Land and Waste Characterisation

In-situ and bulk assay technologies

Helen Beddow
24 March 2010

A SUBSIDIARY OF SOLETANCHE FREYSSINET

Content

- **Land Characterisation**
  - Development of the Groundhog system
  - Groundhog and high resolution gamma spectrometry for delicensing purposes
  - Groundhog for the detection of low energy gamma emitters
- **Waste Characterisation**
  - Naturally Occurring Radioactive Material (NORM) contamination
  - Bag monitor
  - Gamma Excavation Bucket Monitor (GEM system)
  - Conveyor-mounted gamma monitor

Development of the Groundhog system

- **Groundhog 'Classic'**
  - Portable system for the detection of gamma radiation
  - Sodium iodide detector and ratemeter interfaced with a global positioning system (GPS) with sub-metre accuracy
  - Automatic data recording; ~ 1 reading per m^2
  - Simple 3-channel spectrometer
  - Analysis for ^{137}Cs
  - Identification of buried sources
  - > 20,000 readings/day/person
  - > 50,000 readings/day/vehicle
  - Post-processing of the data interpolates between adjacent survey points
  - Produce high resolution contour maps using a geographical information system (GIS).

Development of the Groundhog system

- **Groundhog 'Fusion'**
  - Basic technology of current Groundhog systems
  - 76 x 76 mm NaI detector connected to an ORTEC DigiBase spectrometer
  - Housed in a carbon fibre case – minimise attenuation of gamma radiation
  - Overlapped sampling to optimise detecting discrete sources - particles
  - Multiple energy windows for analysis of many radionuclides
  - Optimal for the detection of ^{137}Cs and other medium-high energy gamma emitters
  - Ultra-mobile 'palm' PCs for flexible data logging and configuration

Delicensing nuclear sites

- **HSE Criterion to meet the detriment to health risk criterion of 10^{-6}/y**
- **Defined activity levels for significant radionuclides**
- **Combined survey using:**
  - **High Resolution Gamma Spectrometry (HRGS) for homogeneous large area contamination in the top 100 mm surface layer of the ground**
  - **Groundhog Fusion to provide additional confidence that smaller (discrete) sources of contamination are not present**
  - **GPS to record measurement locations for both systems**

HRGS

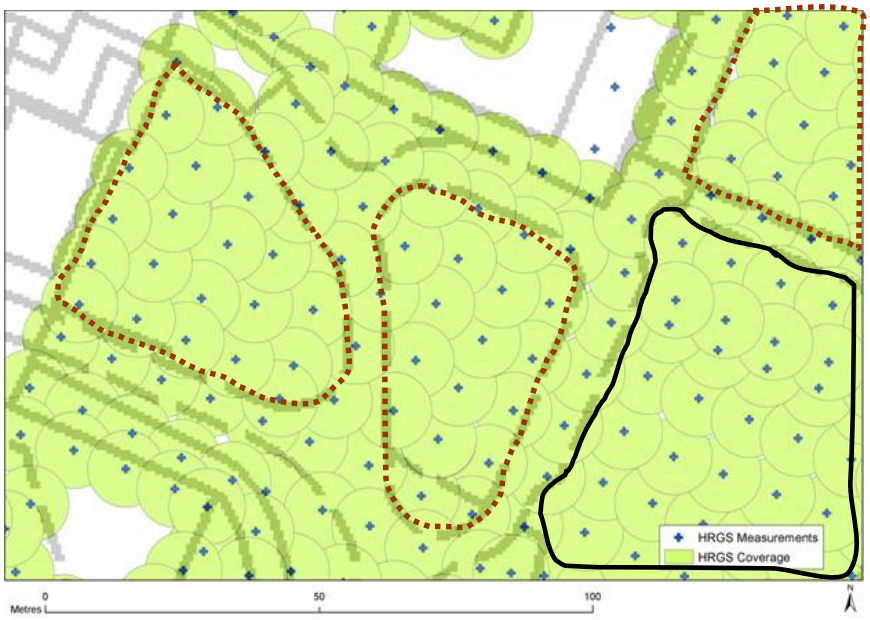
- **Custom-built trolley!**
- **1 metre above ground level**
- **Canberra's computer modelling code, In-Situ Object Counting System (ISOCS) to calculate detector efficiencies**
- **Several iterations of the model to investigate the range of Minimum Detectable Activity (MDA) vs counting time vs measurement radius**
- **For an area with a radius of 7 metres and contaminated to a depth of 100 mm, an MDA of < 0.02 Bq/g for ^{137}Cs & ^{60}Co, achieved in a 150 second count time**

Groundhog 'Fusion'

- **Hand-held and vehicle-mounted**
- **1 measurement per m^2**
- **Configured to measure windows on the gamma radiation spectrum**
- **Configured for the detection of hot spots**
- **Modelled using MCNP to derive the MDA for ^{137}Cs and ^{60}Co**

Depth	Radius	MDA ^{137}Cs (Bq/g)	MDA ^{60}Co (Bq/g)
100 mm	1 m	0.2	0.07
100 mm	3 m	0.1	0.06

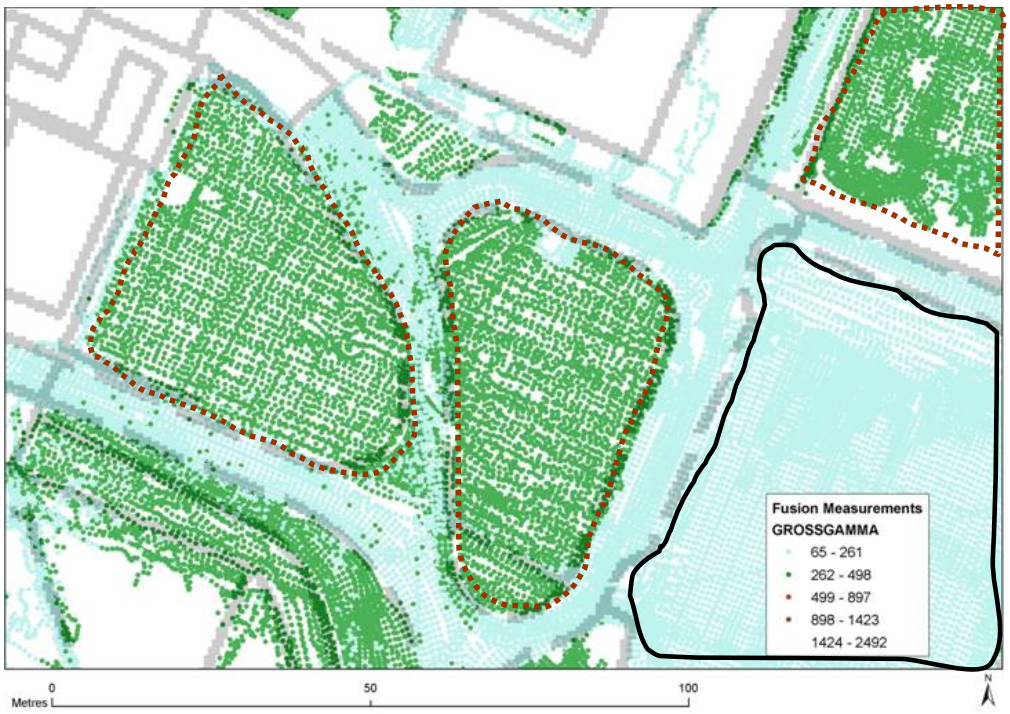
High Resolution Gamma Spectrometry coverage



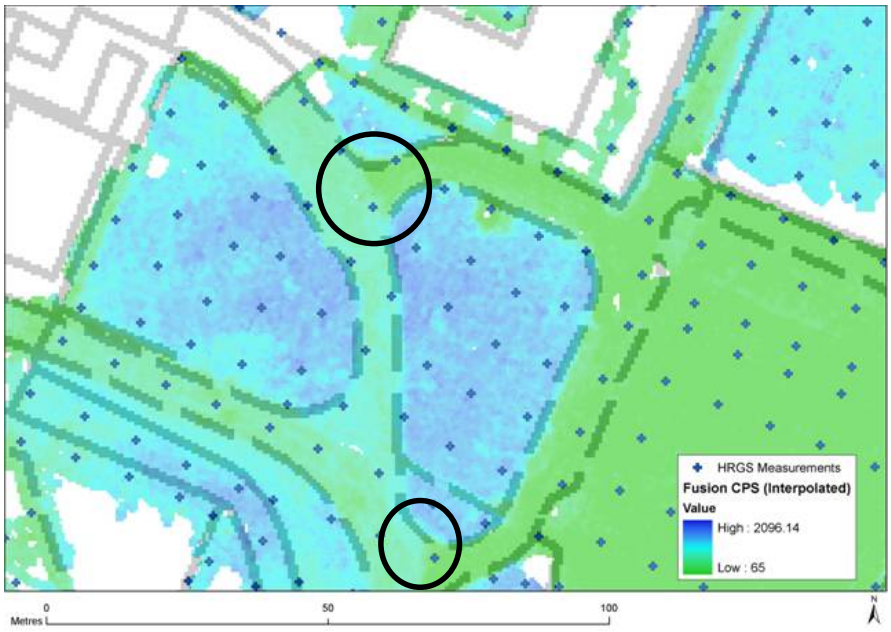
MDA range for ^{137}Cs 0.012 – 0.022 Bq/g

MDA range for ^{60}Co 0.006 – 0.014 Bq/g

Groundhog Fusion high density measurements



Interpolated gross gamma data plus HRGS measurement locations



No small scale anomalies that would invalidate the MDA model for the HRGS survey

Changes in radiation level correspond to changes in ground surface material

Groundhog 'Insight'

- **Uses a Field Instrument for the Detection of Low Energy Radiation (FIDLER) – 125mm diameter by 1.6mm thick Sodium Iodide**
- **Mounted in a Carbon Fibre case**
- **Based on Groundhog Fusion – spectrometry if required; multiple energy windows; over-sampled counting and statistical alarms for particle detection**
- **Beryllium window for enhanced low-energy detection**
- **Optimal for the detection of ^{241}Am, but good performance down to below 10keV**

Groundhog 'Insight' projects

- **Requires a more rigorous approach to surveying – operators need to walk narrow tracks and more slowly. Attempting to make 4 measurements per m^2**
- **Used as part of the post-remediation survey after a fire at a smoke-detector warehouse (^{241}Am). Detected some fragments of smoke detector foils**

Waste Characterisation

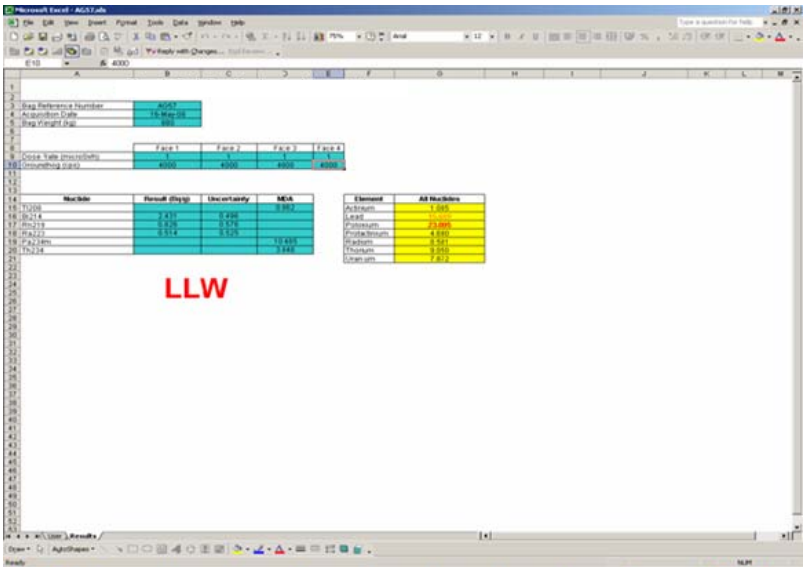
- **Bulk Assay Techniques**
  - Capable of measuring very low levels of radioactivity to determine the correct wastestream
  - Segregation and minimisation of waste volumes

- **A major land remediation project discovered > 7000 tonnes of soil contaminated with enhanced levels of naturally occurring radioactive material (NORM)**
- **Land used for a number of enhanced NORM generating industries:**
  - **Gas mantle production – ^{232}Th + daughters**
  - **Luminising works – ^{226}Ra + daughters**
  - **Phosphate processing – ^{238}U decay chain**
  - **Landfill site – pre-1960 Radioactive Substances Act**

High Resolution Gamma Spectrometry

- In-situ object counting system (ISOCS) to calculate the sample detector efficiencies
- Identification and quantification of radionuclides
- 5 minute count time

Automated spreadsheet for wastestream identification

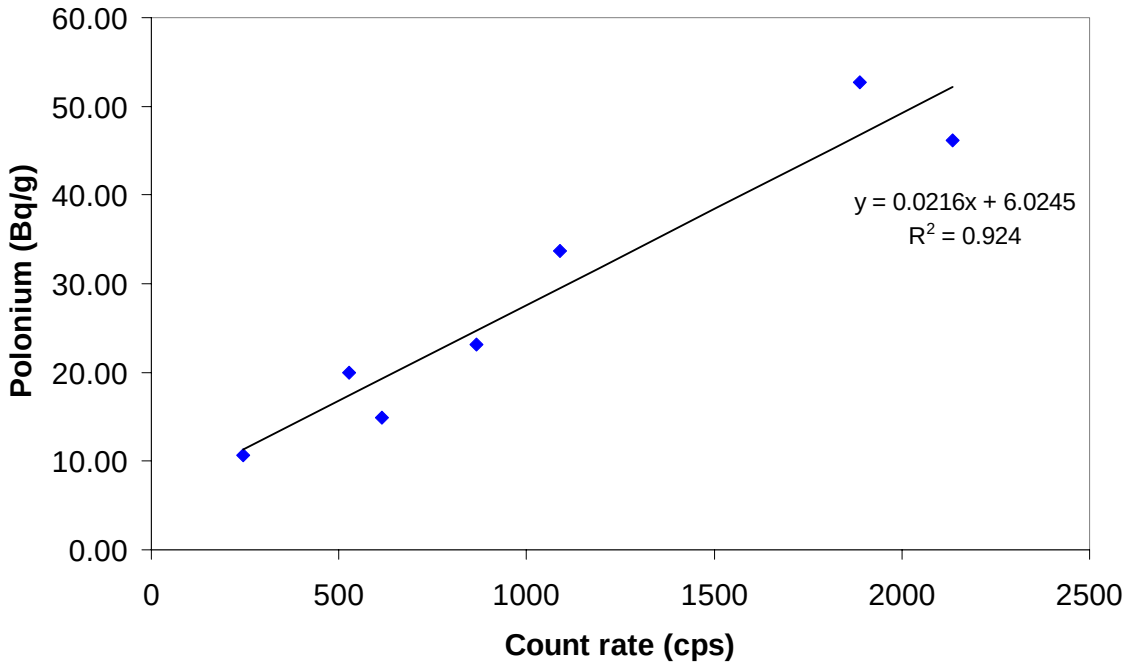


- **Approximately 50 tonnes of material monitored per day**
- **Rate limiting factor – bag handling**
- **The client was under intense time pressure to finish the land works**
- **Requirement to increase throughput**

Gamma Excavation Bucket Monitor (GEM system)

- **Monitoring gross gamma signal from material in an excavation bucket using a hand-held monitor**
- **Required the driver to move away from the active area**
  - Improved throughput
  - Manual handling of the monitor
  - Close proximity to contaminated material and moving plant
- **Large shielded sensor on which the bucket could be positioned for measurement; this still required manual supervision.**
- **Robust assay system capable of increasing the throughput from 5 to hundreds of tonnes per hour**
  - Remove the requirement for manual control, thereby increasing safety
- **Fingerprint to enable use of gross gamma assay**

Gamma Excavation Bucket Monitor (GEM system)

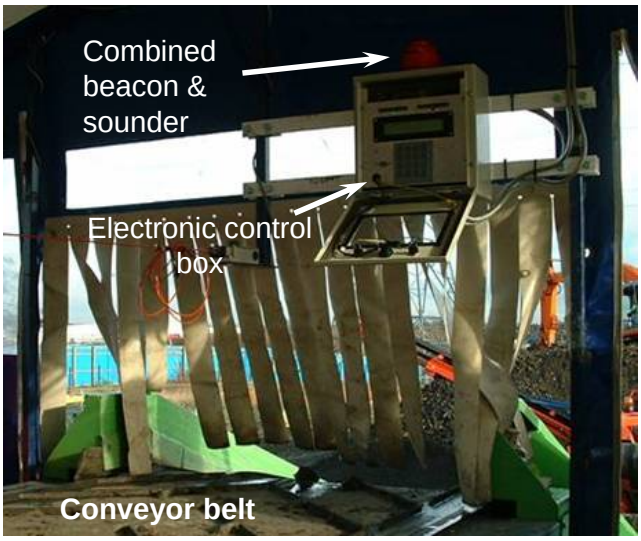


Gamma Excavation Bucket Monitor (GEM system)

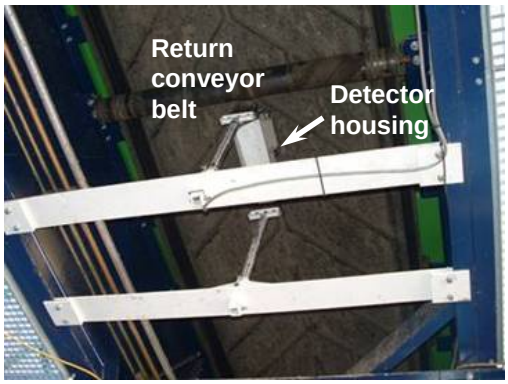
Bucket monitor system built by Bretby Gammatech

- Background and threshold number of counts programmed into the electronics
- 10 second count time
- Approximately 350 tonnes were measured per day
- Data downloaded onto a laptop
- Powered by battery

Conveyor-mounted gamma monitor – 100 tonnes/h

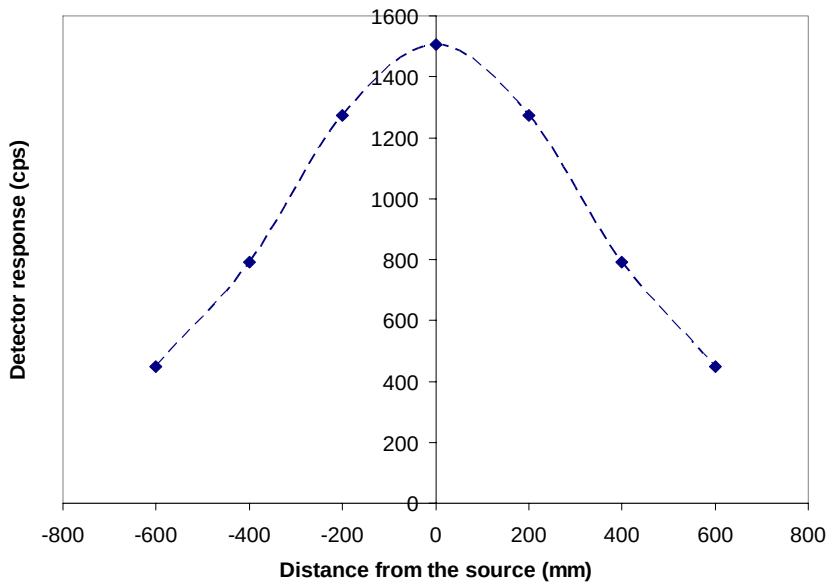


Conveyor monitor system built by Bretby Gammatech



Old radium painted dials

Conveyor-mounted monitor calibration



- **Calibrated experimentally & results compared to Monte Carlo N-Particle (MCNP) modelling data – two sets of data within 10 % of one another**
- **Alarm level programmed into the system.**
- **Data download onto a laptop**

Summary

- **Land characterisation**
  - Groundhog philosophy – portable, completely automatic, large volumes of data, colour contoured maps of surface gamma radiation levels.
  - Groundhog Fusion and Insight – easier to use , but providing more spectral information
  - Combined with HRGS
- **Waste characterisation**
  - Full spectral analysis with HRGS – bag monitor
  - Increased throughput using GEM system and conveyor
  - All data recorded and downloaded onto a laptop