Dounreay Site Restoration Ltd

Information in Support of an Application for Authorisation for the Disposal of Liquid, Gaseous and Solid Radioactive Wastes from Dounreay

2010

Dounreay Site Restoration Ltd

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SUMMARY

The Radioactive Substances Act 1993 requires operators to have authorisations to dispose of radioactive wastes from their sites. Authorisations are reviewed at regular intervals. This application is made by Dounreay Site Restoration Limited (DSRL) to renew the solid, liquid and gaseous authorisations for the Dounreay site.

The current authorisations were originally issued to the United Kingdom Atomic Energy Authority (UKAEA) on 16 July 1999 by the Scottish Environment Protection Agency (SEPA) and transferred to DSRL on 1 April 2008. Each of the authorisations has been varied:

- Solid Radioactive Wastes
  - March 2003 to allow the transfer of contaminated sodium from AEA Technology plc to UKAEA for destruction;
  - 5 July 2005, to update the authorisation to the multimedia format of certificate, following an application to dispose of low level solid radioactive waste to the Low Level waste Repository at Drigg; and
  - 23 June 2008 to include improvement requirements;
- Gaseous Radioactive Wastes
  - July 2003 in response to a variation requested by UKAEA to account for tritium disposal during the low level liquid effluent treatment plant operations;
  - 28 May 2007 to update the authorisation to the multimedia format of certificate; and
  - 23 June 2008 to include improvement requirements;
- Liquid Radioactive wastes
  - October 2004 following a review of the authorisation for UKAEA Dounreay initiated by SEPA following the switch in role of the site from operational to one of mainly decommissioning;
  - 28 May 2007 to update the authorisation to the multimedia format of certificate; and
  - 23 June 2008 to include improvement requirements.

It is recognised by DSRL that the authorisation in place for the disposal of radioactive wastes from Dounreay is based on the application submitted in 1993 and determined by SEPA in 1999.

This application is submitted in support of proposals for revised authorisations to dispose solid, liquid and gaseous radioactive wastes from the Dounreay site to progress the Dounreay Lifetime Plan (LTP).

Past discharges of gaseous and liquid radioactive waste into the environment from Dounreay have had very small impact on members of the public or on the environment more generally. Radiation doses to local people are well below the dose limit of 1 mSv/yr recommended in the EC Directive 96/29/Euratom Basic Safety Standards. Over the last ten years there have been substantial improvements in the management of radioactive materials on the Dounreay site, which have led to a steady reduction in liquid and gaseous wastes discharges. DSRL has an effective system for monitoring the levels of radioactivity discharged from the Dounreay site and complements this by carrying out environmental monitoring measurements in the vicinity that demonstrate the minimal impact of its operations.

During the LTP, there will be modest discharges of radioactive material to the environment as facilities are brought to a condition of passive safety and ultimately dismantled. This document provides information to demonstrate that the overall trend in reducing discharges can be continued whilst undertaking the beneficial decommissioning and restoration of the Dounreay site.

Wastes arising from the processing of foreign contract nuclear material will be packaged and returned to the country of origin in accordance with the terms of the contract and in compliance with the transboundary movement of radioactive materials regulations.

The new limits proposed are based on a review of past disposals and an assessment of future requirements over the period of the LTP through to completion of decommissioning at the Interim End Point[1] [2]. Best Practicable Means (BPM) is considered and applied to all operations to minimise the creation and disposal of radioactive waste. The limits proposed take into consideration ongoing waste minimisation measures. It is necessary to maintain a reasonable margin between expected disposals and regulatory limits in order to avoid unreasonable constraints on the essential flexibility required to progress the decommissioning and waste retrieval work associated with the LTP.

The proposed discharge limits (as summarised in the tables below) will in general have little effect on the exposure of the public to radiation across all pathways, whilst still allowing decommissioning of the site to be progressed. Potential radiation doses (as summarised in the tables below) to the most exposed members of the public have been calculated for discharge at 100% of the proposed limits; doses are 5.9μSv/year for adult exposure to atmospheric discharges and 0.015μSv/year for adult exposure to marine discharges. These doses are much lower, less than 5%, of the Health Protection Agency Radiation Protection Division recommended dose constraint for nuclear sites of 300μSv/year. They are also significantly below the proposed threshold of 20 μSv/year for discharges of radioactive wastes to the environment, as set out by the Government in the 1995 Review of Radioactive Waste Management Policy: Final Conclusions (Cmnd 2919 as amended), below which the regulators should not require further reduction in exposure providing they are satisfied that BPM is being applied to limit discharges. In practice discharges are expected to be lower than the proposed limits and radiation doses will therefore also be lower.

Gaseous Discharge

The following tables summarise the maximum extant authorised gaseous limits and the proposed estimated 12 month discharges from the authorised discharge points, and the calculated estimates of dose to the critical group and the UK and European populations.

Summarised Current radionuclide Authorised Limits (Bq/yr)

EXTANT ATMOSPHERIC DISCHARGE LIMITS						
Extant Groupings						
Radionuclide	Table 4.4	Table 4.2 & 4.7	Table 4.3	Table 4.6	Table 4.5	Extant Total Bq/yr
alpha	9.80E+08	6.06E+06	1.00E+07	1.37E+07	3.00E+05	1.01E+09
beta	4.50E+10	5.15E+07	1.50E+09	3.71E+08	7.50E+07	4.7E+10
H-3	2.00E+12	1.07E+13	4.50E+12	N/A	1.00E+10	1.72E+13
Kr-85	3.00E+15	4.00E+12	4.00E+08	1.00E+12	N/A	3.01E+15
I-129	1.10E+09	N/A	N/A	N/A	N/A	1.10E+09

[1] The Interim End Point is the point in time when all hazards have been made passively safe, decommissioning is complete and only conditioned wastes and any remaining packaged nuclear material await final disposal or transfer from Dounreay.
[2] The Final End Point is the point in time, depending on Scottish Government policy on the governance of radioactive wastes, when the entirety of the Dounreay estate can be de-licensed and released, with or without preconditions, for use.

Summarised Proposed Authorised Limits (Bq/yr)

PROPOSED ATMOSPHERIC DISCHARGE LIMITS						
Extant Groupings						
Radionuclide	Table 4.4	Table 4.2 & 4.7	Table 4.3	Table 4.6	Table 4.5	Proposed Limits 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**

Summarised individual doses (μSv) for atmospheric discharges (excluding component for goat's milk and assuming cow's milk consumption)

Discharge limit		**Proposed Authorised Limit**		**Current Authorised Limit**
Critical Group definition		**Average**	**Extreme**	**Average**
Upper Dose	Infant	6.1	14.0	5.3
	Child	7.1	14.0	7.4
	Adult	5.9	11.0	10
% of dose constraint	Infant	2.0	4.67	1.8
	Child	2.4	4.67	2.5
	Adult	2.0	3.67	3.3

For a description of the full meaning of 'average' and 'extreme' critical groups the reader is referred to An Assessment Of The Radiological Impacts Of Proposed Atmospheric And Liquid Radioactive Waste Disposals From Dounreay, DSRL, 2009

Summarised collective doses (man Sv) for modelled atmospheric cases

Discharge limit	**Proposed Authorised Limit**	**Current Authorised Limit**
UK collective dose	0.023	0.06
EU collective dose	0.12	0.26

Liquid Discharge

The following tables summarise the maximum extant authorised liquid limits and the proposed estimated 12 month discharges from the authorised discharge point, and the calculated estimates of dose to the critical groups and the UK and European populations.

Proposed and Current Authorised Limits for Liquid Discharges (Bq/yr)

Radionuclide	Proposed Limits	Extant Limits
Total alpha	3.67E+09	1.10E+11
Total beta (Excl. tritium)	2.73E+12	4.37E+12
Total Sr-90	2.74E+11	7.70E+11
Total Cs-137	1.27E+12	1.07E+12
Total Na-22	1.30E+10	1.80E+12
Total H-3	1.02E+14	6.9E+12
Total Am-241	1.50E+07	N/A

Summarised individual doses (μSv) for ingestion of marine food products

		Proposed Authorised Limit		Current Authorised Limit
Critical Group definition		Average	Extreme	Average
Upper Dose	Adult	0.015	0.026	0.61
	Child	0.010	0.01	0.51
	Infant	0	0	0
% of dose constraint	Adult	0.005	0.009	0.20
	Child	0.003	0.003	0.17
	Infant	0	0	0

Summarised collective doses (man Sv) for the modelled marine cases

Discharge limit	Proposed Authorised Limit	Current Authorised Limit
UK collective dose (manSv)	0.012	0.03
EU collective dose (manSv)	0.041	0.12

The facilities at Dounreay are such that no direct radiation dose to the local population is expected. As part of the environmental monitoring programme carried out around the site the dose rates at 15 locations around the site perimeter are measured with Thermoluminescent Dosimeters (TLDs). These show that the upper limit to the dose at the nearest habitation is within the variability of natural background and of the order of 5 μGy/y.

DSRL's view is that the environmental impacts of discharges at the proposed limits are greatly outweighed by the substantial benefits to both society and the local community of the decommissioning and environmental restoration of the site being proposed. With respect to sustainable development, it is important that the decommissioning and restoration is allowed to progress rather than leaving the task (and associated environmental burdens) for future generations. On-going decommissioning operations at the Dounreay site also provide valuable development of national expertise in this field and have been shown to contribute to the local community and economy.

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1 INTRODUCTION

This document supports the application of the Dounreay Site Restoration Limited (DSRL) for revision of its authorisations, under the Radioactive Substances Act 1993 (RSA 93):

- to dispose of radioactive wastes to land, water and air from the nuclear licensed site at Dounreay;
- the return of intermediate level waste (ILW) that has arisen from the reprocessing of fuels from foreign countries;
- will arise from the destruction of a quantity of contaminated sodium from Germany; and
- to transfer samples of solid, liquid and gaseous radioactive/potentially radioactive wastes to laboratories, remote from Dounreay, for analysis.

The extant authorisations which became effective from 16 August 1999 (Ref 1) and based on the application submitted in October 1993 (Ref 2), to the then regulator HMIPI, in the expectation that the United Kingdom Atomic Energy Authority (UKAEA) would reprocess liability fuels, carry out decommissioning and employ on site disposals of solid low level wastes. These authorisations have been subsequently varied to address specific areas not previously covered by the original authorisations:

- Solid radioactive wastes authorisation varied to permit the transfer of a quantity of sodium metal from AEA Technology plc to UKAEA and the disposal of the radioactive waste arising from the destruction of the metal (Ref 3);
- The discharge of tritium to atmosphere from the operations of the Low Level Liquid Effluent Treatment Plant (Ref 4);
- The removal of excessive operational headroom between actual discharges and the authorised limits for radioactive liquid disposals to sea (Ref 5);
- The transfer of the solid radioactive waste authorisation, and associated variation, to the multimedia format, by variation (Certificate reference RSA/N/V02/50012/99), following the Scottish Executive direction on the application for the disposal of solid radioactive waste to Drigg, Cumbria (Ref. 31);
- The transfer of the liquid and gaseous radioactive waste authorisations to the multimedia format, by variation (Certificate reference RSA/N/V02/50011/99 and RSA/N/V02/50010/99), prior to transfer of the full suite of authorisations to the new operating company DSRL; and
- The transfer of all three authorisations from UKAEA to the new Authorisation Holder, DSRL.

This document is intended to:

- Describe the current operations which give rise to radioactive wastes at Dounreay and those that are expected to occur over the period of the LTP;
- Describe the arrangements for the management of radioactive wastes and the measures used to minimise the amount of radioactivity in wastes discharged from the site;
- Present proposals for revised numerical limits for disposals to sea and air with a justification of the uncertainties of the proposals;
- Discuss the benefits and detriments associated with the disposals and demonstrate that the benefits outweigh the detriments thereby justifying the proposed discharges and disposals.

An outline history of Dounreay is given in section 2 followed by section 3, legislation and policy within which work involving radioactivity is controlled for the purposes of protection of the public, workers and the environment. A description of DSRL policy relating to the management of operations and radioactive wastes is given in section 4. Past liquid and gaseous radioactive discharges from Dounreay are detailed in section 5 with the environmental monitoring currently undertaken by DSRL and SEPA described in section 6.

A description of the operations giving rise to different types of waste at Dounreay is given in section 7. A Best Practicable Environmental Options BPEO study in 2003, updated in 2009, covering the discharge/disposal of all radioactive waste from the Dounreay site is summarised in section 8. DSRL is required to use Best Practicable Means (BPM) to reduce the arisings and discharges of radioactive waste; the procedures used are discussed and descriptions of how individual plant implement this are given in section 9.

Proposed limits for authorisations to discharge liquid and gaseous radioactive wastes from Dounreay are given in section 10, together with a consideration of the requirements from which they have been derived. The solid waste disposal requirements are also described. The environmental impact of the radioactive operations at Dounreay are discussed in section 11, concentrating on the radiological impact of discharges to the environment at both the proposed limits and at the actual levels which are currently expected to be discharged.

Quality assurance arrangements for measurement and record keeping of emissions and disposals are detailed in section 12. In section 13 the benefits arising from the steady progress of the DSRL work programme (principally decommissioning and radioactive waste management) are summarised and compared against possible detriments and thereby justified. Future developments, that may require future variations to the anticipated Certificate of Authorisation, are laid out in section 14, including details of proposed new treatment and storage facilities for the treatment of ILW recovered from the shaft and silo. Conclusions are drawn together in section 15.

1.1 Scope of the Applications

The application being sought is to replace the current authorisations in relation to the disposal of solid, liquid and gaseous radioactive wastes to land, sea and air. However, DSRL also includes here, in the accompanying application:

- the transfer of samples of solid, liquid and gaseous radioactive wastes, for analytical and characterisation purposes, to external laboratories as shall be agreed with SEPA;
- the transfer of contaminated bulk metals to RSA authorised facilities for decontamination and reuse;
- the transfer of contaminated sodium metal for incineration at RSA authorised facilities;
- transfer of contaminated oils and solvents for incineration at RSA authorised facilities;
- the use of air handling units (AHU), to ventilate directly to atmosphere, within the curtilage of any building with fixed ventilation systems and after fixed systems have been dismantled;
- the disposal of high volume low activity aqueous liquid radioactive wastes to the North Atlantic Ocean via trade/sewage waste facilities;
- radioactive wastes to be returned to the countries of origin, under the terms of commercial contracts, in a solid form but including a gaseous component;
- that proposed limits are applicable to the Dounreay site, in the whole, and are not applied to any specified facility groupings.

Since the granting of the authorisations to UKAEA in 1999 and taking account of subsequent variations and transfers the following have affected the basis of operations at Dounreay:

- The Government announced in June 2001 that further reprocessing of irradiated fuel would not be undertaken at Dounreay;
- The Nuclear Decommissioning Authority (NDA) has been established to take ownership of the decommissioning of redundant civil nuclear facilities, thus providing value for money to taxpayers in the achievement of decommissioning;
- The Lifetime Plan (LTP) has been published, detailing the activities to 2025 required to decommission and remediate the licensed site to an agreed interim end state; and
- The institutional care of the Dounreay site is identified to a final end state in 2300. The point at which the site can be de-licensed.

Undertakings

The LTP is the basis of the implementation of the restoration of the Dounreay site. The principal undertakings are now:

- The decommissioning of the premises;
- The storage of nuclear material and radioactive material on the premises;
- Nuclear material recovery/conditioning operations on the premises;
- The handling and treatment of waste transferred to the Authorisation Holder from the Vulcan Naval Reactor Test Establishment[3];
- The treatment of nuclear material for storage, transfer for permanent safe storage or for disposal;
- The treatment of radioactive wastes to place them in an accepted form for storage, disposal and/or transfer;
- The receipt, treatment, storage and disposal of NDA liability nuclear materials and radioactive wastes, from the Fast Breeder Reactor programme, returned from EU Member states;
- Analytical services in support of the above by destructive and non-destructive analysis and to characterise the environmental effects of the above; and
- Land remediation and restoration to achieve the Interim and Final End Points

The site discharges both radioactive and non-radioactive substances into the atmosphere and into the sea. The radioactive discharges which are the subject of this document are regulated under the Radioactive Substances Act 1993. The non-radioactive emissions are currently regulated under Controlled Activities Regulations (CAR) licenses and two IPPC Permits.

1.2 Context of the Current Review

Authorisations are required to be reviewed periodically (normally every 4-5 years) and revised where necessary. There has been a progressive reduction in gaseous and liquid radioactive waste disposals at Dounreay over recent years, as some of the major nuclear facilities have closed. This, allied to the decision not to continue with reprocessing, means the limits contained in the current authorisations no longer accurately reflect current and future operations to be carried out on site.

[3] The Vulcan Naval Reactor Test Establishment, a Ministry of Defence site, transfers liquid and solid wastes to Dounreay for disposal, treatment and storage under letters of agreement with both SEPA and DRSL.

2 BACKGROUND

2.1 History of Dounreay Site

On 1 March 1954, it was announced that a large-scale experimental fast breeder reactor was to be constructed at Dounreay in Caithness. A number of sites were considered but Dounreay was chosen because it best met the requirements of providing limitless supplies of both sea and fresh water for the plant and good geological conditions. It also provided major employment prospects and opportunities for a geographically remote community.

The purpose of the fast reactor was to demonstrate the feasibility of the process, which would increase the effective usage of uranium fuel compared to that achieved by conventional power reactor systems by converting the non-fissile uranium into plutonium. As well as the reactor, it was decided that fuel manufacture and fuel reprocessing would also be undertaken at the Dounreay site, so that the whole range of fuel-cycle activities associated with fast reactor technology would be located together. In addition, a second reactor was constructed - the Dounreay Materials Test Reactor (DMTR) and a series of back-up laboratories and services were provided.

The Dounreay site is built on a former Admiralty airfield constructed in 1944 (which never became operational) and adjacent farmland. Construction of the site began in March 1955 with the excavation for the Dounreay Fast Reactor’s (DFR's) foundations and in June 1955 construction of the DMTR began. By February 1956 the foundation work for the main process plants had been completed and by mid April 1956, the DFR reactor vessel was delivered to Dounreay, ready to be placed inside the DFR sphere.

By the end of May 1956 the complex of laboratories was well advanced and the tunnel under the seabed for the discharge of low active liquid waste was making steady progress and by September of that year, the shell of the DFR was completed. The DMTR construction was completed in February 1958 and achieved criticality in May 1958. The fast reactor chemical separation plant (for reprocessing of used reactor fuel) was completed in July 1959.

Construction of the DFR was completed in December 1958 and criticality was achieved in November 1959. The first electrical power output from DFR was exported to the national grid on 14 October 1962. Other post irradiation examination and chemical reprocessing cells were completed shortly after that. DFR continued in operation until 1977.

In 1966 a decision was taken to proceed with the 600MW (Thermal)/250MW (Electrical) Prototype Fast Reactor (PFR), which was built to the west of DFR. PFR became operational in 1974 and first supplied power to the grid in January 1975. PFR was originally designed as the forerunner of a large-output commercial fast reactor and was recognised as an important facility within the European collaborative programme.

PFR ceased operation in March 1994, since then Dounreay has been engaged in programmes of reprocessing reactor fuels, manufacturing reactor fuels for MTRs overseas and commercial work, which used spare capacity of existing plants. In 1997 there were a number of problems with the processing activities within the Fuel Cycle Area (FCA) that culminated in the eventual shut down of all activities except those essential to safety, under a formal direction issued by the NII in May 1998.

Following the Government announcement in July 2001 that no more PFR fuel would be reprocessed at Dounreay, UKAEA turned its focus to decommissioning the site and treating a legacy of materials and wastes.

2.1.1 History of Waste Generation at Dounreay

Radioactive waste as solid, liquid discharges to sea and discharges to air is produced as a result of:

Operations – care and maintenance operations prior to decommissioning, but also some operations to fulfil legacy commercial contracts; operational wastes are arising now and wastes from care and maintenance operations will continue to arise for several decades.

Decommissioning – post operational clean out (POCO), dismantling of plants and buildings, remediation of contaminated land etc: most decommissioning wastes have yet to be generated.

Legacy wastes and materials – these are wastes and materials that arose from operations that are no longer carried out on the Dounreay site. They include wastes that exist now that require further treatment/conditioning and materials that are yet to be treated. Treatment and/or conditioning of legacy wastes and materials may give rise to secondary wastes that have to be managed.

2.2 The Dounreay Site and Environment

The Dounreay site is located on the coastline in the county of Caithness in the north of Scotland. It is situated approximately 3 km from the village of Reay to the west and 14km from the town of Thurso to the east. The Dounreay nuclear licensed site covers approximately 55 hectares of land and is shown on the Dounreay Site Location map (Figure 1), along with other adjacent land owned by the NDA.

Approximately 630 people live in a 5 km radius from Dounreay. These are predominantly in the village of Reay but also in sparsely scattered farmhouses closer to the site.

The surrounding area is largely moorland although agriculture is predominant on the coastal strip. Both the arable and grazing land surrounding Dounreay are relatively flat and treeless.

The site is located close to a number of environmentally sensitive areas. There are Sites of Special Scientific Interest (SSSIs) in the region, as well as sites proposed for protection as Special Areas of Conservation (SACs) under the Habitats Directive, or Special Protection Areas (SPAs) under the Wild Birds Directive. The Highland Council has proposed that 61 hectares of the west part of Sandside Bay should be designated as an “Area of Great Landscape Value”.

The land owned by the NDA is not of significant conservation interest. However, there is an interesting area of maritime heath just outside of the NDA’s boundary adjacent to the coast, although this does not have SSSI status. There are five archaeological sites around Dounreay, two of which are scheduled ancient monuments (both burial mounds). Dounreay Castle, which dates from the late 16th century, is located just outside the nuclear licensed site boundary.

Risks to the environment are managed on the site through both engineered (hardware) and management systems. This includes abatement plant, process control instrumentation and containment systems around storage areas. Emissions into the air and water environments are routinely monitored and the results are reported to SEPA. The site also has an environmental management system, certified to ISO 14001.

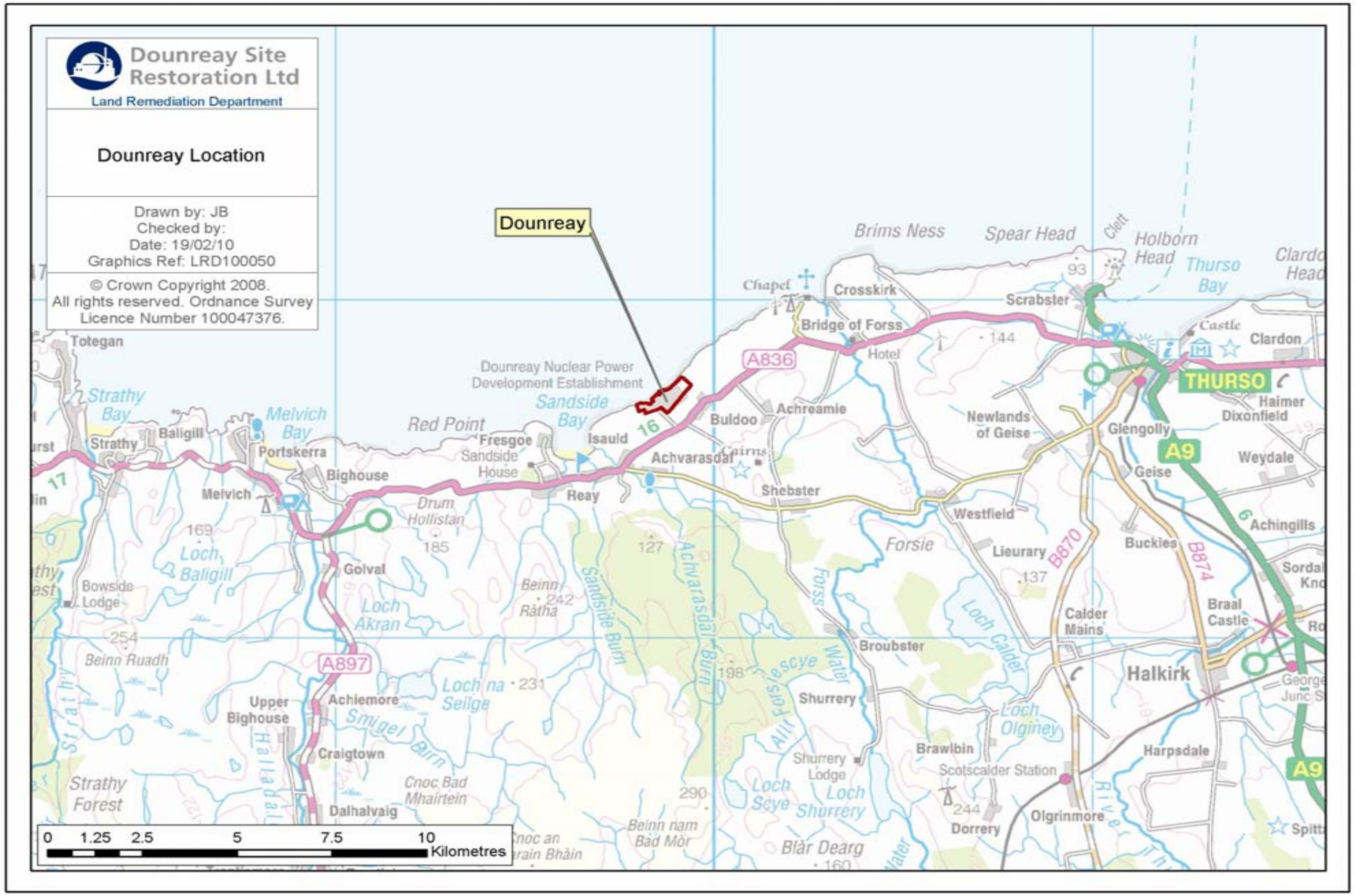

Figure 1 - Dounreay Site Location

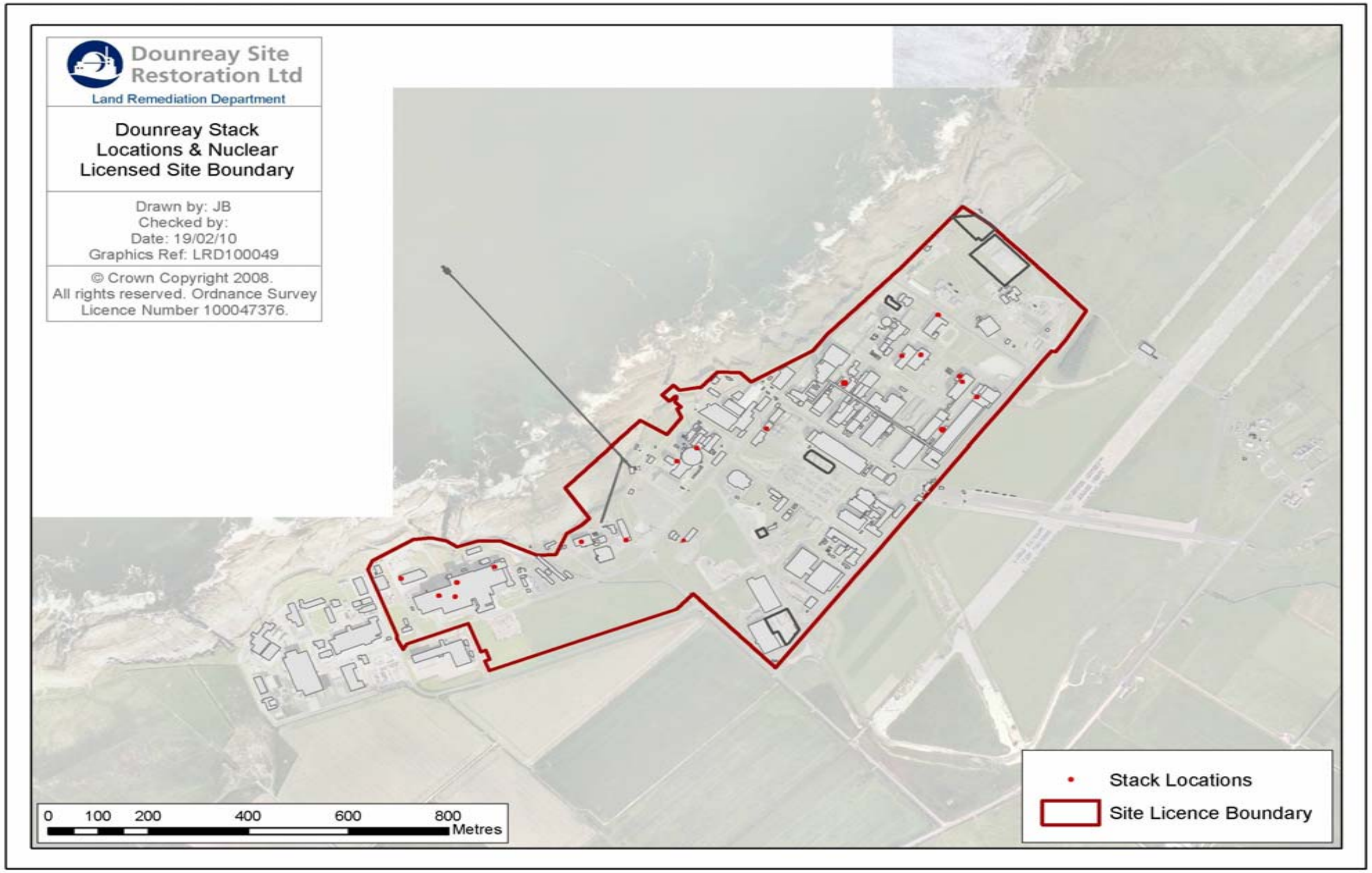

Figure 8 Site Layout

3 LEGISLATIVE AND POLICY FRAMEWORK

3.1 Introduction

Work with radioactive materials in the UK is governed by a range of legislation and supporting regulations encompassing safety and radiological protection in the workplace, protection of the environment and the safety of members of the public.

3.2 Article 37

Article 37 of the Euratom treaty requires that:

‘Each Member State shall provide the Commission with such general data relating to any plan for the disposal of radioactive waste in whatever form as will make it possible to determine whether the implementation of such plan is liable to result in the radioactive contamination of the water, soil or airspace of another Member State.’

This was added to in a Commission recommendation of 6 December 1999, quoting a Court of Justice judgement of 22 September 1988, as follows:

‘Article 37 of the Treaty of 25 March 1957 establishing the European Atomic Energy Community must be interpreted as meaning that the Commission of the European Communities must be provided with general data relating to any plan for the disposal of radioactive waste before such disposal is authorized by the competent authorities of the Member State concerned’.

UKAEA submitted Article 37 statements providing such data to the Commission via the Scottish Executive for the decommissioning of the DFR, for the decommissioning of PFR with a new Liquid Metal Disposal Plant and for the operation of a new waste receipt and conditioning facility (WRACS). These have been reviewed and accepted by the Commission.

The Dounreay Site Restoration Plan, now transferred to the LTP, has been developed as an integrated decommissioning programme and it is leading to a review of other documentation. An Article 37 document to cover the DSRP has been prepared, submitted to the Commission via the Scottish Executive and a favourable opinion was given by the Commission Group of Experts.

An Article 37 update is in preparation to provide to the Commission with revised general data in accord with the review period as advised by the Commission.

3.3 Article 35

Article 35 of the Euratom Treaty requires that each Member State shall establish facilities necessary to carry out continuous monitoring of the levels of radioactivity in air, water and soil and to ensure compliance with the Basic Safety Standards. Article 35 also gives the European Commission the right of access to such facilities in order that it may verify their operation and efficiency. SEPA are required to take due account of this with respect to DSRL’s arrangements for the monitoring of radioactive effluents and for assessing levels of radioactivity in the environment.

3.4 The Regulation of Radioactive Waste Management in the UK

3.4.1 The Health and Safety at Work Act, 1974

Under the Health and Safety at Work Act, 1974, DSRL, as an employer, has a duty to comply with a range of safety requirements, and protect both employees and members of the public from health and safety risks arising from its activities. In accordance with the fundamental principles of regulation of nuclear sites, as with other industrial sites, the operator must assess the risk from all its operations and reduce the risk to a level that is as low as reasonably practicable (ALARP).

3.4.2 The Nuclear Installations Act, 1965

The main purpose of the Nuclear Installations Act 1965 is to provide for the control of nuclear operations. This takes the form of a nuclear site licence, which contains a set of conditions with which the operator of that site must comply. DSRL holds the nuclear site licence for the Dounreay site. The following licence conditions will specifically apply to radioactive waste on a licensed nuclear site:

LC 4: Restrictions on Nuclear matter on the Site
LC 14: Safety Documentation
LC 25: Operational Records
LC 32: Accumulation of Radioactive Waste
LC 33: Disposal of Radioactive Waste
LC 34: Leakage and Escape of Radioactive Material and Radioactive Waste

The operator must ensure that, as far as reasonably practicable, radioactive waste is minimised and is adequately controlled and contained at all times.

The NII is responsible for overseeing the nuclear and radiological safety issues on a licensed site. The NII has powers to direct how waste should be disposed of and stored (RSA 93 Section 14, Accumulation) but do not regulate the disposal of radioactive waste from the site. Radioactively contaminated land on nuclear licensed sites is managed under a safety case.

3.4.3 The Ionising Radiations Regulations, 1999

The discharge of radioactive materials from Dounreay has the potential to cause exposure of members of the public to radiation. The Ionising Radiations Regulations 1999 (IRR99) regulate the radiation exposure of the public and are issued under the provisions of the Health and Safety at Work Act, 1974. These Regulations set the maximum permissible dose to a member of the public at 1 milliSievert per year (mSv/y) excluding exposure due to natural background radiation and medical exposure. They also require that doses be as low as reasonably practicable (ALARP).

3.4.4 The Water Environment and Water Services (Scotland) Act 2003 and The Environment Act 1995

The Water Environment and Water Services (Scotland) Act 2003 requires DSRL Dounreay to obtain licences (from SEPA), under the Water Environment (Controlled Activities) (Scotland) Regulations 2005, (CAR), to discharge non-radioactive effluent and surface waters from the outfalls, into the sea. The licences state the quantity and quality of effluent that can be discharged. Any substantial change in nature, volume or composition of effluent needs consent from SEPA. CAR does not cover any radiological aspects relating to discharges. SEPA has powers to serve an enforcement notice on DSRL if SEPA considers that there has been or likely to be a contravention.

The Environment Act 1995 is a wide-ranging piece of environmental legislation. In particular, it:

- Created SEPA in Scotland and the Environment Agency in England and Wales;
- Amends Control of Pollution Act 1974 and the Environmental Protection Act 1990;
- Amends the Radioactive Substances Act 1993;
- Provides a statutory framework for contaminated land.

The Act provides a legislative framework for the identification and remediation of contaminated land. Contaminated land is land where the local authority considers that:

- Significant harm is being caused, or there is a significant possibility of such harm being caused;
- The Water Environment is being, or likely to be, significantly polluted.

Contaminated land on a nuclear licensed site is designated as a special site, such that SEPA, not the local authority, acts as the enforcing authority. Under the Environment Act, DSRL will be required to remediate land that the NII consider DSRL, or its predecessors, have contaminated. In the case of contamination occurring outside the nuclear licensed site SEPA will act as arbiter for remediation.

3.4.5 The Radioactive Substances Act 1993

The Radioactive Substances Act (RSA) 1993 regulates the keeping, use, accumulation and disposal of radioactive wastes. For a nuclear licensed site the keeping, use and accumulation are exempt from the Act. Any disposal of radioactive waste from site, whether in gaseous, liquid or solid form requires an authorisation under RSA 93 section 13. Subject to assessments of acceptability, such authorisations are in Scotland granted by SEPA. NII acts as a statutory consultee for authorisations to dispose of radioactive wastes from nuclear licensed sites, and liaises with SEPA on matters relating to the management of radioactive wastes. The applications for the authorisations and the authorisations themselves must be put on the public register by SEPA. These requirements are outlined below.

The authorisations include discharge and disposal limits. To comply with their authorisations, DSRL must monitor discharges and disposals to demonstrate that they are within these limits and keep adequate records. Part of the record, as agreed with SEPA, must be sent to SEPA and put on the public register by SEPA. It is not sufficient to comply with the limits in the authorisation, all discharges and disposals must also be minimised and DSRL must demonstrate minimisation of waste discharged i.e. the application of Best Practicable Means (BPM) (Ref 1.).

Under a RSA 93 Authorisation, DSRL must demonstrate that the discharges and disposals do not have an adverse effect on the environment, by carrying out an environmental monitoring programme. The results of the programme must be sent to SEPA routinely, depending on the monitoring frequency, and put on the public register by SEPA.

4 DOUNREAY POLICY AND STRATEGY FRAMEWORK

4.1 Overview of Health, Safety and Environment Policy

DSRL's management of safety is directed at the provision of safe working arrangements across the site for all staff, contractors and visitors. This policy extends to the protection of property, the public and the environment. To fulfill this commitment using continuous improvement, quality assurance standards and achieving legislative compliance with industrial, environmental and radiological safety requirements involves staff and management in developing a positive culture and maintaining a safe and healthy working environment.

DSRL carry out risk and hazard assessments in an endeavour to eliminate the potential for fire, chemical and radiological incidents, security losses, damage to plant or property, thus significantly reducing the chance of any detriment to people or the environment from accidents.

4.2 Safety

Safety is one of DSRL's top priorities. A fundamental driver for decommissioning Dounreay is to provide a long-term guarantee of public safety. But the decommissioning process itself will require the deployment of staff, sometimes in potentially hazardous working environments. In undertaking all activities on the site, DSRL will observe strict safety procedures and will be governed by the regulations and guidelines laid down by the independent regulators.

4.3 Decommissioning and Radioactive Waste Management Policy

4.3.1 Integrated Waste Strategy (Ref 35)

In support of the delivery of NDA strategy, all NDA sites are required to produce and implement an optimised Integrated Waste Strategy (IWS). This is provided though a formal specification and a companion document.

The overall objective of the IWS is to demonstrate how Dounreay will assess and manage all wastes, both radioactive and non-radioactive (including those in solid, liquid or gaseous form) arising from the site's past, present and future operations. The IWS may also include any other waste transferred from other non-NDA sites for management of disposal.

The IWS demonstrates how all waste related activities on the site are integrated and includes a demonstration that the waste can be appropriately managed in accordance with BPEO and BPM, at the time and rate at which it will arise. It is submitted to the NDA as part of the Lifetime Plan review process and will enable Dounreay to demonstrate to its regulators and stakeholders that it is complying with legislation and standards.

DSRL, as Nuclear Site Licensee, is responsible for managing all decommissioning and waste management works on the Site, utilising both DSRL personnel and suitably qualified and experienced specialist contracting companies. The DSRL management team will, throughout the decommissioning works, act in liaison with the regulators.

4.3.2 Sustainable Development

DSRL's plans for waste management are in line with Government policy on sustainable development as expressed in Cm 2919 (as amended) (Ref 6). In particular, the plans do not foreclose any options for the storage, treatment and final disposal of ILW waste until a decision is made on the UK strategy for radioactive waste management. However, in accord with NIREX Letters of Compliance ILW liquid wastes are being converted into a solid form, by cementation, as a part of the requirement to reduce the radioactive hazards on the site. The plans also accord with the agreements given as part of Agenda 21 of the Rio Conference (Cm 2822) and the statutory guidance to SEPA by the Scottish Government under Section 31 of the Environment Act 1995.

The objective of restoring the Dounreay site, as defined in the LTP, is to make it available for unrestricted alternative use or to achieve a permanently safe condition that requires minimal institutional care. In this respect, DSRL is striving to ensure that a burden is not placed on future generations by the nuclear liabilities on the site, both in terms of safety and financially. The decommissioning of facilities and the safe processing of wastes, is achieving a "progressive reduction of the hazard" on the site in line with Government policy and the objectives of the NDA. As described in the section below, particular attention is being given to the minimisation of wastes and discharges to the environment. This is being ensured by undertaking a BPEO study (Ref 14 and 14.1) to underpin the management of decommissioning wastes. The BPEO study is submitted as a supporting document to this application and is discussed in Section 8.

4.3.3 Waste Minimisation

Waste minimisation is an integral part of a comprehensive waste management and safety culture that aims to reduce the environmental impact of the wastes generated at Dounreay.

The waste minimisation strategy involves a comprehensive approach which considers all the different parts of a process. These parts include process selection, the choice of plant design and equipment, plant operation and decommissioning practices. The minimisation strategy is influenced by the whole spectrum of activities, including source reduction, operational practices involving recycling and reuse, and administrative controls of waste management optimisation. The strategy requires an integrated approach considering the relationship between all the types of waste produced by a process.

4.3.4 The Waste Hierarchy[4]

The waste hierarchy aims to encourage the management of waste materials in order to reduce the amount of waste materials produced, and to recover maximum value from the wastes that are produced. It is not applied as a strict hierarchy as many complex factors influence the optimal management for any given waste material. However, as a guide, it encourages the prevention of waste, followed by the reuse and refurbishment of goods, then value recovery through recycling and composting.

The next option is energy recovery, an important level in the hierarchy as many materials have significant embedded energy that can be recovered. Waste prevention, reuse, recycling and recovery are collectively defined by the Organisation for Economic Co-operation and Development (OECD) as waste minimisation. Finally, waste disposal should only be used when no option further up the hierarchy is possible.

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[4] Taken from the SEPA website
http://www.sepa.org.uk/waste/moving_towards_zero_waste/waste_hierarchy.aspx

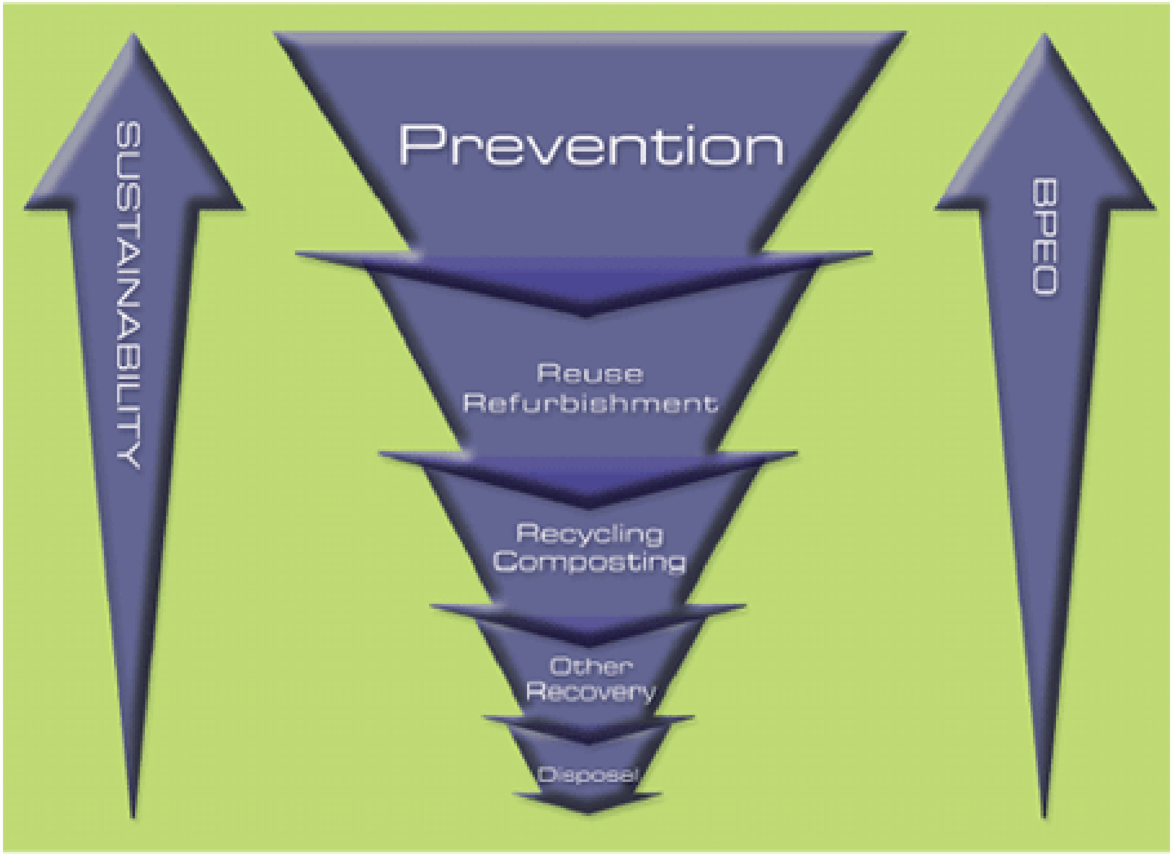


Fig 9 The Waste Hierarchy

This concept invokes a key component of waste minimisation by requiring generators to develop ideas on prevention before looking to the reuse, recycling and disposal options. The Waste Hierarchy reinforces that minimising waste needs to be addressed at the early stages of a process to prevent effectively the generation of waste.

4.4 Environment

4.4.1 Environmental Policy

It is DSRL policy to comply with environmental legal requirements and to improve overall environmental performance. Recognising the importance of environmental issues, DSRL subscribes to and has accreditation for the International Standard ISO 14001. DSRL implements environmental management system (EMS) on the site which meets the requirements of the International Standard ISO 14001 and DSRL's Safety, Health, Environment and Quality (SHEQ) Policy. In particular this includes:

- Assessment of all operations to minimise, where economically practicable, pollution and other impacts on the environment;
- Continual improvement and review of performance and setting environmental improvement objectives;
- Training staff to improve environmental performance and encourage innovative thinking on the subject;
- Complying with all environmental legislation and other commitments;
- Encouragement to recycle materials, reduce wastes and minimise where economically practicable, the use of energy and chemicals;

- Working with contractors to achieve similar standards and encouraging major suppliers and tenants to improve their environmental performance;
- Continuing to be open and honest by publishing a SHEQ policy, the objectives and annual progress reports on environmental performance.

The Dounreay site EMS embraces all non-tenanted plant and facility areas and applies to all DSRL staff and contractors. The EMS addresses all aspects of environmental management on the Dounreay site and covers issues such as transport of materials on and off site, noise, effects associated with the use of fuels, and energy and water and the supply, use and disposal of materials, including radioactive wastes.

4.4.2 Management Structure and Allocated Responsibilities

The following site personnel have specific environmental responsibilities under the site EMS procedures for ensuring environmental performance:

- DSRL Managing Director;
- Director of Assurance;
- The Environment Team Leader;
- Environment Assurance Manager;
- The Independent Assessment Manager;
- Other Dounreay Unit Managers;
- Environmental Advisors;
- All other DSRL staff and contractors.

The Managing Director of the Dounreay Site is responsible for the overall management of the site, including approving the site environmental policy and supporting environmental objectives and targets.

The Director of Assurance is responsible for ensuring the development of the site SHEQ Policy and supporting environmental objectives and targets.

The Environment Team Leader is responsible for ensuring that the development and operation of the EMS meets the requirements of the ISO 14001 standard. Other responsibilities include the provision of advice and support for effective implementation, reviewing the performance of the EMS, production and maintenance of support documentation and ensuring compliance with appropriate environmental standards/regulations.

The Environment Assurance Manager acts as the Site EMS Co-ordinator and is responsible for the day-to-day implementation/operation of the EMS, provision of advice/support and the development of appropriate environmental objectives and targets.

The Independent Assessment Manager is responsible for monitoring the programme of internal audits designed to ensure that the entire EMS is adequately audited.

All other Dounreay Unit Managers must also ensure:

- Compliance with the site SHEQ policy;
- Compliance with site procedures; and
- The effective implementation of the EMS within their areas.

Environmental Advisors provide advice to the ATO Holders of the environmental aspects relevant to the ATO Area.

4.4.3 DSRL Management of Compliance with RSA 93

In accordance with ISO14001, the environmental legal obligations of DSRL are assessed. These environmental legislative obligations include:

- Discharge authorisations, permits and licences;
  - The Certificate of Authorisation for the disposal of radioactive wastes include requirements to operate within specified numerical limits and to comply with specified conditions.
  - DSRL has a Qualified Expert Body, covering the aspects of BPM, Radiological protection, Engineering and Maintenance. The purpose of the Qualified Expert body is to advise the DSRL management on compliance with the limitations and conditions of the authorisation.
  - DSRL has a management system that documents how the conditions of the authorisation will be met.
  - DSRL has an organisation structure that will ensure that DSRL is capable of compliance with the limitations and conditions of the authorisation.

- Planning consents and similar requirements;
  - The Dounreay site is being decommissioned and planning consent/building warrant is required in respect of changes and/or demolition to/of the existing buildings or construction of new buildings

- Undertakings given by the site management to local authorities and other bodies;
- General duties and obligations under environmental law.

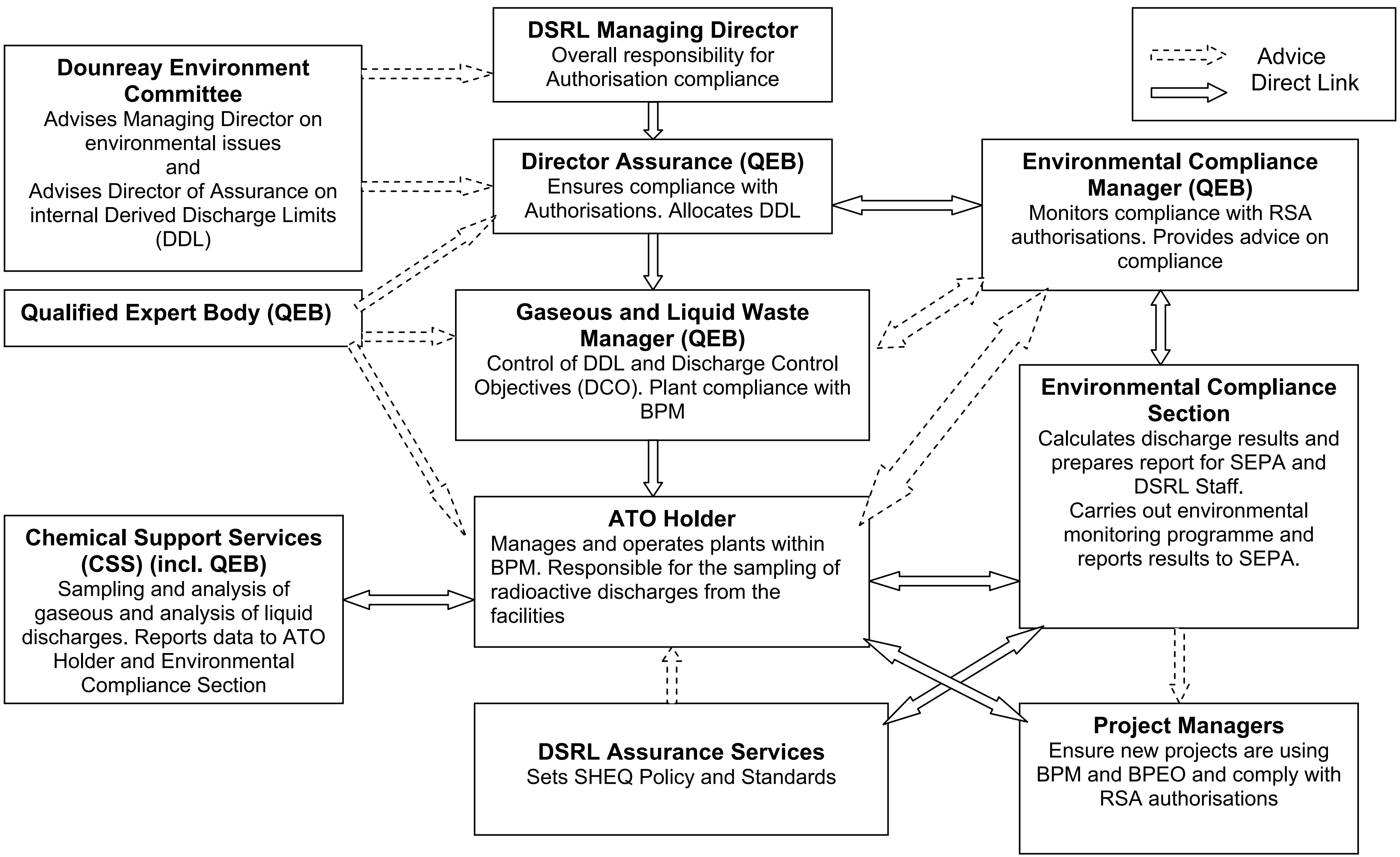


Figure 2 – RSA Authorisation Liquid and Gaseous Responsibility Flowchart

Of particular interest for this authorisation application, the responsibilities for managing radioactive solid, liquid and gaseous discharges under RSA 93 are summarised in Figure 2.

DSRL internally sets Derived Discharge Limits (DDL) for each plant that contributes radioactive wastes to the discharges regulated under the liquid and gaseous RSA authorisations. The DDL is an internal limit that should not be exceeded, thus ensuring that the site total does not exceed 75% of the statutory discharge limits. In addition, as an internal control tool, Discharge Control Objectives (DCO) are set for each plant. The ATO Holders[5] are responsible for ensuring that their plants are operating within the boundaries of BPM and the DCO is used as a tool for demonstrating this through sampling and analysis of their plant's discharges.

The site liquid discharges are sampled at the point of discharge and analysed. Gaseous discharges are sampled as close as possible to the point of discharge, to demonstrate that all discharges are within the DDL and therefore the authorisation. The results of the analysis and sampling are sent to the Environment Team, Environmental Compliance Section. The Environmental Compliance Section reports these results to SEPA, and arranges their retention in compliance with the requirements of the authorisations.

Under the conditions of the extant Certificates of Authorisation DSRL is required to ensure that:

- there is a management system, organisational structure, procedures and resources which are sufficient to achieve compliance with the limitations and conditions;
- there are written arrangements specifying how the Authorisation Holder will achieve compliance;
- there is provision for the appointment of Qualified Experts;
- there are written Environmental Operating Rules and operating instructions;
- there is a written maintenance schedule and written instructions;
- there is adequate supervision of the disposal of radioactive wastes;
- there is adequate supervision of the operation and maintenance of systems; and there is internal audit and review.

Whilst the above arrangements are in place DSRL is currently carrying out a programme of work that sets out the demonstration of compliance to the conditions down to a facility/project level. The work being carried out will culminate in the production of an Environmental Support File (ESF) for each facility/project that handles radioactive materials resulting in radioactive waste disposals to the environment and includes, but is not limited to, the identification of:

- relationship to the conditions as set out in the Certificates of Authorisation;
- systems and equipment that play a role in discharges;
- equipment;
- maintenance requirements;
- procedures/instructions;
- samples, checks; and
- forward actions required to improve the demonstration of compliance.

4.4.4 Operational Control

To monitor and control the effects that certain processes or materials may have on safety and the environment, local instructions have been defined for each plant. These operational controls are for the prevention/minimisation of safety and environmental impacts. With respect to the environment, if an unusual discharge occurs it would be the subject of an appropriate investigation. This would apply to increases in discharge where no breach of limits occurred but where there may be issues on the plant to be addressed.

[5] ATO Holder: Each facility has an appointed holder of the Authority to Operate the facility

There are a number of different local instructions that can include:

- Group instructions;
- Department instructions;
- Standing instructions;
- Operating instructions;
- Temporary operating instructions;
- Maintenance instructions.

4.4.5 Emergency Planning and Accident Prevention Systems

The Nuclear Site Licence requires DSRL to prepare emergency plans for dealing with incidents/accidents which may occur on the Dounreay Nuclear Licensed Site. DSRL has adopted the ‘all hazards approach’ to producing the Dounreay Emergency Plan that contains arrangements for dealing with all major incidents, including those with the potential for environmental impacts and the minimisation of risks to public safety. The Dounreay Emergency Handbook further supports this, detailing how the arrangements of the Dounreay Emergency Plan are implemented.

The Handbook also refers to more detailed procedures which have been prepared for use in an emergency. In addition, the Fuel Cycle Area (FCA), DFR and PFR have Emergency Manuals produced in support of the above to define the initial actions required in those areas in response to various types of emergency in order to ensure the safety of personnel, and where possible, plant. Staff are made aware of all hazards associated with their building operations and are trained in how to respond to emergency situations. This applies to situations that may develop outside the facility but impact upon it.

Immediate action to rectify abnormalities is taken by operators and management staff as a normal part of their duties. All forms of abnormal occurrences are reported, investigated and corrective action taken in accordance with local Dounreay Procedures.

A further part of the immediate action is to notify SEPA, in the case of any occurrence that has an environmental aspect, or the HSE/NII, in the case of any occurrence that has a safety/nuclear safety aspect, as soon as is practicable by the most appropriate communication method.

4.4.6 Training Systems

The competence requirements for all staff are defined in post profiles and are identified by consideration of the tasks and responsibilities associated with the post. These profiles identify the training needs for these posts and these are entered and maintained on a database. Post profiles are frequently contained within plant Training Programmes. In addition, there are also Training Manuals.

DSRL operates both a local site Training Programme and a centrally organised Safety, Health and Environment Training Programme. Both on the job training (e.g. against a specific local operating instruction) and off the job training are provided, as necessary. The latter involves attendance at training courses dependent on the post (e.g. Health, Safety and Loss Control; Fire Fighting; RSA Awareness and Compliance; etc). DSRL staff are given regular formal reviews of their training needs. Plant operators and other personnel are only authorised to undertake tasks once they have been trained for that task.

5 PAST SOLID, LIQUID AND GASEOUS RADIOACTIVE DISPOSALS FROM DOUNREAY

5.1 Solid Disposals

5.1.1 Context

An authorisation for the disposal of solid radioactive waste was issued to UKAEA in July 1999 (effective from 16 August 1999) by SEPA under the Radioactive Substances Act 1993. The authorisation was varied by SEPA in April 2003 and again in July 2005. The varied authorisation is now in the new multimedia format. The authorisation was again varied in June 2007 and transferred from UKAEA to DSRL on 1 April 2008.

5.1.2 Past Disposals

Disposal of low level solid wastes has been to the engineered facilities on the site in accordance with the authorised limitations and conditions. Disposals ceased in March 2005 after which the disposal pits were capped and landscaped, but not closed.

Solid radioactive wastes awaiting disposal are stored on the site and an application was made to SEPA for an authorisation to transfer the historic accumulation, current and future arisings of low level solid radioactive wastes to the disposal facility at Drigg in Cumbria. The application was denied, by direction to SEPA, by the then Scottish Executive on 10 May 2005 [Ref.31].

DSRL has applied for, and been granted planning permission to construct a near surface solid low level radioactive waste disposal facility (LLWR) at Dounreay. The intention is to be able to dispose of the low level waste, stored on the site, to this facility. This facility will have a separate authorisation for the disposal of low level solid radioactive wastes, historic accumulation, current and future arisings from the decommissioning activities on the Dounreay site. Concurrently an application under RSA 93 section 13 has been made to SEPA for the disposal of wastes transferred to the LLWR. This application is now being processed by SEPA with an anticipated decision on final disposal operations in 2014.

5.2 Liquid Discharges

5.2.1 Context

An authorisation for the disposal of liquid radioactive waste was issued to UKAEA in July 1999 (effective from 16 August 1999) by SEPA under the Radioactive Substances Act 1993. The authorisation was varied by SEPA in October 2004 (Ref 5). The authorisation was again varied in June 2007 and transferred from UKAEA to DSRL on 1 April 2008. The authorisation requires DSRL to use and demonstrate that its operations utilise Best Practicable Means to reduce the activity in all the waste discharged and sets numerical limits for certain key radionuclides and are internally controlled as detailed in section 4.4.4. Individual installations are not subject to specific limits within the authorisation, however, as a part of the variation the discharge is divided into two separate streams. These streams cover the discharge from the operations of the Liquid Metal Disposal Plant (LMDP) at PFR and the discharge from all Other Facilities (OF) on the site and each has its own set of limitations by radionuclide and groups of radionuclides. All liquid discharges are made from the site sea discharge tanks to the North Atlantic Ocean via a discharge pipeline which extends 600 metres from the shore. The current authorised limits were determined on the basis of discharges occurring after the

1998 direction and the expected discharges from the programme as known at 2002. The current limits for the site are given, for any consecutive 12 calendar months, in Table 1.

Table 2 Dounreay Site Liquid Effluent Authorisation Limits (as effective from October 2004)

RADIONUCLIDE(S)	OTHER FACILITIES ACTIVITY	LIQUID METAL DISPOSAL PLANT AT PFR ACTIVITY
Alpha emitting radionuclides taken together	90 gigabecquerels	20 gigabecquerels
All Beta and Gamma emitting radionuclides (Other than those individually specified in the schedule) taken together	620 gigabecquerels	110 gigabecquerels
Tritium	5500 gigabecquerels	1400 gigabecquerels
Sodium 22	N/A	1800 gigabecquerels
Strontium 90	770 gigabecquerels	
Caesium 137	1000 gigabecquerels	66 gigabecquerels

N/A Not Applicable

5.2.2 Past Discharges

Discharges from Other Facilities for the years 1999 to 2008 inclusive are given in Table 2 and are shown graphically in Figure 3. Discharges from Dounreay have always complied with the granted discharge limits for any period of twelve consecutive calendar months and over the years 1999 to present have been well within the total authorised discharge limits.

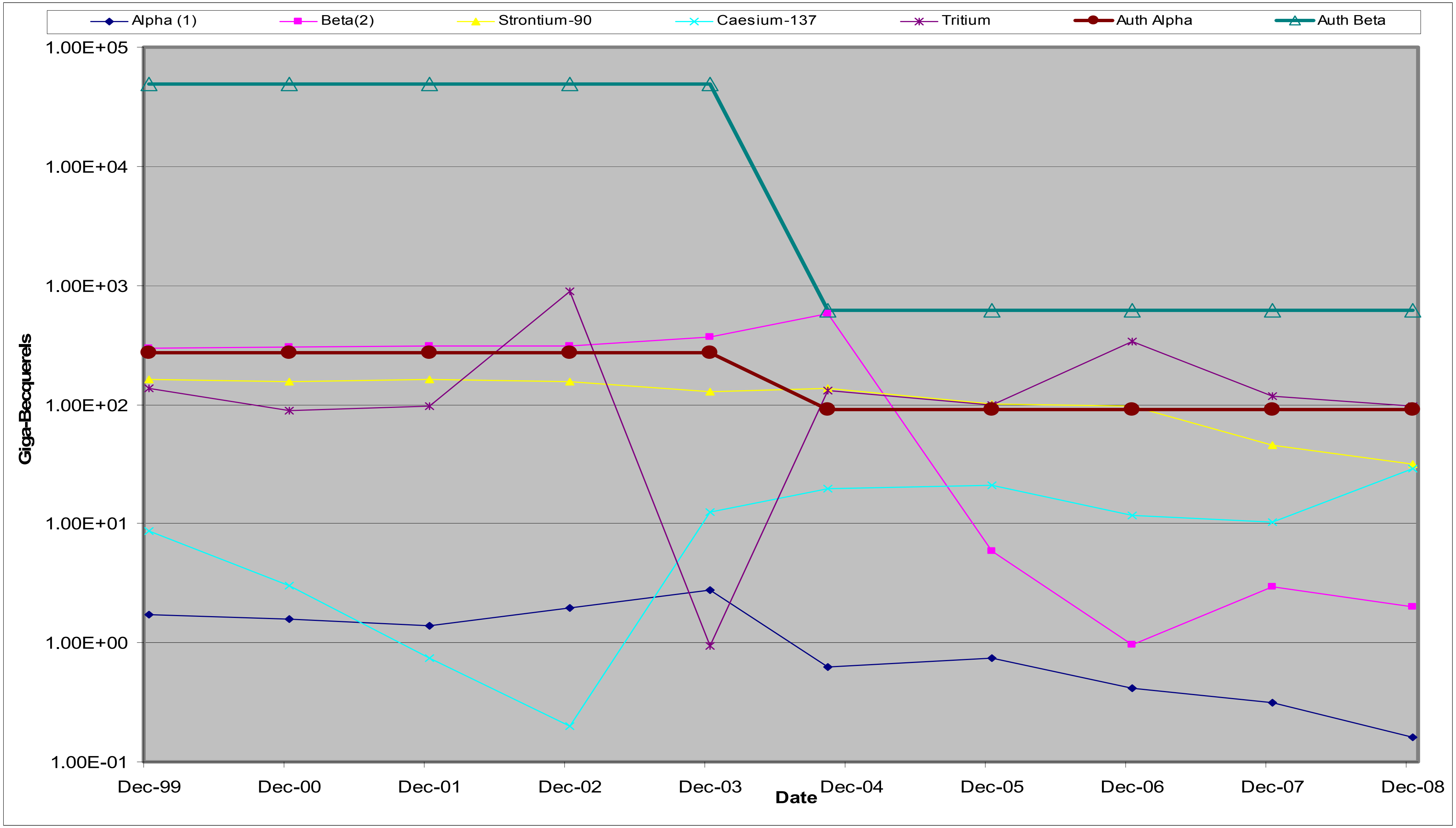
Table 2 - Dounreay Historic Annual Liquid Discharges

SPECIES	LIMIT (99) (GBq)	LIMIT Oct-04 (3) (GBq)	Dec-99	Dec-00	Dec-01	Dec-02	Dec-03	Oct-04	Dec-05	Dec-06	Dec-07	Dec-08
Alpha (1)	2.70E+02	9.0E+01 (4)	1.72E+00	1.57E+00	1.40E+00	1.96E+00	*2.75E+00*	*6.20E-01*	*7.41E-01*	*4.17E-01*	*3.12E-01*	*1.60E-01*
Beta(2)	4.90E+04	6.2E+02 (5)	2.98E+02	3.04E+02	3.09E+02	3.08E+02	3.67E+02	5.80E+02	*5.93E+00*	*9.70E-01*	*2.95E+00*	*1.99E+00*
Strontium-90	7.70E+03	7.70E+02	1.63E+02	1.56E+02	1.61E+02	1.55E+02	1.29E+02	1.36E+02	1.02E+02	9.63E+01	4.57E+01	3.14E+01
Caesium-137	2.30E+04	1.00E+03	8.67E+00	3.03E+00	7.36E-01	2.00E-01	1.26E+01	1.98E+01	*2.09E+01*	1.18E+01	1.03E+01	2.90E+01
Tritium	3.08E+04	5.50E+03	1.37E+02	8.80E+01	9.72E+01	8.94E+02	9.48E+01	1.31E+02	9.94E+01	3.36E+02	1.18E+02	9.61E+01

Units GBq/yr

(1) Excluding Curium 242
(2) Excluding tritium
(3) Other Facilities only
(4) Alpha emitting radionuclides taken together
(5) All Beta and Gamma emitting radionuclides (Other than those individually specified in the schedule) taken together

Figure 3 – Dounreay Historic Annual Liquid Discharges



5.3 Gaseous Discharges

5.3.1 Context

An authorisation for the disposal of gaseous radioactive waste was issued to UKAEA by SEPA in July 1999 (effective from 16 August 1999) (Ref 1). The authorisation was varied by SEPA in July 2003 (Ref 4). The authorisation was again varied in June 2007 and transferred from UKAEA to DSRL on 1 April 2008. The authorisation requires DSRL to use and demonstrate that its operations utilise Best Practicable Means to reduce the activity in all the waste discharged and sets numerical limits for certain key radionuclides. The SEPA Authorisation groups the activities on the Dounreay site and specifies limits for the gaseous discharges from each group as shown in Table 3.

Since gaseous discharges could not be realistically predicted in 1993 for all the alternative decommissioning strategies, the discharge authorisation was based on an upper bounding case of the maximum quantities discharged from the Dounreay site at the time that PFR and the FCA were all fully operational. In 2003, the Certificate of Authorisation was varied and the PFR, PFR Minor Sources and West Minor Sources limits were varied and based on realistic predictions.

Table 3 Site Atmospheric Discharge Authorisation Limits at July 2003

Schedule 4 Table	Activity	Discharge Authorisations
4.2 & 4.7	**PFR (incl PFR Minor Sources)**	
	Alpha emitting radionuclides (excluding radon and daughters) associated with particulate matter	6.06 megabecquerels
	Beta emitting radionuclides (excluding tritium and Krypton 85) associated with particulate matter	51.5 megabecquerels
	Tritium	10.7 terabecquerels
	Krypton 85	4 terabecquerels
4.3	**DFR**	
	Alpha emitting radionuclides (excluding radon and daughters) associated with particulate matter	10.0 megabecquerels
	Beta emitting radionuclides (excluding tritium and Krypton 85) associated with particulate matter	1.5 gigabecquerels
	Tritium	4.5 terabecquerels
	Krypton 85	400 megabecquerels
4.4	**FCA Main Stack**	
	Alpha emitting radionuclides (excluding radon and daughters) associated with particulate matter	0.98 gigabecquerels
	Beta emitting radionuclides (excluding tritium and Krypton 85) associated with particulate matter	45 gigabecquerels
	Tritium	2.0 terabecquerels
	Krypton 85	3 petabecquerels
	Strontium 90	4.2 gigabecquerels
	Ruthenium 106	3.9 gigabecquerels
	Iodine 129	1.1 gigabecquerels
	Iodine 131	0.15 gigabecquerels
	Caesium 134	0.84 gigabecquerels
	Caesium 137	7 gigabecquerels
	Cerium 144	7 gigabecquerels
	Plutonium 241	3.3 gigabecquerels
	Curium 242	0.27 gigabecquerels
	Curium 244	54 megabecquerels
4.5	**West Minor Sources**	
	Alpha emitting radionuclides (excluding radon and daughters) associated with particulate matter	300 kilobecquerels
	Beta emitting radionuclides (excluding tritium) associated with particulate matter	75 megabecquerels
	Tritium	10 gigabecquerels
4.6	**East Minor Sources**	
	Alpha emitting radionuclides (excluding radon and daughters) associated with particulate matter	13.7 megabecquerels
	Beta emitting radionuclides (excluding tritium and Krypton 85) associated with particulate matter	371 megabecquerels
	Krypton 85	1 terabecquerel
	Totals	
	Alpha emitting radionuclides (excluding radon and daughters) associated with particulate matter	1.01 gigabecquerels
	Beta emitting radionuclides (excluding tritium and Krypton 85) associated with particulate matter	47.00 gigabecquerels
	Tritium	17.21 terabecquerels
	Krypton 85	3 petabecquerels

5.3.2 Past Discharges

For the same reasons as for liquid discharges, gaseous discharges from the site over the years 1999 to present represent only a fraction of the discharge authorisation limits. Discharge data for 1999 to 2008 is given in Tables 4 to 8 and shown graphically for the site as a whole in Figure 4.

The trend in gaseous discharges follows the same historic pattern as that for liquid discharges. With PFR shut down, and FCA operations restricted, tritium has been the only significant gaseous emission released recently, though several radionuclides are reported as required by SEPA. Several of the more recent variations in discharges may appear large from the graphs, however, this is because they represent discharges from a number of sources being measured at very low levels, close to the limits of detection, and are in fact only minor changes.

The production of gaseous radioisotopes ceased with the closedown of the PFR reactor. With the exception of tritium, krypton 85 and iodine 129 (and trace quantities of carbon 14) all have half-lives of a few days or less and so radiations from the short-lived species are now negligible.

Table 4. Historical Annual PFR Gaseous Discharges 1999 to 2008

Year to	TRITIUM	BETA	ALPHA
	Bq	Bq	Bq
Dec-99	6.75E+11	*8.70E+05*	*6.51E+04*
Dec-00	1.15E+12	*7.30E+05*	*2.07E+04*
Dec-01	6.14E+10	*4.71E+05*	*3.82E+04*
Dec-02	5.77E+10	*1.25E+06*	*3.69E+04*
Dec-03	1.21E+11	*1.18E+06*	*3.87E+04*
Dec-04	3.65E+11	*4.30E+05*	*3.40E+04*
Dec-05	*3.59E+11*	*3.03E+06*	*3.94E+04*
Dec-06	*8.00E+10*	*1.30E+06*	*3.75E+04*
Dec-07	*1.36E+11*	*5.22E+05*	*3.20E+04*
Dec-08	*6.23E+10*	*2.78E+05*	*3.07E+04*

Table 5. Historical Annual DFR Gaseous Discharges 1999 to 2008

Year to	Alpha	Beta	Tritium
	(Bq)	(Bq)	(Bq)
Dec-99	*2.84E+03*	*5.91E+04*	*1.69E+09*
Dec-00	*1.02E+03*	*1.12E+04*	*7.19E+08*
Dec-01	*1.66E+03*	*9.53E+03*	*6.88E+08*
Dec-02	*1.80E+03*	*1.86E+04*	*6.11E+08*
Dec-03	*1.69E+03*	*5.84E+03*	*5.98E+08*
Dec-04	*2.47E+03*	*1.14E+04*	*9.19E+08*
Dec-05	*2.81E+03*	*1.80E+04*	*6.56E+08*
Dec-06	*7.80E+03*	*2.97E+04*	*1.33E+09*
Dec-07	*8.86E+03*	*3.30E+04*	*1.40E+09*
Dec-08	9.29E+03	3.52E+04	1.48E+09

Table 6. Historic Annual FCA Main Stack Gaseous Discharges 1999 to 2008

	Dec-99	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Alpha	*3.66E+07*	*3.88E+07*	*3.63E+07*	*3.30E+07*	*6.20E+07*	*9.70E+06*	*9.84E+06*	*9.85E+06*	*8.99E+06*	*1.21E+07*
Beta	*1.77E+08*	*1.89E+08*	*2.04E+08*	*2.20E+08*	*3.40E+08*	*2.10E+08*	*2.41E+08*	*2.39E+08*	*1.53E+08*	*2.01E+08*
H3	*1.88E+11*	*3.44E+11*	*3.38E+11*	*2.30E+11*	*2.70E+11*	*4.90E+11*	*2.99E+11*	*2.65E+11*	*1.84E+11*	*1.95E+11*
Kr85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0	1.24E+12	0.00E+00	0.00E+00
Sr90	5.70E+08	4.83E+08	4.05E+08	4.00E+08	2.00E+08	4.70E+07	8.56E+07	7.14E+07	3.50E+07	4.78E+07
Cs137	3.80E+07	5.27E+07	5.99E+07	5.10E+07	1.10E+08	2.50E+07	5.46E+07	3.99E+07	5.92E+06	1.42E+07

Units: Becquerels

Table 7. Historic Annual Gaseous Emissions From West Minor Sources 1999 to 2008

	Dec-99	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Alpha	*2.90E+02*	*1.70E+02*	*9.98E+01*	*1.38E+02*	*6.01E+02*	*1.16E+03*	*1.34E+03*	*1.03E+03*	*2.03E+03*	*2.41E+03*
Beta	*3.90E+03*	*8.00E+04*	*4.65E+03*	*1.34E+03*	*5.54E+03*	*7.50E+03*	*5.20E+03*	*4.27E+03*	*1.01E+04*	*1.28E+04*
H3	-	-	*2.97E+05*	*2.85E+06*	*2.22E+08*	*4.85E+08*	*3.29E+08*	*3.24E+08*	*2.43E+08*	*2.36E+08*

Units: Becquerels

Table 8. Historic Annual Gaseous Emissions From East Minor Sources 1999 to 2008

	Dec-99	Dec-00	Dec-01	Dec-02	Dec-03	Dec-04	Dec-05	Dec-06	Dec-07	Dec-08
Alpha	*1.00E+05*	*1.30E+05*	*1.84E+05*	*2.10E+05*	*1.29E+05*	*9.30E+04*	*7.74E+04*	*6.63E+04*	*7.88E+04*	*6.29E+04*
Beta	*6.40E+05*	*6.20E+05*	*3.69E+05*	*3.33E+05*	*4.32E+05*	*4.84E+05*	*3.84E+05*	*3.95E+05*	*4.63E+05*	*3.66E+05*
Kr-85	-	*3.50E+07*	*0.00E+00*	*0.00E+00*	*0.00E+00*	*0.00E+00*	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Units: Becquerels

Figure 4 Historical Annual Site Gaseous Discharges (Alpha)
(Logarithmic Scale)

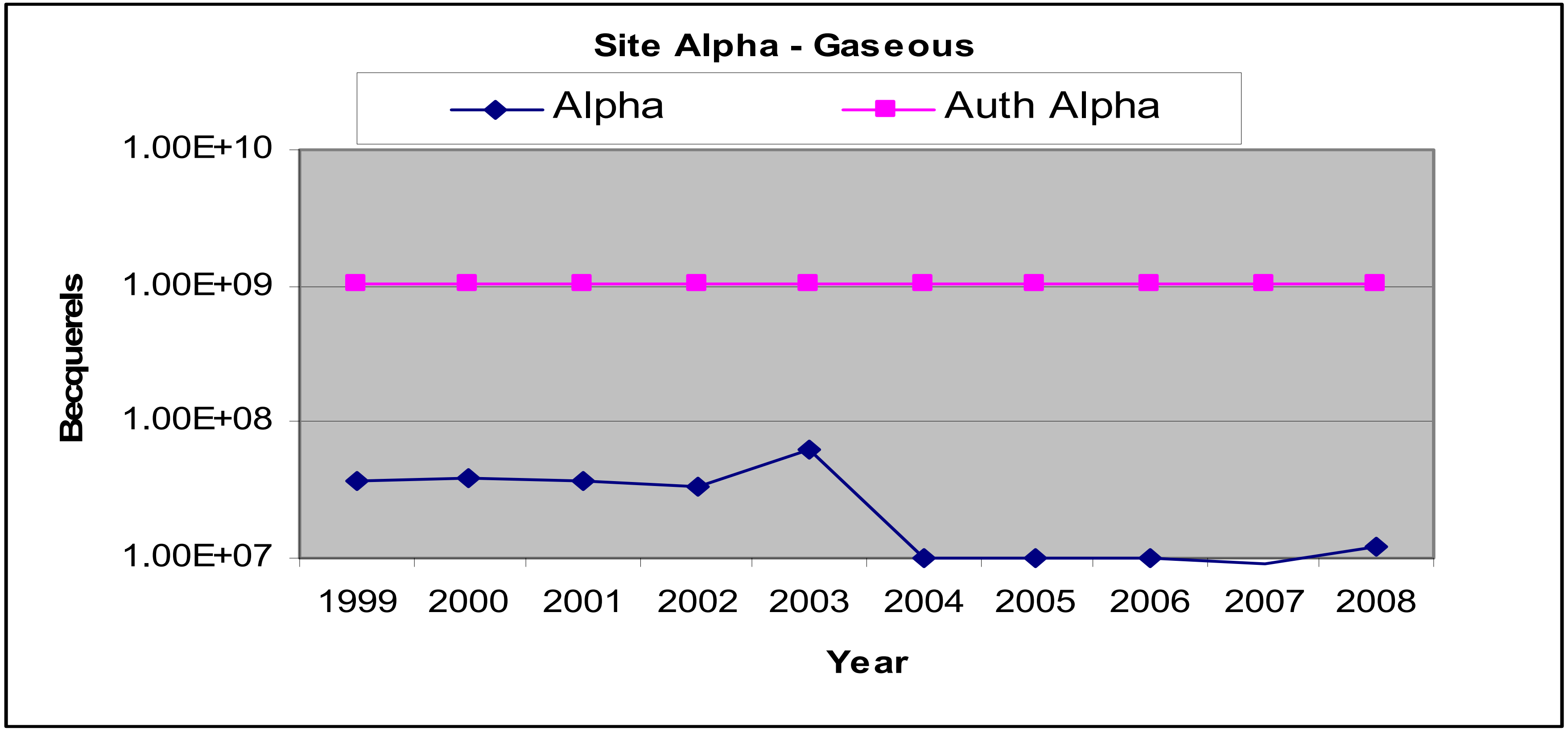


Figure 5 Historical Annual Site Gaseous Discharges (Beta)
(Logarithmic Scale)

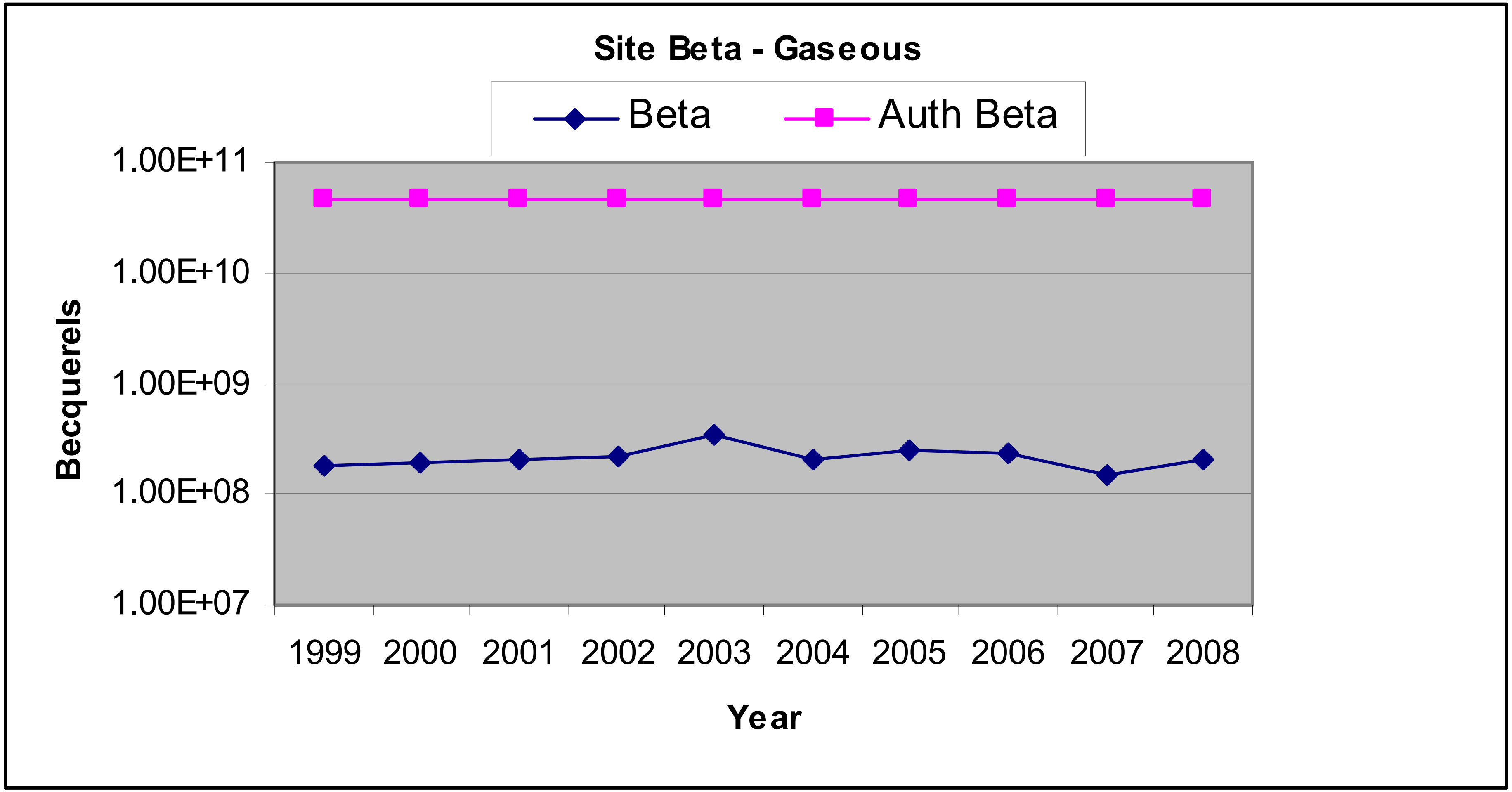
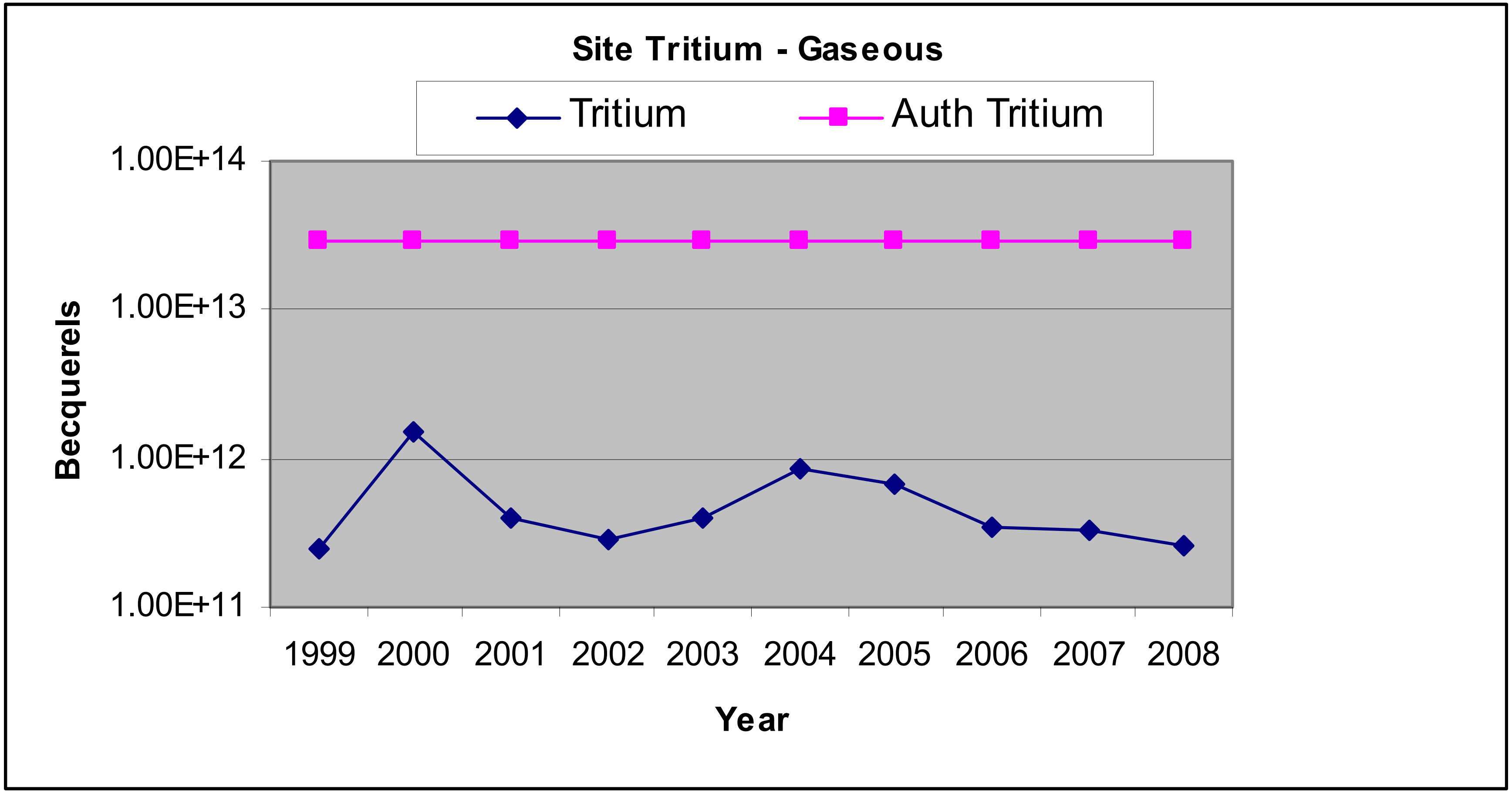


Figure 6 Historical Annual Site Gaseous Discharges (Tritium)
(Logarithmic Scale**)**



6 ENVIRONMENTAL MONITORING

6.1 Requirement for Monitoring

A condition of the RSA authorisations issued by SEPA is that there must be a satisfactory environmental monitoring programme undertaken by DSRL. This has the following main purposes:

- It must demonstrate that the allowed discharges continue to have a minimal effect on the most exposed individuals that is broadly acceptable and within public limits relating to annual exposure;
- It must provide reassurance that allowed discharges continue to be estimated correctly and are within allowable limits;
- They must enable the early recognition of unusual discharges to the environment.

In addition to DSRL sampling, SEPA arranges for an independent programme of monitoring around Dounreay reported annually in the joint publication Radioactivity in Food and the Environment (Table 16, Ref.16) that includes several aims:

- To provide an independent check of environmental monitoring carried out by DSRL
- To provide independent environmental data that can be used to estimate the impact on the environment and public health
- To provide an indication of trends in levels of contamination in key media so as to confirm the level of control of authorised discharges to the environment.

The results of both the DSRL and SEPA environmental monitoring are used in models to assess the radiological impact of discharges based on the assumptions of discharges made at the current and proposed authorised limits. This is discussed in Section 11 and in further detail in a report assessing the radiological impacts of authorised atmospheric and liquid discharges of radionuclides from Dounreay (Ref 25). Doses are considered for the critical group, that is those people likely to be the most exposed as a result of their life style (e.g. diet, age, occupation and dwelling), and for the collective dose to the European population.

6.2 Environmental Monitoring by DSRL

In addition to the statutory programme, Dounreay conducts a supplementary programme of environmental monitoring which, in certain elements, complements the statutory programme. This programme is not a requirement of the authorisation, but is undertaken for the following reasons:

- To obtain the information required to place the potential future radiological impact of Dounreay operations into context
- To meet the needs of a wide range of stakeholders for accessible information about levels of radioactivity in the environment around Dounreay

The statutory programme itself is composed of two sub-programmes - one associated with liquid effluent discharges (the marine programme) and the other associated with gaseous discharges (the terrestrial programme).

There are many routes by which discharged radioactivity reaches man and their relative importance varies with location. In general the exposure pathways resulting from liquid discharges include the consumption of fish, mollusca and crustacea, and external irradiation from deposits on beaches or estuarine areas. The important pathways for atmospheric discharges depend on the particular nuclides involved, for example it could be direct external irradiation from a radionuclide in a passing plume or internal exposure through the consumption of foodstuffs.

Data from the environmental monitoring programme are assessed in the first instance against standard reference levels known as Generalised Derived Limits (GDLs). GDLs relate concentrations in environmental materials to basic dose limits. By knowing how specific radionuclides behave in the environment and the key exposure pathways, limits have been set for the concentrations of these radionuclides in drinking water, soil, etc. This will ensure that the dose received by an exposed individual or group of individuals will be below the appropriate dose criteria.

In the UK GDLs for a range of environmental materials, such as silt, soil and river water are calculated and published by the HPA-RPD (Ref.15). It is recommended that further investigations might be appropriate if levels exceed 10% of the GDLs. (Note: GDLs are intended for general application whereas site-specific Derived Limits (DL) are developed for particular sites and take account of known critical groups and local circumstances).

All measurements made under the DSRL programme are very small fractions of the GDLs. An annual summary of the monitoring results is published.

6.2.1 The Marine Programme

The basis of the statutory monitoring programme at Dounreay to assess the effects of aqueous radioactive discharges upon the environment is detailed within the Certificate of Authorisation number RSA/N/V02/50011/99. Much of the monitoring programme is not required to estimate critical group dose but is needed for other purposes such as supporting discharge monitoring and establishing radionuclide levels in marine indicator materials.

Analysis of winkle flesh collected within 5kms of Dounreay (2 sampling points) in 2008 showed the mean activity of these samples to be less than 0.002% of the derived limit. Samples collected from the sampling point greater than 5kms distance showed activity less than 0.002% of the derived limit, based on adult consumers of winkle flesh. The critical group dose from eating winkle flesh was less than 0.03 μSv or 0.003% of the 1 mSv/y dose limit, assuming equal consumption from the two zones.

Fish and Crustaceans (crab and lobster) samples are taken at approximately six-week intervals. The activity content of round fish, salmon, whelks, crabs and lobsters are shown in Tables 10 to 14.

Commercial salmon nets can become soiled with sediment and they may concentrate particulate radionuclides. During the course of handling the nets fishermen's hands may come into contact with contaminated sediment emitting beta particles. Regular measurements of the radioactivity on the nets are therefore made and the dose rate calculated to ensure that the recommended annual dose limit to the skin (50mSv) is not exceeded. The average dose rate from the nets in 2008 was 0.008 μSv per hour. Based on a handling time of 630 hours per annum this is equivalent to 0.01% of the limit of 50 mSv per year.

The monitoring of beaches and foreshores is also part of the marine discharge monitoring programme. Beta-gamma surveys of the shoreline, at 18 points (6 West and 12 East) extending to 10.4 km West and 23.5km East of the discharge point, continued throughout 2008. Those points within 4 km, West and East, of the discharge point are monitored weekly with all other points monitored monthly. The average annual mean gamma dose rate, measured at 1m, above the surface, for the point with the highest reading was 0.20 μSv per hour during 2008. This dose rate includes natural background levels.

Since 1983 a number of tiny fragments of irradiated fuel have been found on the enclosed Dounreay foreshore, Sandside beach, Dunnet Beach (2005) and, since 1997, on the seabed near Dounreay. Some of the earlier finds have been dated by analysing the fission product ratios and shown to have been irradiated in the mid 1960s. In compliance with the monitoring programme defined in the Certificates of Authorisation (Schedule 13), DSRL has continued monitoring of local public beaches and the Dounreay foreshore for radioactive fragments since that time.

6.2.2 The Terrestrial Programme

The basis of the statutory monitoring programme at Dounreay to assess the effects of gaseous radioactive discharges upon the environment is detailed within the Certificate of Authorisation number RSA/N/V02/50010/99. For assessment purposes, the area around Dounreay is divided into two zones. The area within a radius of 4 km is designated as the inner zone and the area beyond the 4 km radius the outer zone.

The terrestrial monitoring programme is undertaken through the analysis of environmental samples from a range of sources including grass, soil, air, rainwater, sheep faeces, goat's milk and terrestrial foods including meat, vegetables and cereals.

At present there is no defined critical group for discharges to atmosphere and doses via most pathways are essentially zero (less than 0.1 μSv per year). With the possible exception of monitoring goat's milk, none of the programme is necessary on the grounds of estimating significant contributions to critical group doses. Up to 15th August 1999 cow's milk was specified in the statutory monitoring programme. However, available milk supplies were not produced locally and the requirement to sample cow's milk was removed from the programme from 16th August 1999. No commercial dairy herds exist near Dounreay. Goat's milk, which is available locally, is used as an indicator sample in the statutory programme and activities are reported in Table 15.

Grass samples are collected for analysis from 10 locations (6 inner zone and 4 outer zone) at two-week intervals. In 2008, gamma spectrometry analysis of these samples did not reveal the presence of radionuclides greater than the minimum detectable activity (MDA) apart from Cs 137.

Because foodstuff derived from grazing animals is important contributors to dose, GDLs have been calculated for the radioisotopes of strontium, and caesium. The mean activity in grass samples taken, in the inner zone during 2008 expressed as percentages of the GDL were:-

- 0.504% GDL for Sr-90
- <0.079% GDL for Cs-134
- <0.178% GDL for Cs-137.

Soil and sheep faeces are also sampled in the grazing areas. Gamma spectrometry analysis of samples of sheep faeces in 2008 showed the concentration of all radionuclides, apart from Cs-137, to be less than the MDA. The mean Cs-137 concentration in samples from the inner zone was 10.4 Bqkg^{-1}.

Soil samples taken in the grazing areas in 2008 showed that the concentration of radionuclides detected by gamma spectrometry was, apart from Cs-137, less than the respective MDA. The mean Cs-137 concentration was 62Bqkg^{-1} for inner zone samples, or 6.2% GDL.

The results from 4 air sampling stations within 4 km radius of the Dounreay site indicate exposures that are very small percentages of the GDL. For 2008 the calculated dose is 0.02μSv.

Rainwater samples were collected at the sites of the air sampling stations and were analysed for fission products and actinides. The results of the analysis for 2008 indicate a total exposure of <0.25% of the GDL for drinking water. The GDL pessimistically assumes that the rainwater is the only source of drinking water.

6.2.3 Environmental Monitoring by SEPA

SEPA also carries out an independent environmental monitoring programme, the results of which are published annually (Ref. 16) and are summarised in Table 16. The environmental monitoring includes sampling of air, grass and soil and terrestrial foods including meat, vegetables and cereals. Routine marine monitoring involves sampling of seafood around the Dounreay outfall into the North Atlantic and other materials from further afield, and beta and gamma dose rate measurements

The marine surveillance programme relates to the existence of four potential exposure pathways at Dounreay, which are the same as those considered under the DSRL marine programme:

- Consumers of locally collected fish and shellfish
- Sea fishermen who handle nets in the Dounreay area
- People who spend time on the local beaches.
- People who spend time visiting the rocky areas of the local foreshore near the Dounreay site

Crabs, mussels and winkles from the outfall area were sampled. Additionally, seawater and seaweed were sampled as indicator materials. Concentrations of radionuclides in 2008 were generally similar to those for recent years. Technetium-99 in crabs, molluscs and seaweed remained at levels to be expected at this distance from Sellafield, indicating no impact from Dounreay on the build up in the environment of this nuclide.

Table 9 Winkle Flesh Activity Near Dounreay, 2008

Nuclide	Derived limit	Mean Activity			
		(Bqkg^{-1} wet weight)	(Bqkg^{-1} wet weight)	Activity (as % DL)	
		Inner Zone	Outer Zone	Inner Zone	Outer Zone
Mn-54	2.80E+06	< 1.36E-01	< 1.52E-01	< 0.00000	< 0.00001
Co-60	5.90E+05	< 1.72E-01	< 1.69E-01	< 0.00003	< 0.00003
Nb-95	3.50E+06	< 1.58E-01	< 1.82E-01	< 0.00000	< 0.00001
Zr-95	2.10E+06	< 2.67E-01	< 2.75E-01	< 0.00001	< 0.00001
Ru-106	2.90E+05	< 1.16E+00	< 1.22E+00	< 0.00040	< 0.00042
Ag-110m	7.10E+05	< 1.86E-01	< 2.09E-01	< 0.00003	< 0.00003
Cs-134	1.10E+05	< 1.25E-01	< 1.32E-01	< 0.00011	< 0.00012
Cs-137	1.50E+05	< 1.44E-01	< 2.16E-01	< 0.00010	< 0.00014
Ce-144	3.90E+05	< 6.30E-01	< 6.53E-01	< 0.00016	< 0.00017
Sr-90	7.10E+04	1.08E-01	< 9.82E-02	0.00015	0.00014
Pu-238	8.70E+03	1.94E-02	8.85E-03	0.00022	0.00010
Pu-239/240	8.00E+03	9.47E-02	4.73E-02	0.00118	0.00059
Am-241	4.20E+05	7.48E-02	2.89E-02	0.00002	0.00001
Cm-242	1.70E+05	1.63E-03	2.24E-03	0.00000	0.00000
Cm-244	1.70E+04	2.34E-03	1.12E-03	0.00001	0.00001
Total Dose to Critical Group as % of DL				< 0.002	< 0.002

(1) Inner zone means those sample points within 5 km of the liquid outfall.
(2) Outer zone means those sample points further than 5 km of the liquid outfall.
(3) DLs have been determined from IAEA safety series No 115 and Habit Surveys.
(4) All results reported as minimum detectable activity are marked as<.

Table 10 Mean Activity Levels In Fish 2004 To 2008

	Nuclide	2004 Bq/kg	2005 Bq/kg	2006 Bq/kg	2007 Bq/kg	2008 Bq/kg
White Fish	Sodium 22	NR	<0.085	0.0730	0.0620	0.0853
	Manganese 54	<0.071	<0.062	0.0557	0.0483	0.0666
	Cobalt 60	<0.080	<0.079			
	Strontium 90	0.172	0.020	0.1025	0.5500	0.1564
	Zirconium 95	<0.132	<0.130			
	Niobium 95	<0.084	0.07	0.0626	0.0581	0.0741
	Ruthenium 106	<0.556	0.491	0.4586	0.3961	0.5753
	Silver 110m	<0.099	0.087	0.0768	0.0662	0.0915
	Caesium 134	<0.058	0.052	0.0487	0.0427	0.0613
	Caesium 137	0.379	0.304	0.2575	0.2741	0.3264
	Cerium 144	<0.301	0.259	0.2344	0.1880	0.2873
	Plutonium 238	0.0003	0.0016	0.0019	0.0009	0.0011
	Plutonium 239/240	0.0016	0.0020	0.0015	0.0028	0.0019
	Americium 241	0.0061	0.0026	0.0035	0.0036	0.0013
	Curium 242	0.0007	0.0006	0.0009	-0.0001	0.0002
	Curium 244	0.0002	0.0002	0.0003	0.0001	-0.0002

NR – Not Reported

Table 11 Mean Activity Levels In Salmon 2004 To 2008

	Nuclide	2004 Bq/kg	2005 Bq/kg	2006 Bq/kg	2007 Bq/kg	2008 Bq/kg
Salmon	Manganese 54	<0.063	0.0622	0.0509	0.0350	0.0624
	Cobalt 60	0.08	0.0040	0.1351	0.1351	0.1223
	Manganese 54	<0.116	<0.132	NR	NR	NR
	Strontium 90	<0.075	0.0664	0.0581	0.0393	0.0675
	Zirconium 95	<0.518	<0.57	NR	NR	NR
	Niobium 95	<0.090	0.0905	0.0729	0.0506	0.0868
	Ruthenium 106	<0.053	0.0524	0.0436	0.0311	0.0574
	Silver 110m	0.326	0.1356	0.1843	0.2164	0.1880
	Caesium 134	<0.299	0.2232	0.2013	0.1321	0.2920
	Caesium 137	0.00049	0.0006	0.0002	0.0001	0.0000
	Cerium 144	0.00098	0.0009	0.0011	0.0007	0.0010
	Plutonium 238	0.0016	0.0033	0.0052	0.0026	0.0004
	Plutonium 239/240	0.00009	0.0002	0.0000	0.0000	0.0006
	Americium 241	0.00023	0.0001	0.0005	0.0002	0.0000
	Curium 242	<0.063	0.0622	0.0509	0.0350	0.0624
	Curium 244	0.08	0.0040	0.1351	0.1351	0.1223

NR - Not Reported

Table 12 Mean Activity Levels In Whelks 2004 To 2008

	Nuclide	2004 Bq/kg	2005 Bq/kg	2006 Bq/kg	2007 Bq/kg	2008 Bq/kg
Whelks	Manganese 54	<0.238	0.4250	0.1707	0.9533	1.5893
	Cobalt 60	0.041	-	-	-	0.1693
	Manganese 54	<0.446	-	-	-	-
	Strontium 90	<0.291	0.5917	0.1984	1.2785	2.2425
	Zirconium 95	<1.91	-	-	-	-
	Niobium 95	<0.331	0.6043	0.2278	1.3457	2.1212
	Ruthenium 106	<0.202	0.3877	0.1562	0.9262	1.5228
	Silver 110m	<0.240	0.4403	0.1655	0.9969	1.6986
	Caesium 134	<0.896	1.8625	0.6997	4.1443	6.8406
	Caesium 137	0.012	0.0135	0.0109	0.0123	0.0124
	Cerium 144	0.062	0.0611	0.0535	0.0505	0.0581
	Plutonium 238	0.003	0.0598	0.0362	0.0256	0.0224
	Plutonium 239/240	0.00003	0.0052	0.0038	-0.0006	0.0022
	Americium 241	0.00003	0.0013	0.0010	0.0012	0.0018
	Curium 242	<0.238	0.4250	0.1707	0.9533	1.5893
	Curium 244	0.041	-	-	-	0.1693

Table 13 Mean Activity Levels In Crab 2004 To 2008

	Nuclide	2004 Bq/kg	2005 Bq/kg	2006 Bq/kg	2007 Bq/kg	2008 Bq/kg
Crab	Manganese 54	<0.096	0.0901	0.0745	0.0681	0.0776
	Cobalt 60	0.237	0.0881	0.0431	0.1596	0.2743
	Manganese 54	<0.177	-	-	-	-
	Strontium 90	<0.111	0.1052	0.0875	0.0762	0.0955
	Zirconium 95	<0.765	-	-	-	-
	Niobium 95	<0.133	0.1242	0.1033	0.0928	0.1064
	Ruthenium 106	<0.082	0.0775	0.0674	0.0608	0.0703
	Silver 110m	<0.108	0.1269	0.1026	0.0955	0.0891
	Caesium 134	<0.403	0.3775	0.3107	0.2693	0.3287
	Caesium 137	0.004	0.0053	0.0025	0.0044	0.0037
	Cerium 144	0.017	0.0172	0.0127	0.0160	0.0160
	Plutonium 238	0.018	0.0224	0.0181	0.0300	0.0213
	Plutonium 239/240	0.00045	0.0009	0.0034	0.0012	0.0010
	Americium 241	0.00022	0.0005	0.0005	0.0006	0.0003
	Curium 242	<0.096	0.0901	0.0745	0.0681	0.0776
	Curium 244	0.237	0.0881	0.0431	0.1596	0.2743

Table 14 Mean Activity Levels In Lobster 2004 To 2008

	Nuclide	2004 Bq/kg	2005 Bq/kg	2006 Bq/kg	2007 Bq/kg	2008 Bq/kg
Lobster	Manganese 54	<0.106	0.1409	0.0808	0.1745	0.1343
	Cobalt 60	0.077	0.0537	0.3704	0.0847	0.0741
	Manganese 54	<0.201	-	-	-	-
	Strontium 90	<0.125	0.1881	0.0938	0.1985	0.1656
	Zirconium 95	<0.851	-	-	-	-
	Niobium 95	<0.150	0.2016	0.1121	0.2364	0.1862
	Ruthenium 106	<0.091	0.1211	0.0764	0.1579	0.1244
	Silver 110m	<0.244	0.2176	0.1615	0.2535	0.3073
	Caesium 134	<0.429	0.6030	0.3433	0.6911	0.5778
	Caesium 137	0.0023	0.0018	0.0019	0.0044	0.0015
	Cerium 144	0.0073	0.0080	0.0067	0.0160	0.0074
	Plutonium 238	0.034	0.0385	0.0318	0.0300	0.0372
	Plutonium 239/240	0.00033	0.0006	0.0019	0.0012	0.0010
	Americium 241	0.00058	0.0007	0.0005	0.0006	0.0010
	Curium 242	<0.106	0.1409	0.0808	0.1745	0.1343
	Curium 244	0.077	0.0537	0.3704	0.0847	0.0741

Table 15 Results of Milk Sampling near Dounreay 2004-2008

			Mean Activity Concentration During Year (Bq/l)				
Nuclide	**DL(1)**	**Zone(2)**	**2004 (Goats)**	**2005 (Goats)**	**2006 (Goats)**	**2007 (Goats)**	**2008 (Goats)**
Sr-90	10	Outer	0.16	0.13	0.26	0.29	0.180
I-131	20	Outer	<0.14	0.11	0.13	0.12	0.201
Cs-137	100	Outer	<0.17	0.12	0.14	0.12	0.133

(1) The Derived Limit for radionuclides in this table have been calculated on the primary dose limit of 1 mSv effective dose
equivalent commitment recommended by the National Radiological Protection Board.

(2) Inner Zone is 0 - 2.5 km; outer zone is 2.5 - 5 km.

TABLE 16 – Radioactivity in Food and the Environment Near Dounreay 2007

Table 3.3(a). Concentrations of radionuclides in food and the environment near Dounreay, 2007

Material	Location	No. of sampling observ-ations	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}							
			^{3}H	^{60}Co	^{65}Zn	^{90}Sr	^{95}Nb	^{99}Tc	^{125}Sb	^{137}Cs
Marine samples										
Crabs	Pipeline inner zone	4		<0.15	<0.71		<18	2.1	<0.38	<0.13
Crabs	Pipeline	4		<0.15	<0.61		<18		<0.36	<0.11
Crabs	Strathy	4		<0.11	<0.31		<0.79		<0.25	<0.14
Crabs	Kinlochbervie	4		<0.12	<0.27		<0.63	0.34	<0.22	<0.12
Crabs	Melvich Bay	4		<0.14	<0.35		<0.86	0.65	<0.29	<0.14
Winkles	Brims Ness	4		<0.13	<0.32	<0.10	<0.79		<0.27	<0.12
Winkles	Sandside Bay	4		<0.12	<0.30	<0.10	<0.56	5.0	<0.26	<0.15
Mussels	Echnaloch Bay	4		<0.10	<0.30		<0.47	14	<0.27	<0.11
Mussels	Thurso East Mains	4		<0.12	<0.28		<0.30		<0.26	0.35
Fucus vesiculosus	Kinlochbervie	4		<0.10	<0.19		<0.32	95	<0.15	0.33
Fucus vesiculosus	Brims Ness	4		<0.11	<0.27		<0.60		<0.19	0.19
Fucus vesiculosus	Sandside Bay	4		<0.12	<0.30		<0.52	140	<0.24	0.21
Fucus vesiculosus	Burwick Pier	4		<0.10	<0.21		<0.51	35	<0.15	<0.12
Sediment	Oigins Geo	2		<0.12	<0.46		<0.47		<0.28	4.5
Sediment	Brims Ness	1		<0.10	<0.31		<0.41		<0.19	1.5
Sediment	Sandside Bay	1		<0.10	<0.23		<0.28		<0.16	2.8
Sediment	Rennibister	1		<0.10	<0.33		<0.26		<0.22	10
Seawater	Brims Ness	4	<1.0	<0.10	<0.14		<0.16		<0.15	<0.10
Seawater	Sandside Bay	4	<1.0	<0.10	<0.12		<0.11		<0.11	<0.10
Spume	Oigins Geo	2		1.1	<0.98		<1.4		<1.5	36

Material	Location	No. of sampling observ-ations	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}						
			^{154}Eu	^{155}Eu	^{238}Pu	$^{239}Pu+^{240}Pu$	^{241}Am	Gross alpha	Gross beta
Marine samples									
Crabs	Pipeline inner zone	4	<0.18	<0.35	0.0029	0.016	0.020	3.6	78
Crabs	Pipeline	4	<0.16	<0.31			<0.15		
Crabs	Strathy	4	<0.13	<0.24	<0.00099	0.0030	0.053		
Crabs	Kinlochbervie	4	<0.12	<0.21	0.012	0.031	0.15		
Crabs	Melvich Bay	4	<0.15	<0.29	0.0025	0.0058	0.0076		
Winkles	Brims Ness	4	<0.21	<0.25	0.019	0.084	<0.18		
Winkles	Sandside Bay	4	<0.13	<0.24	0.030	0.12	0.19		
Mussels	Echnaloch Bay	4	<0.13	<0.24	0.043	0.21	0.019		
Mussels	Thurso East Mains	4	<0.13	<0.25	0.019	0.078	0.061		
Fucus vesiculosus	Kinlochbervie	4	<0.10	<0.15			<0.11		
Fucus vesiculosus	Brims Ness	4	<0.11	<0.19			<0.13	4.0	290
Fucus vesiculosus	Sandside Bay	4	<0.14	<0.26			0.27	<4.8	430
Fucus vesiculosus	Burwick Pier	4	<0.10	<0.16			<0.11		
Sediment	Oigins Geo	2	<0.21	1.3	3.0	13	6.8		
Sediment	Brims Ness	1	<0.10	0.42	1.5	4.8	6.2		
Sediment	Sandside Bay	1	0.33	<0.27	3.0	12	13		
Sediment	Rennibister	1	<0.15	1.3	0.71	0.67	0.78		
Seawater	Brims Ness	4	<0.10	<0.14			<0.11		
Seawater	Sandside Bay	4	<0.10	<0.11			<0.10		
Spume	Oigins Geo	2	<0.93	<1.4	11	48	44		

Table 16 (cont)

Table 3.3(a). continued

Material	Location or selection[b]	No. of sampling observ-ations	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}								
			^{3}H	^{60}Co	^{65}Zn	^{90}Sr	^{95}Nb	^{106}Ru	^{129}I	^{131}I	^{134}Cs
Terrestrial samples											
Beef muscle		1	<5.0	<0.05		<0.10	<0.13	<0.29			<0.04
Beef offal		1	<5.0	<0.05		<0.10	<0.18	<0.32	<0.77		<0.05
Blackberries		1	<5.0	<0.09		0.39	<0.53	<0.84		<0.10	<0.09
Cabbage		1	<5.0	<0.05		0.14	<0.22	<0.34		<0.08	<0.05
Goats' milk		1	<5.0	<0.06		<0.10	<1.8	<0.62		<0.05	<0.06
Lamb muscle		1	<5.0	<0.05		<0.10	<0.09	<0.24			<0.05
Mushrooms		1	<5.0	<0.08		<0.10	<0.32	<0.71	<2.3		<0.07
Oats		1	<5.0	<0.05		0.37	<0.16	<0.43		<0.07	<0.05
Potatoes		1	<5.0	<0.05		0.13	<0.12	<0.27	<0.55		<0.05
Red berries		1	<5.0	<0.05		1.0	<0.05	<0.22		<0.10	<0.05
Rosehips		1	<5.0	<0.05		0.84	<0.07	<0.33		<0.10	<0.05
Turnips		1	<5.0	<0.05		0.30	<0.19	<0.44	<0.33		<0.05
Venison		1	<5.0	<0.05		<0.10	<0.16	<0.43		<0.10	<0.05
Grass		6	<5.0	<0.05		0.55	<0.23	<0.35	<0.25	<0.07	<0.05
Grass	max					1.2	<0.40	<0.44	<0.32		
Soil		6	<5.1	<0.09	0.15	1.1	<0.33	<0.80	<2.7	<0.09	<0.10
Soil	max		<5.3	<0.14		1.6	<0.67	<1.3			<0.16

Material	Location or selection[b]	No. of sampling observ-ations	Mean radioactivity concentration (fresh)[a], Bq kg^{-1}								
			^{137}Cs	^{144}Ce	^{155}Eu	^{234}U	^{235}U	^{238}U	^{238}Pu	$^{239}Pu+^{240}Pu$	^{241}Am
Terrestrial samples											
Beef muscle		1	0.30	<0.20		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Beef offal		1	0.25	<0.20		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Blackberries		1	<0.09	<0.53							<0.050
Cabbage		1	<0.05	<0.24					<0.050	<0.050	<0.050
Goats' milk		1	0.05	<0.48							<0.10
Lamb muscle		1	12	<0.17		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Mushrooms		1	31	<0.50					<0.050	<0.050	<0.050
Oats		1	0.07	<0.31					<0.050	<0.050	<0.050
Potatoes		1	0.23	<0.18					<0.050	<0.050	<0.050
Red berries		1	0.13	<0.14					<0.050	<0.050	<0.050
Rosehips		1	0.39	<0.22					<0.050	<0.050	<0.050
Turnips		1	0.08	<0.30					<0.050	<0.050	<0.050
Venison		1	86	<0.33		<0.050	<0.050	<0.050	<0.050	<0.050	<0.13
Grass		6	<0.23	<0.24	0.14	0.27	<0.049	0.24	<0.050	<0.050	<0.054
Grass	max		0.59	<0.29		0.84	<0.050	0.81			0.071
Soil		6	28	<0.74	1.4	32	1.6	28	<0.055	0.43	0.29
Soil	max		46	<1.2	1.9	48	2.5	43	0.087	0.59	0.37

[a] *Except for seawater and goats' milk where units are Bq l^{-1}, and for soil and sediment where dry concentrations apply*
[b] *Data are arithmetic means unless stated as 'Max' in this column. 'Max' data are selected to be maxima*
If no 'max' value is given the mean value is the most appropriate for dose assessments

The estimated dose from consumption of fish and shellfish by high-rate consumers was less than 0.005 mSv/yr or less than 0.5% of the annual dose limit for members of the public of 1 mSv/y.

Measurements on the fishing gear of the small number of people who operate a fishery close to Dounreay in 2008 indicated that this pathway was of no radiological significance.

For external exposure over local beaches, gamma dose rates measured over intertidal areas were similar to those measured in previous years. The radiation dose due to occupancy in such areas was less than 0.005 mSv/yr or 0.5% of the1 mSv/yr annual dose limit for members of the public.

Measurements of gamma dose rates above areas of the foreshore remained similar to those for recent years. The radiation dose to the public from these rocky areas was less than 0.006 mSv/y which was less than 0.6% of the annual dose limit for members of the public of 1 mSv/y.

The results for the terrestrial surveillance programme generally show low levels of radioactivity. Low levels of Sr-90, Cs-137 isotopes, Pu isotopes and Am-241 were found in samples. The ratio of plutonium isotopes suggests origins within the nuclear industry. Taking these results together with information on consumption rates, the dose to the most exposed group of local terrestrial consumers, including a contribution due to weapon test fallout, was estimated to be 0.014 mSv/yr or less than 2% of the1 mSv/yr annual dose limit for members of the public. The dose from inhaling air containing Cs-137 at the concentrations reported was estimated to be less than 0.001 mSv/yr.

6.3 Conclusions

The environmental monitoring programmes conducted by DSRL and SEPA have consistently returned data that is similar and both sets of data confirm that levels of radioactivity in the environment as a result of the operations of DSRL at Dounreay are small. They demonstrate that discharges from previous operations have little environmental impact and provide reassurance that current and future planned discharges will have even less impact. They also provide reassurance that doses received by members of the public are very small compared with doses arising from natural sources of radiation, currently estimated to be of the order of 2.2mSv/yr and are well within Government standards for protection of the public.

7 ACTIVITIES GIVING RISE TO RADIOACTIVE WASTE

7.1 Types of Installation

Future activities on the site can be classed under one of the following headings:

- Processes that allow remaining nuclear materials to be managed,
- Processes that render the radioactive wastes into safe forms and
- The activities to decommission the nuclear installations and produce the radioactive wastes.

Additionally third party installations, the MoD Naval Station at HMS Vulcan, use Dounreay facilities as a transfer station.

The site has numerous separate installations ranging from obsolete facilities that can be dismantled immediately, to existing installations that will continue to manage the fuels and wastes well into the future. New installations will also be constructed to address specific waste management requirements during the implementation of the LTP and will have to be decommissioned at a future date.

7.1.1 Fuel Management Activities

Fuel management is an essential part of the future management of the Dounreay site strategy documents and this submission presents the reference strategy for management of fuels on the Dounreay site as known at the present time.

Quantities of unused fuel, spent fuel, fuel manufacturing residues and Post Irradiation Examination (PIE) remnants are present on the site. In addition, smaller quantities of similar materials from a number of legacy commercial contracts and other UKAEA liabilities are either held on Site or scheduled for delivery to site.

The objective of the site fuel management strategy at Dounreay is :

'To treat and condition the fuel and fuel residues on the Dounreay site to ensure they are in a safe, stable form suitable for transport or long term storage.

Following an extensive review of the fuels options during 2008, a minimum treatment option was chosen. This will ensure that all the fuels are treated and conditioned into a safe stable form suitable for long term storage or transport if required. The site strategy for fuel management is in alignment with the developing NDA national strategy for Pu and other fuels management.

Small quantities of fuels have currently been identified to enter the waste routes as CHILW or RHILW and will be conditioned using the plants which are currently being designed and build on the site. These include unirradiated and irradiated thorium, small quantity of irradiated oxides, mixer breeder elements from PFR and some Pu and U contaminated waste streams.

The fuel management operations will make extensive use of existing installations to characterise and repack the fuels, but in addition will require the construction of new facilities for the long term storage of all Dounreay's fuels. As the reference strategies mature and designs for the conditioning, characterisation and repack facilities are developed a better understanding of the utilisation of the existing installations will be understood.

The basic elements of future requirements are:

- Treatment, characterisation and packaging of unirradiated plutonium and uranium bearing materials at Dounreay for long term storage, and transport if required,
- Packing of DFR breeder for transport and treatment,
- Conditioning/packing of natural/depleted uranium for long term storage, and transport if required
- Packing and canning of irradiated PFR fuel for long term storage
- Oxidation and packing irradiated carbide fuel for transport and treatment,
- New combined store for long term storage and management of the site fissile material inventory

The strategies for fuels management are considered in the discharge estimates presented in the proposed discharge limits presented in this application.

7.1.1.1 Treatment of Unirradiated Enriched Uranium Bearing Material

Unirradiated enriched uranium is held on the Dounreay site. The material is distributed amongst roughly 5700 separate items. Some of these materials belong to Department of Business Enterprise and Regulatory Reform (BERR), some to Ministry of Defence and some belong to commercial customers.

This material was included in the 'All Fuels' BPEO, which identified operation of the Fuel Dissolution/Solvent Extraction/Evaporation and Storage and Uranium Oxide Production Line plant in the Dounreay and Hybrid Options to be the preferred choice. The BPEO identified conditioning for disposal as the only available choice in the storage option. Subsequent to the production of this BPEO further work has been undertaken to refine the options and use more robust costs for the upgrades and programme.

The Dounreay Fuels Management Strategy which is included in the revised DSRP Volume 6 proposes to deal with the unirradiated enriched uranium material by recovery of the enriched uranium in the uranium recovery plant and transferring the recovered uranium to authorised users.

Whilst there are a number of potential benefits to be gained from choosing to use this plant the overwhelming argument in its favour is the substantially lower cost of this option compared to options involving the storage and disposal of the untreated material. In order to implement this option a number of upgrades will require to be made to the plant as identified in the BPM review and the Safety Case production process. A modern standard Safety Case is being written and will be implemented and regulator approval obtained before the plant restart and full operations

7.1.2 Waste Management Activities

There are four basic categories of solid and liquid radioactive wastes that are processed independently on site:

- Intermediate Level Liquid Waste (ILLW)
- Solid Intermediate Level Waste (ILW) sub-divided into
    - Remote Handled ILW (RHILW) and
    - Contact Handled ILW (CHILW)
- Low Level Liquid Waste (LLLW)
- Solid Low Level Waste (LLW)

The treatment of most of these wastes has been an essential part of past operations on the Dounreay site. For that reason, many of the licensed process routes already exist on the site.

As well as aqueous LLLW there are also a variety of radioactively contaminated waste solvents and oils, accumulated as a result of irradiated fuel reprocessing operations and associated activities for which transfer off site to a licensed contractor is the reference strategy and for which authorisation is sought.

7.1.3 Decommissioning Activities

Many of the decommissioning procedures undertaken will be standardised, although there may be some difficult or specialised areas to decontaminate and dismantle. The detailed requirements for emptying, cleaning or decontamination and removal of equipment will be assessed and specified during the development of the Plant Decommissioning Plan, decommissioning safety case and BPM for each facility. DSRL participates in National and International research and development into decommissioning to ensure that it keeps abreast of best available techniques.

A series of plant decommissioning studies has been completed to obtain an estimate of data for all wastes generated when each installation on site is decommissioned. These studies have provided radionuclide inventories and throughputs for assessing the adequacy of existing waste treatment routes and, if they are inadequate, for the design of new facilities.

The important data to come out of these studies are the anticipated quantities and the nature of the various different types of waste that the separate installations will contribute during their decommissioning. The contributions can be summed to allow the estimation of the gaseous, liquid and solid wastes from the decommissioning programme. These can then be combined with the arisings from fuel management and existing waste management operations, so that waste arisings for a given period can be estimated. This information has formed the basis for the identification of the proposed numerical limits for discharges of liquid and gaseous radioactive wastes.

7.2 Solid Wastes Considered under this Authorisation

On the 21 May 2002 UKAEA, Dounreay submitted to SEPA an application to dispose of Low Level Solid Radioactive Waste to the national facility at Drigg in Cumbria. On the 10 May 2005 the Scottish Executive directed SEPA to decline the application (Ref. 31).

Thus disposal of the accumulated and expected arisings of solid low level radioactive waste now awaits the construction and implementation into operation of the new Low Level Waste facility at Dounreay.

The BPEO study referred to in the direction concludes that construction of a bespoke facility is the preferred way forward and is expected to start operation in 2014. Waste accumulated and future arisings will be treated and stored at Dounreay pending final disposal. Disposal of solid low level radioactive wastes, in the form of a transfer of conditioned wastes, is applied for at this time subject to conditions as may be set out in the LLW facility's RSA Authorisation.

DSRL has identified that from time to time there is a requirement to transfer samples of solid radioactive/potentially radioactive wastes to laboratories, remote from Dounreay, for analysis and/or characterisation to support decommissioning activities. The fact that the samples originate from a waste, they are therefore classed as waste. Therefore, for any transfer where the total transferred will not be returned to the site, a disposal is considered to have occurred. The waste is non specific in nature ranging from tritiated metals to concrete.

In some cases there may be a requirement to undertake experimental land remediation/treatment experiments. Any such experiments will require the transfer of significant volumes of ground materials (i.e. tonne quantities) to an experimental facility.

Wastes have arisen from the reprocessing of fuels from foreign countries and will arise from the destruction of a quantity of contaminated sodium from Germany. These wastes will be, generally, intermediate level waste (ILW) and after treatment to immobilise the wastes in solid form in a suitable media they will be transferred back to the country of origin.

8 BEST PRACTICABLE ENVIRONMENTAL OPTION

The objective of the Dounreay Site Waste Best Practicable Environmental Option (BPEO) Study is to undertake a systematic examination of potential options for the management of wastes, radioactive and non-radioactive, arising from current and future DSRL operations at Dounreay, and to identify the BPEO for the management of the waste streams identified.

The BPEO is the option for a given practice that provides the most benefit or least damage to the environment as a whole in the long term as well as in the short term, taking into account operational doses and risks, and social and economic factors.

A Site Waste BEPO study was first undertaken in 2003 to underpin the Dounreay Site Restoration Plan. The 2008 Site Waste BPEO study for the Dounreay site provides an update to the 2003 study and its production is a requirement of DSRL's RSA '93 Authorisations (as identified in Schedule 11, Item 1).

The approach used for the 2008 BPEO Study differs from the 2003 BPEO Study as a review of all the Dounreay waste streams was carried out at the start to identify where current waste management strategies were largely compliant with best practice and/or were already underpinned by existing BPEO studies and hence did not require further detailed consideration. This screening exercise drew on the findings of a review of national and international best practice on waste minimisation[6] and enabled a more transparent overall approach, with a more concise front end phase. Thus, the emphasis of the BPEO workshop was placed on waste streams where there was a clear need for an updated assessment. The treatment for most of the ILW, LLW and Non-radioactive waste streams were determined to be BPEO, through this initial screening process. Only the following waste streams required assessment at the BPEO Workshop:

- CHILW Graphite (THTR and Activated Graphite),
- LLW Sludges (Granular, Putrescible and LSA Scale),
- Clean Hazardous Sludge and Exempt Hazardous Sludge.

The assessment process was undertaken by an Options Assessment Panel (OAP) at the BPEO Workshop, held at Dounreay on the 18th and 19th of November 2008. The OAP was made up of employees from DSRL and UKAEA Ltd, in addition to an external stakeholder representative.

In addition to external stakeholder representation within the BPEO Workshop further efforts were made to engage with the wider public. This was carried out in such a way to ensure the completion date, specified within DSRL's RSA '93 Authorisations, could be met. DSRL recognise the importance of a consultative approach and as a means of reflecting stakeholder views, a process that involved parallel working was adopted to allow feedback and involvement during the BPEO study development, via the web-site: www.dounreay.com/waste/waste-options-review.

It is important to note that the identification of a BPEO for a particular waste stream is made in support of decision making. Often final decisions on the way forward with any particular project or modification can involve other factors that cannot be taken into account during the BPEO process. Indeed, regulatory guidance on BPEO[7] states:

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[6] *DEC(09)P175 Review of National and International Best Practice on Waste Minimisation, Issue 2, March 2009*

[7] *Guidance for the Environment Agencies' Assessment of Best Practicable Environmental Option Studies at Nuclear Sites, EA/SEPA, February 2004. www.sepa.org.uk*

"In practice, very few decisions are made solely on the basis of a BPEO study. A BPEO study informs consideration of the balance between the various factors that need to be taken into consideration, and helps reveal the key issues and assumptions, but in general does not define the solution."

9 BEST PRACTICABLE MEANS

9.1 General Principles

Authorisations granted under RSA require that the Best Practicable Means (BPM) be used to minimise the production and release of radioactive waste to the environment. The definition of BPM as given in Dounreay's existing RSA authorisations from SEPA states:

" *that expenditure shall not be incurred whether of money, time or trouble which is, or is likely to be, grossly disproportionate either to the benefit to be derived from, or likely to be derived from, or to the efficacy of or the likely efficacy of, employing them the benefits or results produced being, or likely to be, insignificant in relation to the expenditure*. "

BPM includes not only the apparatus provided to limit the generation of waste but also the management of that apparatus and the general supervision of processes. As a requirement of the extant RSA Authorisations, DSRL has undertaken and submitted to SEPA a BPM methodology (D/PRC 103) that takes an holistic view in relation to liquid, gaseous and solid radioactive waste whilst ensuring that the identified processes remain compliant with the BPM conditions of the authorisation.

The BPM methodology provides a case study based on "Claims, Arguments and Evidence" demonstrating that for a particular process the means employed are practicable and proportionate to the benefits gained from their being employed. At the same time the means are also compliant with the requirements of the Authorisation in respect of ensuring the disposals of radioactive waste are minimised.

The application of BPM requires operators to minimise waste production and disposal, and allows all relevant factors to be taken into account when choosing an optimum solution. It is therefore consistent with the Best Practicable Environmental Option (BPEO) concept discussed in the previous section and also complies with the principle of proportionate regulation, in that the action required is relative to the risks. It should be noted that if a discharge limit is set too low it can distort the optimisation that is inherent in the BPM/BPEO, potentially preventing the operator from acting in the best overall interests of the environment, e.g. reducing liquid discharges might produce a disproportionately large volume of solid ILW. Furthermore, applying a close approach to a limit can also constrain routine operations within a rolling 12 months period, again distorting BPM/BPEO and increasing the operator's costs in money, time or trouble for little or no environmental benefit.

The process of decommissioning raises particular issues which need to be considered with respect to BPM. The transition from operations to decommissioning should include the removal of the bulk of the inventory and result in a significant decrease in hazard once it has been completed. Post operational clean-out (POCO) should be completed as soon as possible to remove any mobile radioactivity. There may be benefits to be gained from deferral of decommissioning operations through radioactive decay and the avoidance of double handling when dealing with process wastes. However, these benefits need to be considered against the fact that time delays allow corrosion and leakage processes to increase resulting in increased potential risk of uncontrolled releases to the environment.

There are a number of other important reasons why decommissioning should not be delayed for longer periods than necessary before beginning:

- Knowledge and experience of the plant may be lost, and these attributes are paramount to straightforward, safe and cost effective decommissioning. Wherever possible the people who operated the plant should play a major role in its decommissioning, especially during POCO and the development or validation of the decommissioning plan;

- Retaining the motivation and continuity of workers;
- Continued employment for personnel who operated the plant;
- The support of the local community;
- Long decay half-life isotope plants, particularly actinide ones, can develop a number of problems, the most significant being the increase in radiation dose rates due to the in-growth of Am-241.

The benefits of deferral include the potential that less radioactive waste is produced and that some of the waste will be of lower specific activity. Minimisation of waste produced has both environmental and financial benefits. Working with less active waste streams can give dose savings and be the best practicable option.

As with all other operations, BPM is applied to decommissioning operations. Airborne discharges are kept ALARP by the selection of decommissioning techniques that minimise the generation of airborne activity. Measures to limit the amount of contamination becoming airborne are taken, including the use of coatings to seal in dust and the vacuuming of dust. Suitable filtered ventilation is provided for decommissioning operations where the generation of airborne activity is possible, such as in conjunction with the use of modular containment systems (tents or rigid structures built around areas being decommissioned). Arisings of liquid waste are minimised by the selection of suitable decommissioning techniques that do not involve the routine use of liquids other than for decontamination purposes. During decontamination operations, liquid wastes are minimised through the use of techniques such as dry swabbing.

As has been identified in the facility descriptions there are aqueous liquids used for once through cooling systems that are directed to the LAD. This was a precautionary measure in case of accidental release from the cooled vessel. It is proposed that where it can be demonstrated that the potential for release of high activity into the cooling waters is below a 10^{-6} event then the cooling waters are directed to the most appropriate drainage outfall.

Where new facilities are required to be constructed to progress decommissioning, they are designed and built to allow decommissioning of the facility to be readily undertaken when its function is completed. Examples of this design consideration include;

- Equipment has been designed to avoid potential contamination traps and to be readily decontaminable. This is to be achieved by the use of stainless steel for the majority of equipment and the use of decontaminable finishes on surfaces;
- Building surfaces that may be contaminated are provided with smooth, durable and decontaminable surface finishes;
- Flushing water systems are provided to enable regular removal of sludge and contamination from within tanks and pumps.

9.2 Liquid Wastes

As an integral part of the Company's overall business management arrangements, DSRL has defined the following guidance principles to ensure that the management of aqueous discharges from the Dounreay site is aligned with the longer-term requirements of UK Government policy and the national radioactive discharge strategy:

- to minimise the production and accumulation of radioactive aqueous waste, so far as is reasonably practicable;
- to segregate wastes according to their activity;
- to establish the BPEO for each class of liquid effluents on the site;

- where reasonably practicable to apply the "concentrate and contain" principle at source to contain radioactivity before effluents are released to the Low Active Drain (LAD) network;
- to apply BPM; and
- to ensure that all discharges of radioactive waste to the environment are as low as reasonably achievable (ALARA).

In respect of liquid waste, the application of BPM by DSRL is based on the following three main elements, which are discussed below:

- Management controls;
- Minimising arisings at source; and
- Treatment of radioactive liquid effluent.

DSRL applies BPM by taking steps to ensure that the effluent management systems and controls are implemented effectively. This includes:

- **Administrative procedures**. Management approval must be obtained in advance for disposals to the LAD, although routine high volume, low activity arisings may be disposed on a continuous basis. This is achieved through compliance with the requirements of site instructions which set out the conditions for disposal of radioactive effluents, including the specification of limits on the concentrations of radionuclides in effluent streams.

  Prior to disposal to sea the effluent tanks are sampled and analysed. A system of mechanical key control is practised on the final disposal valves to sea and only after it has been confirmed that the proposed disposal is within set internal limits is disposal permitted. A second sample is taken as the liquor is discharged for record purposes.

- **Internal discharge limits.** Discharge Control Objectives are allocated to individual facilities. Appropriate investigations are conducted to examine whether discharges are being properly controlled if these levels are exceeded. Trends and unusual results are examined to identify potential problems and to put in place solutions before problems occur.

- **Audits/checks for compliance.** The mandatory procedures are enforced through audits/checks of the system to ensure that compliance by consignors is being achieved.

- **Maintenance and inspection.** Plant items are subject to routine maintenance, testing and inspection at appropriate frequencies. Schedules are maintained and failure to complete maintenance of items identified as critical within the specified times is recorded and subject to enquiry at an appropriate level. The Low Active Drains system is provided with secondary containment and sumps equipped with liquor-level sensors that raise alarms if radioactivity levels exceed pre-set values. The system itself is subject to a schedule of inspection and maintenance.

- **Recycle facility**. Appropriate levels of monitoring at all stages are employed. These include requirements to sample and analyse liquids held in local storage tanks prior to discharge to the LAD. Unless the results from these analyses are satisfactory the liquid is not permitted to be discharged and must be re-cycled within the plant of origin to reduce, for example, the actinide content.

- **Monitoring of input and output activity levels** All plants are required to assess their liquid discharges and report on these in a review of safety to the Safety Working Party. At this meeting the SWP specifically considers disposal issues; it includes independent, specialist consultants in its membership and provides guidance to the committee chairman on the internal discharge limits used to ensure compliance with DSRL's RSA authorisation and the implementation of BPM.

In the past the volume of normal operational waste streams were large because they contained a large input of initially uncontaminated water, arising from services such as once-through cooling water, rain and groundwater drainage, water from changing room wash-basins and showers, etc. Dounreay continues to discharge radioactivity to the sea in the form of aqueous waste, however, the volume has been substantially reduced over the years and more activity has been contained on site as solid waste.

Facilities are designed and operated such that the generation of liquid waste is kept as low as reasonably achievable. Minimum quantities of liquid are used wherever possible and analytical samples, particularly those containing fissile materials, are returned to the plant of origin for recycling. Where feasible recirculating, rather than once through, cooling systems are used. In all cooling systems where the coolant could in principle become contaminated, close attention is paid to construction to minimise the possibility of leak paths permitting the radiological contamination of coolants and pressure testing of cooling coils prior to use is mandatory in some plants. On-line monitoring is also used in drain lines associated with non-recirculating cooling circuits to activate rapid closure of such lines or redirection of the effluent flow if excessive radiation is detected.

The application of BPM to minimising the radioactive content of liquid effluent discharges has always rested with, and will continue to rest with upstream source plants that discharge effluent to the Low Active Drains (LAD). At the source plant, any sentenced discharge to the active drains has control mechanisms and procedures to protect against inadvertent high releases. Some systems are set up for continuous discharge. All transfers must be agreed by the Waste Services Unit (WSU) in writing, in advance of the transfer. Liquors that do not meet the standard for LAD disposal are diverted for further treatment. Abatement of liquid waste streams at source obviates the need for abatement at the point of discharge. This is the preferred method of treatment for liquid radioactive effluent at Dounreay as it enables it to be:

- Tailored to specific streams;
- More effective in applying to concentrated streams.

Abatement at the point of discharge is, however, employed through the use of filtration to ensure that any particulate that is not removed by settlement post facility transfer is captured and not released to the environment.

The selection of new abatement plant will not be unduly constrained by current practice. Although new techniques are constantly kept under review, tried and tested techniques will be preferred when selecting techniques to be used.

Treatment methods for liquid radioactive effluent incorporate the use of flocculation, pre-filters and filters to remove material in the particulate form and ion-exchange resins to remove dissolved radionuclides. The equipment used is discussed on a plant by plant basis in the following sections (9.2.1 to 9.2.18). These sections cover the main plant on site, but are not an exhaustive list.

9.2.1 Low Level Liquid Effluent Treatment Plant and Low Active Drain (LAD)

The management of Liquid Low Level Waste (LLLW) at Dounreay is based upon controlled and authorised discharges to sea. The principal LLLW route consists of transporting aqueous effluent across the site from the plant that it arises in via the Low Active Drain (LAD) to the Low Level Liquid Effluent Treatment Plant (LLLETP) for discharge to sea at a depth of 24m, 600m from the shore at high water. The LAD connects most plants at Dounreay including the DFR, PFR and the Vulcan Naval Reactor Test Establishment (VNRTE), which is also permitted to dispose of liquid waste to sea via the Dounreay outfall. The principal operational installations that produce LLLW have two internal drainage systems, with entries to the LAD and, in some cases, a Suspect Active Drain. The latter is used, to hold up for monitoring, effluent (once-through cooling systems, showers, etc) that is only contaminated in fault conditions. In this way, inadvertent discharges of activity are avoided.

The LLLETP was not designed as an effluent treatment plant for the specific removal of radionuclides. The plant design objective was only for pH conditioning of effluent although a limited removal of some radionuclides may occur as an indirect consequence of the process since the plant has been engineered to allow settling out of precipitated species and for the routine removal of sludges to the Sludge Receipt Tank for appropriate treatment as either low level or intermediate level solid radioactive waste.

It was recognised that further abatement of particulate could be achieved by the installation of a final filter within the sea discharge line. This has been implemented by fitting a 50µm filter to the sea discharge line. Any particulate captured in the filter will be recovered to the Sludge Receipt Tank for appropriate treatment as either low level or intermediate level solid radioactive waste.

9.2.2 DFR

The primary circuit coolant to the DFR reactor is considered to be a high hazard category waste that is programmed for disposal by mid 2013.

The DFR sodium/potassium alloy (NaK) coolant is a highly reactive liquid metal that must be converted by controlled chemical reaction into a stable material that is suitable for disposal. The NaK Disposal Plant (NDP) process involves the reaction of NaK with caustic solution to produce sodium and potassium hydroxides. These will be neutralised with nitric acid to produce the corresponding nitrates. The nitrate solution will be passed through an ion exchange process to remove caesium and will then be sampled prior to discharge to the LAD. All liquid wastes from the NDP process are to be filtered, pH adjusted and sampled prior to discharge. Non-compliant liquids can be returned for further ion exchange. Ion exchange was adopted as the favoured approach for removing caesium from the effluent following assessment of the potential radiological impact of the unabated discharge of the aqueous waste stream from the NaK disposal process.

The DFR Fuel Storage Pond water has been recirculated through ion exchange resins to remove a significant proportion of the activity in the ponds to allow for removal of the storage furniture. The next stages of the ponds decommissioning are programmed for the period August 2010 to June 2013 and comprise water treatment and sludge removal followed by concrete removal.

These activities will result in gaseous and liquid radioactive waste discharges and the creation of solid radioactive wastes in the form of ion exchange resins, filters and concrete.

After completion of the disposal of the primary coolant the nuclear material, in the form of fertile breeder elements, will be removed from the reactor, separated to individual “slugs”, cleaned and placed into appropriate containers for interim storage.

The removal of the breeder elements will be carried in two phases:

- Active commissioning of the treatment facility in the period May to August 2012;
- Operations in the period July 2014 to February 2016.

The operational facility will then undergo Post Operational Clean Out in the period November 2016 to March 2017.

The primary coolant destruction will result in a residue being left in the reactor vessel and associated pipework. The destruction of this residue is programmed after the removal of the nuclear material in the period January 2018 to May 2023 with final clean POCO and decommissioning of the furniture and equipment extending to the Interim End State for the site.

9.2.3 PFR

The bulk of the discharges from the PFR over the next few years will arise from the destruction of residual primary circuit sodium from the reactor vessel, sodium residues from the irradiated fuel cells and the decontamination of removable reactor components.

The intended method of destruction of the residue (remaining bulk and surface adhering film) is the Water Vapour Nitrogen (WVN) process, a process where steam (water vapour) is introduced to the sodium metal surface within an inert nitrogen gas carrier. The concentration of the steam is generally of the order of 5% of the total gas volume. This process produces a caustic (sodium hydroxide) liquor that can be neutralised using acid and the neutralised liquor passed through abatement to reduce the activity prior to final discharge to sea.

The Effluent Treatment Plant (ETP) and/or Caesium Removal Plant (CRP) will be used to treat the liquors arising from the WVN process of sodium destruction, depending on operational efficacy.

The CRP uses an ion exchange medium to remove caesium preferentially from the feed solution. The product is monitored continuously for caesium to indicate when the ion exchange column needs replacing. Tanks hold up the treated effluent until it has been sampled and assayed to ensure conformance with local discharge limits, effluent is then discharged in batches to the PFR low active drain.

The ETP uses an ion exchange medium to remove caesium preferentially from the neutralised liquor. The product is monitored continuously for caesium to indicate when the ion exchange column needs replacing. Tanks hold up the treated effluent until it has been sampled and assayed to ensure conformance with local discharge limits, effluent is then discharged in batches to the PFR low active drain.

Na-22, which is the second most abundant species, after Cs-137, in terms of activity, cannot be practicably separated or abated other than by natural decay (half-life of 2.6 years). Over the period since the reactor was shutdown this has reduced the initial inventory by a factor of around 40 for PFR effluents. The contribution to critical group dose will be minimal from this radionuclide after mixing and dispersion in the sea. For Co-60, with a half-life of 5.27 years, natural decay has resulted in a major reduction on the initial inventory and filtration will provide abatement given the original particulate nature of the material. Co-60 removal by any other means is not justified; filtration has been adopted for this waste stream. The abatement of tritium is not practicable and given the volumes and tritium activity levels it is not possible to use delay and decay strategy if decommissioning of PFR is to be progressed.

The removal of furniture and equipment and final demolition of the PFR facility is expected to be completed by 2024.

9.2.4 Chemical Analysis Laboratories

There are several discharge points to the LAD from the fume cupboards used for analysis. Some fume cupboards also discharge via the Plant Washings Drain (PWD) to the Plant Washings Tank (PWT) along with certain gloveboxes and cells. The discharge comprises mainly analytical effluents. The high Pu, U-235 and activity samples that remain after analysis are often returned to the plant (for appropriate processing) from which they came and hence are generally not put to the LAD. The LAD is the most suitable disposal route for most sentenced analytical effluents. They are occasionally put to the PWT when activity levels are high (e.g. washout of Highly Active Liquor (HAL) cell floors to minimise airborne emission levels). The controls on discharges to drain are mainly managerial; there are no delay/decay/sentencing tanks in place. Discharges to the LAD are filtered using a coarse filter. Discharges are filtered in the laboratory before discharge to drain if particulate matter is visually identified in analytical residues.

9.2.5 Facility for Fuel Dissolution/Solvent Extraction/Evaporation and Storage and Uranium Oxide Production Line

Liquid effluents discharged from this facility fall into two categories, active and suspect active, each with their own in-plant drains. The active and suspect active liquors are then directed to the site LAD. Cooling waters on condensers, steam condensates from the dissolvers and evaporators all go to the LAD via the Suspect Active Drain (SAD). These liquors are not sampled but are continuously monitored by alarming gamma detectors in the drain. The raffinates (except those containing thorium), distillate from the evaporators, Ammonium Di-Uranate (ADU) supernate liquors and also scrubber liquors (closed loop on dissolvers) also go to the LAD, but only after sentencing of the liquors. The LAD is the most suitable disposal route for these high volume and low activity liquors. If activity levels in the sentenced effluent are higher than acceptable for discharge to the LAD, the effluent is returned to the facility for further abatement treatments to reduce the activity to acceptable levels.

Cooling water discharges are relatively clean of particulate since cooling water is locally filtered before it is fed to the plant and the cooling water systems should be relatively clean being a once through stainless steel system. Steam condensate should also be clean and is contained in stainless steel systems. There is an in-line mesh filter between each dissolver and the solvent extraction plant.

9.2.6 Waste Processing Facility

There is no practicable alternative to the use of the Waste Processing Facility for receipt, processing, repackaging and sentencing of Remote Handleable Intermediate Level Waste (RHILW) on the site. The operations are centred on the Waste Posting Cell (WPC), which has 2 sub-cells available for the task. There are cells that are used for the temporary storage of a significant inventory of fissile material. This represents the most significant radiological hazard from the plant but fuel storage is necessary pending the future availability of arrangements for managing the fuel on or off site.

Out of cell liquid effluent arisings that could be contaminated (i.e. from the sub-change room wash hand basin and active shower facility) pass to a $5m^3$ Plant Washings Hold-up Tank (PWHT). The effluent is sampled and analysed before sentencing to the plant washings tank for further treatment or directly to the Low Active Drain (LAD).

All in-cell pipelines have also been permanently capped off and all water access to the cells blanked off. Therefore no liquor can be discharged to drain from in-cell operations. The tanks currently each hold less than 15 litres of liquor. The addition of any chemical solutions to the cells is very restricted and limited to small amounts of essential decontamination agents. Natural evaporation to dryness of these agents is intended.

9.2.7 Research Reactor Fuel Reprocessing Plant

This plant contains several drains. These consist of the High Active Drain (HAD), Plant Washings Drain (PWD), LAD and the Non-active Drain (NAD). There is currently not intended to be any liquid discharges to the HAD or PWD. Both these drains will be physically isolated/disconnected during Stage 1 decommissioning. There will be discharges to the LAD, mainly as a result of discharging the large treated volume of water from the pond via the plant sentencing tank. Discharges from the pond will first receive <10 μm filtration and then ion-exchange treatment to reduce the discharge activity from the un-dissolved particulate and the activity held in the dissolved impurities respectively. This abates the main radionuclides present (i.e. Cs-137 & Sr-90). Prior to discharge to the LAD, the liquor will again receive <10 μm filtration as a contingency measure (e.g. against any ion-exchange resin bed instability). If any activity or particulate matter levels in the associated sentencing tank liquor are initially unacceptable, the liquor can be re-routed back through the filter and ion-exchange plant connected to the pond.

The radioactivity content of the pond water and pond sludge is dominated by Cs-137 and Sr-90. These latter two nuclides will dominate the small radioactive releases to the marine environment from the Research Reactor Fuel Reprocessing Plant. The filtration abatement is adopted in order to minimise discharge of particulate matter. An existing ion-exchange plant was previously installed in the Research Reactor Fuel Reprocessing Plant, primarily for operator dose reduction/safety reasons. Therefore with relatively modest financial investment coupled with the small volume of resultant ILW generated from resin disposal, DSRL has implemented operation of the ion exchange plant. This approach reflects practicable application of the “concentrate and contain” principle rather than “dilute and disperse”.

There are no intended process liquid discharges to the LAD from either of the proposed washout treatments in the Highly Active Cell (HAC) and Medium Active Cell (MAC) vessels. At worst only very low activity levels and small volumes of sentenced condensate will be discharged to the LAD from the short-term evaporation operations. There is very limited scope for further improvements and none identified that would be of worthwhile practical benefit, that would not be disproportionate (e.g. cost) to benefit gained in attempting to further reduce discharge levels. Significant plant modifications/improvements have been invested to prevent or minimise radioactive releases into the environment from Stage 1 and 2 decommissioning.

Any sump liquor arisings in the HACs will be sentenced to establish the most appropriate disposal route, depending on activity levels. It is anticipated that there should be no such sump liquor arisings except in the unlikely event that there are dissolver vessel integrity problems.

There are relatively small volumes of condensate arisings from the evaporator operation which will be sentenced and discharged directly to the LAD, if appropriate. Cooling waters (e.g. supply to cooling coil/condenser in the evaporator) will contain no radioactivity under normal operations and require no abatement. In the unlikely event that activity does enter the cooling waters stream, the connected Effluent Monitoring System will alarm and automatically isolate the cooling waters supply and trip the heating to the evaporator.

Discharges from the wash hand basins and personnel showers will be discharged unsentenced and unabated direct to the LAD, since application of abatement is not practicable for these small volumes and trace activity levels.

9.2.8 Laundry Facility

The laundry aqueous discharges are collected in a sentencing tank prior to discharge through a 10 μm filter to the LAD.

9.2.9 The Fast Reactor Fuel Reprocessing Plant and Evaporator and Export Plant

Following the Government decision in 2001 that this plant would not be dealing with the fuel legacies on the Dounreay site, the plant is now to undergo decommissioning.

The only likely discharges from the Fast Reactor Fuel Reprocessing Plant area to the LAD, in the short to medium term, will be those from the decontamination glovebox and possibly some discharges due to washing out equipment. Local aqueous effluent treatment will be considered for future decommissioning operations, in the context of high anticipated volumes of decontamination wash liquor and the demands on the site effluent treatment facilities. The decisions on how far to take decontamination will be made on a case-by-case basis for each cave, cell, evaporator unit etc. taking into account safety and the environmental benefits of decontamination using that part of the BPM methodology that allows for BPM decision analysis.

9.2.10 Liquid Waste Treatment and Storage Facility

The processes in the Liquid Waste Treatment and Storage Facility are designed to ensure that the radionuclides present in the liquid wastes are captured and stored for future transformation into a solid product. The liquors held in the Liquid Waste Treatment and Storage Facility will be progressively treated in the Dounreay Cementation Plant or a new cementation and ILW storage facility currently at the design phase of construction. During the Dounreay LTP, any liquid ILW from remaining operations and from decommissioning installations in the FCA will require treatment. Actinides extracted from these wastes will continue to feed the raffinate tanks until they are no longer needed.

Liquid Waste Treatment and Storage Facility liquid discharges to the LAD comprise either cooling water flows monitored by in-line gamma probes linked with automatic shutdown valves or sentenced discharges from the flocculation plant sentencing tanks or from the monitoring tanks which receive condensates from the evaporators.

9.2.11 Solid LLW Disposal Pits

Each LLW pit has a sump, from which there is one discharge point to the LAD. The LAD is considered the most suitable disposal route for these effluents in view of the low levels of activity in the effluent. Around 5000m^3/yr of leachate is discharged to the LAD in total. The activity associated with this discharge is very low and reasonably constant and DSRL wish this waste stream to be considered for continuous discharge via the closest foul drain rather than the LAD. Discharge direct to the sea is appropriate since given the very low activity levels there is no practicable abatement of the active species present.

9.2.12 ILW Shaft

This facility comprises the underground shaft used for the originally authorised disposal of solid ILW. The waste is stored below a level of water maintained between tight levels. Groundwater ingress is pumped out automatically to the LAD, activated by a high level in the shaft. Day to day operations currently comprise mainly daily checks on shaft conditions including checking instrumentation readings. Operations involving pumping of the head of water to maintain the regulated level and sampling are performed as necessary. However, the level is always kept below the groundwater level to promote the net water flow into the shaft rather than out of the shaft into the groundwater.

2008 saw the completion of a project to install a grout curtain around the circumference and length of the shaft. The completion of this project has resulted in a drop, of the order of 70%, in the water ingress with a resultant drop in the radioactivity being routed through the LAD.

An on-line filter is used to remove suspended solids in the shaft water prior to discharge to the LAD to ensure compliance with the requirement to minimise solid particulates in the liquid effluent. An ion exchange unit has been installed on the shaft discharge to the LAD to specifically reduce Sr-90 and Cs-137 activity levels discharged following identification of any enhanced ('spike') levels arising in the shaft water prior to routine discharge.

The long-term plan is to remove the waste from the shaft, and immobilise the waste in a purpose built treatment facility prior to storage in a retrievable above ground store.

9.2.13 Wet Silo and Ultrafiltration Pilot Plant

The Wet Silo comprises an underground vault containing ILW waste (low alpha, high beta/gamma). It was designed for wet storage i.e. the waste is stored under a level of water, although "pyramids" formed on top of the waste piles and these have previously protruded above the liquid level. Historically the water level was intentionally increased in the Silo and then reduced in order to improve the dispersion of the new wastes, below the silo water line. This practice was eventually halted. The application of a mechanical "sweep arm" in the silo was later employed during the then routine receipts of wastes, to improve waste storage packing efficiency. The long-term plan is to remove the waste from the silo and immobilise the waste in a purpose built treatment facility prior to storage in a retrievable above ground store.

An ultrafiltration pilot plant (UPP) is used as an abatement unit to remove activity from the silo water during discharge to the LAD. This is an infrequent operation. Such techniques offer the possibilities of reducing particulate burdens of liquids more efficiently than "passive" filtration and may also employ treatment of liquors to promote precipitation of soluble radioactive species, which are then removed from the liquor stream by the filtration process.

The UPP is due to be decommissioned and demolished as it stands on the footprint of the Shaft/Silo waste retrieval and treatment plant. A BPM case has been made for any silo water to be treated through the shaft filtration/ion exchange plant.

9.2.14 Alpha Laboratory/The "Head End" Area/High Active Cell Suite/Pulsed Column Laboratory

Cooling waters discharge to the LAD along with waste waters from fume cupboards. The cooling water discharge is not used at present. The fume cupboard facilities are to be decommissioned within the next 5 years. All discharges are sentenced before release. The LAD is the most suitable disposal route for these low activity liquors. There are discharge points to the PWT but these are rarely used.

With the exception of the wash hand basins and sinks, all other discharges to the LAD are filtered down to 1 µm prior to LAD disposal.

9.2.15 Dounreay Cementation Plant

The Cementation Plant is a facility used primarily for the cementation and subsequent temporary storage of MTR ILW Raffinates. The facility is also used for the "overpacking" of solid ILW waste drums.

There are two discharge points to the LAD, one from the "Washings Vessel" which collects washings and spillages for sentencing before either discharge to the LAD or recycling. Dilute washings would not be recycled. The second is from the decontamination glovebox. The LAD is the most suitable disposal route for these LLW effluents. There are contingency filters (<1 μm on the discharge to the LAD i.e. two filters on the discharge to the washings vessel and two filters on the manipulator decontamination glovebox that discharge directly to the LAD.

9.2.16 Decontamination Facility

There is one discharge point to the LAD from the sentencing tanks within the Decontamination Facility. These tanks can also discharge to the PWT in the rare event that higher activity levels are detected in the effluent. Since the operation of the Decontamination Facility to date, there have been no discharges from the facility to the PWT. The routine discharge to the LAD comprises the diluted acid used for decontamination, wash waters and shower and sink waste waters.

Insoluble contaminants are filtered before discharge to the LAD using commercially available 20 μm filters. The nature of the decontamination process in the Decontamination Facility is always likely to generate radioactive particulate in decontamination liquors. Removal of particulate matter is undertaken by filtration at source to prevent trace particulate being carried forward from the holding and sentencing tanks. There are 16 filters arranged in parallel in the filter glovebox.

The soluble contaminants removed during decontamination are put to the LAD since this is the most appropriate disposal route for mainly water based effluents containing relatively low levels of activity. The arisings can be reduced through swabbing and this is undertaken where possible (which produces solid LLW for disposal instead).

9.2.17 Waste Receipt, Assay, Characterisation and Supercompaction (WRACS) Facility

There is one discharge point to the LAD from one of the sinks in the washroom area. There are no process liquor release points to the LAD or any other drain. Liquors that may arise during supercompaction are retained and absorbed into a solid absorbent.

9.2.18 The Post Irradiation Examination (PIE) Facility and Storage Pond

The Post Irradiation Examination Facility and Storage Pond areas are currently under decommissioning and continued decommissioning operations in the PIE facility will not generate any liquid discharges. The liquor that was contained within the Storage Pond itself has been removed and the Pond structure decommissioned. The ongoing strip-out of certain remaining peripheral equipment (e.g IX wash-out tank, fresh water filter and de-ionisation unit) associated with the Pond may result in very small quantities (<30 litres) of liquor requiring disposal to the LAD.

The two DMTR underground liquor sentencing tanks are currently held in Care and Maintenance in preparation for decommissioning. It is expected that the liquor contained within these tanks will be routed through the existing connection, in the DMTR Storage Pond area, to the LAD for discharge following filtration and ion exchange.

9.3 GASEOUS AND AIRBORNE WASTES

The application of "Best Practicable Means" (BPM) with respect to gaseous and airborne wastes involves regular assessment of discharge levels and a continuing review of the procedures and treatment methods used to reduce the radioactive content of discharges. DSRL requires the operators of radioactive facilities to apply BPM through implementation of safety instructions on radioactive waste storage and disposal, and work is only carried out by trained personnel under appropriate supervision.

The current practice for the management of gaseous waste arisings at Dounreay is generally to treat them local to the facility in which they arise. In some instances, gaseous waste arisings are locally pretreated or combined prior to treatment and discharge.

Management has taken the form of:

- Collection;
- Filtration to remove radioactive particulate material;
- Adsorption to remove gaseous radioactive species, if practicable;
- Sampling, monitoring and discharge to the atmosphere.

In all these respects due account is taken of current good practice. Where practicable, DSRL is undertaking work to bring the ventilation systems that serve the facilities on the Dounreay site up to the standard of NVF/DG001[8]. This requires each system to:

- Meet statutory and mandatory requirements;
- Show that BPM has been employed;
- Comply with the ALARP principle;
- Provide an acceptable working environment ;
- Provide operator protection by maintaining the required depressions and flows whilst collecting contaminated air flows;
- Control airborne discharges which could be released from the facility;
- Ensure airborne discharges are effectively dispersed into the atmosphere;
- Ensure that non-statutory and thus statutory discharge limits are not exceeded.

Safety reviews and assessments are regularly carried out together with individual BPM reviews on a plant-by-plant basis.

At Dounreay BPM is implemented by the following measures:

- **Operational control at source**. This is achieved through a combination of administrative and engineered controls. Radioactive materials are enclosed so far as possible in experimental/process cells. Enclosures (glove boxes, fume cupboards etc) are decontaminated and materials disposed in sealed containers as soon as possible and frequently during operations. Loose contamination is immobilised where possible (for example by the use of coatings), or damped down with a water spray to prevent it becoming airborne. The air intake to the building may be filtered, to reduce the arisings of dust.

[8] An Aid to the Design of Ventilation of Radioactive Areas, NVF/DG001, January 2009

- **Minimisation of materials.** Limits are placed on the type of operations carried out and the quantities of materials that can be used, taking account of the form of any contamination that might arise (wet, dry, dusty operations) and the specific activity of material etc. Different limits are set dependent on the type of enclosure used.

- **Use of filters.** High Efficiency Particulate Air (HEPA) filters are used to remove particulate activity prior to discharge to the atmosphere. Single or two stage testable HEPA filters fitted into the ventilation systems are considered to be BPM for atmospheric discharges of airborne particulate. Filters are operated in parallel to give redundancy and permit filter changes without discharge of unfiltered air. The efficiency of removal of particulate material is at least 99.9% for one stage of filtration, and is higher for filters in series. HEPA filters are individually tested to the relevant British Standard prior to installation and in-situ testing is carried out periodically or when filters, or the filtration system, has been changed. Local HEPA filters are also fitted to glove boxes and cells to prevent contamination of the ventilation trunking so far as possible; this adds a further stage of filtration from the most highly contaminated areas.

- **Use of modular containment systems.** The use of modular containment systems with HEPA filtered extracts is implemented for certain activities involving potentially dusty processes, such as decommissioning operations involving the cutting-up of contaminated equipment e.g. glove boxes. This technique has been used successfully in decommissioning operations at Dounreay to reduce radiation doses to workers and minimise discharges of particulate material to atmosphere.

  Modular containments are generally used within a facility. However, it has been recognised by DSRL that the use of modular containment outside of areas that have a monitored discharge route could be beneficial. For this reason DSRL is including in this application the use of modular containment with separate discharge monitoring where this type of containment is used outside the normal facility ventilation systems.

- **Maintenance of ventilation/filtration systems.** Systems used to discharge wastes (such as fans, filters and discharge points) are maintained in good repair, and operations must be carried out and supervised by appropriately trained and experienced staff. Filters are fitted with gauges, to indicate the dust burden across the filters, which are regularly inspected. The readings obtained are used to initiate consideration of filter changes.

- **Monitoring of activity.** Extract systems in the principal outlets have isokinetic sampling systems to measure discharges of total alpha and total beta activity, and tritium. Where discharge is to the environment the sampling systems incorporate duty and standby pumps to provide a high level of reliability. Static air samplers and alarming duct monitors are used to detect any escape of contamination into the working areas. This would indicate acute problems immediately. Regular testing of monitoring systems and associated flow rates is undertaken to ensure confidence that the systems are functioning correctly. Where monitoring of discharges is not practicable (as is the case generally for krypton-85), cautious assessments are made on the basis of the amount of material involved.

- **Internal discharge limits.** Discharge Control Objectives are allocated to individual facilities. Appropriate investigations are conducted to examine whether discharges are being properly controlled if these levels are exceeded. Trends and unusual results are examined to identify potential problems and to put in place solutions before real problems occur.

- **Safety reviews**. All facilities are required to submit a time controlled report on safety related matters in order to gain approval for continued operation. Part of the requirements for approval is to demonstrate, where applicable, that discharges are being properly controlled and that BPM is being applied to minimise discharges. In addition, holders of Authorities to Operate (ATO) for facilities are required to provide more detailed information on the origin and control of discharges.

Whilst discharges of alpha and beta particulate material are minimised through the use of HEPA filters, there is no practicable alternative to the direct discharge to atmosphere (i.e. without abatement) of tritium and krypton-85. The only gaseous radioactive species that is expected to be discharged to the atmosphere in significant amounts is tritium. The main option to reduce gaseous emissions of tritium would be to extract it as tritiated water vapour and discharge it to sea as a liquid, where the radiological impact is lower. However, this would be contrary to the Government's national discharge strategy, and the cost would be disproportionately high compared to any benefits.

For discharges of krypton-85, which is a relatively long-lived inert gas, there is also no reasonably practicable alternative to discharge to atmosphere, given the very low radiological impact of the discharges. Krypton-85 does not bond chemically with other substances and it cannot be isolated by chemical reaction with a solid substrate. It is relatively insoluble in liquids. It can be trapped by physical adsorption onto activated charcoal at low temperatures but the gas will desorb at normal storage temperatures, and there would only be virtue in trapping and holding the gas if the half life were short enough to take advantage of decay. A review of the separation and immobilisation of krypton was undertaken on behalf of HMIP (Ref 21). This showed the technology was available but that further development work under radioactive conditions would be required prior to application. On consideration of the balance of the benefits of radiation dose reduction against the resources that would need to be expended to capture the relatively low levels of Kr-85 from the various facilities on the Dounreay site, such investment is not considered to be warranted. This position is in line with the recommendation made by the Environment Agency review of radioactive discharges from the Sellafield site (Ref 21).

While decommissioning, ventilation must be maintained for safety reasons until the time when radiologically controlled areas are no longer required. However, it is likely that ventilation systems will require modifications because of the changed duties; for example, a system that only discharged inert gases during reactor operation would require the addition of filters to remove dust created when dismantling the reactor structures. Radioactive airborne dust generation is considered to be the most environmentally hazardous operation during decommissioning. This will be associated mainly with the strip out of vessels, pipework, valves etc and the appropriate size reduction and packaging of waste into standard approved waste containers. These operations are all unavoidable and routine control measures will be implemented to minimise activity release and demonstrate application of BPM.

As described in Section 5.2.1, DSRL's gaseous RSA authorisation groups activities in specific areas on the Dounreay site. Within these areas, in some cases there are numerous separate stacks. The locations of the stacks are shown in Figure 11, which identifies the plants they serve and the height of each stack. The following sections (9.3.1 – 9.3.18) describe the treatment methods applied to potentially radioactive discharges to the atmosphere on a plant by basis. Again these sections cover the main plant on site, but are not necessarily an exhaustive list.

9.3.1 DFR

Aerial disposals of gaseous radioactive waste from DFR are vented to atmosphere via a stack 50m above ground level provided for that purpose; no other discharge points are provided. The gaseous discharges from the decommissioning activities will arise from:

- the destruction of the primary NaK through the NaK Disposal Plant;
- the removal, cleaning and packaging of the nuclear material removed from the DFR Reactor;
- disposal of fuel storage pond water;
- demolition of fuel storage ponds;
- destruction of the reactor primary and secondary coolant residuals; and
- disposal of reactor furniture and equipment

Atmospheric discharges from the NDP will be water scrubbed, heated, HEPA filtered and diluted with air to a safe level (<0.1 vol.% hydrogen), prior to being discharged via a dedicated flue in the DFR stack. Scrubbing prevents caustic carry-over in the gas phase from the NDP and is adopted where gas streams are wet and corrosive.

The annexes and pond areas, where decommissioning work will be undertaken, including temporary work enclosures, are provided with an active ventilation system to separate flues within the DFR stack. All gaseous discharges are passed through pre-filters followed by HEPA filters and are then continuously sampled iso-kinetically for particulates and tritium.

9.3.2 PFR

The PFR is provided with a main ventilation stack that discharges 40 m above ground level and an 18 m stack that serves the Buffer Store. There are also a variety of other ventilation outlet points which comprise the PFR Minor sources. These outlets from which species are or may be emitted during the decommissioning operations on the PFR are:

- The 32 m vent for the Secondary Sodium Circuit on the vent annex roof provided for cleanout of the circuits. The vent is not currently in use, however, future operations of secondary sodium destruction will utilise this vent;
- The 7 m vent at the sodium tank farm building to be used principally for the sodium inventory destruction operations;
- The 40 m vent for the Alkali Metals Laboratory

The bulk of the gaseous discharges from the PFR over the next few years will arise from the destruction of primary circuit residual sodium from the reactor vessel, sodium residues from the irradiated fuel cells and the decontamination of removable reactor components and the steam cleaning of boron carbide (B_4C) control rods.

All gaseous discharges are passed through HEPA filters with 50% over design capacity. According to AECP 1054, the building and Caesium Removal Plant (CRP) areas require single HEPA filtration, while the vessel vent (a high contamination (C4) area) is doubly filtered.

Tritium gas release during the destruction of the sodium, sodium residues and B_4C control rods will increase significantly (Ref. 32). The abatement of tritium is not practicable and will therefore not be employed.

Krypton 85 gas release during fuel handling operations at PFR has a potential to result in a significant increase. The potential release is noted (Ref. 32) and, as with tritium, abatement is not practicable and will not be employed to reduce the activity released to atmosphere.

The discharge flow is sampled continuously by modern iso-kinetic equipment for tritium gas and particulate activity. Krypton-85 activity will be calculated depending on the operations carried out. The ventilation systems have been designed against the worst-case accident conditions and will provide protection against particulate radioactive release.

The PFR ventilation systems are as designed for an operational reactor, ancillary post irradiation facilities and decontamination facilities and as stated above have a 50% over design capacity. These systems are not ideal for the decommissioning activities that will be carried out and DSRL is in the process of rationalisation of the ventilation systems to best suit the future programme, to ensure that BPM is applied to decommissioning.

9.3.3 Fuel Cycle Area (FCA) Ventilation

The FCA comprises a number of facilities that historically served the UKAEA remit of providing the complete nuclear fuel cycle, including waste stores and waste treatment facilities.

The majority of facilities in the FCA discharge gaseous wastes through a common discharge point D1213. This consists of a 55 m high stack and its associated building which houses the extract fans. There is a direct ductwork connection from DMTR to the D1213 stack discharge, which bypasses the extract fans. The extract from the facilities supported by the stack are treated within the facilities prior to venting to twin cast concrete ducts which run beneath the D1209 Service Corridor.

There is known to be a problem with an accumulation of particulate materials in the underfloor ductwork. The exact quantities are not known, however, the ventilation ducts beneath the FCA access corridor are radioactively contaminated. A solution to this problem was agreed with SEPA and an action plan adopted in accordance with the variation in the UKAEA gaseous discharge authorisation dated 16 July 2003 and subsequent variations. The programme of work associated with the action plan are due for completion in 2010 at which time the facilities contributing to the D1213 stack will be routed to two 30m stacks dividing the facilities by geographical north/south location. The inputs to the new stacks are HEPA filtered downstream from the source facilities thus mitigating against the problems encountered with the duct serving the D1213 stack.

The other facilities:

- the active laboratories and parts of D1215;
- Decontamination facility;
- Waste Receipt, Assay, Characterisation and Super-Compaction;
- Marshall Laboratory; and
- CHILW Store.

These named facilities comprise a discharge group referred to, by DSRL, as the “East Minor Sources”.

9.3.4 Analytical Laboratories

D1200 laboratories have a 20m stack Known as D1200 stack) and an 18m stack (known as D1226 Stack). They are part of the, DSRL defined, East Minor Sources in the RSA Authorisation. The stacks are an integral part of the building ventilation system. The ventilation systems in D1215 discharge either to the D1200 stack (Plutonium Analysis Laboratory (PAL) fume hoods) or the D1213 discharge system (space, glovebox and cell).

There are primary and secondary HEPA filters on gloveboxes and most cells (some cells are treble filtered) and single HEPA filters on most fume cupboards. The only exception is on the extract from the uranium laboratories which passes to the D1200 Stack unfiltered. Space extracts are present in laboratories without fume cupboards and are unfiltered as is the cell extract from certain cells.

Double HEPA filtration on plutonium contaminated gloveboxes is adopted. This is necessary to minimise the routine release of particulate matter associated with such toxic material. Single HEPA filtration on other fume cupboard extracts is adopted since the hazards and risks from activity releases are significantly lower than for Pu gloveboxes.

9.3.5 Facility for Fuel Dissolution/Solvent Extraction/ Evaporation and Storage and Uranium Oxide Production Line

Extracted air passes to the “North” and “South” ducts. The North duct serves the “Wet” extracts (process vessels and storage tanks), “dry” extracts (gloveboxes), the “fumehood” extracts (fume cupboards and “C” bin repacking facility) and some space extracts. The South duct serves the Amber Area (a storage area within the facility) and the remaining space extracts.

The Wet extracts pass through demisters and then 2 primary HEPA filters arranged in parallel. The use of demisters prolongs the efficiency and reliability of the HEPA filtration. There is one duty and one standby local extract fan. Many process vessel vents are also scrubbed to remove non-radioactive contaminants such as ammonia and hydrogen fluoride using either water or caustic soda (e.g. the off-gases from the oxide furnaces). The dissolvers and the evaporators are each equipped with water cooled condensers and the recovery dissolvers each with a scrubber column. The use of single HEPA filtration on the process vessels and tanks is adopted since there is only a small risk of some particulate release (levels released would undoubtedly increase though if no abatement were applied), even from the dissolvers. In the latter case, the application of a scrubber system, the history of the need for infrequent replacement of the filters and the low aerial particulate duct monitoring results, all support single stage filtration.

The Dry extracts are double HEPA filtered and the Fumehood extracts single HEPA filtered. The handling in gloveboxes of liquids and powders especially, carries a higher risk of potential release and double HEPA filtration is appropriate in this instance. However, single stage HEPA abatement on the fumecupboard extract is adopted as only lower levels of radioactivity are routinely present within that containment. Tertiary filtration is provided on the recently upgraded extract from the Amber Area: primary filtration consists of pre-HEPA filters and spark arrestors that are located on flexible ducting to enable them to be located adjacent to decommissioning activities; secondary and tertiary HEPA filtration is achieved using a mobile filter unit with two fans. The pre-HEPA filters will reduce the amount of contamination that may potentially build up in the ducting and thus make future decommissioning less hazardous.

9.3.6 Waste Processing Facility

The only direct aerial radiological emissions to the environment are from the filtered and monitored airflow from the cells that exhaust through the active ventilation system and to a lesser extent from the unfiltered and monitored extract from the Cell Maintenance Area (CMA). Separate ventilation systems are installed to the cells, gloveboxes and external general areas and cell pressures are maintained at a negative pressure with respect to cell external ambient pressure. The ducting for each of these areas, with appropriate filtration fitted, eventually combine prior to discharge.

Primary and secondary extract HEPA filtration provides double filtration for the north/south cells and Waste Posting Cell (WPC). Double HEPA filtration is used in assisting to control and reduce radioactive particulate emissions. The application of double HEPA filtration in this instance serves no routine significant environmental benefit but is a contingency safeguard, primarily for potential accident situations. A DF of 10,000 is not essential to deal with the challenge from routine operations in the cells. As a precaution the primary filters in the north and south leg cells have spark/debris arrestors. This is a routine precaution to reduce the risk of fire in the ventilation duct from entry of sparks.

9.3.7 Research Reactor Fuel Reprocessing Plant

The Research Reactor Fuel Reprocessing Plant ventilation extract vents to D1213 stack. This is via local filters and fans, all purposely installed in the Research Reactor Fuel Reprocessing Plant to support decommissioning Stages 1& 2. The aerial releases are necessary as a safety measure to protect personnel working in the plant. Both managerial and engineering systems are used to minimise aerial discharges from the Research Reactor Fuel Reprocessing Plant to the environment.

The Red (most active) extract (from HAC, MAC, and pond) will contain a total of three moisture eliminators (i.e. demister pads) that will remove any water/moisture droplets carried over from those areas and this will protect the efficiency and operating lifetime of the downstream filters. Similarly an electric heater is also provided in the ventilation duct to protect against high humidity levels in the duct and thus further provide against potential “blinding” of the downstream filters. The Red extract consists of two parallel banks of filters that each contains a coarse pre-filter, primary HEPA filter and secondary HEPA filter. Coarse pre-filters are considered necessary in this instance due to the potential airborne particulate activity resulting mainly from the extensive and lengthy period of strip out and size reduction operations. The high levels of radioactivity present in the cells and the potential risks from a radioactive release during decommissioning merit the use of secondary HEPA filtration as an added contingency to further minimise the release of aerial particulate.

The Green extract (i.e. building general areas space extract) will have three parallel banks of filters that each contain a coarse filter, a primary filter and a secondary filter. The filtration is only provided as a safety contingency in case of the remote possibility that there is an incident that involves the major release of activity (e.g. spillage of dissolver liquor washout) into the general working environment of the plant.

The Blue system supply of clean air into the plant receives coarse and fine filtration prior to entering the building. There is only a remote risk of the input air being radioactive and therefore there is no requirement to have this filtered. However, industry best practice now generally involves standard filtration of air inputs for new systems as in this case.

The gloveboxes, sample stations and sample cabinets in the Research Reactor Fuel Reprocessing Plant do not have local HEPA filtration (except the MA sampling glovebox with a redundant cylindrical filter) and rely on the Red Extract filters The use of local filtration in addition to the consequential secondary and tertiary that would be available is not considered justified.

9.3.8 The Fast Reactor Fuel Reprocessing Plant and Evaporator and Export Plant

The active and space extract ventilation in both the Fast Reactor Fuel Reprocessing Plant and the Evaporator and Export Plant is discharged to the D1213 stack. This extracts from caves, cells, gloveboxes, fume cupboards and from the general building areas (space extracts). The ventilation systems in both the Fast Reactor Fuel Reprocessing Plant and the Evaporator and Export Plant include an active vessel vent system that collects vents arising from process vessel out breathing and the various nitrogen sparges, pneumacator nitrogen flows and air lift pump nitrogen flows. Vessel ventilation extract from the inactive chemical make up and feed tanks, in the inactive feed tanks area, is discharged via a small mini-stack adjacent to the area. There are no radioactive emissions from this mini-stack.

Releases into air are minimised from the active ventilation systems by the use of HEPA filters. Extracted air from the Fast Reactor Fuel Reprocessing Plant passes to the “North” and “South” ducts. The North duct serves the caves, dissolver cells and most of the gloveboxes. These vent via the “Active Filter Change” Facility (AFCF), comprising several primary and secondary filters in series. The South duct serves the Residue Recovery Plant (RRP), where the discharges are single HEPA filtered, and some gloveboxes that are double HEPA filtered. The Evaporator and Export Plant discharges are all double HEPA filtered and the space extract is also HEPA filtered. Vessel vent extract is via a dry packed scrubber before combining with the glovebox extract, prior to filtration of the latter.

The vent from the redundant Dissolver Cell (DC) 4 dissolver previously passed to a wet scrubber for removal of iodine using a mercuric nitrate solution. There is also a condenser and a wet NOx scrubber available for the RRP dissolver vessel off-gas. The abatement requirements on the Fast Reactor Fuel Reprocessing Plant and the Evaporator and Export Plant ventilation systems are a reflection of the historical risks and demands from reprocessing/processing operations. However, current demands on the abatement systems are significantly smaller under the surveillance regime. It is impractical to remove abatement that is undoubtedly not justified at present to be later reinstalled once decommissioning advances.

9.3.9 Liquid Waste Treatment and Storage Facility

The Liquid Waste Treatment and Storage Facility ventilation comprises a “Vessel Ventilation System” and “Cell Extract Ventilation” system. Both vent to the D1213 Stack.

A shortfall of the system is the formation of aerosols which can lead to the levitation of activity to the ventilation system. Heating is installed before the HEPA filters to prevent condensation on them, hence prolonging their life and minimising waste. There are 2 scrubbing plants on the vessel vent system: on evaporator No.1 (a dry scrubber) and on the floc plant. The dry scrubber allows particle dis-entrainment without putting water to drain. Condensing and cooling systems minimise vapour losses to atmosphere. There are a number of dis-entrainment devices throughout the vent systems to minimise droplet loss into the ventilation system.

9.3.10 ILW Shaft

There are no ventilation systems in the ILW Shaft Facility. Although the shaft is allowed to vent naturally it does not have routine monitoring for potential airborne activity emissions. Following the shaft explosion in 1977, negligible airborne activity was detected with the shaft top left open to atmosphere. As current operations involve no ILW posting operations in or out of the shaft, all fugitive airborne emissions from the shaft are considered to remain negligible; this is discussed further in section 10.

9.3.11 Wet Silo and Ultrafiltration Pilot Plant

The silo breathes out to atmosphere via HEPA filters and the UPP has a ventilation system, equipped with a fan and HEPA filters, which discharges to a dedicated 10 m stack on the

UPP building. Emissions to atmosphere from the silo area are trivial, based on environmental monitoring of airborne levels and no further abatement is required.

9.3.12 Materials Test Reactor

The Materials Test Reactor Facility ventilation is extracted to the FCA Stack. The vent is HEPA filtered. The ventilation is required for safety reasons (i.e. a precaution against deterioration of the structure by corrosion and to provide clean air for personnel in the working environment.

9.3.13 Alpha Laboratory/ The "Head End" Area/ High Active Cell Suite/ Pulsed Column Laboratory

This facility has its own dedicated 24m stack. There are several ventilation systems in the building with different levels of HEPA filtration depending on the source risk:

- The **"Red" extract system** handles ventilation from the High Active Cells and gloveboxes. Discharges to the Red extract system are filtered using a double HEPA filtration system. There is some tertiary filtration in areas where fuel cropping was done (i.e. a HEPA filter in cell 1).
- The **"Amber" extract systems** handle the space extract from the Pulse Column area and the space extract and fume cupboard extracts from the Alpha laboratory. Discharges to the Amber extract system undergo single HEPA filtration. However, the decontamination fume cupboard receives double HEPA filtration (local single filter before entering the amber extract filtration in the plant room).
- The "**Green" extract system** handles space extract from the Head End store and general building areas. Discharges to the Green extract system are not filtered except extract from the Head End fuel store that is single HEPA filtered.
- The Pulsed Column Laboratory has been separated from the above ventilation systems and has its own dedicated 17.5m stack. Discharges from the stack are HEPA filtered to ensure minimisation of discharge and as mitigation for potential incidents.

9.3.14 Cementation Facility

The Cementation Facility ventilation system extracts discharge to the FCA Stack. All process areas handling radioactive materials are contained within remote handling cells and have HEPA filtration on their gaseous extracts. The Solids Cells, the Liquid Cell, Restricted Access Room and Master-Slave-Manipulator (MSM) glovebox have double HEPA filtration.

The process vessels vent to an aqueous scrubber before release into the ventilation system. There is a cyclone in the drum filling area to knock out cement dust to reduce the loading on the cell HEPA Filters. There is also dis-entrainment capability in the vent lines to minimise droplet loss into the ventilation system. The scrubbing water flow is a closed-loop recirculation system to avoid drain discharges. In practice the scrubber is run with the packing just wetted, allowing particle dis-entrainment without the use of large quantities of water. This is considered to be BPM

9.3.15 Decontamination Facility

The Decontamination Facility has its own 18m stack. The stack is an integral part of the building ventilation system. Operations are not inherently high polluting processes. However controls are important to minimise releases into the environment, especially since alpha contaminated equipment is handled. HEPA filtration is used primarily as safety mitigation for potential incidents, but is also supportive to minimising aerial releases of activity.

There is also a scrubber on the "Red" (active) extract. Although the scrubber's primary function is to remove toxic chemical vapours/gases, it also contributes to reducing the radioactive particulate emissions.

9.3.16 Waste Receipt, Assay, Characterisation and Supercompaction (WRACS) Facility

WRACS has its own 13m stack. Releases into air are minimised by the use of 2 large primary HEPA filters arranged in parallel. Single stage abatement is justified in this case on active extract for the processed solid LLW, given the low levels of activity associated with the handling of this waste. Each is preceded by a coarse filter. There are no primary filters on the compactor glovebox or any associated vortex amplifier. These were considered unnecessary for safety or environmental reasons. The space extract is unfiltered and passes through a louvered vent in the side of the building.

9.3.17 The Post Irradiation Examination (PIE) Facility, DMTR Storage Pond and RHILW Store

The only release point to atmosphere is that from the ventilation system that serves the PIE, Pond and Store areas. This vents to atmosphere via a common duct to the FCA Stack. This is needed to ensure safe disposal of workplace and cave air extraction.

Releases into air are minimised by the use of double HEPA filtration. Air extraction from the maintenance area enters the PIE cave. The space extract from the D9814 pond area is single HEPA filtered via the D1251 secondary filter bank.

The HEPA filters on the PIE Cave were originally installed for the previous operational phase of the facility and not the significantly less arduous burden on the filters from the current care and maintenance activities. Future decommissioning of the facility will place an increased demand on the filtration system.

9.3.18 Low Level Liquid Effluent Treatment Plant (LLLETP)

There is a 15.7m high stack on the LLLETP building for the discharge of ventilation extracts. All process vessels, cabinets, gloveboxes etc operate under a slight negative pressure for operator safety reasons. There is also space ventilation supplied to areas within the main buildings.

HEPA filters are provided throughout the system primarily as safety mitigation for potential incident conditions.

The air inlets to the building are fitted with pre-filters as a measure to minimise the particulate entering the space areas of the facility thus preventing additional particulate being drawn into the extract system.

10 PROPOSED FUTURE DISPOSAL LIMITS

In deriving the proposed revised limits, consideration has been given to the past performance in meeting the limits specified in the current authorisations and, as far as possible, the measures taken, or initiated, to prevent or minimise gaseous and liquid waste arisings. Account is also taken of expected future operations at Dounreay and the major programmes of work associated with the LTP. It is likely that these will result in increased discharges of radionuclides compared to those made in recent years, when operations involving the generation and treatment of wastes have been at relatively low levels.

For the new plants that have yet to be designed and built, it is not possible at this stage to provide precise quantitative data on the annual gaseous and liquid discharges foreseen. For the purpose of deriving upper bound estimates of discharges for this submission, it is necessary to assume that arisings from operating the plants themselves will be typical of other similar plants on the Dounreay site, where such plant exist.

Liquid and gaseous discharge estimates have been made on a facility basis and from these future discharge limits are proposed. The proposed limits take account of the uncertainty of the initial estimates set against whether the operations to be carried out are existing operations or new.

Previous gaseous limits have been set for facility groupings:

- “**FCA Main Stack**” (the 55m stack associated with facility D1213 as defined in the extant authorization Table 4.4);
- “**PFR**” (the 40m stack associated with the PFR and the 18 m stack associated with the IFBS as defined in the extant authorization Table 4.2);
- “**DFR**” (the 51m stack associated with the DFR as defined in the extant authorization Table 4.3);
- “**West Minor Sources**” (the 10m stack associated with the facility D9833, the discharge pipe at a height of 6m from facility D1115, the 17m stack associated with facility D3000, the 10m stack associated with facility D2167 and any ventilation outlet on any temporary containment enclosure used for decommissioning work outwith the curtilage of any facility taken together as defined in the extant authorization Table 4.5);
- “**East Minor Sources**” the 18m stack associated with facility D1200, the 20m stack associated with facility D1226, the 21m stack associated with facility D2670, the 18m stack associated with facility D2900, the 17m stack associated with facilityD9867, the 10m stack associated with facility D6499, the 13m stack associated with facility D8570. the 13.5m stack associated with facility DN060, the 10m stack associated with facility D8550, and the 17.5m stack associated with facility DN141 taken together as defined in the extant authorization Table 4.6);
- “**PFR Minor Sources**” (the 10m stack associated with the Sodium Analysis Laboratory, the 6m stack associated with the sodium tank farm and the 32m stack associated with the Prototype Fast reactor secondary sodium circuit ventilation system as defined in the extant authorization Table 4.7)

taking account of estimated discharge activities to ensure that where low levels of discharge would occur these were not regulated against a proportionately high limit. DSRL has recognised that regulation against group limits was justified for the site operations in force at the time of the granting of the extant authorisation. However, DSRL now considers that the decommissioning of the site up to 2025 with a progressive programme of facility demolition counters the partitioning of the authorised discharge points into set groupings for the purpose of setting defined limits. The requirement to use BPM to minimise disposals from the discharge source will ensure for each discharge point there is evidence of minimisation of the discharge. The setting of a site limit will assist the decommissioning of the site by affording a degree of flexibility, within the bounds of BPM, that DSRL believes is required for the decommissioning of the site.

Dounreay Site Proposed 12 Month Discharge (Gaseous)	
Radionuclide	Proposed Limits (Bq/yr)
Total alpha	**7.28E+06**
Total beta (Excl. tritium and krypton-85)	**2.94E+09**
H-3	**7.82E+13**
Kr-85	**5.76E+14**
I-129	**1.00E+09**

Dounreay Site Proposed 12 Month Discharge (Liquid)	
Radionuclide	Proposed Limits (Bq/yr)
Total alpha	**3.67E+09**
Total beta (Excl. tritium)	**2.73E+12**
Sr-90	**2.74E+11**
Cs-137	**1.27E+12**
Na-22	**1.30E+10**
H-3	**1.02E+14**
Am-241	**1.50E+07**

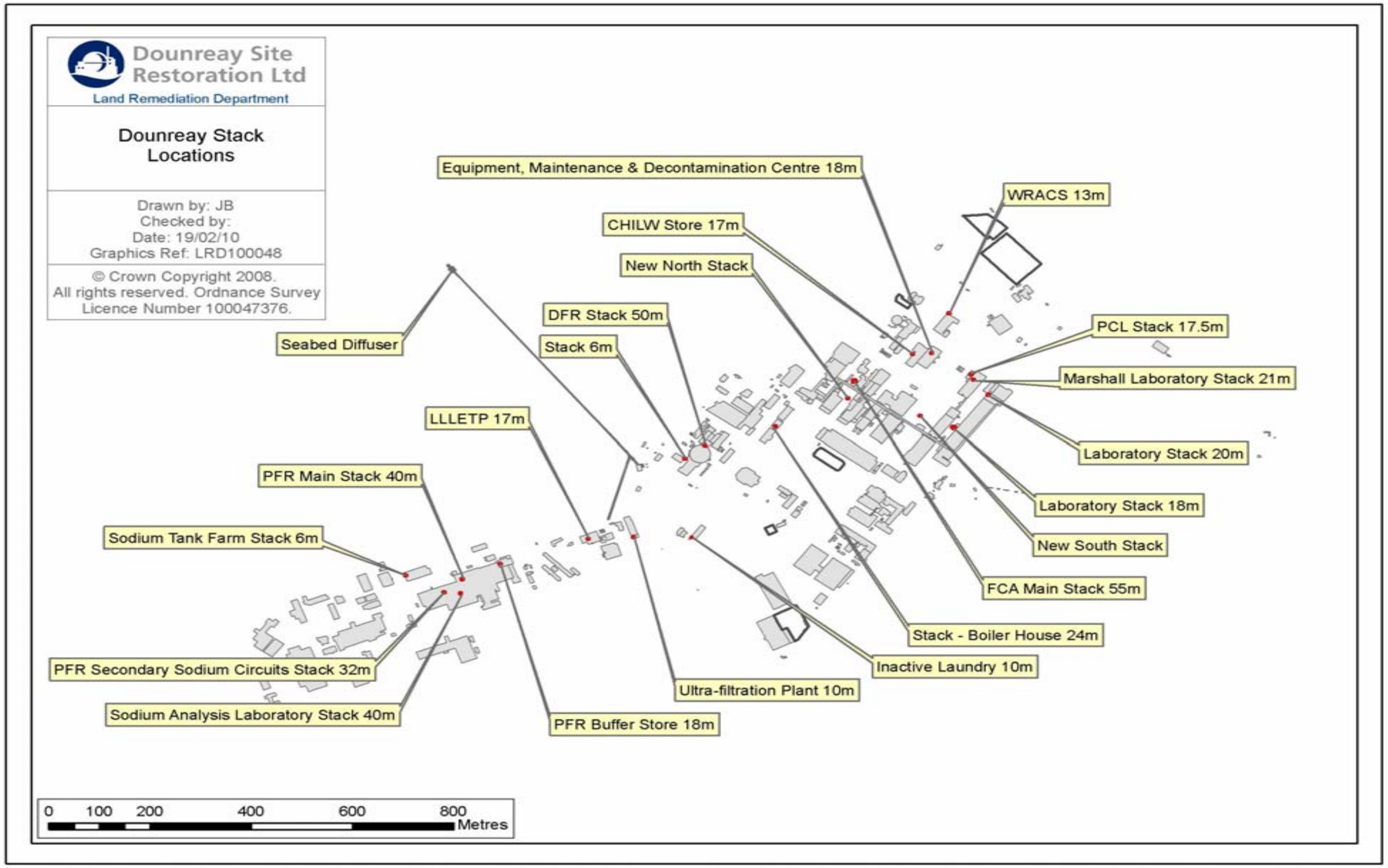

Figure 7 Map of Gaseous Discharge Points (incls Boiler house) and Liquid Discharge Point

10.1 Liquid Discharges

10.1.1 General

During the site LTP, LLLW must be treated both from any remaining operations and from decommissioning. By far the greatest proportion of this waste is lightly contaminated water. However, on site there are also contaminated oils, solvents such as tributyl phosphate and odourless kerosene, and chemical wastes such as zinc bromide solution and others that must also be treated as contaminated. The quantities of radioactive liquors arising from decommissioning are, in terms of volume and activity, predicted to be significantly smaller than those occurring up until 1996 when the FCA was operating at near maximum capacity. The management of these wastes is discussed separately in section 14.2.

Previous liquid discharge authorisations have been based on reprocessing continuing at Dounreay. Following the decision that there will be no further reprocessing with the focus on decommissioning and progressing the LTP, DSRL consider that it is appropriate to review the current discharge limits and projected discharges up to the IEP. The result of this review is appropriate new twelve month rolling discharge limits as proposed in the table above.

The proposed limits are based on a review of past disposals and an assessment of future requirements over the next few years. These limits take into consideration ongoing waste minimisation measures. However, it is necessary to maintain a reasonable margin between expected disposals and regulatory limits to avoid unreasonable constraints on essential in work programme flexibility. The limits for liquid disposal recorded in the Certificates of Authorisation granted in 1999 were derived as two times the perceived need at that time. This margin was granted to allow for variations in disposals arising from any required changes in operational procedures. The same approach has been used for this application. The limits proposed have been based on a criterion to account for variability and to maintain flexibility. The magnitude of unplanned but foreseeable events causing liquid discharges during decommissioning is less than those from unplanned but foreseeable events causing liquid discharges during operation. However, the decommissioning of radioactive facilities introduces uncertainties with respect to waste arisings compared to previous operations. It is possible that short-term minor increases in discharges may occur during decommissioning. Control of work, through the use of BPM, will minimise the chances of such an event, and the sampling of all significant facility discharges prior to their release to the LAD should ensure that the activity in discharges are minimised.

The radionuclides individually identified in the proposed limits are included for a variety of reasons. Strontium-90 has been included because it provides a significant proportion of the total beta disposed; although it does not contribute a significant dose to the local population. Tritium, which also does not contribute substantially to dose, is included because it constitutes a numerically large activity disposed. Other radionuclides in the list contribute to critical group doses and are included for that reason.

10.1.2 LTP Discharge Requirements

As a basis for substantiating the requirements for liquid waste discharges over the LTP, the projections given (Ref. 35) were made for the various decommissioning and waste management operations across the site to support the LTP. These are based on operational experience and on estimates of the volumes and radioactive content of arisings from decommissioning operations, including retrieval and processing of accumulated wet wastes.

The total quantities estimated from the decommissioning studies have been allocated uniformly over the rest of the LTP to 2025, and represent the quantity and nature of the maximum throughput for the liquid waste treatment processes on site.

10.1.3 PFR Liquid Metal Disposal Plant

The primary source of discharge through this discharge route has ceased with almost all of the contaminated sodium at PFR having been destroyed. This discharge route does not include other discharges from PFR and its future use will not result in any significant radioactive liquid discharge.

10.1.4 Remainder of Site

Estimates have been made of the discharges from each facility that discharges liquid effluent to the LAD. Many of these are small and effort has thus been concentrated on the more important sources.

The key basis for the limits being proposed is that they reflect the individual plant abatement applied, as described in Section 9.2. The figures (Ref. 35) will inevitably change as operational plans become established, though they provide a basis to the proposed discharge limits for a liquid discharge authorisation. The discharge profile is not constant over the LTP period with peaks when higher levels of activity will be discharged. In the early years, DFR NaK disposal and emptying of the DFR Fuel Storage Pond contribute significantly to discharges. In addition, the early stages of decommissioning include post operational clean-out that can be expected to involve emptying and washing out vessels that have held radioactive liquors. This will lead to increased discharges in the earlier stages of the LTP, and a gradual decline consistent with UK strategy as decommissioning progresses.

The results from the sampling and analysis of the NaK batches during active commissioning and their assessment against estimates of the radiological inventory of the NaK made prior to active commissioning of NDPIXP has shown that the radiological inventory of the NaK is within the bounding case radiological inventory data used to support previous NDP BPM cases with the exception of Sr-90.

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

Previous estimates of the level of fissile material in the inventory of the NaK have however been shown to be an overestimate by several orders of magnitude (based on NaK sample results during active commissioning).

The total Sr-90 inventory of 126 GBq is on average an order of magnitude greater than previously estimated (16.5 GBq). Although there has been an increase in Sr-90 activity level in the NaK that could challenge the robustness of the current BPM case, a review of the gaseous beta discharges and liquid Sr-90 discharges show that Sr-90 is being minimised to close to or below minimum detectable levels.

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

Other important assumptions include the difficulty of estimating inventories for the Research Reactor Fuel Reprocessing Plant. The two main areas of radionuclide holding are in the dissolver vessels (containing undissolved/insoluble fission products, e.g. mainly Sb-125) and the pond. The exact activity and composition of undissolved fission product activity in the dissolvers is not known for certain. The radioactivity content of the pond water and pond sludge has been determined and found to be dominated by Cs-137 and Sr-90. These latter two nuclides will dominate the liquid radioactive releases to the LAD from the Research Reactor Fuel Reprocessing Plant.

The Shaft liquor activity is generally consistent, though occasional ‘spikes’ of activity can occur. The requirement for discharges from this facility has been proposed at a level that takes these spikes into account.

Liquid effluent arisings from the adjacent Vulcan Nuclear Reactor Test Establishment are transferred under authorisation to DSRL, for discharge to sea via the Dounreay pipeline and are therefore required to be covered within this authorisation. The quantity of each radionuclide disposed in any month from Vulcan is dependant on the operations being carried out at the time. It is estimated that the activity disposed of during any 12 month period will be around 5 GBq β/γ

10.1.5 Summary of Estimated Future Liquid Activity Arisings

Estimates of future active liquid discharges from general operations and decommissioning activities are shown (Ref.34). These estimates are based on the programme of decommissioning work and waste management activities identified in the LTP, and with due allowance for uncertainties in the inventory established from sampling. These have been used to propose liquid discharge limits for the next authorisation period. During the waste recovery and processing operations of the early phase of the LTP discharges are expected to increase significantly. Under the current programme, gross beta discharges are predicted to peak at around 500GBq in the period 2014 to 2015 and then drop off rapidly to level of about the order of 150GBq for remaining decommissioning operations. Discharges of alpha activity follow a fairly flat profile with a maximum discharge of approximately 2.5 GBq.

No practicable abatement of tritium is available for treatment of tritiated liquid wastes, so these will continue to be discharged in line with the strategy described in the DSRP BPEO study.

10.2 GASEOUS DISCHARGES

10.2.1 General

During the site LTP, gaseous discharge will continue from any remaining operations and from decommissioning. In deriving the proposed limits, consideration has been given to the past performance of meeting the authorised limits. Account has also been taken of likely future operations across the site to implement the LTP and the measures taken, or initiated, to prevent or minimise airborne waste arisings. The requirements are discussed below on a group-by-group basis in Sections 10.2.2 to 10.2.7.

Although discharges in recent years have been well below authorised levels, some of the future operations planned within the LTP are expected to give rise to increased quantities of atmospheric discharges. The radioactivity in gaseous discharges during decommissioning is generally less than in operation, due to there being a fixed inventory of radioactive material rather than a continuing addition of radioactive material to be processed. Therefore the potential for significant releases over short periods is reduced. However, there are some operations such as the DFR NDP that can significantly increase discharges over a short period, even though enhanced abatement measures are being applied.

10.2.2 Dounreay Fast Reactor

The bulk of the gaseous discharges from the near-term decommissioning activities associated with the DFR will arise from the destruction of primary NaK coolant. Only space extract ventilation discharges will be produced from the pond decommissioning operations, they are therefore not expected to contribute significantly to the total DFR discharges. DFR discharge requirements over the LTP are shown (Ref. 35). Increases in all discharge limits are proposed over the existing authorisation to allow decommissioning of the DFR to be progressed.

The tritium inventory of the DFR NaK coolant has been assessed, from samples taken during the active commissioning of the NaK destruction plant, as 24 GBq

In addition to the tritium from the NaK disposal, during the same period there are 7.1 GBq of tritium, taken to be discharged during the discharge and clean up of the DFR pond.

Following completion of the NaK destruction, discharges will be dominated by the Breeder Removal Project (BRP).

Krypton 85 is present in the DFR blanket gas and potentially held in pockets in the NaK. If the blanket gas pressure is reduced by venting to atmosphere there will be a release to atmosphere of krypton 85. An estimated limit of 200 MBq/yr krypton 85 is considered to be sufficient to permit the more frequent de-pressurising of the blanket gas that will be required for further decommissioning within the next five years. The conservative estimate of 0.2 GBq/yr for Kr85 is based on 2008 discharge results from the purging of the reactor gas blanket (RGB) and the predicted level of purges supporting NDP and BFR commissioning/operations. It is predicted that there will about 180 purges of the RGB, based on a two year best case operational campaign for NDP, and the maximum discharge per purge of 1.0 MBq. The krypton 85 discharge associated with the breeder fuel removal is estimated to be 30 TBq/yr falling back to 1GBq/yr thereafter until all of the NaK is destroyed and the blanket gas can be released. Total beta emissions from decontamination are more difficult to predict, due to the uncertainties of the activity hold up in the NaK circuits, and a relatively large margin on estimated discharges is required to cover the uncertainties.

10.2.3 Prototype Fast Reactor

All tritium in the residual alkali metal inventories will be discharged as either liquid or gaseous effluent from the process. Tritium, of the order of 150 TBq/yr, will also be discharged from the steam cleaning of B_4C control rods used during the operational period of the reactor.

Particulate beta discharges are expected to continue at a relatively constant level from decommissioning activities until around 2013, when the beta activity is expected to increase due to reactor residue cleaning and then drop back around 2015. Compared to the existing authorisation, increases in the discharge limits proposed for alpha and beta emitting radionuclides are required to allow the described decommissioning activities to be undertaken.

10.2.4 Fuel Cycle Area Stack

The figures presented (Ref. 35) are the requirements to allow a range of decommissioning and waste retrieval and processing operations to be undertaken in the contributing facilities to the FCA Stack. There are a number of separate plants within which operations are managed independently. Operations are not undertaken on a sequential basis, so the proposed limits take the most conservative case that all the discharge requirements for each plant could be required at the same time. However, the projected discharges are far lower than when reprocessing was being undertaken.

Major uncertainties exist on the FCA requirements given the varied range of tasks being undertaken. However, all the discharge limits proposed for the FCA are substantially lower than the existing limits.

The FCA Stack and the associated underground spine duct are programmed to be replaced by two stacks, each servicing geographically appropriate facilities feeding into above ground spines. This change is programmed to be completed in 2010.

10.2.5 Other Gaseous Discharge Sources

Aerial discharges arise from a variety of other minor sources at Dounreay. The discharge requirements are given (Ref. 34). Slight increases in the alpha and beta limits are proposed compared to the existing authorisation, a new limit is proposed for Kr-85 and a limit is proposed for tritium discharges that may arise from decontamination of alkali metal wetted components from PFR and DFR and decontamination of components being prepared for exempt disposal.

10.2.6 Summary of Estimated Future Gaseous Activity Arisings

Estimates of future active gaseous discharges from general operations and decommissioning activities are presented in Ref. 35. These estimates are based on the programme of decommissioning work and waste management activities identified in the LTP, and with due allowance for uncertainties in the inventory established from sampling. These have been used to propose gaseous discharge limits for the next authorisation period. During the waste recovery and processing operations of the early phase of the LTP discharges are expected to increase and then stay constant for the remaining decommissioning operations. Discharges of alpha activity and beta activity follow fairly flat profile with a maximum discharge of the order of 7.5 MBq/yr (alpha) and 3.5 GBq/yr (beta).

No practicable abatement is available for treatment of tritiated gaseous wastes, so these will continue to be discharged in line with the strategy described in the DSRP BPEO study. The estimates for tritium suggest discharges increasing to the order of 80 TBq/yr.

No practicable abatement is available for treatment of krypton 85 gaseous waste. There is a finite inventory, albeit reducing with normal radioactive decay, of this gas locked up in irradiated fuels and in the tagging gas of unirradiated fuels of the order of 600 TBq. To prevent the release to atmosphere of krypton 85 from these fuels during the handling operations to place the fuel in safe storage would take significant research and development and expenditure on plant that is not warranted when balanced against the public dose detriment of a 100% release. The dose to the public in the 50th year of exposure given a discharge of 200TBq/yr is 0.021µSv. Given that there is a finite inventory of krypton 85 at Dounreay and the radiological consequences are minimal, it is proposed that this radionuclide is not specifically limited in any granted authorisation.

10.3 POTENTIALLY ACTIVE DISCHARGES

10.3.1 Introduction

It has been determined that there are several very small (but not zero) discharges of radioactivity from the Dounreay site, which are not explicitly covered by the extant RSA

Authorisation. SEPA has been informed about the discharges and studies have been undertaken to better identify the sources of the discharges and their environmental impact. Most of the areas identified as potential sources of discharge of activity have been routinely sampled as part of the Dounreay land remediation programme. This has provided assurance that the discharges have been of no environmental significance.

Routes for both liquid and gaseous potentially active discharges are identified below, their significance is discussed and the required reassurance monitoring arrangements are considered. Two types of release are described; direct discharge as a general local release and releases into a system leading to a discharge point which is not covered under the RSA authorisation. Significant releases of radioactive material from the site due to events or incidents are not taken into account, not being required by the RSA 93 which only considers routine releases. These are dealt with under Dounreay arrangements and reported to the regulators as appropriate.

10.3.2 Liquid Wastes

Trade waste and cooling water streams are directed to the LAD system because of the potential presence of activity. However, as well as the LAD system, there are management systems on the Dounreay site for several other effluent streams:

- Foul drainage and sewage effluents;
- Storm and surface water.

These liquid streams are either not radioactive or contain very low levels of radioactivity. The systems are not designed to collect radioactive discharges other than natural background activity and possible trace levels from some of the change rooms. The segregation of these effluent streams has environmental benefits in reducing secondary wastes associated with active effluent treatment. Management requirements prohibit the consignment of active wastes to the inactive systems. Where appropriate, notices are in place to reinforce these requirements.

The foul waste stream is a high volume, nominally inactive stream. However it is clearly not possible to guarantee that it is completely free of trace levels of radioactivity. Sewage is collected by the foul waste drainage system. The wastes are discharged via six designed outfalls regulated under the Controlled Activities (Scotland) Regulations. Outfalls 1-4 are fitted with milliscreens to reduce the volume of solids discharged to the marine environment by maceration.

The results from regular sampling of the outfalls during 2008 gave discharge activities comparable with rainfall activity levels measured in the terrestrial monitoring programme. The mean Cs-137 activity level for the outfalls was between 0.03Bq/l and 0.56Bq/l. Activity levels of the other radionuclides were below detection limits.

Approximately 50% of the site comprises impervious surfaces (i.e. roofs, parking areas and the remnants of runways). Runoff from these impermeable areas is mainly routed directly to sea via storm drains and the six sea outfall pipes. The drainage system is designed to avoid contamination of roof and surface water, although account needs to be taken of the fact that trace amounts of radioactivity could be washed off from site surfaces through rainfall. Some of the radioactivity arises from authorised discharges to air (especially tritium), but a large proportion of the alpha and beta radioactivity in this discharge will be naturally occurring and comparable to background levels of activity.

The Mill Lade, which flows through the western side of the site, collects surface water from the immediate locality of its run and gains from groundwater to the north of the Dounreay site. Analysis of water samples taken from Mill Lade show activity levels even lower than those of engineered outfalls. This is believed to be because of the very high dilution. However, surface water run off is not predictable since it is governed by the amount of rainfall which falls on the site and therefore the amounts of trace radioactivity it carries off. There will be a strong correlation between the amount of radioactivity carried off site, and the amount of rainfall. Although the specific activity is negligible, because of the very high volume flow this may still give rise to a discernible annual activity level.

The ground surface external to buildings is mainly concrete and occasionally tarmac. In places there is no hardstanding; areas are either covered by gravel or grass. The hardstanding over much of the site has cracks, allowing rainwater run-off, windblown dust and other contaminants to possibly enter the ground rather than be collected in the surface water system. The near surface geology of the Dounreay site suggests that surface water that fails to be collected by the surface water drains or the Mill Lade will either run directly seaward or reach the sea via the groundwater.

The regional groundwater flow system is described in detail in (Ref 39). Groundwater flow is demonstrated to be rapid by the seasonal changes in groundwater composition caused by the deposit in winter of wind-born sea spray. Groundwater flow is directed from inland areas northwards towards the coast. The water table is mainly shallow and the majority of flow takes place within 5 m of ground surface, in the uppermost highly weathered layer of the bedrock. Deeper groundwater flow is slow in the low permeability siltstones of the Devonian bedrock. Groundwater discharge is mainly via the site's engineered drainage system and offshore – there are few locations where there is perennial discharge of groundwater from the observable cliff and foreshore. During 2000, sampling of the seepage that runs across the foreshore in the vicinity of Outfall 4 detected an average Cs-137 level of 7 Bq/l. Analysis of groundwater taken from an array of on-site boreholes typically shows negligible levels of activity, similar to that of the foul water outfalls, except for the boreholes adjacent to the solid low level waste disposal pits, the Shaft, and in the vicinity of the former radioactive liquid effluent treatment plant.

There are groundwater flows for which intervention is currently being carried out and the resultant groundwater is directed to the LLLETP. This creates a significant ingress to LLLETP and a dilution to the operational liquors collected. The volumes of water that would be redirected are of the order of 3500 m^3 per month (equivalent to 8 sea discharge volumes per month and the average activity concentrations are of an upper order of 85 Bq/litre beta/gamma, 75 Bq/litre Cs-137, 10 Bq/litre Sr-90, <3.5 Bq/litre alpha and <2 Bq/litre Am-241 based on 2007 data. Although the activity is detectable, it is "close to zero" and not practicable to abate. It is therefore proposed that these groundwaters are directed to the most appropriate foul/sewage discharge outfall. In respect of protecting members of the public and the environment the contribution to the critical group dose from the discharges using the dispersion model PC Cream is 6.8E-04 µSv in the first year of exposure and rising to 7.5E-04 µSv in the 50th year of exposure.

10.3.2.1 Proposed Aqueous Discharge Routes

It is proposed where it has been identified that there is continuous groundwater flow with an activity concentration of less than 5 Bq/l Alpha and less than 100 Bq/l beta that these are authorised for discharge from the Dounreay site via an appropriate foul water/sewer drain.

It is proposed that:

- the outfalls/potential discharge routes identified should be defined in the new authorisation;
- these discharge routes are administered separate to the site discharge limits;

- regular effluent sampling will be undertaken of the foul/sewage discharge outfalls to confirm that the activity concentrations in the effluent do not exceed the proposed levels; and.
- monitoring be undertaken of an array of bore-holes and the cliff face, the results of which will be reviewed to further confirm that there are only very low releases of activity from the site and that these have no radiological impact or environmental effect.

10.3.3 Airborne Releases

There is potential for airborne activity to enter the wider air environment from sources not identified as discharge points. The identified sources where releases could potentially take place are:

- Openings in facility final containments (e.g. open doors and windows);
- Extract fans from facility external containments not explicitly identified as discharge points;
- Unsealed containments leading directly to the external environment (e.g. open tanks);
- Open undisturbed ground

Good operational practice and regular maintenance ensure that there are no significant releases from the first of these sources although there was potential for minor discharges in the past when there was a practice of leaving loading bay doors open, however, this has been discontinued. Design and improved operating procedures ensure that any contribution from this source is trivial. This is backed up by the presence of alpha and beta in air monitors to detect the presence of activity within relevant facilities.

There are a number of unregulated fans on site, but these serve the many non-active areas. All extracts from containments where contamination may arise and lead to radioactive discharges are regulated.

The 3rd identified source provides the greatest risk of a discharge from a location not specifically identified as a discharge point. Several active plant areas are unsealed and provide a direct pathway for releases to the atmosphere. In addition (4th bullet point) there are small areas of low-level contaminated ground on the site which provide a potential source of contaminated airborne particulate through resuspension. These include;

- the old liquid effluent treatment plant in D1211;
- the Shaft; and
- the Low Level Solid Waste Pits.

The D1211 facility has been replaced by the Low Level Liquid Effluent Treatment Plant (LLLETP), which has a filtered vessel extract system to prevent releases of radioactivity from the LLLETP building. LLLETP has a HEPA filtered discharge stack which is a RSA authorised discharge route, contributing a very small amount to the total site gaseous effluent discharge.

Releases from the LLW pits are minimised by covering the pits with a geotextile cover and capping with top soil. Local environmental air ("Tacky Shade") monitoring has shown very low levels (<5 Bq/month) of fugitive release, indicating that this source is not a concern with respect to atmospheric discharges.

Additionally to the above identified potential sources of release to atmosphere the process of decommissioning will require the use of portable air handling units to ventilate temporary structures within or adjacent to facilities. The ventilation of these temporary structures is usually managed such that the air discharged is directed to the facility engineered ventilation system however, there are cases where the utilisation of the facility ventilation is not practicable. In these cases it is proposed that the abated discharge from a temporary enclosure is assessed and added to the facility discharge as the impacts would be the same in terms of source.

10.4 SOLID WASTES

10.4.1 General

From time to time materials (e.g. ground spoil, sludges, building fabric) arise that require detailed destructive analysis that cannot be carried out on the Dounreay site (e.g. hydrocarbon analysis, semi and volatile organics, metals, specific radionuclide analysis, etc.). These materials are either contaminated or potentially contaminated. DSRL has agreement under the extant authorisation for the transfer of solid radioactive wastes, for analytical and characterisation purposes, and this is included in the accompanying application as a disposal route for small volumes.

Under the terms of commercial fuel reprocessing and waste processing contracts, there are conditions for the return of solid radioactive wastes to the countries of origin. The wastes will be in the form of cemented drums of intermediate level radioactive wastes, generally comprising the liquid raffinate wastes from the reprocessing of irradiated fuels but also include processed wastes (e.g. contaminated sodium)

In the treatment, processing or reprocessing of materials, wastes were created that have either been assigned to a particular stream or arise as a secondary waste. When processing nuclear material the secondary waste has the potential to contain plutonium, uranium etc. creating a unique handling problem. There exists at Dounreay, in storage, a quantity of plutonium contaminated material (PCM/CHILW) waste that has to be repackaged for long term storage and/or disposal. Final disposal is likely to be to a plutonium recovery facility at Sellafield.

10.4.2 Low Level Solid Radioactive Wastes

Disposal of the accumulated and expected arisings of solid low level radioactive waste is dependant on the realisation of a disposal facility at Dounreay. Construction of a LLW disposal facility, is not expected to start until 2013. Waste accumulated and future arisings will be treated and stored at Dounreay pending final disposal.

The accumulated Low Level Solid Radioactive Wastes will be disposed of to the new Dounreay Low Level Waste Repository via a grouting plant. The grouting plant will be a part of the final conditioning process before the new facility accepts the waste in accord with its own Certificate of Authorisation.

With respect to land remediation, where there is a large volume of contaminated ground material, there is potential to carryout trials on varying remediation techniques. Any such trials would require the use of significant, tonne quantities, of material to be excavated and transferred to a controlled facility. It is proposed that disposal from Dounreay is authorised for long term experimentation elsewhere.

10.4.3 Samples for Analysis and Characterisation

Samples will be transferred to an analytical laboratory authorised to receive and dispose of solid radioactive wastes. That part of the sample that is recovered from the analysis may be returned to Dounreay for disposal through the relevant authorised routes.

On present transfers of samples it is anticipated that the volume of waste samples transferred in any 12 months will not exceed 1000 litres and the weight transferred in any 12 months will not exceed 1 tonne.

The main radionuclides that have the potential to be present are:

Plutonium isotopes, Americium-241, Uranium isotopes, Caesium-137, Strontium-90, Cobalt-60

The maximum concentrations of activity in the samples will be the upper bounds for low level solid radioactive wastes :

Alpha	$4x10^9$ Bq/Te
Beta	$12x10^9$ Bq/Te
Tritium	$12x10^9$ Bq/Te

10.4.4 Foreign Contract Waste

Wastes arising from the processing of foreign contract material will be packaged and returned to the country of origin in accordance with the terms of the contract and in compliance with the transboundary movement of radioactive materials regulations.

The volume and weight of wastes transferred to originating countries will be dependent on the ability of those countries to receive the waste, the mode of transport and the rate at which transfers can be achieved.

The concentration of the radionuclides in wastes packages being returned will depend on the source material prior to conditioning and packaging. However, each package will not exceed the following radionuclide content

Radionuclide	**Maximum Content**
Sr-90	$1x10^{14}$ Bq
Cs-137	$1x10^{14}$ Bq
Total uranium	25 g
Total plutonium	4 g
Total curium	0.1 g
Total beta/gamma	$4x10^{14}$ Bq
Total alpha	$5x10^{11}$ Bq

AEA Technology, has under contract, 514 drums of sodium metal from Forschungszentrum Karlsruhe GmbH for disposal by reaction with an aqueous solution of sodium hydroxide and neutralisation to sodium chloride and water. An authorisation was granted to AEA Technology allowing transfer of the sodium to UKAEA, now DSRL, for disposal in the PFR SDP. DSRL shall use the BPM to retain the activity of the waste in a solid matrix should the destruction of the sodium remain the preferred option for disposal of this waste source. Treatment shall be conducted in compliance with the conditions and limitations of the Certificate of Authorisation granted to DSRL

DSRL shall dispose of all the resultant solid wastes by removing it or causing or permitting its removal from the premises to Forschungszentrum Karlsruhe GmbH at an address notified to SEPA.

10.4.5 Nuclear Materials

The strategic value of all nuclear material in the United Kingdom is the subject of ongoing discussion with the nuclear industry, government and the regulators. DSRL is aware that the disposal of radioactive waste is a devolved matter for the Scottish Government, that Scotland does not have a continuing nuclear commitment and the strategic value of the nuclear material on nuclear sites in Scotland is yet to be resolved. DSRL notes the European Union proposed Council Directive (Euratom)[9] on the safe management of the spent nuclear fuel and radioactive waste. In noting the proposed directive, DSRL is of the view that only the nuclear material declared as waste should be subject of any authorisation granted for the disposal of radioactive waste. All such declared wastes will be notified to SEPA. All other nuclear material will be transferred or stored, as appropriate to the UK national stockpile.

The nuclear material presently on the premises at Dounreay will be treated to either:

- recover the uranium, plutonium and thorium; and/or
- to place the material in a form suitable for long term storage and/or disposal; and/or
- to place the material in a form suitable for transfer to another licensed site for further treatment or storage; and/or
- return to the country of origin.

[9] COM(2004) 526 final, Amended proposal for a COUNCIL DIRECTIVE (Euratom) on the safe management of the spent nuclear fuel and radioactive waste. Brussels, 8.9.2004

11 IMPACTS OF RADIOACTIVE DISCHARGES FROM DOUNREAY

11.1 Environmental Radiological Assessments

11.1.1 Introduction

The movement of radionuclides through the environment, from the point of discharge to the point at which a dose is received by a human receptor, can be simulated by mathematical modelling. Such modelling is generally undertaken by considering the transport of material through the environment based upon the conditions pertaining at the time of release. Where adequate data are available the assessment makes use of realistic parameter values. Where data are unavailable or are considered to be uncertain conservative assumptions are made such that the parameter value selected will tend to lead to an overestimate of likely dose. This conservative approach aims to ensure that the public and the environment are protected from excessive risk.

The maximum potential doses that could be received by members of the public as a result of authorised atmospheric and marine discharges of radionuclides from the Dounreay site are estimated in the assessments undertaken and presented in the report “An Assessment of the Radiological Impacts of Authorised Atmospheric and Liquid Discharges of Radionuclides from UKAEA Dounreay” (Ref 25). This section summarises the information from the assessment on the possible consequences of proposed discharge levels in terms of radiation dose. This will assist the decision-making process associated with establishing permitted discharge limits.

Doses can be assessed for different pathways by which radioactivity could enter the body. In the case of discharges to atmosphere, the most direct route by which radioactivity would affect populations would be breathing in of the radioactivity in the air. Additional contributions might also come from consumption of locally produced food, milk etc and also from the incremental (i.e. above that already received from natural background) direct radiation received from deposits of radioactivity on the ground.

11.1.2 Assessment Methodology

The principal component of the assessment methodology is the PC CREAM computer code. This code was developed by the National Radiological Protection Board (Ref. 22) (now the HPA-RPD) and was based upon a report commissioned and published by the European Commission (EC) (Ref. 23). It comprises a suite of environmental transfer models to simulate the transfer of radionuclides through the environment. Discharges to the atmosphere, to the sea and to rivers can all be modelled to assess the radiological impact of discharges of radionuclides from virtually any site. PC CREAM has been widely used across Europe to determine the potential radiological impacts of routine discharges.

The modules included within PC CREAM include an Assessor module, which implements the environmental models based upon either conservative default input parameter values or based upon parameter values calculated by the prior running of the other modules. For example, the marine module (DORIS) enables site specific parameter values to be used to describe the local and regional marine compartments. This capability can be used to refine the modelling study in line with detailed site-specific information. However, if such information is not readily available the Assessor module contains default parameter values for a range of UK sites (including Dounreay) which allow the model to be run without excessive data collection.

The assessment program performs the essential dose assessment role. The program can be used with input data libraries provided with the system, with those generated by the user using the supporting programs, or with those generated by their own programs, provided they are in PC CREAM format. The availability of data is such that there was no basis for altering the basic default values used by the Assessor module and therefore the support programmes were not implemented in this study. This represents a conservative approach as the default values used in PC CREAM Assessor are deliberately selected to ensure that doses tend to be overestimated rather than underestimated. This conservative approach was used throughout the study, for example in selecting consumption rates where habit data is not available.

The model uses habit data (e.g. food consumption, occupation rates) and dosimetric data to estimate radiation doses. The dose coefficients for inhalation and ingestion (i.e. dose received from per unit intake of radioactivity) used in the calculations followed ICRP60 dosimetry.

PC CREAM provides results in terms of annual individual committed effective dose (referred to simply as individual dose) and collective effective dose equivalent (referred to as collective dose) to the defined population of interest.

All individual dose calculations were undertaken for the 50th year (i.e. the assessment assumes that the same level of discharge has taken place for 49 years prior to the year for which the assessment is made, thereby allowing for an accumulation of activity in the surrounding environment). Collective doses are calculated with a truncation time of 500 years and for the populations of both the United Kingdom and the European Union. All predicted doses are calculated as effective dose as given in ICRP 60.

It should be noted that the doses predicted for current discharges in this latest assessment of radiological impacts (Ref 25) are not directly comparable with the results of earlier studies. They are different because more recent methods and information have been used in the latest study to reduce uncertainty. The estimated doses due to current discharges are presented as a consistent means of comparison for the estimates of future doses.

11.1.3 Reference Groups

A member of the public could conceivably receive a radiation dose via one or more of the pathways identified above. A reference group can be defined which is reference of those likely to be most exposed to the highest radiation doses as a result of their lifestyle (e.g. diet, age, occupation and dwelling). In some cases it is possible to identify the actual members of a reference group, but in other cases this is not practicable, so hypothetical individuals are adopted with habits likely to result in an exposure at least as high as any real members of the public. The radiation dose to members of such a reference group is then calculated.

Two reference groups were defined for the assessments presented, the first (described as the average reference group) describes activity levels which will tend to lead to a high level exposure compared to the general population. The second group (described as the extreme reference group) describes activities at the maximum observed or maximum expected rate. In practice it is very unusual for an individual or group of people to exhibit more than two features leading to a relatively high dose rate. The results obtained using this extreme reference group are therefore highly conservative.

11.2 Assessment of the Impact of Atmospheric Discharges

The PC CREAM model was implemented using the site selection option for Dounreay which automatically implements the atmospheric assessment module.

Releases of radionuclides to atmosphere take place through a large number of stacks and vents across the Dounreay site. For the purposes of the current RSA authorisation these stacks and vents are combined into 6 stack groups. The six stack groups are:

- Dounreay Fast Reactor (DFR) – where releases from a number of sources are combined and released via a single stack;
- East Minor Sources (EMS) – where several small releases occur from separate buildings;
- Fuel Cycle Area (FCA) – where a number of separate sources discharge to atmosphere via a single stack;
- Prototype Fast Reactor (PFR) – where discharges occur from the PFR reactor;
- West Minor Sources (WMS) – where a number of sources discharge separately to atmosphere; and
- PFR Minor Sources (PFRMS) – where releases occur from other outlets in the vicinity of the PFR complex.

Discharges from the Vulcan NRTE stack are not taken into account, because they are not a part of the defined premises and are covered by a separate RSA 93 authorisation.

The stack groups comprise a number of individual sources that operate intermittently and it is not possible to define representative average release conditions. The approach taken is conservative and will tend to lead to an overestimation of possible concentrations, thereby ensuring that the public is protected against excessive doses.

The exposure pathways available to PC CREAM and analysed in this assessment for adults, children (nominally aged 10 years) and infants (nominally aged 1 year) were:

- Consumption of cow meat
- Consumption of cow liver
- Consumption of sheep meat
- Consumption of sheep liver
- Consumption of green vegetables
- Consumption of root vegetables
- Consumption of grain
- Consumption of fruit
- Inhalation of radionuclides in the plume
- External gamma irradiation from airborne radionuclides
- External beta irradiation from airborne radionuclides
- External gamma irradiation from deposited radionuclides
- External beta irradiation from deposited radionuclides
- Inhalation of resuspended radionuclides

Although there are no dairy farms in the surrounding area the consumption of cow's milk has been included in the assessment as it is possible that such activities may occur in the future. In addition, a farm producing goat's milk has been identified and separate calculations have been undertaken for the consumption of goat's milk and goat's milk products. PC CREAM does not include goat's milk as a pathway but information on the transfer coefficients indicates that concentrations of most radionuclides in goat's milk and associated products would be higher than would be expected in cow's milk and associated products (Ref. 27). The equations used in PC CREAM show a direct correlation between transfer coefficients, concentrations in milk and dose. Therefore, if each nuclide-specific dose calculated by PC CREAM for cow's milk and cow's milk products is multiplied by the nuclide specific ratio of the fodder-goat's milk transfer coefficient to the fodder-cow's milk transfer coefficient, then the result will provide an estimate of the dose via the goat's milk pathways.

The individual doses predicted from atmospheric discharges for the four cases are detailed in (Ref. 25). They assume discharges at 100% of the current and proposed limits. These results should be considered in the light of the public dose limit of 1000 µSv/y and the generally applied dose constraint of 300 µSv/y for members of the public for planned discharges (Ref. 26).

Table 17 Summarised individual doses (µSv/yr) for atmospheric discharges (excluding component for goat's milk and assuming cow's milk consumption)

Discharge limit		Proposed Authorised Limit		Current Authorised Limit
Critical Group definition		**Average**	**Extreme**	**Average**
Upper Dose	Infant	6.1	14.0	5.3
	Child	7.1	14.0	7.4
	Adult	5.9	11.0	10
% of dose constraint	Infant	2.0	4.67	1.8
	Child	2.4	4.67	2.5
	Adult	2.0	3.67	3.3

For a description of the full meaning of 'average' and 'extreme' critical groups the reader is referred to An Assessment Of The Radiological Impacts Of Proposed Atmospheric And Liquid Radioactive Waste Disposals From Dounreay, DSRL, 2009

It may be seen from the results that the conservatively estimated doses based upon the existing discharge limits are well within the dose constraint for public dose due to authorised discharges of radionuclides. Doses due to the proposed discharge limits will be similar to those from the existing limits. Even in the extremely conservative case of a child receiving 14 µSv/y, they are relatively small when compared with that arising from natural background (2,200 µSv/y). In practice, discharges would not be expected to be made at the limit, and for some types of activity, discharges may be zero in a given year.

Ref. 30 shows the doses that could be received by individuals consuming very large quantities of goat milk and milk products at a distance of 4 km south west of the Dounreay site. The highest predicted dose is for infants consuming goat's milk at the extreme critical group definition. The conservatively estimated dose for discharge at 100% of the current limits is less than 5% of the dose constraint and is not therefore a cause for concern. Based on discharge at 100% of the proposed discharge limits, this will not be significantly different. Doses at this level would not be expected to result in any detectable health or environmental impacts.

There is no dose limit or regulatory guidance on acceptable levels for collective dose. However, it is generally considered that releases of radionuclides which give rise to doses below 1 manSv/yr can be considered to have negligible consequences in terms of population impacts.

It may be seen from the results shown in Ref. 25 that all assessed doses, for both the existing discharge limits and the proposed future discharge limits, are well below 1manSv/yr. The collective dose, truncated to 500 years to both the UK and European populations, is estimated to reduce marginally.

Table 18 Summarised collective doses (man Sv) for modelled atmospheric cases

Discharge limit	Proposed Authorised Limit	Current Authorised Limit
UK collective dose	0.023	0.06
EU collective dose	0.12	0.26

11.3 Assessment of the Impact of Marine Discharges

For marine discharges the PC CREAM model was implemented using the site selection option for Dounreay which automatically implements the marine assessment module for Scottish Waters with the regional compartment defined as being Scottish Waters East. As with the atmospheric assessment, the individual dose calculations were undertaken for the 50th year and collective doses are calculated with a truncation time of 500 years, for the UK population.

Doses from marine discharges were only calculated for the discharges based upon 100% of the existing authorised discharge limits and 100% of the values proposed for the future discharge limits. Current actual discharges are much lower than the limits and it is expected that future discharges will also be below the proposed limits.

Radionuclides released into the sea are dispersed by the action of currents and by diffusion. Some radionuclides interact with sediments suspended in the water and may therefore be transported to and from the seabed. Interaction with sediments can also lead to contamination of the beaches. Radionuclides in the water or attached to sediments can enter the aquatic foodchains, giving rise to radionuclides in foodstuffs consumed by man. Radionuclides in the sea can also be returned to the terrestrial environment in sea spray. Finally, radionuclides in the water can lead to contamination of fishing gear.

All exposure pathways available to PC CREAM were analysed by this assessment for adults, children (nominally aged 10 years) and infants (nominally aged 1 year). The pathways assessed were:

- Consumption of fish
- Consumption of crustaceans
- Consumption of molluscs
- External gamma irradiation from radionuclides in sediment
- External beta irradiation from radionuclides in sediment
- External gamma irradiation from radionuclides in fishing gear
- External beta irradiation from radionuclides in fishing gear
- Inhalation of sea spray

The results discussed in detail in (Ref. 25) show that maximum doses due to the discharge of liquid effluent into the sea are expected to reduce considerably as a result of the decreased discharge limits. Ref. 25 shows the possible exposure of members of the public in the marine food reference group would reduce from about 0.2% of the dose constraint of 300 μSv/y proposed by the Government for a single new nuclear source to around 0.005%. The consequences of exposure at this level would be negligible.

Table 19 Summarised individual doses (µSvyr) for ingestion of marine food products

		Proposed Authorised Limit		Current Authorised Limit
Critical Group definition		Average	Extreme	Average
Upper Dose	Adult	0.015	0.026	0.61
	Child	0.010	0.01	0.51
	Infant	0	0	0
% of dose constraint	Adult	0.005	0.009	0.20
	Child	0.003	0.003	0.17
	Infant	0	0	0

External exposure and inhalation of seaspray during occupancy of the beach would give rise to even lower doses, being less than 0.1% of the dose constraint from discharges at the current limits and reducing by approximately 5 times to below 0.02% of the constraint for discharges at the proposed limits . External exposure and inhalation of seaspray during occupancy of geos would also give rise to lower doses, being less than 0.1% of the dose constraint for discharges at the existing limits and reducing to approximately 0.003% of the constraint for discharges at the proposed limits. Exposure during the handling of fishing gear would be expected to give rise to very small doses, less than 0.02% of the dose constraint at current discharge limits reducing to less than 0.001% at the proposed limits. Doses to members of the public from marine discharges are therefore very low even when based on significantly conservative assumptions.

The maximum collective dose due to the modelled proposed marine discharge limits is expected to reduce to less than 40% of existing levels from discharges at the current limits. Future discharges at the proposed limits will be much less than 1 man Sv, even when calculated for the entire EU population (0.04 manSv).

11.4 Conclusion

The latest assessment of the radiological impact of discharges from Dounreay (Ref. 25) was undertaken in a highly conservative manner. This approach will tend to report significantly higher doses than would be experienced in practice but it serves to ensure that the public is protected against any significant risk from the discharges. It is clear from the results discussed above that the maximum possible exposure of the public as a result of emissions at the current site discharge limits is well within the dose constraint of 300 µSv/y. It is therefore clear that any realistic exposure pattern would result in doses that are negligible and would not be expected to result in any observable consequences at either an individual or a population level.

It is further shown by these results that the proposed reductions in discharge limits will substantially reduce the exposure of the public from operations by DSRL to an even lower level than is currently the case. In general, doses across all pathways will be reduced by a factor of more than three. The risks associated with the doses arising from the proposed atmospheric and liquid discharges will be very small. In making this statement, it is recognised that radiation dose carries a finite risk but that risks to individuals are small when compared with any other accepted standard. This is true either by reference to exposure from natural background radioactivity (since the likelihood of any harm or injury is less than 1 % of that arising from natural background) or in comparison with any other risk of harm that might be regarded as tolerable. Further reductions in discharges would therefore not produce any significant benefits.

It is argued that the current doses are well below levels at which significant expenditure could be justified in order to secure further dose reductions, subject to the proper application of BPM. This is particularly the case given that the proposed limits cater for the highest anticipated discharges during the authorisation period and that in practice the discharges from the LTP decommissioning activities will vary from year to year, so the doses received by the public will be considerably lower than assessed.

11.4.1 Impact upon Flora and Fauna

The International Atomic Energy Agency (IAEA) concluded in 1992 that there is no convincing evidence that chronic dose rates below 1 $mGyd^{-1}$ (approximately 40 $nGyh^{-1}$) will harm plant or animal populations in the terrestrial environment. The report also stated that in the aquatic environment, limiting chronic dose rates to the most exposed individuals to less than 10 $mGyd^{-1}$, (approximately 400 $nGyh^{-1}$) would provide adequate protection for the population.

12 QUALITY ASSURANCE, MEASUREMENT AND RECORD KEEPING

12.1 General

The technical requirements that have to be satisfied to demonstrate compliance with authorisations for disposals of radioactivity to the environment have to be demonstrable within the DSRL Management System. This will cover matters such as maintenance of apparatus and methods for measurement of discharges for comparison with the authorised limits. The requirements for reporting of discharges will also be stipulated, including the keeping of records. The requirements for environmental monitoring will also be defined.

DSRL works within quality assurance procedures that are ISO 9001 compliant, and are regularly audited both internally and externally. All work, including record keeping and management of processes, will be carried out to these procedures.

12.2 Managing Documentation and Records

There is a Dounreay procedure for the control of all documents, data and forms. The principles adopted also apply to both electronic and hard copy documents. Management system documentation is reviewed at intervals of not more than 5 years. Master lists of all document types contain titles, identification and issue status.

Changes are normally reviewed and approved by those who performed the original endorsement and approval. Where this is not practicable, those nominated for this task have access to pertinent background information and have demonstrated competence in the area concerned. Amendment is effected by complete re-issue of documents in the appropriate media.

12.2.1 Records

Data vital to the safe management of facilities or the commercial well-being of the organisation is saved on a network drive thereby allowing systematic back-up of the data. If it is not possible to use the network drives and such data is held locally, users implement other arrangements for systematic back-up of critical data. Hard copies and/ or electronic copies of many records are retained in accordance with DSRL Retention Schedules (e.g. keeping of particular statutory records).

Records made in accordance with the authorisations are kept until such time as SEPA notifies DSRL that the records need no longer be kept. The records are kept in a secure location, in fire resistant safes where applicable. In addition the Nuclear Installations Act specifies retention periods for certain records relating to nuclear operations, with which DSRL complies.

12.3 Monitoring and Measuring Performance

Regular monitoring and measuring of performance is undertaken. Examples include:

- Reporting of radiological and non-radiological discharges to air and sea to the environmental regulator (SEPA);
- Reviewing unusual occurrences;
- Undertaking formal and planned maintenance;
- Review of facility BPM studies;

- Setting annual EMS objectives and targets;
- Undertaking annual reviews of a plant's performance.

12.3.1 Monitoring and Control Systems

DSRL undertakes a statutory environmental monitoring programme to assess the impact of radioactive effluent discharges to the environment over an extensive period of time. The results are regularly published in the public domain and reflect the low impact on the environment from Dounreay site operations. The statutory environmental monitoring programme and the discharge equipment are agreed with SEPA.

Control of radioactive waste disposal is achieved through the implementation of BPM and the use of Management System documentation such as:

- Operating Instructions;
- Environmental Management Requirements;
- Environmental Operating Rules;
- Guidance Notes; and
- Standards.

12.3.2 Communication and Reporting of Incidents of Actual or Potential Non-compliance and Complaints

The requirements for initial and external reporting of unusual occurrences are documented in site procedures. Incoming queries, complaints and communications from the regulatory bodies on environmental issues are registered and are sent to the relevant site contact. Incoming communications regarding complaints or queries from the public or other interested parties, for example the press, on environmental issues are directed to the Dounreay Communications Department personnel, who find the appropriate staff to answer queries.

12.4 Auditing

There is an ongoing annual site programme of inspection audits of radiological and non-radiological environmental systems that are integrated into the comprehensive DSRL Audit Programme. Performance against these audits is regularly reviewed and reported by the Independent Assessment Manager to DSRL senior management. The inspection audits are conducted by staff who are independent from the management team associated with the activity operations or projects under review.

Following every audit inspection an audit report is prepared and forwarded to relevant managers. This ensures that any requirements for improvements, changes to work programmes or for extra resources can be agreed and implemented. It also ensures that management is fully aware of performance against the scope of the audit review.

DSRL is accredited to ISO 9001 and is subject to yearly surveillance audit and an accreditation audit at a frequency of no less than every 3 years.

13 DECOMMISSIONING RATIONALE

13.1 Advantages Gained from Progressing Decommissioning

The LTP is the core of DSRL's mission to manage the NDA's nuclear liabilities and associated responsibilities at Dounreay. Carrying out the plan in a way that is safe and secure, environmentally responsible, represents value for money and is publicly acceptable.

The need to safely decommission redundant facilities as soon as is reasonably practical is recognised, in line with Government policy as outlined in the 'Review of Radioactive Waste Management Policy: Final Conclusions' (Ref. 6). This is compatible with the concept of sustainable development in terms of managing radioactive wastes to safeguard the interests of existing and future generations.

In developing the LTP, the implications of delaying the decommissioning of facilities contaminated with radioactive materials are taken into account. It has been concluded that delay is not justified for buildings contaminated with materials with long half-lives, where little or no benefit is gained from radioactive decay processes. The LTP and its associated activities are assessed by HSE/NII to ensure that the planned work can be carried out safely and that hazards are reduced in a systematic and progressive way.

The decommissioning process essentially involves the removal of radioactive materials (i.e. wastes) from redundant facilities and immediate surrounds for disposal. The wastes are packaged and disposed of where a disposal route is available or stored in purpose-built facilities if a disposal route is not currently available. This process results in improved containment and control of radioactive wastes.

The Dounreay site, by virtue of its scale, cannot be hidden from view, either from the immediate surroundings or from more distant locations. However, the progressive removal and/or size reduction of buildings on the Dounreay site and appropriate landscaping will improve the visual amenity of the area in the longer term.

The LTP will progressively clear the site. At the end of decommissioning the area currently occupied by the Dounreay site will be released for alternative use or to a permanently safe condition that requires minimal institutional care.

13.2 Economic and Social Benefits

The costs of decommissioning the Dounreay site are assessed by DSRL in line with the LTP as agreed under contract with the NDA. The NDA costs are borne by the UK Government and thus ultimately by the UK taxpayer. DSRL seeks to maximise value for money whilst continuing to ensure that all operations are carried out in a manner which is as safe and environmentally responsible as possible.

The salaries of staff directly employed at Dounreay, by DSRL and its contractors, provide a major contribution to the local economy of Caithness. DSRL therefore brings considerable economic benefits to the communities surrounding the Dounreay site, including support of local employment through the purchase of goods and services. It is both a large direct employer and supplies significant indirect and multiplier employment. This helps to maintain the cohesion and prosperity of the rural community. The continued decommissioning of the Dounreay site will provide significant levels of employment for a number of years and during this time the expenditure associated with this employment will continue to benefit the local community and the industry sector as a whole.

The number of permanent staff employed at the Dounreay site is lower than when the reactors and fuel reprocessing facilities were operating and will continue to reduce as decommissioning continues. However, many extra staff are needed to perform the various decommissioning tasks. The employment of appropriately skilled and experienced contractors has benefits in enabling DSRL to gain access to a wider range of skills and staff. Contractors are given opportunities to demonstrate their skills and capabilities, and to work with DSRL to develop ideas for improving techniques used in decommissioning processes. The DSRL decommissioning and waste management programme therefore contributes to the skills base of contractors in the UK. The knowledge gained in the decommissioning of Dounreay's redundant facilities is therefore of benefit in supporting the industry sector.

13.3 Evaluation of Radiological Effects

In Section 11, the doses arising from atmospheric and liquid discharges are shown to be very small. In making this statement, it is recognised that radiation dose carries a finite risk. The assertion is made given that risks to individuals are small when compared with any other accepted standards. This is true either by reference to exposure from natural background radioactivity (since the dose to the reference group is less than 1% of that arising from natural background (2,500microSv/y)) or in comparison with any other risk of harm that might be regarded as tolerable. Further reductions in discharges would therefore not produce any significant benefits to the local population.

The collective dose is also very low. Taking account of the HSE's latest guidance (Ref 33) on cost benefit analysis of reducing collective dose, reducing discharges below that of the proposed future limits would be difficult to justify for the expenditure of more than the order of £36,000 per year for aerial discharges and £20,000 per year for liquid discharges. This would assume that all of the dose could be averted. There are currently no known options that could achieve this end at the appropriate level of cost.

It is therefore argued that doses from discharges at the proposed discharge limits are well below levels at which significant expenditure could be justified in order to secure further dose reductions, subject to the proper application of BPM.

The results from studies discussed in section 3.3.5 show that the current levels of discharges from Dounreay do not result in doses that have any significant effect on marine or terrestrial biota or exceed recommended levels where they should be further investigated. This gives confidence that discharges at the future proposed reduced limits will continue to have no demonstrable impact.

13.4 Non-radiological Impacts

This section provides a brief overview of the non-radiological impacts of DSRL's radioactive operations.

13.4.1 Geology and Hydrogeology

DSRL's current radioactive operations are considered to have an insignificant effect on the geology and hydrogeology at Dounreay. The site's effluent systems are appropriately maintained and managed to protect the ground and groundwater. This includes the bunding of tanks used for the storage of materials and the inspection of pipework and storage areas. An extensive programme of work to update the infrastructure services at the site has been undertaken in recent years, including surface water management systems and effluent services. This is helping to ensure that the geology and hydrogeology are protected from ongoing operations at the site and that effluent services meet modern standards. As part of the site's monitoring programme, DSRL sample and monitor a range of boreholes in and around the site on a quarterly basis to assess the quality of groundwater.

13.4.2 Effluent Treatment and Disposal

DSRL produces non-radioactive, mainly aqueous effluents in association with and additional to its radioactive operations. Trade and sewage effluent is discharged from the site via six sea outfalls. These discharges contain a range of non-radioactive components including metal ions. The amounts of metals disposed of via the trade effluent route are well below the limits specified in the discharge consent for trade waste. The effects on the environment of the effluent and waste discharged are considered to be insignificant. Monitoring of the discharge of non-radioactive effluents is undertaken by DSRL, in addition to the monitoring of radioactive effluent.

Discharges of non-radioactive effluents are subject to discharge consents issued by the SEPA under the Pollution, Prevention and Control (Scotland) Regulations 2000 and the Controlled Activities (Scotland) Regulations 2005. Compliance with the permit and licences ensures that the impacts of any non-radioactive species are very small.

13.4.3 Transport

There are environmental impacts associated with the transport of freight and the travel of employees and contractors to and from the Dounreay site. These include the emission of carbon dioxide, nitrogen oxides and other exhaust gases. The impacts on the environment resulting from transport operations are similar to those associated with other sites with similar numbers of employees and are will not change substantially with the rate of progress of the LTP.

13.4.4 Air Quality

Some of DSRL's radioactive operations produce minor non-radioactive atmospheric emissions, for example water vapour and acidic gases. The levels of these emissions are small. Emissions are monitored to ensure that they comply with the limits specified in the site's PPC Permit.

13.4.5 Climate

None of the operations which give rise to radioactive wastes at Dounreay have any effect on the climate of the area in which the site is located.

13.4.6 Natural and Cultural Heritage

Land owned by the NDA at Dounreay is not of significant conservation interest, but beyond the boundary there is an area of interesting maritime heath adjacent to the coast. However, this site has not been designated as a Site of Special Scientific Interest (SSSI). The nearest SSSI is Sandside Bay at Reay, which is approximately 2km west of the site. The continuing operations which give rise to radioactive wastes at Dounreay will not have any additional effect on either the fauna or flora surrounding the site.

There are five archaeological sites located around Dounreay, two of which are scheduled as ancient monuments. One of these is Dounreay Castle, which dates to the late 16th Century, and is located within the site boundary close to the shore. This was the site of a contamination incident in 1957, from spillage of fission product liquor used to measure dispersion of radioactivity in the sea. Following a remediation project in 1997/98, risk assessments concluded that the levels of residual contamination do not present a significant health or environmental risk and do not therefore warrant any further immediate action. The continuing operations which give rise to radioactive wastes at Dounreay will not have any additional effect on the area's cultural heritage, however, regular reassurance monitoring will be carried out on the Castle area.

13.4.7 Visual Impact

The Dounreay site is extensive in area and has many buildings. As such it is inevitable that the site has a significant visual impact in the immediate area. Part of the visual impact is associated with operations which give rise to radioactive wastes and also with building structures associated with safety systems. However, the visual impact of the site is limited at more distant locations, in part because of local topography.

The visual impact of the site is comparable with that of other large industrial sites. The operations which give rise to radioactive wastes will have no additional visual impact beyond that which already occurs. Progression of the LTP will gradually reduce the visual impact of the site as facilities are removed.

13.4.8 Noise

The operations of a large industrial site such as Dounreay inevitably result in noise emissions, such as those associated with vehicle movements, the operations of ventilation systems and the testing and operation of public address and alarm systems needed in the event of an emergency. However, this does not cause significant noise nuisance off-site.

14 FUTURE DEVELOPMENTS

14.1 General

The quantities and diversity of material that must be treated during the LTP, particularly from decommissioning, are greater than can be managed by the present waste treatment facilities. New installations are therefore needed to implement the LTP and will include:

Waste Retrieval/Import/Export

Shaft waste retrieval headworks
Silo waste retrieval headworks

Other Facilities

New Low Level Waste Disposal Facilities

As described in Section 9, all new plant will be designed and constructed taking into account waste minimisation and eventual decommissioning.

15 CONCLUSIONS

The stated objective of DSRL is to restore the site so that it may be made available for unrestrictive alternative use or to a permanently safe condition that requires minimal institutional care. To progress this, decommissioning is being carried out as soon as and as far as reasonably practicable. To enable the required operations to take place for the decommissioning and site restoration programme, there is a requirement for revised discharge authorisations for liquid and gaseous radioactive wastes. Past discharges of gaseous and liquid radioactive waste into the environment from the Dounreay site have had a very small effect on local people or on the environment more generally. Radiation doses to local people are well below the internationally recommended dose limit.

The application of BPM (as described in Chapter 9) and changes in operation on the site has ensured that discharges have generally been well below the current authorised limits. Opportunities have been identified to reduce most discharge limits, thus reducing the headroom between discharges and limits. without posing undue risk to progress of the LTP. However, if the headroom between actual discharges and discharge limits is too restrictive, both financial and environmental costs can be incurred because of delay to the programme.

DSRL is committed to ensuring that operations at Dounreay are carried out safely, and that radiation doses to workers and members of the public are as low as reasonably practicable, and that minimal harm occurs to the environment. It has been shown that the proposed reductions in discharge limits will, in general, reduce the exposure of the public across all pathways by a factor of 2 to 3, whilst still allowing decommissioning of the site to be progressed. Potential radiation doses to the most exposed members of the public have been calculated for discharges at 100% of the proposed limits. These doses have been assessed as being much lower than the HPA-RPD's recommended dose constraint for nuclear sites of 0.3 mSv/y. These are also significantly below the proposed threshold of 0.02mSv/y for discharges of radioactive wastes to the environment set out by the Government in the 1995 Review of Radioactive Waste Management Policy. In practice discharges are expected to be lower than the proposed limits and radiation doses will therefore also be lower.

Progress of the LTP is consistent with the concept of sustainable development; defined as managing the nuclear liabilities on the site now rather than leaving them for a future generation to deal with. The LTP, as well as ensuring a safe transition of the redundant plant from an active state to passive storage and eventual release of land for re-use, is contributing to the development of technology and capabilities for decommissioning to the benefit of managing nuclear liabilities on a wider scale. On-going decommissioning operations at the Dounreay site have been shown to contribute to the local community and economy.

In determining whether practices that give rise to radioactive waste and consequent exposure of individuals to radiation are acceptable, it is necessary to demonstrate that the benefits outweigh the detriments. DSRL believes that the substantial benefits to both society and the local community which will accrue from implementing the LTP to decommission the Dounreay site greatly outweigh the very small detriments associated with the discharges of liquid and airborne radioactive wastes. In consequence, it is concluded that even if the operations required to progress the programme give rise to discharges up to the proposed authorised limits, these are acceptable.

The long term strategy of the LTP is to immobilise the radioactive wastes in a passive solid form and either dispose, where possible, now or store until a final disposal option is available. Completion of the LTP to the IEP will achieve the goal of a long term reduction in discharges from the Dounreay site.

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