



**Dounreay Site  
Restoration Ltd**

**INVESTIGATION REPORT  
L2(09/10)19582**

**INVESTIGATION INTO  
CONTAMINATION FINDS ON NEW LLW FACILITY FOOTPRINT**

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**Date:**

## **INVESTIGATION INTO CONTAMINATION FINDS ON NEW LLW FACILITY FOOTPRINT**

### **1 TERMS OF REFERENCE**

- 1.1 The Level 2 investigation was convened by the Head of Assurance Unit on Wednesday 19<sup>th</sup> August 2009.
- 1.2 The Terms of Reference are listed in the Convening Authority Memorandum as follows:
- 2.1 To determine, if possible the likely timescale and mechanism for the deposit of the two finds.
  - 2.2 To determine the activity associated with the finds.
  - 2.3 Determine whether there are wider implications of the finds and if additional monitoring is deemed to be necessary.
  - 2.4 To consider the implications of the finds and their potential effect on the LLW project.
  - 2.5 To consult any independent experts necessary to establish the above points.
  - 2.6 Inform the Operational Feedback Team of the actual and potential consequences. The Operational Feedback Team will confirm the Class of the UNOR.
  - 2.7 To compile a summary of the key findings within 2 days for dissemination to relevant managers and operators, via the Convening Authority.
  - 2.8 In conjunction with the Operational Feedback Team, determine the immediate and underlying causes using the SCAT terminology.
  - 2.9 To prepare a report with conclusions and recommendations within five working days.
  - 2.10 Following the Action Review Meeting, prepare a synopsis for dissemination to the site covering; what happened, conclusions and lessons learnt.
- 1.3 A copy of the Convening Authority's Memorandum is provided in Appendix 1.

### **2 INVESTIGATION TEAM PANEL**

- 2.1 Members of the investigation team were as follows:

Phil Cartwright	Lead Investigator
TW	Member, WSU RPA
EP	Member, Assurance Unit
SR	Member, Safety Representative
JH	Technical Advisor, Assurance Unit

### **3 BACKGROUND TO THE INITIATING EVENT**

- 3.1 The New LLW Facility (D3100) project required a baseline survey of the area designated for the development of the new LLW disposal facility. Following discussion with the Contaminated Land and Particles team it was agreed that the most appropriate equipment to carry out the survey was the Groundhog EV2 system. This is used for wide area monitoring of beaches and other areas where a grid referenced gamma survey is required. The main survey would be carried out with the vehicle mounted system, with difficult to access areas covered by the hand-held system.
- 3.2 The survey commenced on Monday 20<sup>th</sup> July with an objective of providing a GPS referenced map of the gamma readings over the new LLW facility footprint which was assessed from an overlay on the OS map as approximately 447,000 m<sup>2</sup>. The timeframe for the survey was not precisely set as the Groundhog equipment would be used to complete the survey of the LLW facility footprint and would make use of the survey equipment when it was not being used for beach survey activities.
- 3.3 During the morning of 13<sup>th</sup> August an area of higher activity was found. This was marked and a short period afterwards a second indication of higher activity was found. The position of the initial finds is shown in Appendix 2.
- 3.4 During beach monitoring any find is immediately retrieved by the Groundhog operator. Finds during land surveys are marked and retrieved by a member of the contaminated land team. This difference in practice is because beach finds are subject to tides and hence prompt recovery is necessary.

#### **4 INCIDENT**

- 4.1 Following notification of the suspect finds the required paperwork was completed and in the afternoon of 13<sup>th</sup> August, Mr A, a member of the contaminated land team, went to the area to retrieve the finds. He was accompanied by the Groundhog operator and followed the standard procedures for the recovery of a spot of contamination.
- 4.2 The first area was excavated using a trowel to a depth of 20cm, the normal depth approved on the work permit. There was initially no activity detected on removal of the vegetation and only low activity detected from the soil as the hole deepened. The detected activity within the hole did not seem to change as the hole was deepened. As Mr A did not have containers to take further material, the source appeared to be dispersed and he had approached the maximum depth on his work permit, the excavated material was returned to the hole and the vegetation was replaced.
- 4.3 The second area was excavated and the activity was found to be pin-pointed within a small volume of soil from a depth of 5-10cm. The Groundhog operator indicated from his experience he believed the find to be a particle. He carried out an activity assessment, as used for beach particles, which indicated a particle activity in the region of 2.8E4 Bq Cs-137. The particle was packaged for return to site.
- 4.4 Mr A returned to the first area of contamination the next morning equipped with spade and revised paperwork, bags and containers to take the excavated material and samples. An area one width by two widths of the spade was cut through the vegetation and was removed to a depth of 20cm. The activity on the base of the removed area was indicated to be a few counts above background but no Cs spectral peak could be detected (Exploranium). The material was bagged for return to the

site. The activity in the hole persisted. The first sample was taken at this point from the hole.

- 4.5 The hole was excavated further to a depth of ~35cm and the removed material placed in a second bag. The removed material was very wet and indicated activity was present which was verified with detection of the Cs-137 spectrum. Checks within the hole indicated low activity with no further indication of Cs. Further samples were taken from the sides and base of the hole.
- 4.6 The samples and the excavated material were packaged and returned to the site.

## **5 VISIT**

- 5.1 Members of the Investigation Team visited the site of the finds on the morning of 21<sup>st</sup> August.
- 5.2 The area is unimproved wet grassland, with a flora distinct from that of the improved field that lies directly to the south. Cross-leaved Heath, Devil's Bit Scabious and Marsh Marigold were present in an adjacent depression. These are indicative of the perennial wetness of the area. At the time of the visit, the water table was very close to ground surface, the holes left by removal of the finds contained water, the ditches close to the finds were running and there were areas of standing water. Ferruginous films on some of the water indicate that the groundwater is reducing at shallow depth. There was no evidence of recent grazing, unlike the field to the south (cow pats). Cattle on the area concerned would have caused significant poaching.
- 5.3 The location is some distance from areas likely to be visited by Dounreay staff in the normal course of their duties. Access requires crossing a fence with no convenient gate, the area is wet ground likely to result in wet feet even wearing standard-issue boots.
- 5.4 Photographs are provided in section 11.

## **6 FOLLOW UP TO THE INCIDENT**

- 6.1 As the finds resulted from the planned monitoring of the area there was no requirement to formally interview those involved. The Investigation team considered areas for investigation and then undertook the work and reported back their findings for discussion and incorporation in the report. The work involved additional checks of the excavated areas, further analysis, searches of information and reporting of relevant findings. These are detailed below.
- 6.2 **Find Activities**
  - 6.2.1 The particle was analysed by the DSRL labs. The results indicated 5.7E4 Bq Cs-137 and 1.35E1 Bq of Nb-94. This allows us to say with some confidence that the particle originated from irradiated DFR fuel. DFR particles are believed to have been created by 'excursions' during dissolution, prior to reprocessing of the fuel, in the D1206 reprocessing facility, between 1969 and 1979. Particles are believed to have entered the liquid discharge route, via the scrubber liquor and would also have been transferred to the solid waste facilities. The presence of DFR particles in the environment is mainly associated with liquid discharges.

- 6.2.2 The assessment of the activity associated with the dispersed source has not been as straightforward as for the particle. As the area was carefully excavated it was obvious that the activity was not a point source. The soil and vegetation was collected in two bags and returned to site. Three samples of soil were also taken from the hole, following excavation and were analysed. The two bags containing the vegetation and soil were taken to DN060 and processed through NDA 40 ISOCS.
- 6.2.3 The analytical results from the hole showed very low levels of activity,  $3\text{E-3 Bq gm}^{-1}$  to  $8\text{E-2 Bq gm}^{-1}$ . This indicates both materials at background levels plus a limited amount of remaining contamination.
- 6.2.4 The ISOCS assessment of the bags indicated Bag 1 (the higher activity material) weighed 15.12Kg and failed the SoLA criterion for exempt waste at an average, from two counts, of  $0.67 \text{ Bq gm}^{-1}$  equating to a total activity of  $1\text{E4 Bq}$ . Bag 2 weighed 11.94Kg and would pass the exempt criterion at an average, from two counts, of  $0.35 \text{ Bq gm}^{-1}$ , equating to a total activity of  $4.2\text{E3 Bq}$ . The total activity for the material in the two bags is  $1.42\text{E4 Bq}$ .
- 6.2.5 Comparison of these results indicated there was only a small quantity of activity remaining in the hole. It also indicated that the material from the surface to 20cms depth had a lower activity to the material from 20-35cms. Bag 1 was opened and the material was spread out and checked with a detector. There did not seem to be significant variation in the activity in any area. Four samples were taken for chemical analysis. The results of the samples ranged from  $0.3\text{Bq gm}^{-1}$  to  $0.54 \text{ Bq gm}^{-1}$  Cs-137.
- 6.2.6 A further check was requested of the excavated hole and two other 'control' holes, each 10m from the original hole. NDA section used a hand held 3"x3" NaI detector with the Inspector 1000 analyser to scan each hole. This showed that trace quantities of Cs-137 remain in-situ in the excavated hole, whilst no signal was seen in either control hole.
- 6.2.7 Examination of the data for naturally occurring radionuclides revealed that there are differences in the natural radionuclide content of the excavated contaminated material (LSNs 91826-9), compared with the material sampled from the edge and base of the hole (LSNs 91766-8). For example, the mean K-40 content of the residual material is  $0.6 \text{ Bq/g}$  compared with the mean for the material removed of  $0.3 \text{ Bq/g}$ . Statistical testing shows that this difference is significant at >99%. A value of  $0.6 \text{ Bq/g}$  is consistent with the site background value calculated in NFR/LRP/08/035 v8. For Ra-226, representing the U-238 content of the material, the respective values are  $0.072$  and  $0.039 \text{ Bq/g}$  and the difference is significant at 98%. Again, the lightly contaminated material has an activity consistent with the site background. For Th-232 levels (estimated from measurements of Ac-228), the values are  $0.014$  and  $0.008 \text{ Bq/g}$  respectively and the difference is significant at 95%. The lightly contaminated material from the sides and base of the hole has an activity signature consistent with the site background.
- 6.2.8 It is concluded from the analysis that the more heavily contaminated material is intrinsically different from the remaining material. From the work undertaken during the investigation, it has not been possible to verify or establish the nature or potential importance of this difference.

### 6.3 Aerial Survey Information

- 6.3.1 In 1998 Dounreay contracted AEA Technology to undertake an aerial radiological survey of the Dounreay area. The survey was done from a helicopter using a Gamma

Spectrometer, over an area of approximately 130sq km outside the Dounreay site. The survey detected levels of Cs 137 above the general background in a few areas. Indicated levels of between 70 and 150Bq/kg were noted along the coastline between Dounreay and Crosskirk. The report stated that all levels of caesium activity are well below the Generalised Derived Limit of 1000Bq/kg and do not pose any significant threat to the public or the environment. It also stated that the slightly increased levels along the coastline North of Landfill 42 are probably due to site discharges via a sea to land mechanism. It goes on to state that elevated levels to the East of the site probably arose from site discharges to the air. All levels detected during this survey were consistent with the environmental sampling programme.

- 6.3.2 The levels detected during the aerial survey were all of very low level and do not suggest any relation to the two finds. It is very unlikely that such finds would be visible in such an aerial survey.

#### **6.4 Environmental Monitoring**

- 6.4.1 A review of the results of Dounreay environmental monitoring programme was undertaken to establish if there was any information that indicated any similar contamination finds, local to the Dounreay site.

- 6.4.2 As part of the programme of sampling and monitoring, sheep faeces is routinely collected from the field adjacent to the find area and Health Physics monitoring is conducted at Oigin's Geo East and West which is located within several hundred metres of the finds. Following review of the survey and analysis data, and discussion with Mr D, DSRL, the enhanced levels of Cs137 and actinides detected in the local terrestrial environment, by the environmental sampling, is attributable to historic discharges from Dounreay, nuclear weapons fallout and the Chernobyl incident. There was no record of any particles or discrete pockets of contamination found in the farm land surrounding the Dounreay site.

- 6.4.3 During discussion with Nuvia Limited District Survey Health Physicist Mr K it was suggested that during the foreshore survey, conducted by Waste Chem in the 1990's, two flakes of black material were detected on the cliff top to the east end of the site. The final report and data were checked for any reference to either this or any similar finds during the survey. Ref PR/251/001. Investigation of Ground Contamination to the Seaward Side of the Dounreay Site. The areas of contaminated ground highlighted during the survey were attributed to known events and spillage areas. The low active shale like material reported was believed to be fossils. There did not appear to be any discrete areas of contaminated ground, similar to the pocket of contaminated soil being investigated.

#### **6.5 Photographic Review**

- 6.5.1 Aerial photographs of the area from 1959 to the latest one available in 1997 were studied. These show that there have not been any land-filling operations at the location concerned. Drainage ditches look relatively freshly dug in the earliest photograph; these same ditches are still visible on the ground, but are now much degraded. Fence line positions have not changed since the 1950s. There was no indication of cropping or disturbance of the land surface visible in any of the photographs. This was reinforced by the visit to the site. The field to the south of the finds has been used for grazing in the last year whereas the area of the find is not believed to have been used for at least 10 years. It is therefore concluded that there has been no organised activity by DSRL and its predecessors at this location. It is possible that the area has been grazed sporadically, but not regularly. Since this is

the first time that the area has been monitored, the contamination could have been present for a long time. The fact that the contamination was not at the surface further implies that it has been there for many years. However, 'many' cannot be quantified from the information available.

6.5.2 It was noted that the area of the find had been designated for development in the 80s as part of the European Demonstration Reprocessing plant project which did not go ahead.

## 6.6 Find Removal

6.6.1 The removal of the finds indicated useful information. Both areas were covered by a substantial mat of vegetation which included mosses, Cross-leaved Heath, Devil's Bit Scabious and Common Heather (Ling). The finds were below the main root mass in what appears to be mineral soil. From the vegetation present and the thickness of the root mass, the investigation team conclude the particle and the contamination must have remained undisturbed for 10years or more.

6.6.2 The depth of the finds also provides some indication of burial timescale, although in the soft ground of the finds the team could not rule out other burial mechanisms, such as worms which were seen in one excavation.

## 6.7 Transport Mechanisms

6.7.1 The finds of particles both off and on-site were reviewed. The position of the particle close to the Landfill, not far from the site and within the range of storm blown sea-spume would support an airborne transit mechanism. However, the number of particles found at Landfill 42 and from the coastline at this end of site is small. Similarly, the evidence of particles at the east end of the site is limited, although this was close to the transport route for DMTR particles. Identification of the particle as a DFR particle would suggest it has come from the sea or has been deposited on the site during waste movements and been moved by the wind, until deposit in the position of the find. The relative proportion of DFR to MTR particles found on site is less than the proportion found on the seabed.

6.7.2 Potential sources and mechanisms for the transportation of the dispersed material were considered by the investigation team as questions;

- Could the find be recent? Given the depth of the activity, even considering cattle potentially being in the area the arrivals would have to have occurred over a decade ago. From photos and historical knowledge of the area no excavation type work has been undertaken in the area.
- Is there evidence of work in the general area? Boreholes have been created in the vicinity in the last two years however no contamination was detected during this work. There was also no evidence of vehicle tracks in the immediate area of the finds.
- Has this route been used by vehicles or pedestrians? Given the terrain (boggy and wet throughout the year) this is not a vehicle or pedestrian route.
- Could an animal have spread the contamination? Animal (cat, rabbit) ingesting material in known contaminated ground on site and passing the activity out in the faeces? This is not impossible but very unlikely. Rabbits are observed in the Landfill 42 area where the ground is much drier, but were not seen on the area of the finds. The saturated nature of the land would tend to deter rodent populations.

- Could the positioning be malicious or the result of an unauthorised deposit? Very unlikely as the area is relatively difficult of access, involving wet feet much of the year.
- What are the potential sources? Windblown material from Landfill 42, East end of site, foreshore? Active material was deposited at Landfill 42 in the past, particularly in the north part of the landfill, 50-150 metres distant to the NW. Areas of similar contamination have also been found at the east end of the site. The possibility of contamination of some kind being blown this distance cannot be excluded; this is also the direction of the strongest winds. There have been some documented finds on the foreshore, but none were found consistent with this spot.
- Is there a likely source? Main stack? Activity has been discharged in the past from the D1213 and other stacks and some of this activity falls onto the ground. The D1213 stack, as the highest stack, would seem to be the most likely to result in transfer of activity over a large distance, under favourable wind conditions. Spots of contamination have been picked up on site routinely in the past – typically with an activity of 10-100 Bq Cs-137. The D1213 stack sample lines were cleaned in 2002 and samples of the dust retrieved were analysed. These had an activity ~170 Bq/g. On this basis, the dispersed find requires a lump of dust weighing 85 g to transfer the observed amount of activity. This is considered to be implausible. Stack emissions have been considerably higher in the past ( $>10^{11}$  Bq/yr Cs-137 in the early 1970s compared with  $5 \times 10^7$  Bq in 2002. High discharges in 1971 and 1972 were notable. Exceptional stack discharges are also recorded:  $10^6$  dpm/m<sup>3</sup> beta activity discharged from the Criticality Facility in 1960 (nearest stack to the find), causing roof contamination;  $6 \times 10^{11}$  Bq (nuclides not recorded) discharged from D1213 in 40 mins in 1964;  $1.5 \times 10^{11}$  Bq I-131 discharged from D1213 in an incident in 1965,  $1.8 \times 10^8$  Bq Cs-137 discharged from the D1213 stack as aqueous spray over 36 hours in 1974 (information from SESG-TSG(96)P36 Appendix 3). Ground contamination by a more highly active speck of airborne material cannot be excluded, the mass of CsNO<sub>3</sub> required is  $\sim 6 \times 10^{-9}$  g, which could be transported in air very readily until washed out by a raindrop. The presence of the DFR stack (awaiting disposal) at the east end of site is not a source as DFR particles were produced during reprocessing operations.
- Other contamination mechanisms? Contaminated spume spraying onto the fields? Spume is known to have transferred activity, discharged to sea under authorisation, back on land. Accumulations of short-lived radionuclides in heads of geos have also been reported previously. The site surface survey has revealed a plume of low-level contamination extending east from the location of the liquid discharge point. This plume does not approach the location of concern, and is of lower activity at this distance. Marine transfer is considered to be unlikely for the dispersed source.
- Other closer sources? DN059 was a non-active incinerator sited at the east end of the site. Subsequent investigation has not found the degree of contamination that would be expected to be present had it been used for occasional, undocumented active disposal. This source is therefore considered to be very unlikely.

## 6.8 Review of Incidents

- 6.8.1 The index of Dounreay incidents was reviewed to determine whether a link between a past incident and these finds could be made. Incidents that led to high discharges via the FCA stack, and one in the criticality facility, would seem to be the most likely

contributors to a spot of contamination with sufficient activity that could be deposited in a single location. No significant release of activity associated with a single incident was found after 1974.

- 6.8.2 A number of incidents that led to high airborne activity within buildings were considered, but none were found which led to a direct release outside the building.
- 6.8.3 There were a number of incidents investigated that led to contamination being detected off site. These seem to fall into three categories. The first being investigations associated with particle finds, which have been developed to the current days understanding of the particles issue, after many years of investigation and expert opinion. The second being investigation of other finds on the foreshore and beaches in Caithness. Of note is the find in 1971 of an item containing sufficient activity to be easily detected by the health physics instruments of the time and being attributed to discharge from site through the liquid discharge system through the coarse strainer within the discharge tanks. The strainer was noted to be mild steel and essentially no longer in place, providing a route for buoyant materials that entered the discharge system to exit the site. The investigation recommended replacement with a stainless strainer. The third is conditions which led to defeat of the contamination control measures in place at the time which led to contamination both on site and off-site. Contamination carried by personnel onto buses in the 80s and 90s were fairly low levels compared to levels reported in 1975. A number of contributing incidents, including ones that led to parts of a road being removed outside a reprocessing facility, focus on flask movements and a survey of the site roads which indicated contamination spread right out to the bus stances and onto the buses themselves. The management of the time acknowledged there had been a loss of control and introduced improved standards.
- 6.8.4 It is noted that during the search for incident reports some of the early records were scheduled for destruction. Fortunately all of the records requested were found, including those initially believed to have been destroyed.

## 6.9 **Review of Site Contamination**

- 6.9.1 The records of 5597 Cs-137 analyses held in the IMAGES database for solid samples have been reviewed. 89 have previously been identified as particles or spots, with 11 categorised as DFR particles. The results can be filtered down in several ways; attention was focussed on those apparently reported as 'activity per sample' and those where the reported number is >1000 Bq (per gram or per sample). This process has identified some apparent inconsistencies in the data set. There are 265 results reported as 'per sample', 27 of which are in the range 10 000-31 600 Bq, i.e. 10% of finds are within half an order of magnitude of the reported finds. The activity itself does not appear unusual. The location of finds >1000 Bq is shown in Figure 1).
- 6.9.2 The site is able to model activity plumes for emergency planning. The model shows disposition of activity at various distances under differing environmental conditions. Disposition of a spot of activity at a distance from the site would require both high activity and strong wind with no precipitation.
- 6.9.3 Review of data from the site-wide monitoring programme in 2004 has revealed a number of areas of slightly elevated activity in the east part of the site. One of these corresponds to former barriered area 107, and is associated with the former storage of contaminated items. A small number of finds on Landfill 42 form a linear feature ~100 m long. An area near the former DN059 incinerator facility is indicated as

having elevated background over a wide area ~100 000 m<sup>2</sup> (SSESWP(04)P474 UKAEA site surface gamma survey completion report, October 2004. Data held in IMAGES database). Three other localised areas of activity are visible

## 6.10 Inland Particle Finds

6.10.1 This would appear to be the first particle find outside the licensed site at a distance inland. It is not possible to say whether particles found on the Dounreay site have all resulted from losses during transfer operations, or whether some of them may have been blown ashore. Similarly, some of the finds along the cliff tops may have been come from the sea or directly from the site. The greatest proportion of DFR particles is associated with the seabed at ~20% of the population. It is also notable that higher activity DFR particle finds on the foreshore are unusual as it is believed they break-up under the energetic sea conditions that would bring them ashore in this area.

6.10.2 Does this open another area for consideration within the particles project? This is not believed to be the case. It has long been recognised that there is the possibility of particles being windblown. This was considered within the health effect studies with reference being made to the smaller size and hence likely lower activity of windblown materials. However, sand, seaweed and other pieces of flotsam and jetsam are found well beyond the cliff-edges. It is therefore not possible to say that particles have not been relocated in this way. This was a consideration that led to the survey of the Reay Golf course in 2006-7, a major inland area where sand from the Sandside beach and dunes is known to deposit during gales. It also had the advantage of being a wide area accessible to the Groundhog system. The entire course was monitored, a total area of 760,000m<sup>2</sup>, including areas where grass cuttings were put. No finds were made.

## 6.11 Potential Health Effects

6.11.1 The health effects associated with contact with Dounreay particles have been researched in detail (HPA report RPD-EA-03-2006). The particle find is at the low end of particle activity and would be unlikely to result in health effects through contact, inhalation or ingestion. Similarly, the other find is a dispersed source with a low radioactive content per gram. Contact with the material is unlikely to cause any health problems associated with the radioactive content. Inhalation or ingestion of a significant amount of the material is not credible.

6.11.2 Similarly, transit into the food chain would seem to be unlikely to lead to any discernible effects, although this could only be confirmed by the Food Standards Agency who would run a specific model for the case to determine the potential effect.

## 6.12 Wind Data Consideration

6.12.1 DSRL operates two meteorological stations. Wind data from the station located closest to the area of investigation have been examined. Wind speed and direction are measured every second and averages are recorded for every minute and hour. Hourly average data have been used in compiling this summary, to reduce the data processing effort. Data have been considered for the years 2001-2008, although only the years 2001, 2002 and 2008 have data coverage >90%. Datasets with poor data coverage are potentially biased.

6.12.2 'Average' wind can be considered in a number of ways:

- The actual prevailing wind direction, i.e. the direction from which wind blows most frequently;
- The 'perceived' prevailing direction, i.e. the direction from which noticeably strong winds blow;
- The true average direction, i.e. the direction of the integrated displacement over the year, of a notional balloon in the atmosphere.

These directions are different.

6.12.3 A clear pattern emerges. The prevailing wind direction in most years is from the south-east. Other frequent wind directions are, in order, from the west and north north-west. The strongest winds are from the west or occasionally the north north-west. The average wind direction is consistently from the south south-west. South-easterly winds are most likely in the summer months, and westerly and northerly winds are most likely in winter months. The data are summarised in the table below.

Year	Data coverage	Ave. wind (deg)	Prevailing wind		Strongest wind		Other direction	
	%		Speed (km/hr)	Dir (deg)	Speed (km/hr)	Dir (deg)	Speed (km/hr)	Dir (deg)
2001	90.2	210.5	25.3	152.6	29.8	347.3	29.7	277.5
2002	99.6	189.4	29.1	147.4	31.7	277.5	-	-
2003	77.5	208.4	26.7	147.5	32.2	272.6	31.6	337.6
2004	87.3	223.7	29.7	287.2	34.9	272.5	22.0	152.3
2005	88.6	214.2	24.8	152.3	35.5	272.4	33.7	337.4
2006	56.7	204.5	21.5	152.2	30.3	272.1	27.6	352.2
2007	80.4	222.1	31.2	277.6	35.0	267.0	16.4	152.3
2008	100	205.7	23.0	142.3	38.5	262.4	33.5	337.3

The prevailing wind is calculated from the amount of time in a year the wind comes from a specific direction, irrespective of strength, with the speed being the average speed of the wind from that direction. The strongest wind direction utilises both direction and wind speed to determine the direction that most strong winds have come from in a year, with the speed being the average speed from that direction.

### 6.13 Completion of the Survey

6.13.1 The survey of the off-site portion of the new LLW facility footprint, by the vehicle mounted system was completed on 26<sup>th</sup> August. No further particle or unexplained areas of contamination were found. The total area of coverage was 402,481 m<sup>2</sup>.

6.13.2 Areas of low level contamination associated with the concrete taxiway were also found. These finds were consistent with previous areas of contamination due to Dounreay discharges, weapons fallout and Chernobyl at the edge of the Dounreay runway. (Nukem/NE/0273 Dounreay Runway, November 2001 - February 2002).

6.13.3 Soil samples and grass samples were taken from the area. The highest soil result was 0.75Bq/g well within the range of the 0.3-1.6Bq/gm found in 2002. The grass sample results show a maximum activity level of 9Bq/kg.

- 6.13.4 The use of the Groundhog system for such surveys, where wide areas of ground can be scanned provides auditable results. The system capability for particle detection is well known, but needs further development in its application for land survey.

## **7 FINDINGS**

- 7.1 The findings of this investigation are based upon the work carried out by the investigation team and documentary evidence that was found.
- 7.2 The findings are as follows:
- 7.2.1 There is no definitive on-site source or transport mechanism for either the particle or the area of contamination. The position of the finds and knowledge of weather support slightly different mechanisms. The particle is most likely to have been windblown from the sea, Landfill 42 surface or from the main site. The area of contamination is most likely to have originated from the FCA stack at a time when the authorised discharges were much higher than the levels of today. The distance from the stack can only be supported by a hypothesis of high activity and strong wind. Similar activity finds have been found, closer to the stack, on site. If the stack was the source of the contamination it is difficult to explain how no other elevated areas of contamination were found along the axis of high wind speed. Perhaps there have been other spot sources which have been dispersed by rain and groundwater and the persistence of the spot found is linked to the composition of the ground it was found in. Further work to understand this fact was not possible within the timeframe for this report.
- 7.2.2 The position of the finds, the vegetation present and the absence of information related to disturbance of the land in the area of the finds would point to natural processes being the reason for the depth of the finds. The investigation team believe both were deposited at least 10 years ago but further work would be required from an expert in soil and vegetation growth to provide a more precise timeframe.
- 7.2.3 Review of available information, including site incidents, discharges, contamination mapping and photographs point towards the early 1960s through to the early 1980s as the likely time when the original items could have been created. Whether they arrived at the location at the same time is unknown.
- 7.2.4 Considering the circumstantial evidence in the two points above, the timeframe for the disposition of the material may be 30 years.
- 7.2.5 Completion of the survey and the absence of any further similar finds should provide some confidence that there are unlikely to be areas of contamination found in the near surface during excavations for the new facility.
- 7.2.6 The review of the site contamination distribution maps from the coast indicate the effect the liquid discharges have had. This seems to have been omitted as a contributing reason for the low levels of activity found at the edges of the runway.
- 7.2.7 The availability of information within the IMAGES system, the Contaminated Land Library and the efficient retrieval of documents from site archives aided the investigation team in researching the potential origin of the finds.

## **8 SYSTEMATIC ROOT CAUSE ANALYSIS**

- 8.1 The terms of reference for the investigation included the requirement to carry out SCAT analysis of the incident. Following discussion within the team and further discussion with assurance it was agreed that the overall application of SCAT would not be beneficial in this case. However, some of the basic route causes should still be highlighted.
- 8.2 The investigation was initiated following the discovery of a particle and contamination in an off-site area. The discoveries are a credit to the improvements in beach monitoring equipment implemented during 2007. The use of this equipment in non-beach areas to provide auditable monitoring results is good practice. The equipment has the capability of detecting spots of contamination and point sources in the near surface region. Depth of detection is dependant on activity. The detection of low levels of activity adjacent to the Dounreay site should not have been a surprise.
- 8.3 The source of the contamination was the discharge of activity from the Dounreay site and is the result of different standards of equipment, work practices, knowledge and discharge authorisations during the early years of site operation. No definitive mechanism was determined for the transport of the activity to the find locations, although airborne contamination was most likely.
- 8.4 Communication with the regulators, other government agencies and local stakeholders is an area DSRL have improved and should ensure continues.

## **9 CONCLUSIONS**

- 9.1 The conclusions of the investigation are detailed below under a separate paragraph for each of the Terms of Reference.

### **9.2 TOR1 - To Determine, If Possible the Likely Timescale and Mechanism for the Deposit of the Two Finds**

- 9.2.1 The investigation team could not determine a definite transfer mechanism for either find, nor could they determine a definitive timescale.
- 9.2.2 The most plausible explanation for the particle is wind transport from the sea, Landfill 42 or the main site.
- 9.2.3 The most plausible explanation for the find of elevated activity is aerial deposition from the stack, at a time of high activity discharge or when a spot of high activity was transported in strong winds.
- 9.2.4 It is clear that neither find is of recent origin. Both are thought to have remained undisturbed at the find locations for at least 10 years and could have been there for 30 years or more. The activity of the contaminated area may have been the result of particulate discharge from the main stack. Discharges as a result of normal operations and incidents were much higher in the 60s and 70s than now.
- 9.2.5 The apparent difference in composition of the soil associated with the contamination may be a factor which led to the persistence of the contamination.

### **9.3 TOR2 - To Determine the Activity Associated With the Finds**

- 9.3.1 The particle was analysed in the DSRL laboratories and was found to have an activity of 5.8E04 Bq Cs-137. The presence of Nb-94 identifies this as a DFR particle.

- 9.3.2 The other find did not have the characteristics of a particle. It was a dispersed source of activity, Cs-137 in soil, with a total calculated activity of 1.42E04 Bq.
- 9.3.3 In addition to the above finds there were some areas of raised activity found adjacent to the runway taxiways. These areas are at the low end of the range of previous finds associated with runway run-off.
- 9.4 **TOR3 - Determine Whether There are Wider Implications of the Finds and if Additional Monitoring Is Deemed to be Necessary**
- 9.4.1 The circumstances leading to the investigation, and the investigation itself, have established that the history of authorised discharges from the site has resulted in deposition of radioactivity on the ground to the east of the discharge locations. It is possible that localised areas of distinctly elevated activity will have resulted from this. It is clear from the small number of finds during this survey exercise that these elevated areas of activity are infrequent and localised. The finds along the taxiway are associated with locally special circumstances and are a confirmation of earlier finds. The health implications of the finds have not been formally assessed, but are expected to be insignificant. The results from the analysis will be forwarded to FSA who will consider whether an assessment is warranted.
- 9.4.2 The Groundhog system provides a quality radiation footprint in the form of a map. The use of the system to provide information is good practice. It is however, a sensitive system and will detect radioactivity in the near surface below the threshold of health risk. In other words, finds by the Groundhog system should be checked but it may not be necessary to remove them.
- 9.4.3 There is no clear driver for additional monitoring given the likely history, the number and the activity of the finds, the extent of the monitoring already carried out and the current land use. A potential mechanism for contamination is understood, although the details remain obscure. There is no indication of health detriment and therefore limited drive for remedial action. It is not clear whether additional monitoring would improve understanding of the contamination mechanism, or whether further monitoring would provide reassurance.
- 9.4.4 Consideration of the likely source (main stack) and the mechanism for transfer (high winds and wind direction) would lead to an area beyond the site where further monitoring could be carried out. The absence of finds further away from the site during the monitoring of the LLW footprint, together with the absence of a large number of unexpected finds at the East side of site, gives some confidence that there is not a widespread problem.
- 9.4.5 Given the above it is concluded that additional widespread monitoring off-site is unnecessary. However, reassurance monitoring of some areas could be considered, following discussion with local residents, if there is a specific concern.
- 9.5 **TOR4 - To Determine the Implications of the Finds and Their Potential Effect on the LLW Project**
- 9.5.1 The finds and the areas of contamination at the edge of the runway need to be formally assessed by FSA so that definitive information can be passed to the local stakeholders. The discovery of any radioactive find will always result in an adverse reaction. The availability of sound independent expert advice allows such finds to be put in perspective.

- 9.5.2 The engagement of the local stakeholders in the LLW project and the stages as it progresses has already been recognised. These finds have highlighted the importance of continuing with this approach.
- 9.5.3 Completion of the survey has not resulted in further finds. The finds themselves should not change the approach of the project. The Groundhog system provides an auditable map of the gamma readings detected at the time of the survey. The finds were detected by increases in activity compared to the background and indicate activity within the surface layers.
- 9.5.4 The LLW project can gain confidence from the results, but should also consider the finds in terms of their excavation plans. Further work on the likely timeframe for the find burial process and the overall gamma maps provide a good starting point for the project.
- 9.6 **TOR 5 - To Consult Any Independent Experts Necessary to Establish the Above Points**
- 9.6.1 The investigation team had a good mixture of professional and personal expertise. The work has highlighted some areas where further work is recommended and some expert advice should be sought. Contact with the FSA provided initial comfort with respect to the food chain. However, it is important that the information from these finds is reported to FSA to allow them to decide whether a formal assessment is required.
- 9.6.2 Consideration was given to involving an expert in soil depth and plant life. This was deemed not to be necessary as further refinement of the burial timescale was not believed to be important.
- 9.6.3 Similarly, the find of the particle on land outside the licensed site was unexpected. The Chairman of COMARE and the Chair of PRAG(D) have been made aware of the finds and should be informed of the investigation results.

## **10 RECOMMENDATIONS**

- 10.1 It is recommended that the results of the finds and the analysis of the samples are passed to FSA.
- 10.2 Consideration should be given to completion of the work on the composition of the soil, to establish whether this was a contributor to the longevity of the find.
- 10.3 The availability of historic information greatly assisted the progress of this investigation. Maintenance of quality records must continue and will aid the decommissioning process. The record retention schedule should be reviewed to ensure information like this is retained for the life of the site. (Dounreay Incident records in particular.)
- 10.4 The Groundhog or similar system should continue to be used to generate auditable clearance information for use in support of future de-licensing of areas of the site.

11 PHOTOGRAPHS



The hole left following excavation of the contamination. Note the water level.



**Position of the find relative to LF 42 fencing**



**View to the East**



**Hole left by removal of Particle**



**View towards the site**



**Vegetation in the area**



**Dimensions of the contamination excavation ~40cmx20cm**

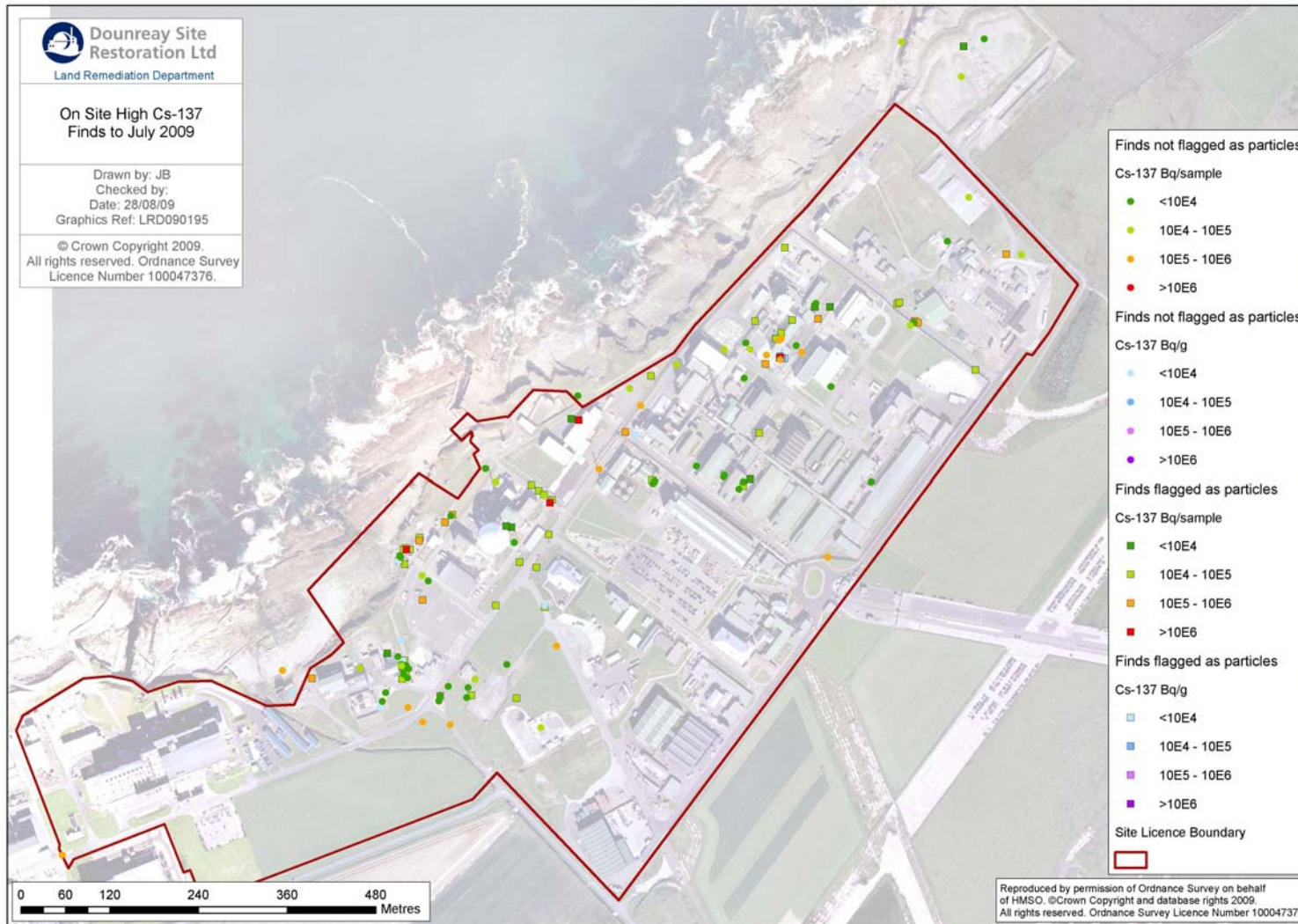


12 TABLE 1 ANALYSIS RESULTS

Area 2 Soil Samples and Bag Samples Results																	
Report Sheet No Input Required				Results are all wet weight													
LSN	Date	Sample Code	Sample Point	K 40 Bq/g	Error 2-Sigma	Mn 54 Bq/g	Error 2-Sigma	Co 60 Bq/g	Error 2-Sigma	Nb 95 Bq/g	Error 2-Sigma	Zr 95 Bq/g	Error 2-Sigma	Ru 106 Bq/g	Error 2-Sigma	Ag 110m Bq/g	Error 2-Sigma
Results in Red- Detector not calibrated																	
91766	17-Aug-09	CGIT	Area2 14Aug09/S1	6.22E-01	3.98E-02	< 1.00E-03	<	1.02E-03	<	1.10E-03	<	1.90E-03	<	9.69E-03	<	1.41E-03	<
91767	17-Aug-09	CGIT	Area2 14Aug09/S2	5.46E-01	3.84E-02	< 1.47E-03	<	1.35E-03	<	1.54E-03	<	2.61E-03	<	1.18E-02	<	1.95E-03	<
91768	17-Aug-09	CGIT	Area2 14Aug09/S3	6.33E-01	3.79E-02	< 1.04E-03	<	1.12E-03	<	1.10E-03	<	1.70E-03	<	8.33E-03	<	1.44E-03	<
91826	21-Aug-09	cgit	bag1 21aug09/s1	2.54E-01	2.05E-02	< 7.38E-04	<	6.93E-04	<	7.85E-04	<	1.24E-03	<	8.51E-03	<	1.02E-03	<
91827	21-Aug-09	cgit	bag1 21aug09/s2	2.29E-01	1.53E-02	< 5.07E-04	<	5.24E-04	<	5.56E-04	<	8.88E-04	<	6.66E-03	<	6.72E-04	<
91828	21-Aug-09	cgit	bag1 21aug09/s3	4.26E-01	2.26E-02	< 5.47E-04	<	5.48E-04	<	5.83E-04	<	9.56E-04	<	5.47E-03	<	7.42E-04	<
91829	21-Aug-09	cgit	bag1 21aug09/s4	3.06E-01	1.94E-02	< 5.90E-04	<	5.97E-04	<	6.17E-04	<	1.04E-03	<	6.15E-03	<	7.84E-04	<
Report sheet no INPUT required																	
LSN	Date	Sample Code	Sample Point	Tl 208 Bq/gm	Error 2-Sigma	Pb210 Bq/gm	Error 2-Sigma	Bi 212 Bq/gm	Error 2-Sigma	Pb 212 Bq/gm	Error 2-Sigma	Bi 214 Bq/gm	Error 2-Sigma	Pb 214 Bq/gm	Error 2-Sigma	Ra 224 Bq/gm	Error 2-Sigma
Results in red not "real" Detector not calibrated																	
91766	18-Aug-09	CGIT	Area2 14Aug09/S1	7.10E-03	1.46E-03	5.09E-02	1.82E-02	3.67E-02	1.86E-02	1.96E-02	2.56E-03	3.43E-02	9.80E-03	4.00E-02	6.52E-03	6.56E-02	2.10E-02
91767	18-Aug-09	CGIT	Area2 14Aug09/S2	5.21E-03	2.05E-03	< 2.24E-01	<	2.85E-02	<	1.57E-02	2.72E-03	3.05E-02	1.39E-02	3.04E-02	6.08E-03	5.57E-02	2.20E-02
91768	18-Aug-09	CGIT	Area2 14Aug09/S3	6.07E-03	1.70E-03	< 4.24E-02	<	2.74E-02	1.52E-02	2.19E-02	2.41E-03	3.15E-02	1.09E-02	3.11E-02	5.56E-03	8.04E-02	1.91E-02
91826	21-Aug-09	cgit	bag1 21aug09/s1	< 2.00E-03	<	7.03E-02	4.45E-02	< 1.75E-02	<	1.17E-02	2.61E-03	1.41E-02	6.29E-03	1.63E-02	4.52E-03	2.02E-02	1.30E-02
91827	21-Aug-09	cgit	bag1 21aug09/s2	4.37E-03	1.58E-03	< 9.96E-02	<	1.27E-02	<	9.83E-03	2.05E-03	8.99E-03	4.75E-03	1.27E-02	3.99E-03	2.25E-02	1.14E-02
91828	21-Aug-09	cgit	bag1 21aug09/s3	4.80E-03	1.17E-03	1.87E-02	6.95E-03	2.73E-02	1.35E-02	1.09E-02	1.90E-03	2.30E-02	5.51E-03	1.18E-02	3.05E-03	1.93E-02	9.60E-03
91829	21-Aug-09	cgit	bag1 21aug09/s4	4.89E-03	1.26E-03	3.23E-02	9.89E-03	2.38E-02	1.21E-02	1.54E-02	2.20E-03	1.33E-02	5.17E-03	1.66E-02	3.57E-03	3.40E-02	1.37E-02
Area 1 Particle Results																	
	Date	Sample Code	Sample Point	Cs-137 Bq/sample	%Error 2-Sigma	Co-60 Bq/sample	%Error 2-Sigma	Nb-94 Bq/sample	%Error 2-Sigma	Cs-134 Bq/sample	%Error 2-Sigma	Am-241 Bq/sample	%Error 2-Sigma				
First 1 hour cont	13-Aug-09		Area 1	5.80E+04	2	< 6.70E-01	<	1.30E+01	21.3	< 3.30E+00	<	2.30E+01	<				
Second 1 hour count	13-Aug-09		Area1	5.60E+04	2	< 5.70E-01	<	1.40E+01	19.5	< 3.20E+00	<	2.20E+01	<				

Area 2 Soil Samples and Bag Samples Results															Comments	Date reported	Date last reported	18/08/2009
Report Sheet No Input Required																		
LSN	Date	Sample Code	Sample Point	Cs 134 Bq/g	Error 2-Sigma	Cs 137 Bq/g	Error 2-Sigma	Ce 144 Bq/g	Error 2-Sigma	Am 241 Bq/g	Error 2-Sigma	Alpha Bq/g	Beta Bq/g	Sample Weight (Grams)				
Results in Red- Detector not calibrated																		
91766	17-Aug-09	CGIT	Area2 14Aug09/S1	< 1.09E-03		8.00E-02	4.57E-03	< 5.77E-03		< 1.83E-03		2.60E+00	2.32E+00	206.78	New Result	21/08/2009		
91767	17-Aug-09	CGIT	Area2 14Aug09/S2	< 1.37E-03		7.14E-03	1.86E-03	< 8.00E-03		< 8.38E-03		2.61E+00	2.34E+00	185.50	New Result	21/08/2009		
91768	17-Aug-09	CGIT	Area2 14Aug09/S3	< 9.62E-04		3.05E-03	1.49E-03	< 5.31E-03		< 3.71E-03		2.84E+00	2.91E+00	273.39	New Result	21/08/2009		
91826	21-Aug-09	cgit	bag1 21aug09/s1	< 8.97E-04		4.30E-01	2.06E-02	< 4.93E-03		< 2.74E-03				168.99	New Result	24/08/2009		
91827	21-Aug-09	cgit	bag1 21aug09/s2	< 7.49E-04		5.40E-01	2.66E-02	< 4.65E-03		< 4.03E-03				241.82	New Result	24/08/2009		
91828	21-Aug-09	cgit	bag1 21aug09/s3	< 6.01E-04		3.03E-01	1.69E-02	< 3.63E-03		8.50E-04	6.41E-04			231.92	New Result	24/08/2009		
91829	21-Aug-09	cgit	bag1 21aug09/s4	< 6.58E-04		3.66E-01	1.74E-02	< 4.06E-03		< 1.04E-03				196.62	New Result	24/08/2009		
Report sheet no INPUT required																		
Results are all wet weight																		
LSN	Date	Sample Code	Sample Point	Ra 226 Bq/gm	Error 2-Sigma	Ac 228 Bq/gm	Error 2-Sigma	Th 232 Bq/gm	Error 2-Sigma	Th 234 Bq/gm	Error 2-Sigma	U 235 Bq/gm	Error 2-Sigma	Sample Weight (Grams)				
Results in red not "real" Detector not calibrated																		
91766	18-Aug-09	CGIT	Area2 14Aug09/S1	8.01E-02	2.36E-02	< 5.52E-03		1.58E-02	3.24E-03	9.45E-02	2.82E-02	4.57E-03	1.35E-03	206.78	New Result	19/08/2009		
91767	18-Aug-09	CGIT	Area2 14Aug09/S2	6.38E-02	2.83E-02	< 7.23E-03		1.16E-02	4.56E-03	< 4.87E-02		< 1.89E-03		185.5	New Result	19/08/2009		
91768	18-Aug-09	CGIT	Area2 14Aug09/S3	7.09E-02	1.93E-02	1.41E-02	4.15E-03	1.35E-02	3.77E-03	8.94E-02	2.71E-02	< 1.51E-03		273.39	New Result	19/08/2009		
91826	21-Aug-09	cgit	bag1 21aug09/s1	2.74E-02	2.21E-02	< 3.43E-03		8.38E-03	3.04E-03	1.76E-02	2.22E-02	1.56E-03	1.26E-03	168.99	New Result	24/08/2009		
91827	21-Aug-09	cgit	bag1 21aug09/s2	3.95E-02	1.71E-02	< 2.41E-03		7.51E-03	2.72E-03	< 2.77E-02		2.25E-03	9.77E-04	241.82	New Result	24/08/2009		
91828	21-Aug-09	cgit	bag1 21aug09/s3	2.66E-02	1.16E-02	8.33E-03	2.21E-03	8.24E-03	2.01E-03	2.76E-02	1.01E-02	< 8.96E-04		231.92	New Result	24/08/2009		
91829	21-Aug-09	cgit	bag1 21aug09/s4	6.17E-02	2.01E-02	5.52E-03	2.25E-03	8.40E-03	2.17E-03	< 1.49E-02		< 1.06E-03		196.62	New Result	24/08/2009		
Area 1 Particle Results																		
		Sample Code	Sample Point															
First 1 hour cont	13-Aug-09		Area 1															
Second 1 hour count	13-Aug-09		Area1															

Figure 1 - On Site High Cs-137 Finds to July 2009



## APPENDIX ONE

Dounreay

Form D329

To *Mr P Cartwright*

### LEVEL 2 INVESTIGATION

#### **L2(09)19582 – Contamination finds on LLW Footprint**

Dear Phil

- 2 Please act, on my behalf, as Lead Investigator into the possible origin and implications of the two finds of radioactivity within the area designated for the new LLW facility.
- 3 You are required to produce a report into the investigation within five working days. The investigation's Terms of Reference are:
  - 2.1 To determine, if possible the likely timescale and mechanism for the deposit of the two finds.
  - 2.2 To determine the activity associated with the finds.
  - 2.3 Determine whether there are wider implications of the finds and if additional monitoring is deemed to be necessary.
  - 2.4 To consider the implications of the finds and their potential effect on the LLW project.
  - 2.5 To consult any independent experts necessary to establish the above points.
  - 2.6 Inform the Operational Feedback Team of the actual and potential consequences. The Operational Feedback Team will confirm the Class of the UNOR.
  - 2.7 To compile a summary of the key findings within 2 days for dissemination to relevant managers and operators, via the Convening Authority.
  - 2.8 In conjunction with the Operational Feedback Team, determine the immediate and underlying causes using the SCAT terminology.
  - 2.9 To prepare a report with conclusions and recommendations within five working days.
  - 2.10 Following the Action Review Meeting, prepare a synopsis for dissemination to the site covering; what happened, conclusions and lessons learnt.
- 4 The composition of the investigation team is at your discretion but general advice is to keep to the necessary minimum. A Safety Representative and the Independent Assessment Team should be invited.

Yours sincerely

*A Wratten*  
CONVENING AUTHORITY

## **Guidance for Lead Investigators**

### **L2/L3 Investigations**

- This is a full time commitment (other pressing work to be suspended).
- Visit the area early and take photographs.
- Speak to relevant people informally (one option is round the table discussion). Formal interviews with transcript notes are not always required.
- The criteria for Dealing with Human Error (PRC 0001 Appendix 9) will be handed out during discussion or prior to interview and needs to be emphasised to personnel.
- Ensure that any discussions on people issues are carried out in closed offices and that confidentiality is maintained outside the investigation. Technical issues may be discussed in open plan offices.
- Report should be concise with a factual section (incident details and follow up), conclusions, root causes and corrective actions. A two page report may well suffice.
- The root cause analysis part can be discussed with Operational Feedback either after the RCA has been drafted or advice is readily available at any stage during the Investigation from Operational Feedback. The recognised root cause analysis tool used by DSRL is Systematic Root Cause Analysis Technique (SCAT). SCAT charts will be handed out to the Investigator at the outset of the Inquiry.
- Identified corrective actions should be separated into short term (to allow safe restart of plant) and long term actions as set out in the Terms of Reference letter. You should agree timescales for the short term actions (normally less than one month for close out) with recipients and then launch them (within the five day report submission deadline). Any longer term or site wide actions should also be discussed with recipients and will subsequently be taken at a specially convened Action Review Meeting to which you will be invited, as Lead Investigator.

Before embarking on the investigation, Operational Feedback will brief you on salient facts and relevant documentation. Assurance Unit will provide output from the Fact Finding Meeting (if appropriate). Throughout the investigation, Operational Feedback will be on hand for any advice required.

## APPENDIX 2

### LLW FOOTPRINT CONTAMINATION FINDS

