The Effect of Radiological Protection Policies and Work Programme on Radiological Measurements at the Dounreay Site.

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Abstract

Over the past ten years a number of radiological control developments have been introduced at Dounreay, including improved electronic dosimetry, modular containments systems, and contamination control. During the same time period the site has continued its move from being an operational site to a decommissioning site.

Throughout this time period the results of a number of radiological measurements have been collected and demonstrate good dose limitation and optimisation of exposure. This paper looks at the trends in radiological measurements and considers what changes in the Dounreay site work practices can be correlated with the measurement trends.

Key words: dosimetry, radiological, monitoring, trends, control

Introduction

Dounreay staff who potentially could receive a significant internal dose are routinely monitored using several techniques. This paper considers the correlation between both the Whole Body Monitoring and urine analysis with the decommissioning work programme. In addition the working environment is monitored using air samplers. This data gives a large source of high quality data which should reflect the radiological conditions of the site.

Over the past ten to twelve years the Dounreay site has undergone many changes. This includes the commencement of decommissioning operations and the implementation of significant new radiological protection protocols.

This paper looks at the trends in radiological measurements at the Dounreay Site and considers how changes in work practices, the decommissioning activities and other factors can be correlated with the measurement trends

Data Collection, processing and analysis

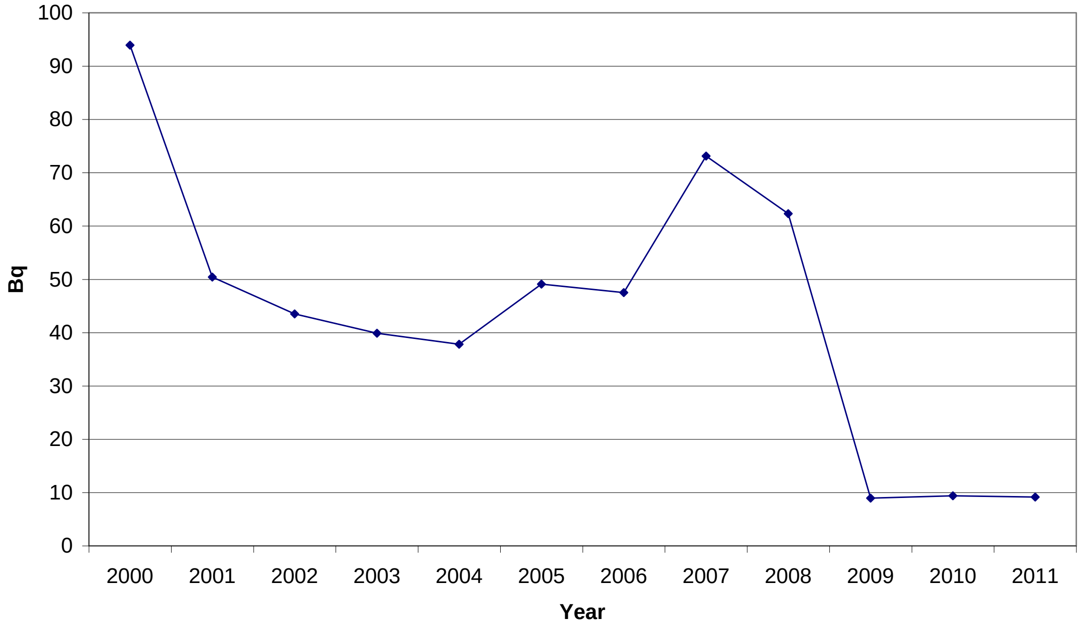
Whole Body Monitor data – Caesium 137

Certain staff at Dounreay, based on their work activities, are whole body monitored annually. The most frequently detected man made radionuclide is ^{137}Cs. The ^{137}Cs may originate either from intakes on the Dounreay site or from diet. Following the Chernobyl accident in 1986 a large amount of ^{137}Cs was deposited in the Scottish uplands. This resulted in elevated levels of ^{137}Cs being present in some animals in the human food chain, particularly deer [1]. In poor grazing areas with low clay content [2] the deer will eat plants which concentrate ^{137}Cs, resulting in elevated levels of ^{137}Cs in venison which may be consumed by Dounreay workers. Venison is not the sole source of ^{137}Cs from the environment; other foodstuffs, particular lamb and mutton from hill sheep also provide an intake route[3].

Caesium-137 measured using the Whole Body Monitor (WBM) at Dounreay may be present due to dietary intake or workplace intakes. In order to help differentiate personnel attending the WBM are asked questions about their diet. If the measured ^{137}Cs is greater than 200 Bq then the source of the ^{137}Cs is examined more carefully.

To examine long term trends in measured ^{137}Cs the mean activity per WBM in each year has been calculated for the time period of 2000 to 2011. The results are shown in figure 1. The mean ^{137}Cs value reduces each year from 2000 to 2004 which is consistent with the continuous reduction of ^{137}Cs in the environment. There is a reversal of that trend in 2005 when the mean value of ^{137}Cs increases and remains at a higher level until 2008. The mean ^{137}Cs value the drops to a very low value of less than 10Bq in 2009 and stays at this value into 2011.

Figure 1: Mean ^{137}Cs Whole Body Monitor Results for Dounreay



In September 2005 the Dounreay Cementation Plant (DCP) was temporarily shut down following a raffinate spill. Cleaning of the spill in the DCP finished in 2008 [4]. The period of enhanced ^{137}Cs coincides with the period of clean up in DCP which strongly suggests that low level of intakes of ^{137}Cs did occur during the clean up operation. Once the work in DCP was completed the mean measured ^{137}Cs dropped to the low level consistent with the ^{137}Cs in the environment continuing to drop.

Uranium air sampler results

The graphs in figures 2 and 3 show the mean alpha activity per air sampler position per month. All the air sampler positions have been included, so the graph includes positions where work was carried out with respiratory protection.

Figure 2 shows the mean alpha activity per air sampler for the research reactor uranium fuel fabrication plant. An increased level of measured activity occurred in 2004 which coincides with the last production run of fuel. Another increase in measured activity occurred in 2007 coinciding with decommissioning work prior to the demolition of the plant.

Figure 3 shows the mean alpha activity per air sampler for the Dounreay uranium billet production plant. There is a significant enhancement of measured activity in 2009 which coincides with the decommissioning of a heavily contaminated area [5]. The mean alpha activity per air sampler includes an air sampler which was located within the Amber Area which consistently recorded enhanced levels of activity during the decommissioning work.

Figure 2: Research reactor fuel fabrication plant mean activity per position per month

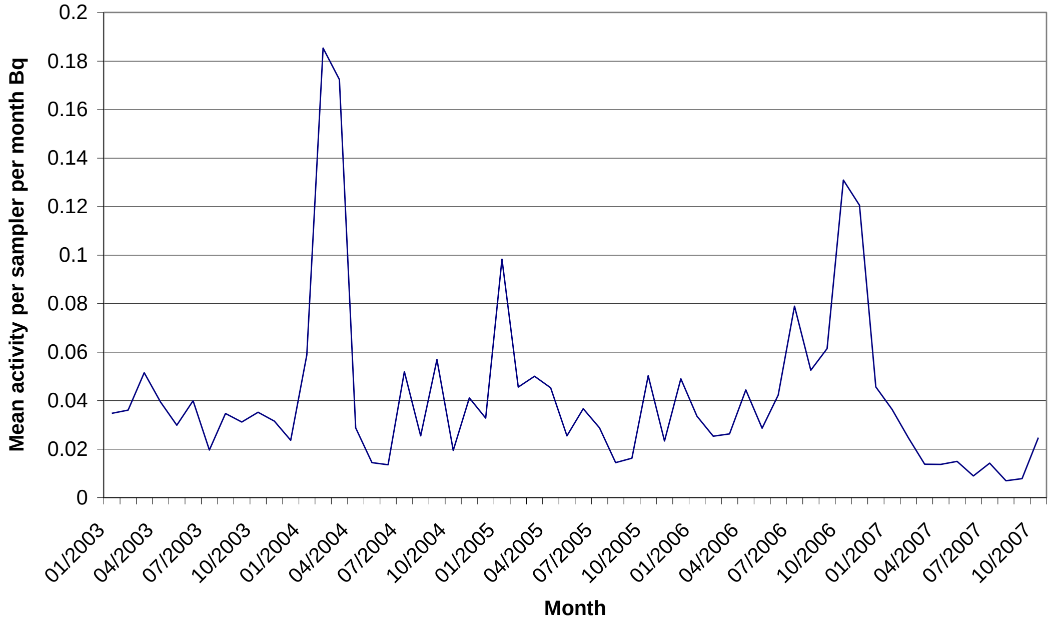
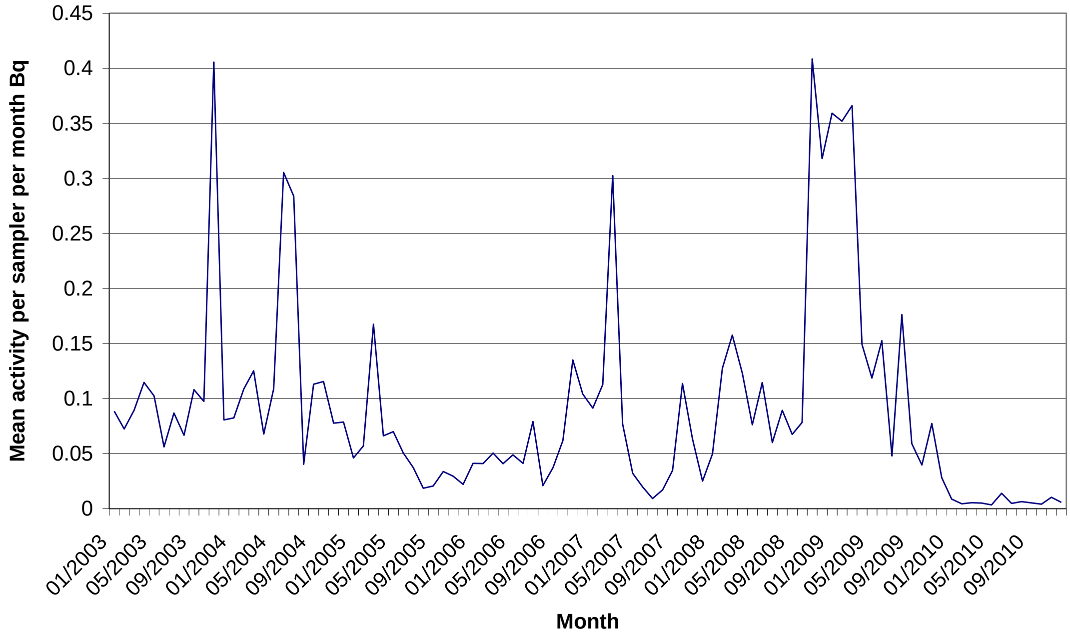


Figure 3: Uranium billet production plant mean activity per position per month



Uranium in urine

Some classified personnel on the Dounreay Site, with the potential for uranium intakes provide annual urine samples. The mean ^{234}U, ^{235}U and ^{238}U per year are shown in figure 4. Uranium excretion is affected by diet with levels of ^{234}U and ^{238}U shown to be in the region of 0.46 mBq/day and 0.41 mBq/day for non exposed personnel according to a previous study [6]. The graph shown in figure 4 gives higher excretion rates which appear to decrease over time with random increases and decreases from year to year.

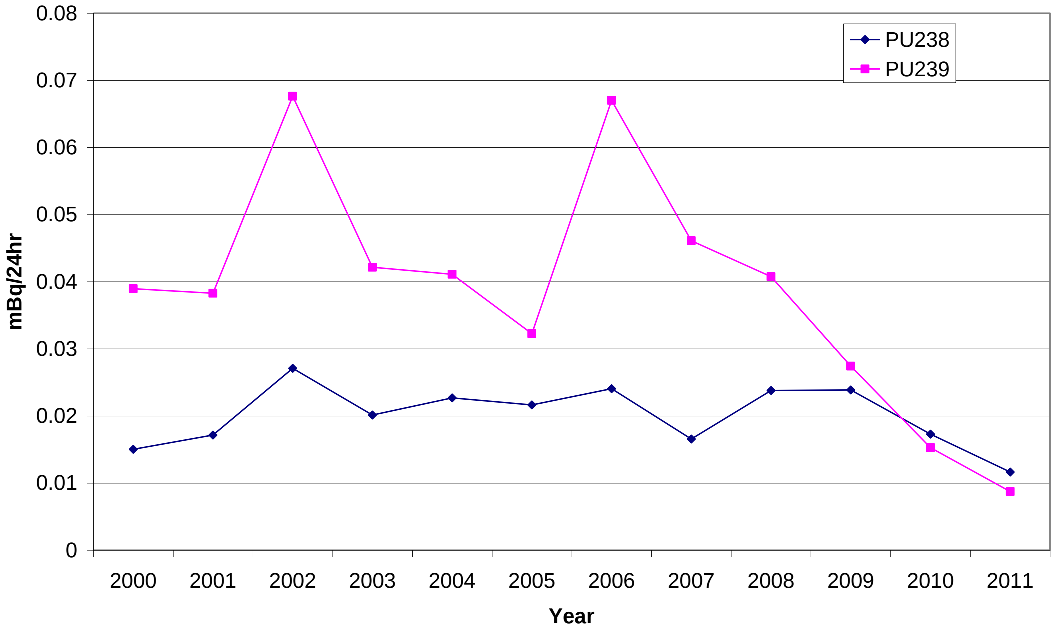
The variations shown in the mean urine results shown in figure 4 appear to show no relationship to the activity in air measured by the Static Air Sampler (SAS) values in the uranium buildings as shown by figures 2 and 3. For instance uranium in urine values shows a low point in 2009 whereas the uranium measured in the uranium processing plant using SAS is at a highpoint.

The downward trend in the uranium in urine results suggests that a combination of the radiological protection protocols and a reduction in activity due to decommissioning is reducing the low level intakes of uranium in the work place. A short term increase in the decommissioning work programme did not result in an increase in the uranium results.

Figure 4: Mean Uranium in urine results per year

Plutonium in urine

Figure 5: Mean Plutonium in urine results per year



The graph in figure 5 shows two peaks in the measured ^{239}Pu. The raised level in 2002 coincides ventilation strip out work in a former Post Irradiation Examination facility now used to handle waste. The second ^{239}Pu peak in 2006 coincides with the decommissioning work carried out in the Pulsed Column Laboratory [7].

Up to 2009 the level of ^{239}Pu is consistently above ^{238}Pu, reflecting which plutonium nuclide predominates on the Dounreay site. From the 2006 peak the level of ^{239}Pu measured consistently reduces to a point in 2009 when then the measured values for ^{238}Pu and ^{239}Pu are indistinguishable.

The overall downward trend in the plutonium in urine results suggests that the radiological protection protocols is reducing the work place intakes of plutonium despite an increase in the decommissioning activities.

Radiological Protection Protocol implementation

Table 1 shows the timescale of the introduction of radiological control protocols at the Dounreay site.

Table 1: Radiological control protocols at the Dounreay site.

Engineered improvements		**Procedural improvements**	
Upgrade of ventilation systems – various buildings	early 2000s	Introduction of Dounreay Codes of Practice	1999
Containment design – use of Moducon	early 2000's	Dounreay Modification Report system	2003/4
Profiling in containments to reduce turbulent eddies	2006 onwards but not extensively used yet.	Zero tolerance approach to loose contamination in Controlled Contamination Low areas	2006
		Disposal of legacy wastes and redundant equipment	post 1998 NII audit
Decommissioning		Risk assessed method statements	2000
Reduction in the number of permanent Contamination moderate areas	late 90s onwards	Single use air fed suits	2008
		Increased use of 'H' type vacuum cleaners, strippable coatings	increased usage throughout the 2000s
Clean up of fixed contamination	early 2000s	New decontamination agents	as above
		Respirator fit testing	1999
Decommissioning of facilities	ongoing	New air fed suit (PCL)	2006
		RP training	1999 onwards
Shutdown of facilities	ongoing	Hierarchy of control philosophy	1999 onwards

Discussion

Throughout the time period of this review new radiological protection protocols have been implemented. While it is not possible to associate any of the individual protocols directly with a change in a radiological measurement the general trend of the measured quantities is down at a time when decommissioning has increased.

In some cases work campaigns can clearly be linked to increases in levels of measured radionuclide such as ^{239}Pu in urine in 2002 and 2006 and the increase of ^{137}Cs against the previous trend for 2005 to 2008

Clearly the intake of radionuclides from the environment through diet can provide a confounding factor when attempting to assess the workplace doses. The graphs presented within this paper, however, show that trends in radiological measurements caused by workplace intakes may still be observed. Indeed the reduced level of intake of ^{137}Cs from the environment now means that using a WBM is more sensitive to workplace intakes.

The lack of correlation between the air sample results and urine results for uranium point to the successful protection of the worker. Despite some uranium being present in air this has not resulted in intakes to the workers. This may be explained by the higher air sampler measurements occurring in locations were workers were protected with respiratory protective equipment.

Conclusions

Over the period of time reviewed the three methods of measuring exposure show an overall decrease of radionuclide intake.

Despite both ^{137}Cs and uranium measurements being affected by diet it is possible to see trends in the workplace intakes.

Results of all three measurement methods correlate with campaigns of work identified on the Dounreay Site.

The global radiological measurements give an insight into intakes in the general working population of the Dounreay site which is not possible with the individual results.

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