	Cs-137							-	-	-			2.50E+09					
PSP/IHX	alpha																	
	beta						4.27E+10	4.27E+10	4.27E+10									
	Cs-137						4.25E+10	4.25E+10	4.25E+10									
other	alpha																	
	beta											2.50E+09	2.50E+09	2.50E+09		3.00E+09	3.00E+09	
	trit											1.50E+10	1.50E+10	1.50E+10				
	Cs-137											3.00E+10	3.00E+10	3.00E+10		3.00E+09	3.00E+09	
Totals	Alpha		1.53E+07	1.54E+07	2.30E+05	2.30E+05	3.75E+06	6.87E+06	6.81E+06	3.29E+06	3.28E+06	1.76E+05	4.10E+07	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Beta (ex H-3)		1.17E+09	1.24E+09	4.68E+08	4.68E+08	4.34E+11	6.70E+11	6.70E+11	2.34E+11	7.08E+08	8.51E+10	9.00E+10	8.50E+10	0.00E+00	6.00E+09	6.00E+09	0.00E+00
	H-3		8.16E+09	1.68E+10	5.00E+13	5.00E+13	9.01E+11	2.05E+12	2.09E+12	1.20E+12	1.67E+10	3.17E+10	1.50E+10	1.50E+10	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Cs-137		1.41E+07	1.41E+07	0.00E+00	0.00E+00	1.97E+11	3.05E+11	3.05E+11	1.08E+11	0.00E+00	3.00E+10	3.25E+10	3.00E+10	0.00E+00	3.00E+09	3.00E+09	0.00E+00
	Na-22		0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.61E+09	6.61E+09	6.61E+09	3.70E+06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

4 Gaseous Discharges from Facilities Elsewhere on Site

4.1 The radioactive gaseous discharges across the facilities on the site are currently grouped into six DSRL groupings/RSA Certificate Schedule tables:

- Fuel Cycle Area Main Stack/Table 4.4 (the 55m D1213 stack serving the ventilation of the majority of the Fuel Cycle Area plants and including the DMTR complex);
- West Minor Sources/Table 4.5 (all radiological facility stacks between the DFR and PFR complexes); and
- East Minor Sources/Table 4.6 (all radiological facility stacks East of the DFR complex).

4.2 The D1213 stack serves as the discharge conduit for the following facilities.:

- D1203 – Fuels processing and recovery;
- D1204 – ex Materials Test Reactor Fuels processing;
- D1205 – Laundry;
- D1206 – ex Fast Reactor Fuels reprocessing;
- D1207 – Store;
- D1208 – High Active Liquid waste storage and conditioning;
- D1215 and D1218 – High activity and Plutonium chemistry laboratories;
- D1217 – ex Post Irradiation Examination (PIE) facility;
- D1231 – Store;
- D1234 – Evaporator;
- D2001 – ILW waste handling and PIE cells; and
- D2700 – Cementation plant.

These facilities feed into the D1209 ventilation duct for final discharge via the D1213 stack

- D1250 – Dounreay Materials Test Reactor (DMTR) building; and
- D9814 and D8571 – The DMTR fuels storage pond and the PIE caves.

These facilities feed into a ventilation link duct directly feeding into the D1213 stack.

The D1213 stack and the D1209 duct are to be replaced by October 2009. After completion of the change over of the ventilation systems the discharge estimates will have to be re-assessed to ensure that the limits requested in the 2009 application continue to be applicable.

4.2.1 Each facility's discharge is sampled for alpha and beta activity and, where appropriate, for tritium activity. The 12 month average discharge for alpha and beta, from the contributing facilities to D1213, is of the order of 1/2 orders of magnitude less than the 2008 12 month average for the statutory samples for the D1213 stack. This discrepancy is a function of measurements for D1213 at or very close to the minimum detectable activity (MDA) for each of the measured nuclides or groups of nuclides and/or pick up of activity from the common duct which is known to be contaminated.

4.2.2 In the years 2010 to 2015 it is estimated that the alpha and beta discharge will increase to a level above the MDA. This is due to the work to be carried out in D1206, D1234 and D1204. However the tritium and iodine will, in the same period remain below the MDA. The krypton activity is estimated from the known activity held within the fuel elements that will be treated in the period.

4.2.3 The D1213 stack discharge estimates are taken as the estimated facility discharges for alpha and beta.

4.2.4 The D1213 stack discharge estimates for tritium are taken as the upper range of the MDA.

4.2.5 The D1213 stack discharge estimates for iodine is as the extant authorised limit, taken as the upper range of the MDA.

4.3 For the gaseous discharge, the alpha and beta estimates are doubled to account for new decommissioning , the tritium and iodine-129 are set at a level commensurate with the analytical limit of detection;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
H-3	5.13E+11	5.13E+11
I-129	1.00E+09	1.00E+09
Beta (Excluding Tritium)	7.28E+08	1.46E+09
Alpha	3.24E+06	6.48E+06

D1213 T1 – ESTIMATES OF GASEOUS DISCHARGE FROM CONTRIBUTORY PLANTS

			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
D1203	alpha		4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	4.50E+04	3.00E+06	3.00E+06	3.00E+06	4.50E+04	4.50E+04	4.50E+04	
	beta		5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	5.50E+04	4.00E+06	4.00E+06	4.00E+06	5.50E+04	5.50E+04	5.50E+04	
D2580	**alpha**		1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03		
	beta		3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03	3.60E+03		
D1231	**alpha**		1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	
	beta		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
D1208	**alpha**		1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03		
	beta		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03		
D1204	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03							
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05							
	H-3		1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+09							
D1206	alpha		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04		
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05		
D1207	alpha		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04								
	beta		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04								
D1208	alpha		1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03
	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04
D1215/18	alpha		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04							
	beta		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04							
D1217	alpha		5.00E+03	5.00E+03	5.00E+03													
	beta		5.00E+04	5.00E+04	5.00E+04													
D1231	alpha		1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03							
	beta		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03							
D1234	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03					
	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04					
D2001	alpha		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04						
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05						
D2700	alpha		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05
D1250	alpha		2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03					
	beta		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03					

	H-3		2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	2.50E+09	1.00E+09					
D1251	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03						
	beta		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04						
LOD	H-3		5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11	5.00E+11

D1213 T2 - ESTIMATES OF GASEOUS DISCHARGES FROM THE FUEL CYCLE AREA MAIN STACK (Totals of above contributors)

D1213 Fuel Cycle Area Stack Predicted future 12 month discharge (Bq)

Totals	**Alpha**		**2.32E+05**	**3.86E+05**	**4.68E+05**	**4.63E+05**	**5.06E+05**	**4.05E+05**	**3.41E+05**	**3.41E+05**	**2.87E+05**	**3.24E+06**	**3.18E+06**	**3.17E+06**	**2.19E+05**	**2.19E+05**	**1.65E+05**	**6.12E+04**
	Beta		**6.99E+05**	**6.98E+07**	**7.28E+08**	**7.28E+08**	**7.28E+08**	**3.88E+08**	**3.87E+08**	**1.48E+06**	**1.04E+06**	**4.83E+06**	**4.68E+06**	**4.66E+06**	**7.18E+05**	**7.18E+05**	**5.92E+05**	**1.72E+05**
	Tritium		**5.13E+11**	**5.13E+11**	**5.13E+11**	**5.13E+11**	**5.13E+11**	**5.13E+11**	**5.13E+11**	**5.13E+11**	**5.04E+11**	**5.03E+11**	**5.01E+11**	**5.00E+11**	**5.00E+11**	**5.00E+11**	**5.00E+11**	**5.00E+11**
	Krypton		**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**	**0.00E+00**

4.4 The East Minor Sources (EMS) is a grouping of facilities, as set out in the extant authorisation table 4.6, that discharge radioactivity to atmosphere via various dedicated stacks of varying heights. The grouping comprises all stacks (excluding D1213) that are East of the DFR facility:

- D1200 – D1200 laboratories and D1215 space extract and fumehoods
- D1226 – D1200 laboratories
- D2670 – Marshall laboratory excluding the pulse column glovebox
- DN141 – Marshall laboratory pulse column glovebox
- D2900 – Decontamination facility
- D6499 – Low Level Waste pits repackaging facility
- D8570 – Waste Receipt Assay Characterisation and Super compaction facility
- D9867 – High alpha low beta/gamma waste store
- DN060 – Waste Compliance facility

4.4.1 An estimate of continuing discharge has been made for each of the facilities. The estimate was derived essentially from the high end of potential discharge with the following exceptions:

- D2900 tritium discharge which is based on potential discharge from decontamination of large items from PFR and DFR; and
- DNO60 discharges. The Waste Compliance facility is a new treatment facility designed to remove surface contamination, using dry decontamination methods, for which discharge estimates have been made by comparison with the American facility RACE.

4.4.2 With the exception of D1200 alpha and D2900 and DN060 all measured discharges are at or very close to the MDA. D1200 alpha has on occasion been measured as a 'real' discharge and this is reflected in the higher estimate in all future years.

4.4.3 A further estimate of 1.00E+10 Bq tritium has been made to account for potential tritium release from DN060 should it be required. This figure has no basis other than the potential for the decontamination of tritium contaminated items at the DN060 facility.

4.5 The D1200 alpha, D2900 and DN060 beta and D2900 tritium estimates are doubled to allow for laboratory dismantling and new operations at DN060 and D2900;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
H-3	1.00E+10	2.00E+10
Kr-85	4.00E+12	4.00E+12
Beta (Excluding Tritium and Krypton – 85)	8.30E+05	1.70E+06
Alpha	1.83E+05	3.70E+05

EMS T1 - ESTIMATES OF GASEOUS DISCHARGES FROM THE EAST MINOR SOURCES

EAST MINOR SOURCES Predicted future 12 month discharge (Bq)																		
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
D1200	alpha		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04							
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05							
D1226	alpha		2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04							
	beta		2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05	2.00E+05							
D2900	alpha		4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04			
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05			
D8570	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03			
	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04			
D9867	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03										
	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04										
Other	H-3		1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10
D2670	**alpha**		5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	5.80E+04	
	beta		3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	3.60E+05	
	Kr-85		4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	4.00E+12	
DN141	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	
	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	
Total	alpha		1.88E+05	1.83E+05	1.83E+05	1.83E+05	1.83E+05	1.83E+05	1.73E+05	1.73E+05	1.73E+05	1.03E+05	1.03E+05	1.03E+05	1.03E+05	5.80E+04	5.80E+04	0.00E+00
	beta		8.40E+05	8.30E+05	8.30E+05	8.30E+05	8.30E+05	8.30E+05	7.70E+05	7.70E+05	7.70E+05	4.70E+05	4.70E+05	4.70E+05	4.70E+05	3.60E+05	3.60E+05	0.00E+00

4.6 The West Minor Sources (WMS) is a grouping of facilities, as set out in the extant authorisation table 4.5, that discharge radioactivity to atmosphere via various dedicated stacks of varying heights. The grouping comprises all stacks (excluding the PFR groups) that are West of the DFR facility:

- D3000 – Low Level Liquid Effluent Treatment Plant (LLLETP), the final receipt of active liquor prior to discharge to the marine environment.
- D9833 – Ultrafiltration Pilot Plant, used to filter Silo liquor prior to discharge to LLLETP
- D1115 –Storage of a full PFR Primary Cold Trap Loop filter.
- D2167 – Laundry for works clothing

4.6.1 The estimate of gaseous discharges from D3000 are held at the current values. These were the theoretical limits of detection used for the variation (V01) to the extant Certificate of Authorisation RSA/N/50010/99. There is considered to be no need to revise these in light of the recorded discharges.

4.6.2 The D9833 gaseous discharges have been reasonably constant for alpha and within one order of magnitude for beta depending on operation of the Ultrafiltration Plant.

4.6.3 The D1115 PCTL containment is regularly purged to provide assurance that the oxygen level in the containment is kept within preset values. The alpha and beta discharges are insignificant, generally being below 1 Bq per purge. The tritium discharge is however different in that if the sodium reacts with oxygen then a significant, in relation to the facility norm, release of tritium can occur. Thus an estimate has been made based on the previous discharges.

4.6.4 The D2167 Laundry estimates of gaseous discharge are based on the results obtained to date in the expectation that these will not differ significantly in the future.

4.7 For the gaseous discharge the alpha, beta and tritium estimates are as the estimates;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	1.10E+04	1.10E+04
Beta	4.00E+04	4.00E+04
Tritium	1.01E+10	1.01E+10

WMS T1 - ESTIMATES OF GASEOUS DISCHARGES FROM THE WEST MINOR SOURCES

WEST MINOR SOURCES Predicted future 12 month discharge (Bq)																		
			2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Facility	Nuclide																	
D3000	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03
	beta		2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04	2.00E+04
	H-3		1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10
D9833	alpha		1.00E+03	1.00E+03	1.00E+03	1.00E+03	1.00E+03											
SILO	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04											
D1115	alpha		10	10	10	10	10	10										
	beta		10	10	10	10	10	10										
	H-3		1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08										
D2167	alpha		5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03	5.00E+03
	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04
Total	alpha		1.10E+04	1.10E+04	1.10E+04	1.10E+04	1.10E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04
	beta		4.00E+04	4.00E+04	4.00E+04	4.00E+04	4.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04	3.00E+04
	H-3		1.01E+10	1.01E+10	1.01E+10	1.01E+10	1.01E+10	1.01E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10

5 Liquid Discharges from facilities other than DFR (Section 2) and PFR (Section 3)

5.1 The radioactive liquid discharges from the site to the North Atlantic Ocean occur by the pumping of collected liquors from the LLLETP. The LLLETP is a collection and treatment plant for radioactive liquors generated in the various facilities across the site. The DFR and PFR facilities have been dealt with at sections 2 and 3 above. This section will deal with the remaining sources:

- D1200 – chemistry laboratories;
- D1203 – fuel processing and recovery;
- D1204 – ex Materials Test Reactor Fuels processing;
- D1205 – Laundry;
- D1206 – ex Fast Reactor Fuels reprocessing;
- D1207 – Store;
- D1208 – High Active Liquid waste storage and conditioning;
- D1209 – ventilation duct;
- D1212 – Low Level Waste pits;
- D1215 and D1218 – High activity and Plutonium chemistry laboratories;
- D1225 – Shaft;
- D1224 – Shaft ion exchange facility;
- D1234 – Fuels handling;
- D2001 – ILW waste handling and PIE cells;
- D2900 – Decontamination facility;
- D9833 – Silo water filtration;
- D8571 – DMTR PIE facility; and
- Site Services Unit – Areas of the site including DFR Outfall, Boreholes, Occupational Health Department.

5.1.1 The majority of the facilities have discharged liquor to LLLETP during recent years. . The discharges from D1205, D1225 and D1224 demonstrate very little variation but the analytical facilities of D1200 and D1215 demonstrate very wide variation that is a function of the samples received for analysis.

5.1.2 An estimate of future discharge has been made for each based on the future programme and past discharges.

5.2 For the liquid discharge, the alpha is increased by a factor of 1.5 and rounded down, the beta has the strontium 90 (principal source is the Shaft) subtracted and the remainder is increased by a factor of 1.5. The tritium, Cs-137, Sr-90 and Am-241 are increased by a factor of 1.5;

Radionuclide	Estimate (Bq/yr)	Proposed Contribution to Site (Bq/yr)
Alpha	2.13E+09	3.19E+09
Beta (Excluding tritium)	1.69E+11	1.26E+11
Tritium	-	-
Caesium-137	6.54E+10	9.81E+10
Strontium-90	8.50E+10	1.28E+11
Americium-241	1.0E+07	1.50E+07

LIQUID T1 - ESTIMATES OF LIQUID TRANSFERS TO THE LLLETP

LIQUID DISCHARGES TO LAD (Bq)																		
Facility	Radionuclide		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
D1203	alpha		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+08	1.00E+08	1.00E+08	2.50E+04	2.50E+04	2.50E+04	
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	5.00E+09	5.00E+09	5.00E+09	3.50E+04	3.50E+04	3.50E+04	
D1209/13 Sump	alpha		1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	5.00E+07						
	beta		4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	2.00E+08						
D1208	alpha		1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08		
	beta		2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09		
D1200	alpha		1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07				
	beta		1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08				
D1204	alpha		2.00E+08	2.00E+08	1.00E+04	1.00E+04	1.00E+04											
	beta		9.00E+10	9.00E+10	1.00E+05	1.00E+05	1.00E+05											
	Sr-90		6.50E+10	6.50E+10														
	Cs-137		6.00E+10	6.00E+10														
D1205	alpha		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00								
	beta		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00								
D2167	alpha		5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07								
	beta		2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08	2.50E+08								
D1206	alpha		1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06	1.00E+06							
	beta		1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07							
	Cs-137		1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07							
D1207	alpha		1.00E+05	1.00E+05	1.00E+05	1.00E+05												
	beta		1.00E+06	1.00E+06	1.00E+06	1.00E+06												
	Cs-137		1.00E+06	1.00E+06	1.00E+06	1.00E+06												
D1215/18	alpha		1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07				
	beta		1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08	1.00E+08				
D1225/24	alpha		5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07						
SHAFT	beta		5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10	5.00E+10						
	Sr-90		2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10						
	Cs-137		5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09	5.00E+09						
D1234	alpha		2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+08	2.00E+07	2.00E+07	2.00E+06						
	beta		2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+09	2.00E+08	2.00E+08	2.00E+07						

D2001	alpha		5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04	5.00E+04							
	beta		1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05	1.00E+05							
D2900	alpha		3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08	3.00E+08
	beta		3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09	3.00E+09
LLW Pits	alpha		1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09	1.00E+09
	beta		1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10
D9833/ SILO	alpha		5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07	5.00E+07							
	beta		1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10	1.00E+10							
Manhole 5	alpha		2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07	2.00E+07
Castle Seep	beta		4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08	4.00E+08
	Cs137		3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
	Sr 90		4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07
	Am241		1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07
D1310	alpha		2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03	2.00E+03									
	beta		1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04	1.00E+04									
Site Services	Alpha		2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06
	Beta		1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07
D1211	Alpha		3.00E+07	3.00E+07	3.00E+07	3.00E+07	3.00E+07											
	Beta		6.00E+08	6.00E+08	6.00E+08	6.00E+08	6.00E+08											
Bore holes	alpha		8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05	8.00E+05
	beta		7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06	7.00E+06
LAD Manholes	alpha		5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05	5.00E+05
	beta		2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06
Vulcan	alpha		6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05	6.00E+05
	beta		2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06	2.00E+06
Totals	alpha		2.13E+09	2.13E+09	1.93E+09	1.93E+09	1.93E+09	1.90E+09	1.90E+09	1.72E+09	1.67E+09	1.65E+09	1.54E+09	1.54E+09	1.42E+09	1.42E+09	1.32E+09	1.32E+09
	beta		1.69E+11	1.69E+11	7.89E+10	7.89E+10	7.89E+10	7.83E+10	7.83E+10	7.65E+10	7.62E+10	7.08E+10	2.06E+10	2.06E+10	1.54E+10	1.54E+10	1.34E+10	1.34E+10
	tritium		0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
	Cs-137		6.54E+10	6.54E+10	5.36E+09	5.36E+09	5.36E+09	5.36E+09	5.36E+09	5.36E+09	5.36E+09	5.35E+09	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08	3.50E+08
	Sr-90		8.50E+10	8.50E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	2.00E+10	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07	4.00E+07
	Am-241		1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07	1.00E+07

6 CONCLUSIONS

6.1 There are uncertainties in the estimates of future discharge ranging from moderate to significant. Where the uncertainty is moderate it is generally associated with ongoing processes that have historically returned reasonably constant discharges or sampling is able to provide reasonable confidence to the estimate. Where the uncertainty is significant it is generally associated with new processes (e.g. NaK destruction), where analytical results are sparse or the process has historically returned discharge results of the order of the analytical limit of detection.

6.2 Taking the uncertainties into account it is possible to adjust the estimates to allow flexibility whilst maintaining control and sum these estimates to provide an overall proposed site limit for both gaseous and liquid discharges.

6.3 The gaseous estimates are amended to provide the proposal in Site Gaseous T1:

- West Minor Sources(as defined):- For the gaseous discharge the alpha, beta and tritium estimates are unchanged;
- East Minor Sources (as defined):- For the gaseous discharge the D1200 alpha, D2900 and DN060 beta and D2900 tritium estimates are doubled to allow for laboratory dismantling and new operations at DN060 and D2900;
- FCA:-For the gaseous discharge, the alpha and beta estimates are doubled to account for new decommissioning , the tritium and iodine-129 are set at a level commensurate with the analytical limit of detection and the krypton-85 is left at the estimate;
- DFR:- For the gaseous discharge, as the project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the krypton is left as estimated; and
- PFR estimates are doubled, as the project is made up of new processes, except for krypton which is left as estimated.

SITE GASEOUS T1

PROPOSED ATMOSPHERIC DISCHARGE LIMITS
As Per Extant Groupings

Nuclide	Authorisation Schedule 4 Table	4.4	4.2 & 4.7	4.3	4.6	4.5	**Site Proposed Need Bq/yr**
alpha		6.48E+06	1.28E+05	3.00E+05	3.70E+05	1.10E+04	**7.28E+06**
beta		1.46E+09	7.80E+08	7.00E+08	1.70E+06	4.00E+04	**2.94E+09**
H-3		5.13E+11	7.50E+13	2.70E+12	2.00E+10	1.01E+10	**7.82E+13**
Kr-85		0.00E+00	5.69E+14	3.00E+12	4.00E+12	0.00E+00	**5.76E+14**
I-129		1.00E+09	-	-	-	-	**1.00E+09**

6.4 The liquid estimates are amended to provide the proposal in Site Liquid T1:

- DFR:- For the liquid discharge, as the project is made up of new processes, the alpha and beta estimates are doubled, the tritium estimated for the NDP project is doubled and the caesium 137 and strontium 90 are as for total beta;

- PFR :- For the liquid discharge, as the project is made up of current processes and new processes, the alpha beta and caesium 137 estimates are rounded up, the tritium is doubled and the sodium 22 is left as estimated;

- Other contributors:- For the liquid discharge, the alpha is increased by a factor of 1.5 and rounded down, beta has the strontium 90 (principal source is the shaft) subtracted and the remainder is increased by a factor of 1.5, tritium is increased by a factor of 1.5 and the strontium 90 and caesium 137 estimates are rounded up;

SITE LIQUID T1
Proposed Limits (Liquid Discharge)

	DFR Estimate (Bq/yr)	**PFR Estimate (Bq/yr)**	**Rest of Site Estimate (Bq/yr)**	**Site Proposed Need (Bq/yr)**
Total alpha	4.00E+08	8.20E+07	3.19E+09	3.67E+09
Total beta (Excl. tritium)	1.26E+12	1.34E+12	1.26E+11	2.73E+12
Total Sr-90	1.47E+11	-	1.28E+11	2.74E+11
Total Cs-137	5.60E+11	6.10E+11	9.81E+10	1.27E+12
Total Na-22	-	1.32E+10	-	1.30E+10
Total H-3	2.40E+12	1.00E+14	-	1.02E+14
Total Am-241	-	-	1.50E+07	1.50E+07