CHARACTERISATION OF THE DOUNREAY CASTLE SITE USING THE GROUNDHOG SYSTEM

TECHNOLOGY

Process description

The Groundhog system measures gamma radiation and records the position of the measurement using a GPS (Global Positioning System).

Mechanism

Gamma radiation probe can either be carried by personnel (as in this case) or vehicle mounted and driven over the site. Readings of gamma radiation and location are recorded in real time.

Cost

Not available

Duration

Not available

Benefits

- ✓ Recognised by regulators as suitable for characterisation of radioactively contaminated land.
- ✓ Very rapid surveys
- ✓ Can be used to record positions of other sampling methods, eg boreholes
- ✓ No need to grid sites
- ✓ Data is visually mapped
- ✓ Proof that site has been 100 per cent surveyed
- ✓ System is cost effective
- ✓ Data is readily useable for use with GIS systems

Limitations

- × Does not identify the depth of contamination
- × The exact nature of the contaminant
- × Does not identify alpha
- × System has been developed in recent times for identifying beta emitters, though this capability is limited to hardstanding, smooth surfaced soils and short grass areas

BACKGROUND

Site

Dounreay Castle, Caithness, Scotland (ND 983670)

Problem

Presence of radioactive contamination due to past operations

Key objectives

To establish the magnitude of the problem, the nature of the contamination and its extent and severity

Objectives

- Provide data for risk assessment and safety case
- Determination of remediation method(s)
- Integrated approach to site characterisation
- As a post remediation assurance tool

Lessons

- The Groundhog system would be used at the start of an investigation to determine the initial risk to potential site workers. It would also be used to confirm the presence of radioactivity at locations suggested by the desk study.
- The Groundhog will also integrate well with other technologies, as the GPS system can be used in conjunction with other sampling methods.
- Integrated approach to site characterisation
- As a post remediation assurance tool

Application

Background

Dounreay Castle is located at the mouth of the Mill Lade at the northern boundary of the UKAEA Dounreay site. As a result of past operations at the UKAEA Dounreay site the castle environs were affected by radioactive contamination. The two sources of contamination identified were effluent dispersion experiments carried out in the mid-1950s and leakage of the low-radioactive drainage system.

Site history

The castle dates back to the 16th century and was last occupied in 1863. It is today in a ruinous state, unroofed and overgrown. The structure is based on a tower house of L-shaped plan that is normally associated with the lowlands of Scotland. A 19th-century cottage abuts the castle's most easterly wall. This is one of the last buildings that once formed part of an extensive post-medieval settlement of the area. The castle has been granted scheduled monument status.

During the mid-1950s a series of dispersion characteristics experiments were carried out at the Dounreay site. The purpose of the experiments was to provide data for the design of a sea discharge system for effluent containing radioactivity. The experiments involved the discharge of a mixed fission product liquor into the Pentland Firth. As a result of leakage and spillage in the castle grounds, fission products contaminated the courtyard of the castle.

The contamination of the castle drain (combined sewer) and the foreshore occurred due to the migration of fission products and actinides from the low-radioactive drainage system to the non-radioactive drainage system.

Surveys

Groundhog was used for a baseline gamma flux survey. The survey was carried out before the remediation. This was done to identify the areas of highest external radiation dose. Once identified, this contamination was removed so that restrictive working practices and increased dose were ameliorated in the short term.

Operational constraints

Groundhog does not identify the depth of the contamination. A high degree of personal protective equipment (PPE) may be required on highly contaminated sites to carry out the initial study. The degree of PPE depends on the mechanism deployed, ie: if the site is suitable, the system can be vehicle mounted and will reduce the need for PPE as long as appropriate filters are in place on the vehicle. In terms of the capability of the

system, there is a depth limit for accurately monitoring beta\gamma contamination in soils, this is approximately 200mm for gamma and at the surface on hardstanding, smooth soil or short grassed areas for beta. The beta system is slower than the gamma system and can only be used in fair weather. The system accuracy can also be affected by "shine" generated by adjacent nuclear facilities.

Results

Groundhog highlighted the areas of highest external dose to be located within the castle courtyard (Figure 1). Activity concentrations of up to 2000 Bq/g Caesium-137 were recorded in the upper layers of the soil profile. The contamination was shown to extend into the cottage but not the tower house of the castle.

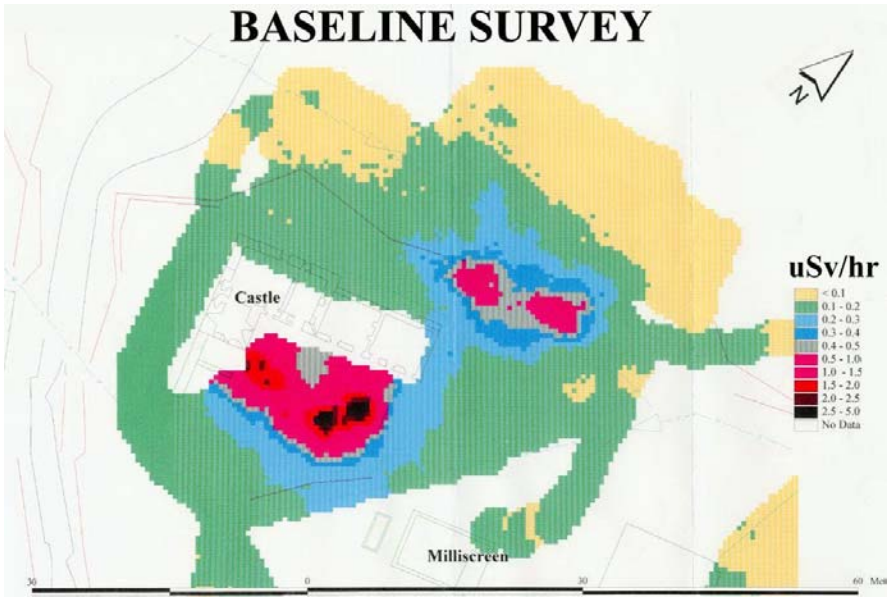

Figure 1 *Groundhog survey of Dounreay Castle pre remediation*

The foreshore area was contaminated with up to 35 Bq/g Caesium-137, 18 Bq/g Plutonium-239 and 240, 8.6 Bq/g Plutonium-238 and 7.4 Bq/g Americium-241. Monitoring of boreholes installed upstream of the castle environs showed that migration was insignificant.

The remediation involved the excavation of an area of 900 m^2 to a maximum depth of 3m. The excavation was backfilled with clean material as well as excavated material that was assessed as being below the target limit (1 Bq/g artificial alpha and 4 Bq/g beta).

Following the remediation a survey of the site was carried out using the groundhog system. The results showed that the levels were less than 0.3 µSv/h across the site (Figure 2).

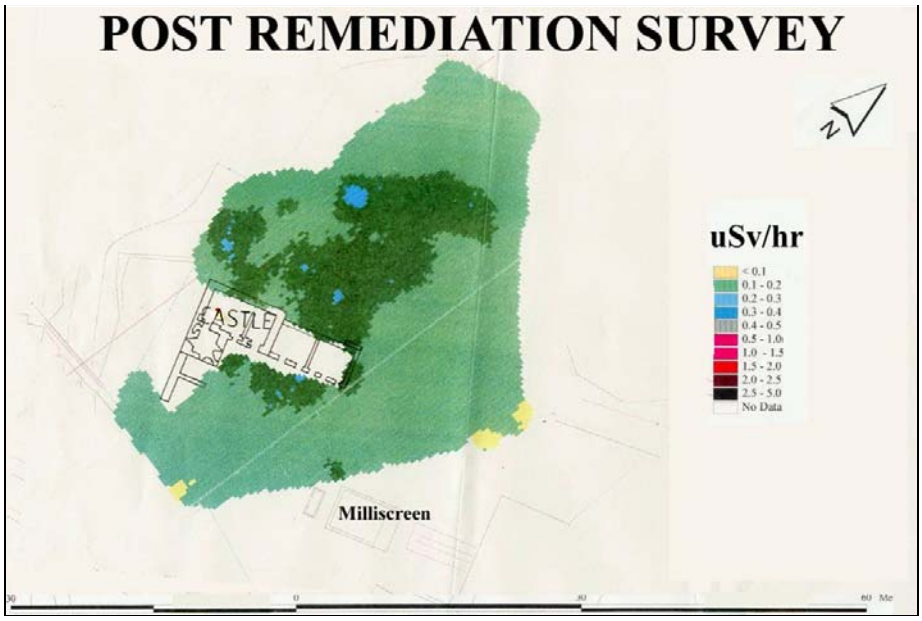

Figure 2 *Groundhog survey of Dounreay Castle Post Remediation*

Assessment of technology performance

Technical

The Groundhog system provided a fast way of assessing the extent of the radioactive contamination. It also allowed the areas of highest external dose to be identified and remediated so as to overcome the need for restrictive working practices.

Financial

Due to the rapid nature of the Groundhog system sites can be surveyed very quickly. This reduces the cost of surveying. Also, the identification of the most highly contaminated areas can potentially reduce the overall remediation costs.

Legal/regulatory

The Ionising Radiation Regulations 1999, require contaminated sites to be designated. Groundhog results allowed a more detailed risk assessment to be conducted to support production of the safety case, before works were carried out on the site. Remediation commenced in the castle courtyard, the area of highest external radiation dose identified by Groundhog. The reason for this was to remove the contamination that resulted in elevated doses, so that restrictive working practices and increased dose uptake could be removed in the short term, in accordance with the ALARP (As Low As Reasonably Practicable) principle.

Workability

The Groundhog system is easily transported around the site. It can be either vehicle-mounted or carried by a person. The information is then downloaded into a GIS, which gives a visual representation of the site data and allows integration with health physics and other data.

Technology risk management

The groundhog system only identifies beta\gamma radiation. Although the system is not able to directly identify the contaminant present, it can be calibrated to a particular energy window such as Cs-137. Care needs to be taken with the geology of the site, as the presence of different soils and rock types can affect readings. The Groundhog system does not identify the depth of the radioactive contamination.

Remediation

In close co-operation with a specialist archaeological contractor, the ground around the Castle was carefully excavated in slices of 20cm depth. This method allowed the safe removal of contaminated material and a detailed recording of the site archaeological history. The initial stage of the remedial works is shown in Figure 3. Remediation works completed during 1998 allowed open access to the site for the first time in 40 years (Figure 4).

Figure 3 *Beginning the remediation of Dounreay Castle*

Figure 4 *Dounreay Castle after remediation*