Scottish Universities Environmental Research Centre

Brief Demonstration Flight of SUERC AGS System. Inner Solway, 20th July 2005

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1. Introduction

This survey of the Inner Solway area was conducted on the 20th July 2005, to demonstrate the SUERC Airborne Gamma Spectrometry (AGS) system purchased by QinetiQ for use from fixed wing aircraft in support of security operations. The system has been transferred to AWE in preparation for fixed wing deployment. At time of transfer, a short training session was arranged at SUERC, followed by a demonstration flight using a helicopter to provide hands on experience over a known area for AWE and MOD staff.

The survey area consisted of two large salt marshes (Rockcliffe Marsh and Burgh Marsh), separated by the river Eden, and had been surveyed many times since 1992; most recently in April 1999 and June 2000 (Sanderson *et. al.* 2001).

The equipment was installed into an AS355 Twin Squirrel helicopter at Cumbernauld Airport on the afternoon of the 19th July, and a functional flight test performed that day. The following morning, the first survey team deployed from Cumbernauld testing the system on route for the Solway, and starting survey prior to refuelling at Carlisle airport. The remainder of the team deployed to Carlisle and assisted with data acquisition in rotation during the 20th July Survey lines were separated by approximately 500m were flown east-west, each line being approximately 12km long. One line was flown on arrival in the survey area, with the rest of the survey flown following refuelling at Carlisle. A final short flight included a hover manoeuvre over the centre of Rockcliffe Marsh and a series of lines over the same area at increasing ground clearance. Mapping computers were set up in Carlisle airport and used to demonstrate real time data reduction and mapping. At end of survey, the equipment was transferred to an AWE vehicle and taken to Aldermaston.

This short note summarises the data recorded and maps produced. All data have been digitally archived and can be used for training purposes.

2. Results

Initial results were analysed at Carlisle Airport, using calibration coefficients derived for the ECCOMAGS exercise in May 2002 (Sanderson *et. al.* 2003). The ^{137}Cs distribution determined in the field using working calibration parameters is shown in figure 1. This map shows considerably less ^{137}Cs activity per unit area than the 1999 data, and the mapping parameters used have smoothed out some of the details of the distribution.

Prior to the survey, a set of measurements was taken on calibration pads at SUERC. These have been used subsequently to generate a revised stripping matrix. Though the survey did not include the standard set of measurements to determine other calibration parameters, there is some data that can be used to approximate these parameters. A couple of lines at the western edge of the survey area crossed the Solway at fairly high tide, and the data from these have been used to determine a detector background. A hover manoeuvre over Rockcliffe Marsh has been used to determine altitude correction and approximate sensitivity coefficients, assuming the radiation environment of this area hasn't significantly changed since 1999. These revised parameters were used for post-survey data analysis at SUERC.

The ^{137}Cs distribution determined following this analysis is shown in figure 2, which shows a distribution very similar to that previously measured. The major differences can be attributed to the lack of proper ground controls in the calibration, and some changes in the radiation

environment including significantly higher tidal conditions during this survey and the substantially reduced signal from the western part of Burgh Marsh that had previously been observed to be rapidly eroding.

Figure 3 shows the gamma ray dose rate for this region. This shows the enhanced gamma dose rates on the salt marshes due to the ^{137}Cs activity, and also very much lower dose rates for inland areas corresponding to wet peat bogs.

The natural series activities are shown in figures 4-6. The correlation between the salt marshes and enhanced ^{40}K specific activity indicate that there are some residual interferences in the data, ie: that the stripping matrix used is not entirely correct. The uranium series is mapped using ^{214}Bi gamma rays. Radon gas in the air during survey can result in contamination of the aircraft with this daughter isotope, and hence much higher signals than given by terrestrial sources. This appears to have happened with the data collected on the first couple of lines, resulting in the very high ^{214}Bi specific activities in the northern part of the survey. Part of this enhanced ^{214}Bi signal is also showing as a residual interference in the thorium series, mapped using ^{208}Tl gamma rays.

Figure 7 shows the profile plots of ^{137}Cs activity per unit area along a single line that was flown at a range of different heights. It can be seen that as the ground clearance increases the quality of the data collected degrades, with the peak activity per unit area decreasing and spatial features become less well defined. Table 1 gives the mean ^{137}Cs activity per unit area for the section of each of these lines across the highest activity sections of Rockcliffe Marsh. It can be seen that, in addition to a general reduction in measured activity per unit area, the uncertainties associated with such measurements also increase with ground clearance.

Altitude	Mean ^{137}Cs (kBq m^{-2})
200ft	52.7±3.4
300ft	48.3±3.5
400ft	45.3±4.0
500ft	38.0±4.2
1000ft	38.5±10.5

Table 1: Mean ^{137}Cs activity per unit area along flight line across Rockcliffe Marsh at different heights.

References

Sanderson, D.C.W., Cresswell, A.J., White, D.C., Murphy, S., McLeod, J., 2001. *Investigation of Spatial and Temporal Aspects of Airborne Gamma Spectrometry.* DETR Report No. DETR/RAS/01.001.

Sanderson, D.C.W., Cresswell, A.J., Anthony, I.M., Murphy, S., 2003. AGS Exercise Team Report for SURRC, UK. *An International Comparison of Airborne and Ground Based Gamma Ray Spectrometry. Results of the ECCOMAGS 2002 Exercise held 24th May to 4th June 2002, Dumfries and Galloway, Scotland.* pp. 263-275.

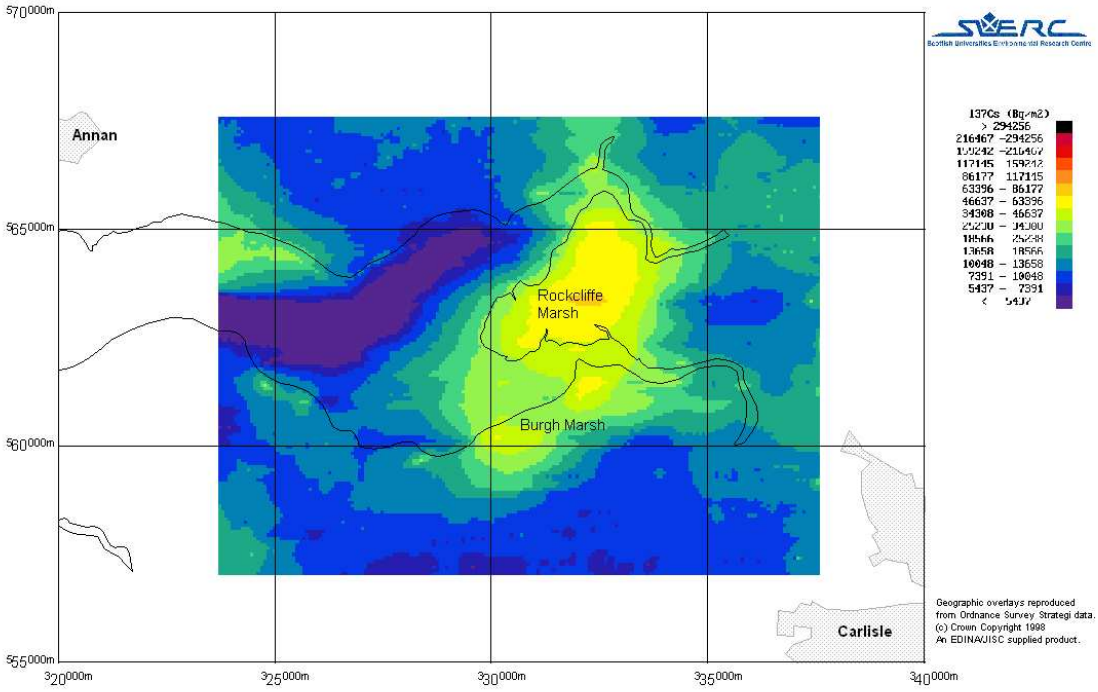

Figure 1: ^{137}Cs distribution determined using working calibration values in the field.

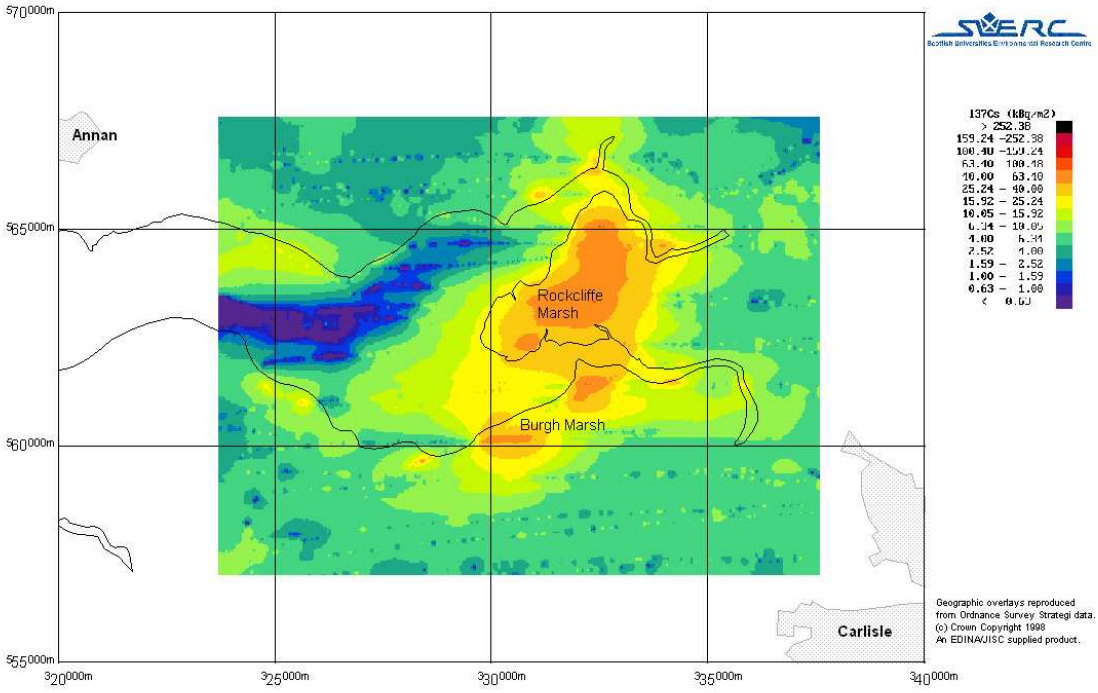

Figure 2: ^{137}Cs distribution determined after review of calibration values.

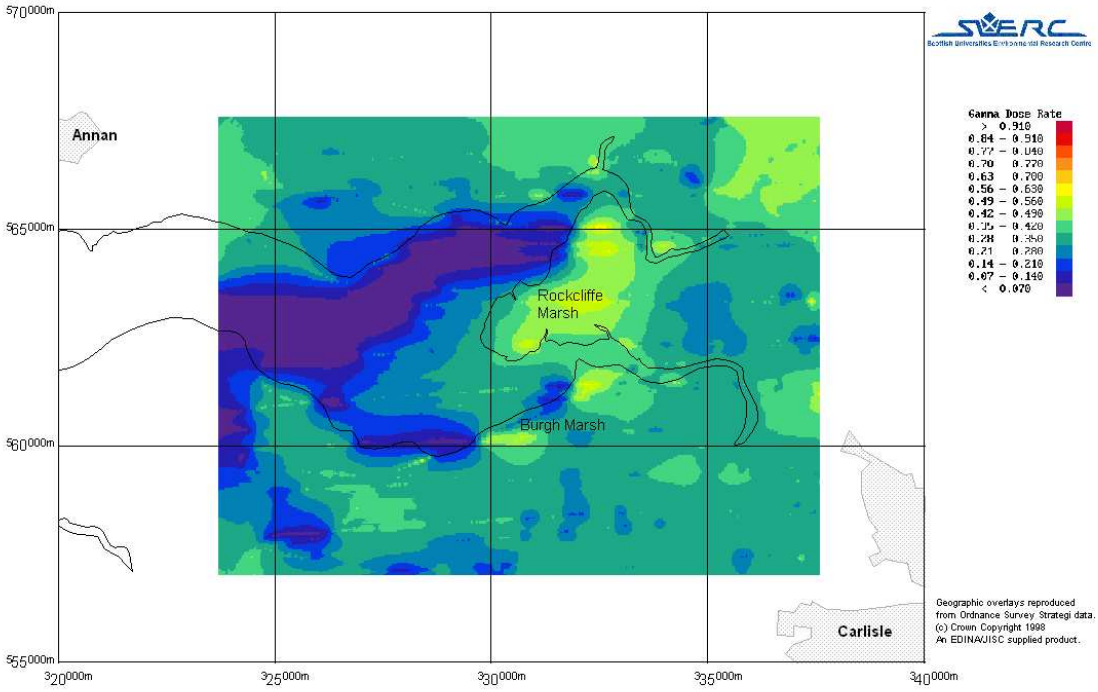

Figure 3: Gamma ray dose rate (mGy a^{-1}) determined in this survey.

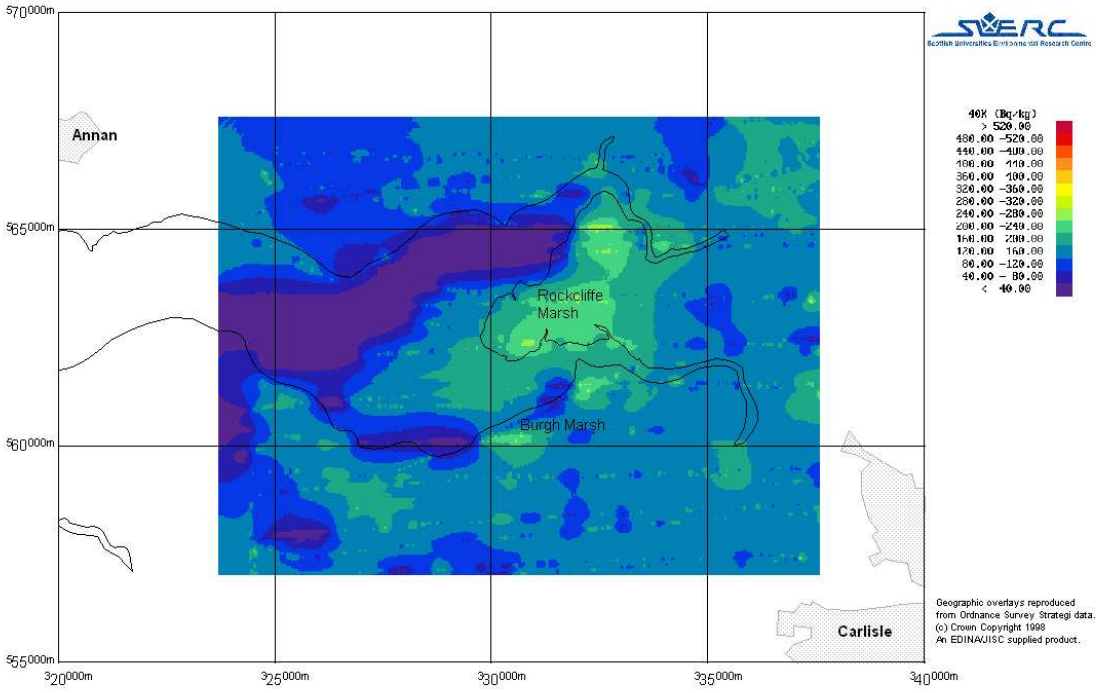

Figure 4: ^{40}K distribution determined in this survey.

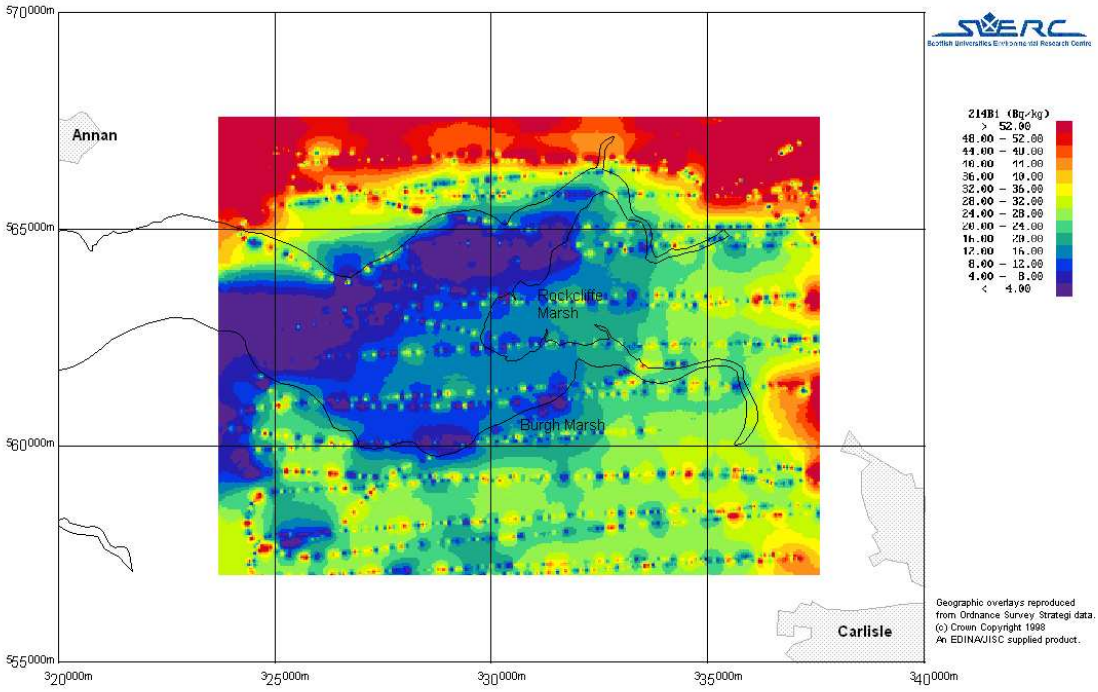

Figure 5: ^{214}Bi (uranium series) distribution determined in this survey.

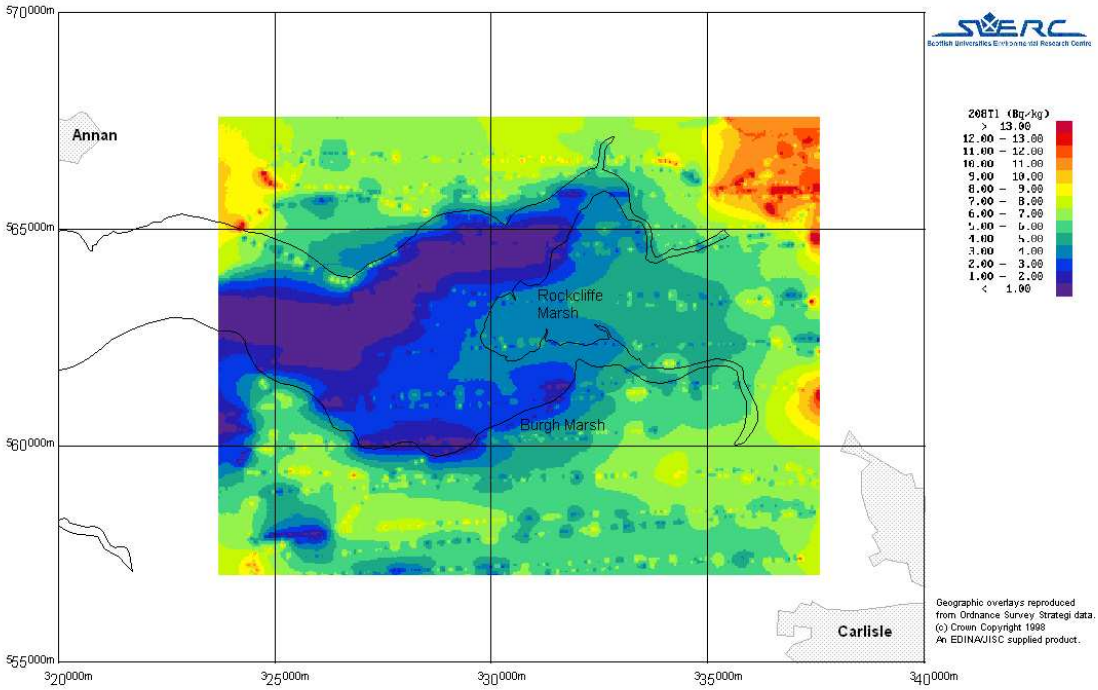

Figure 6: ^{208}Tl (thorium series) distribution determined in this survey.

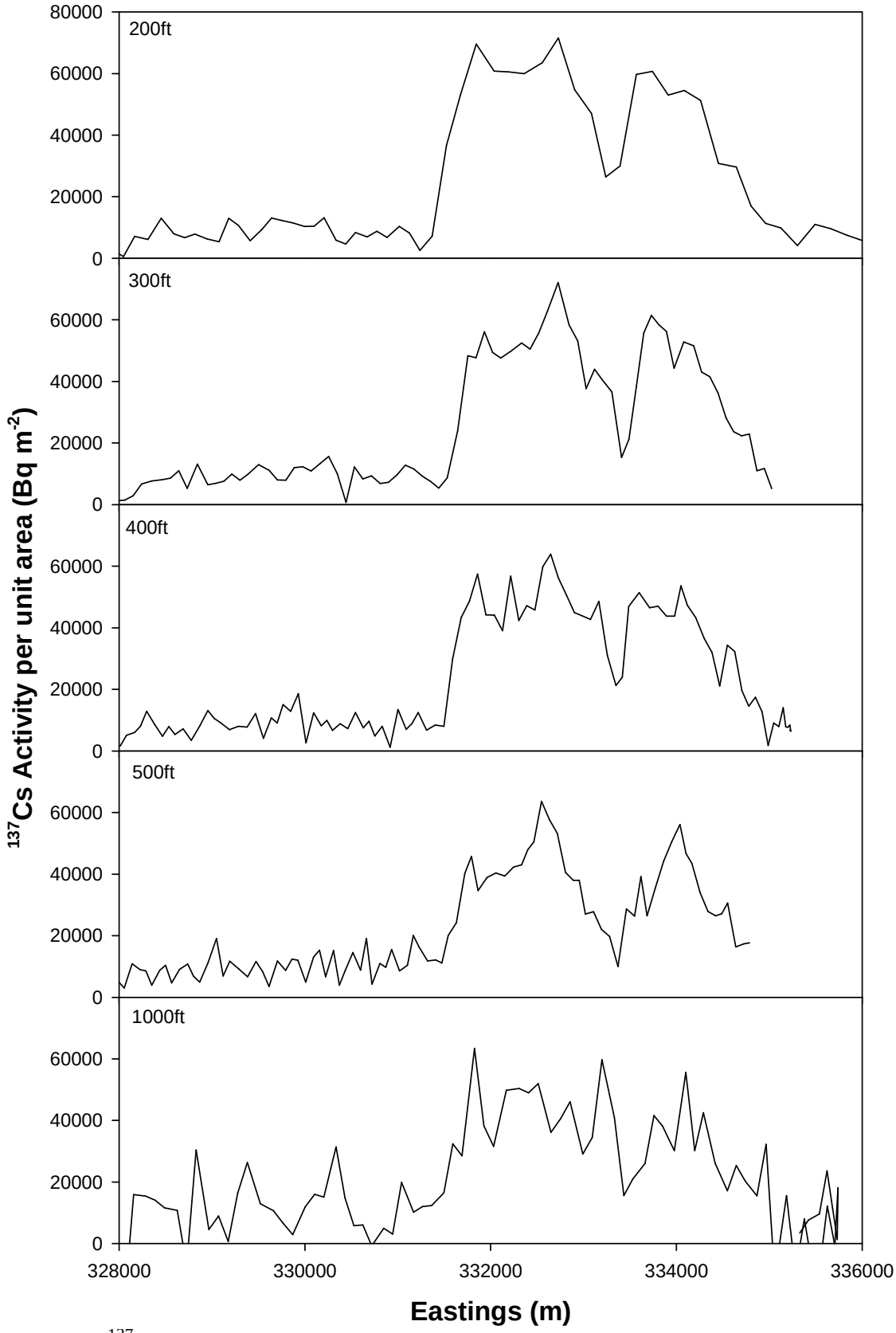

Figure 7: ^{137}Cs activity per unit area measured along the same line at different heights.

Appendix A: Calibration Coefficients Used

Window	Channel Range	Energy Range (keV)	Background (cps)
^{137}Cs	95-132	570-792	52.8±0.6
^{60}Co	170-208	1020-1248	20.7±0.2
^{40}K	220-265	1320-1590	22.4±0.2
^{214}Bi	270-318	1620-1908	9.5±0.1
^{208}Tl	390-450	2340-2700	7.8±0.1
Gamma dose rate	75-480	450-2880	199±2

Table A1: Spectral windows and background values.

	^{137}Cs window	^{60}Co window	^{40}K window	^{214}Bi window	^{208}Tl window
^{137}Cs source	1	0.169	0	0	0
^{60}Co source	0.662	1	0.531	0	0
^{40}K source	0.738	0.506	1	0	0
U source	3.919	1.660	0.959	1	0.044
Th source	3.896	1.201	0.896	0.662	1

Table A2: Stripping matrix.

Window	Altitude correction coefficient	Sensitivity coefficient	Unit
^{137}Cs	0.0071	0.207	kBq m^{-2}
^{60}Co	0.0080	1	cps
^{40}K	0.0090	2.99	Bq kg^{-1}
^{214}Bi	0.0100	6.25	Bq kg^{-1}
^{208}Tl	0.0112	0.538	Bq kg^{-1}
Gamma dose rate	0.0077	0.0007	mGy a^{-1}

Table A3: Altitude and sensitivity coefficients.

Root file name	Number of records	Description
Jul02	556	Radar altimeter check at Cumbernauld and transit flight to survey area
Jul03	176	First line of survey
Jul05	999	Seven lines of survey
Jul06	511	Remainder of survey
Jul09	485	A single line at a variety of heights and speeds, and hover manoeuvre

Table A4: Summary of data files.