Scottish Universities Research & Reactor Centre

Report on SURRC Participation in the ECCOMAGS Project Resume 2002 Exercise

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Summary

The SURRC Airborne Gamma Spectrometry (AGS) team participated in the ECCOMAGS Project Resume 2002 Exercise held in SW Scotland between 24th May and 4th June 2002. The SURRC team used a recently upgraded system comprising an electronics and computing rack, a 16 litre NaI(Tl) detector and a single 50% relative efficiency Ge (GMX) detector. The equipment was successfully installed in the field, and, apart from a few minor bugs in the software that were corrected, performed well.

The SURRC team collected data from the whole of each of three common areas and 2½ of the composite mapping areas between 28th and 31st May. In total some 30000 NaI(Tl) spectra were recorded, with approximately 16500 GMX spectra, in 22 hours of survey time covering an area of approximately 800 km^2.

Spectral stripping factors for the NaI(Tl) system were determined from calibration pads just prior to deployment. Background measurements were made on at least a daily basis during the exercise, and altitude correction factors were determined from hover manoeuvres over the Inch Farm calibration site. A sensitivity coefficient for ^{137}Cs activity per unit area determined from the Inch Farm data was consistent with values determined previously on similar sites. A value for dose rate conversion used for many years, and verified against ground based measurements on several occasions, was used. At present the natural activity data has not been evaluated.

Processed data for the NaI(Tl) system reporting ^{137}Cs activity per unit area and dose rate were provided to the exercise coordinators, along with a full spectral record and maps produced from this data, before the end of the exercise. No changes to the data processing coefficients have been applied since the exercise. The GMX ^{137}Cs data was processed after the exercise, and submitted to the exercise coordinators in January 2003.

The results of the survey flights, both dose rate and ^{137}Cs activity per unit area, are presented here. The results for the common areas agree very well with those produced by other European AGS teams participating in the exercise, and the ground based measurements.

Acknowledgements

The Airborne Gamma Spectrometry (AGS) team at the Scottish Universities Research and Reactor Centre are grateful for the financial support and encouragement given to them by the sponsoring organisations SNIFFER (Scottish and Northern Ireland Forum For Environmental Research), Scottish Executive, Environmental and Heritage Service (Northern Ireland), Scottish Environment Protection Agency, the Environment Agency, and British Nuclear Fuels, as well as the Food Standards Agency (London). They are also grateful to the European Commission - DG RTD for support for team mobilisation costs.

The aircraft used for the exercise was supplied by PDG Helicopters, and flown by Campbell Brant. Liquid nitrogen, for cyrogenic cooling of the Ge detector, was supplied by Lloyds Syddell. Anne Sommerville and Mark Giannitrapani assisted with fieldwork.

The team are also grateful to Mr David Brinton, Assistant Factor for the Earl of Stair Estates for allowing helicopter access to the private airfield on the Stair Estate for aircraft parking and refuelling, and to West Freugh airbase for refuelling services and hanger facilities.

Contents

1. Introduction

Airborne gamma ray spectrometry (AGS) has a unique capability for recording environmental radioactivity over large areas in short timescales. For this reason it is emerging as a key technique for gathering information on radioactive contamination for emergency response. Recent work, in particular a Concerted Action funded under the European 4th Framework and the ongoing ECCOMAGS project (European Calibration and Coordination of Mobile and Airborne Gamma Spectrometry) funded under the European 5th Framework, has established the role of AGS in nuclear emergency response. This has included the production of draft protocols on using AGS methods for mapping dose rate and radionuclide deposition as a first step towards harmonisation of methodology and standardisation of results. A major component of the ECCOMAGS project is to test and validate these procedures in the form of an international collaborative trial.

To this end, an exercise took place between the 24th of May and the 4th of June 2002 with operations conducted from the West Freugh airbase, located in the Dumfries and Galloway region of SW Scotland. Airborne and ground-based measurements were taken at three calibration sites (pre-characterised prior to the exercise) and three common areas to facilitate intercomparisons between airborne measurement teams, and between airborne and ground based methods. Additional tasks involving surveying of adjacent areas were defined to demonstrate the capability of AGS to map large areas collaboratively.

The Airborne Gamma Spectrometry (AGS) team based at SURRC fully participated in this exercise. This report details the instrumentation and methodology employed by the SURRC team during the exercise, and the results of the survey tasks.

2. Equipment

The system used by the SURRC team consisted of a high volume 16 litre thallium doped sodium iodide (NaI(Tl)) spectrometer, a single 50% efficiency Ge semiconductor (GMX) detector, an electronics rack containing power supplies, nucleonics and computer and two GPS systems. The first GPS system, a Navstar unit attached to the electronics rack and connected to the logging computer, was used to log the aircraft position at the start and end of each spectrum recorded. The second system, a hand held Garmin unit, was programmed with waypoints for the survey grids and was used by the pilot for navigation.

The equipment used was an updated system, based on the same principles as the older systems that have been used by the SURRC team for many years. The new system uses a more modern computer, a detector pack with new or refurbished crystals, new MCA cards allowing greater flexibility in the use of different detector systems, and custom software written in C++ using the same principles as the older software. The computer contains a 600MHz Celeron processor, with 128MB RAM and a 10GB hard drive, with an internal IDE 250MB ZIP drive for data back up. A 14bit analogue-to-digital/digital-to-analogue (ADDA) card is used to measure the voltage output of the aircrafts' radar altimeter. An Ortec μACE multichannel buffer card was installed to collect spectra from the NaI(Tl) detector. An Ortec 920E 16 input MCB with computer interface card were used to collect spectra from the GMX detector, the extra channels could be used to collect data from additional Ge detectors. The software uses the same data acquisition method and data storage formats as codes used on the older systems, with changes to the user interface (including an optional spectral display) and real-time spectral analysis using six spectral windows.

The equipment was installed in a twin engine AS355 Squirrel helicopter, fitted with a radar altimeter, at the disused Castle Kennedy airfield just to the north of the West Freugh airbase on the morning of Sunday 26th May 2002, as the airbase itself was closed over the weekend. Initial test flights were conducted, including calibration of the radar altimeter reading by means of a hover manoeuvre and background measurements over Luce Bay, and exercise survey tasks were started. Later analysis of the data, specifically the background measurements, indicated that one of the crystals was not operating; checks determined that this was because it hadn't been turned back on following trimming of the detector pack.

During the course of the survey a few minor faults with the system were noted. Some software bugs were corrected during the survey, although a major bug which prevented the use of the more sophisticated Garmin GPS unit for position logging was not fixed until after the exercise. A faulty earth connection in the cable connecting the rack to the aircraft power supply was noted towards the end of the survey. This resulted in a loss of the radar altimetry signal due to earthing through the cable. The fault was fixed in the field and the suspect ground clearance data checked by comparison of the altitude recorded by the GPS system with a Digital Terrain Model (DTM), which showed that the recorded ground clearance was OK.

3. Methods

3.1 Overview of Method

The detector system performance (gain, resolution and sensitivity) was checked at the start of each day, and trimmed as necessary. Background measurements were made over Luce Bay at the start or end of most survey flights. During flight the NaI(Tl) detector gain was monitored using the ^{40}K peak at 1462keV. Spectra were recorded from the NaI(Tl) spectrometer with a 2s integration time, and 4s for the GMX detector. Files containing 2 NaI(Tl) spectra and one GMX spectrum were written to disk, together with timing information, GPS positioning data and time-averaged radar altimetry data.

Six spectral windows were defined, 5 nuclide specific channels (for ^{137}Cs, ^{60}Co, ^{40}K, ^{214}Bi and ^{208}Tl) and a sixth window corresponding to 450-3000keV was used to determine dose rate. Background count rates for each of these channels were determined from flights over Luce Bay. Spectral stripping factors were determined for the 5 nuclide specific spectral channels using doped concrete calibration pads prior to installation. Altitude correction factors were determined from hover manoeuvre data, and sensitivity factors were used to convert stripped altitude corrected count rates in each window to calibrated values for nuclide specific activity concentrations and dose rate. These sensitivity factors were determined in reference to the Inch Farm calibration site.

Values for the detector backgrounds in each of the 6 windows, altitude correction factors and sensitivity coefficients were used within the data acquisition code to write gross, net and stripped count rates and calibrated values to summary files during acquisition. At the end of each day all the data were copied from the hard drive onto ZIP disk for archival and restored to another computer for verification of data integrity.

3.2 Details of Data Processing Method

The data processing algorithm used converts the number of counts in a given window, N_i, to calibrated activity concentration, A_i, by a number of steps. The number of counts in a window i is converted to a gross count rate, C_{gi}, by dividing by the integration time. A net count rate, C_{ni}, is then produced by subtraction of a background count rate, C_{bi}, recorded over water.

$$C_{ni} = C_{gi} - C_{bi}$$

Spectral interferences between channels are then stripped from the net count rate data. A stripping matrix, $\boldsymbol{S}$, giving the fractional interference for each nuclide window in the other nuclide windows, is formed from data collected from a series of calibration pads with perspex absorber sheets to simulate an air path of several 10 s of metres. The inverse of the stripping matrix is applied to a vector containing the net count rates in each of the five radionuclide channels, $\boldsymbol{c_n}$, producing a vector containing the stripped counts in these channels, $\boldsymbol{c_s}$.

$$\mathbf{c}_s = \mathbf{S}^{-1}\ \mathbf{c_n}$$

This is coded simply as a series of linear equations in which the elements of $\boldsymbol{c_s}$, C_{si}, are the sum over all five radionuclide channels of the product of the elements of $\boldsymbol{c_n}$ and the elements s_{ij}^{-1} of the inverted stripping matrix.

$$C_{si} = \sum_j C_{nj}\ s_{ij}^{-1}$$

Differences between the laboratory geometry and field geometries, as well as possible differences in detector performance in the laboratory and field, may introduce small systematic errors in the stripping. These can be corrected for by using a small intercept in the sensitivity calibration coefficients, although this requires the use of at least two calibration sites with different activity levels.

The altitude correction coefficients normalize the stripped data to a ground clearance of 100 m, using an exponential altitude dependence. The altitude corrected count rates, C_{ai}, are determined from the stripped count rates, C_{si}, by:

$$C_{ai} = C_{si}\, e^{(A-100)*a_{ci}}$$

where A is the ground clearance and a_{ci} the altitude correction coefficient. The altitude correction coefficient is determined from the gradient of a plot of the logarithm of stripped count rates against altitude at the calibration site.

The sensitivity calibration constants, s_i and s_i', convert the altitude corrected stripped count rates to calibrated activity concentration units (kBq m^{-2} or Bq kg^{-1}). They are determined from the slope (s_i) and intercept (s_i') of a plot of stripped count rate against activity concentration on the calibration sites for calibration manoeuvre data. To determine the intercept at least two calibration sites are required; for this exercise a single calibration site (Inch Farm) has been used for the analysis, so a zero intercept is used. The calibrated activity is simply:

$$A_i = s_i C_{ai} + s_i'$$

The principal source of uncertainties for open field geometries is the statistical counting error in the gross count rate, ΔC_{gi}.

$$\Delta C_{gi} = \frac{\sqrt{N_i}}{T}$$

where T is the integration time and N_i is the number of counts in channel i, which is simply $C_{gi}T$. This could be reduced by using a longer integration time, but at the expense of the spatial precision of the reading. The uncertainty in net count rates, ΔC_{ni}, includes the error in the background count rate, ΔC_{bi}.

$$\Delta C_{ni} = \sqrt{\Delta C_{gi}^2 + \Delta C_{bi}^2}$$

In practice, C_{bi} is determined from a large number of readings and has a negligible uncertainty in comparison to the uncertainty of a single measurement.

The stripping procedure introduces an uncertainty in each radionuclide channel that is dependent on the uncertainties on the net count rates of other radionuclides in the environment. Due to the relatively large number of spectra recorded with long (30 s) integration times used to determine the stripping matrix, the statistical uncertainties of the elements of the stripping matrix are negligible and are not considered in this analysis. The uncertainty in the net count rate is propagated through the stripping matrix

$$\Delta C_{si}^2 = \sum_j (\Delta C_{ni} \;\; s_{ij}^{-1})^2$$

This uncertainty derived solely from counting statistics is then used for the uncertainty on the calibrated values after application of the relevant altitude correction and sensitivity factors, and included in the PRD output.

The data are mapped using an inverse distance weighted algorithm of the form r^{-p} with p and a maximum search range determined empirically to produce a smoothed map that highlights the features of interest without either over-emphasizing individual results or over-smoothing. The mapping program generates bitmap images with geo-referencing information in a separate text file, which can then be imported into GIS packages where a vector map overlay can be applied to produce final maps.

3.3 Data analysis

3.3.1 NaI(Tl) data

Background values were determined over open water at least once each day, during this exercise these measurements were made over Luce Bay. The background values measured are given in Table 3.1. The background values on the 26th May were recorded using 3 crystals and scaled by 4/3, the mean of these values were used for subsequent analysis. As it can be seen, the later measurements do not vary significantly from these values. Table 3.2 shows a comparison of these values with earlier surveys. It can be seen that the backgrounds are comparable to more recent surveys (which used the same aircraft), and considerably less than the 1996 surveys (using a different aircraft).

A set of measurements on calibration pads was performed on the 25th May at SURRC to determine the stripping factors for the new detector pack. Four pads are used, three doped with ^{40}K, uranium and thorium and a blank pad; with additional measurements with sheets doped with ^{137}Cs or a point ^{60}Co source placed on the blank pad. Approximately 10mins of spectra were recorded with 7 perspex absorbers, equivalent to approximately 70m of air, between the detector and each pad. The stripping factors determined for the detector are given in Table 3.3. Comparison of these with previous measurements of stripping factors, in November 2000, given in Table 3.4 shows greater scatter of uranium and thorium gamma rays (^{214}Bi and ^{208}Tl peaks) into lower energy spectral windows. This is possibly due to the presence of a thin sheet of aluminium in the base of the new detector pack for strengthening the case.

The stripped count rates from hover manoeuvre data at the Inch Farm calibration site were plotted against altitude using a log scale. The slope of the regression through these data points give the altitude correction factors. These are given in Table 3.5, along with values from previous surveys. It can be seen that these factors are extremely stable, even with different aircraft used.

The stripped altitude corrected count rates for the data collected during the hover manoeuvre at the Inch Farm calibration site were used to generate sensitivity factors with reference to the working values for the activities determined during pre-characterisation field work and past experience of detector calibration including previous calibrations, Monte Carlo simulations of detector response and theoretical modelling of the effect of source depth profiles. The sensitivity values used for this exercise, along with those used in other recent surveys, are given in Table 3.6.

The dose rate sensitivity factor used is one that has been used by the SURRC team for many years, and is reported in the SURRC Annexe to the dose rate protocol (ECCOMAGS 2002). The dose rates determined by AGS using this method have been favourably compared to ground based measurements on several occasions (Sanderson *et al* 1992, Sanderson *et al* 1993).

The sensitivity factor for ^{137}Cs used was determined for the measurements at Inch Farm. It is similar to the calibration factors determined in recent surveys (in 1999 and 2000) using calibration sites on the Caerlaverock salt marsh in the Inner Solway, with a mean mass depth of approximately 15 g cm^{-2}. During some recent work in NW Cumbria it was shown that ^{137}Cs activity concentrations from a terrestrial site, with a mean mass depth of 8.5 g cm^{-2} determined from a limited set of soil samples, were over estimated by a approximately 20% using the Caerlaverock calibration. From this previous experience, a sensitivity of approximately 0.27 kBq m^{-2} cps^{-1} would be appropriate for such a terrestrial environment. This was, however, for the old detector pack whereas the new pack has a 5mm thick aluminium sheet inside the pack for structural support. It would be expected that this would provide some additional attenuation of the signal, and hence increase the sensitivity constant above this level. The 0.32 kBq m^{-2} cps^{-1} value used here would not seem unreasonable.

Date	Time	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6
26/05	1125	39.5±0.6	13.4±0.4	14.4±0.4	7.4±0.3	5.6±0.3	143±1
	1410	39.9±0.7	14.6±0.4	15.6±0.4	6.9±0.3	6.0±0.2	145±1
27/05	1840	34.2±0.8	13.5±0.5	14.7±0.5	6.3±0.3	5.3±0.3	129±1
	1940	34.0±0.7	13.9±0.5	16.0±0.5	5.8±0.3	5.7±0.3	130±1
28/05	1015	36.7±2.2	12.4±0.6	15.9±0.7	7.1±0.7	5.8±0.5	134±2
	1230	37.4±0.8	14.7±0.6	15.6±0.6	7.9±0.3	5.9±0.4	141±2
	1315	38.2±0.5	14.7±0.3	15.6±0.4	7.0±0.3	5.5±0.2	140±1
	1610	42.1±1.1	16.2±0.7	17.9±0.7	9.2±0.4	5.4±0.5	154±3
29/05	1005	35.1±1.1	12.7±0.5	15.4±0.5	6.9±0.5	5.1±0.3	133±2
Values used		39.7±0.5	14.0±0.3	15.0±0.3	7.2±0.2	5.8±0.2	144±1

Table 3.1: Background count rates for the NaI(Tl) system measured during the exercise.

Date	Survey	Ch1	Ch2	Ch3	Ch4	Ch5	Ch6
May 2002	ECCOMAGS Exercise	39.7±0.5	14.0±0.3	15.0±0.3	7.2±0.2	5.8±0.2	144±1
June 2000 Sanderson *et al* 2001b	DETR West Cumbria	34.5	14.2	15.9	7.9	7.4	155
March 2000 Sanderson *et al* 2001a	DETR West Cumbria	39.0	15.5	17.0	7.3	7.3	154
October 1996 Sanderson *et al* 1997b	Sizewell	53.8	20.1	21.5	11.7	8.9	202
September 1996 Sanderson *et al* 1997a	Newbury	54.6	20.4	21.2	11.6	9.7	205

Table 3.2: Comparisons of NaI(Tl) backgrounds over previous surveys.

	Window				
	^{137}Cs	^{60}Co	^{40}K	^{214}Bi	^{208}Tl
^{137}Cs	1	0	0	0	0
^{60}Co	0.45	1	0.21	0	0
^{40}K	0.72	0.51	1	0	0
^{214}Bi	4.63	1.99	1.04	1	0
^{208}Tl	4.19	0.87	0.81	0.60	1

Table 3.3: Stripping factors measured May 2002.

	Window				
	^{137}Cs	^{60}Co	^{40}K	^{214}Bi	^{208}Tl
^{137}Cs	1	0.005	0	0	0
^{60}Co	0.51	1	0.52	0.037	0.024
^{40}K	0.67	0.49	1	0	0
^{214}Bi	3.37	1.52	0.96	1	0.075
^{208}Tl	2.53	0.69	0.62	0.45	1

Table 3.4: Stripping factors measured November 2000 (Sanderson *et al* 2001c).

Window	May 2002	April 1999-June 2000 Sanderson *et al* 2000, 2001a, 2001b	September 1996 Sanderson *et al* 1997a
1	0.0130	0.0132	0.013
2	0.011	0.010	0.01
3	0.00898	0.010	0.01
4	0.00584	0.00661	0.009
5	0.00760	0.00768	0.007
6	0.00945	0.00945	0.0098

Table 3.5: Altitude correction coefficients for the NaI(Tl) system.

Window	May 2002	June 2000 Sanderson *et al* 2001b	April 1999 Sanderson *et al* 2000	September 1996 Sanderson *et al* 1997a	Units
1	0.321	0.340	0.282	0.11	kBq m^{-2}
2	1	1	1	1	cps
3	11.44	6.817	6.78	6.77	Bq kg^{-1}
4	3.77	2.019	3.16	3.16	Bq kg^{-1}
5	0.819	0.575	0.47	0.47	Bq kg^{-1}
6	0.0007	0.0007	0.0007	0.0007	mGy a^{-1}

Table 3.6: Sensitivity coefficients for the NaI(Tl) system.

3.3.2 Ge data

The data processing method used for the Ge spectrometry data was identical to that employed for the NaI(Tl) system, except no spectral stripping was employed. Six spectral windows were defined covering peaks for ^{241}Am, ^{137}Cs, ^{60}Co, ^{40}K, ^{214}Bi and ^{208}Tl. In principal a background could be determined using spectral windows on either side of the peaks with an interpolation between them, however here the backgrounds were determined from measurements over water. Low statistics in the spectral windows corresponding to all isotopes except ^{137}Cs resulted in no altitude correction and sensitivity coefficients being defined for these. The data for ^{137}Cs were, however, calibrated using data collected from the hover manoeuvre at the Inch Farm calibration site. An additional window, reporting simple count rates for a low energy window, was used to aid identification of data affected by microphonics that were then deleted from the calibrated data set.

4. Results

The SURRC team collected data from the whole of each common area (X on the 28th and 29th May, Y on the 28th May and Z on the 29th May), the whole of composite areas F (29th and 30th May) and D excluding the common area already surveyed (31st May) and the northern half of area E at 1km line spacing (31st May). Details of the survey flights are given in Table 4.1. In total approximately 30000 NaI(Tl) spectra were recorded using all four crystals (with a further 4500 using 3 crystals) and 16500 GMX spectra were recorded during some 22h survey time. The data recorded using 3 NaI(Tl) crystals has not been analysed at present.

4.1 NaI(Tl) data

The ^{137}Cs activity per unit area and environmental dose rate determined for area X are shown in Figure 4.1. It can be seen that the highest levels of ^{137}Cs activity and dose rate are associated with the estuarine salt marshes at Wigtown and Baldoon Sands, with the River Bladnoch producing a distinct negative feature separating the two areas of salt marsh. Areas of higher ^{137}Cs activity are also observed on the higher ground to the south east of Kirkinner and around and to the south of Sorbie. The dose rate distribution in the terrestrial environment shows higher values along the western edge of the higher ^{137}Cs levels, and is associated mostly with the local geological variations rather than Chernobyl fallout. Some areas of very low dose rate to the south of Kirkinner are associated with areas of peat moss (along Dowlaton Burn and Grennan Moss).

The ^{137}Cs activity per unit area and environmental dose rate determined for area Y are shown in Figure 4.2. The ^{137}Cs activity is largely confined the higher ground including Garheugh Fell, Craignarget Hill, Knock Fell, Craiglarie Fell and Challochglass Moor. Conversely, the higher dose rates are observed on the lower lying areas around Auchenmalg and the northern edge of Mochrum Fell to the south of Culshabbin, with low dose rates associated with the peat mosses around the lochs in the eastern part of the survey area. The large lochs in the eastern part of the survey area, Castle Loch and Mochrum Loch, are negative features in both the ^{137}Cs activity and dose rate distributions.

The ^{137}Cs activity per unit area and environmental dose rate determined for area Z are shown in Figure 4.3. The ^{137}Cs activity levels in this area are generally very low, with relatively higher levels on the higher ground to the east of Chlenry Burn. The dose rate for this area is also very low.

The ^{137}Cs activity per unit area and environmental dose rate determined for the composite mapping areas are shown in Figure 4.4. The highest ^{137}Cs activities are associated with the salt marshes around the northern and western sides of Wigtown Bay, with elevated levels also observed on the high ground between the Water of Fleet and Wigtown Bay, Cairnsmore of Fleet and around Wigtown and Whithorn. The highest dose rates are on Cairnsmore of Fleet and the higher ground near the coast of Wigtown Bay and Whithorn.

Date	Start Time	End Time	No. of files	Comments
26/05/02	12:10	14:20	1000	Test flight, background over Luce Bay 14 lines of area X only 3 crystals used
	15:15	16:55	1300	Background over Luce Bay Finish area X IF and WG calibration manoeuvres only 3 crystals used
	17:40	18:25	640	Background over Luce Bay 2 lines in area Y, 1 line in area Z
27/05/02	18:35	19:45	870	Area Z including background CK calibration
28/05/02	10:10	13:10	1740	Background over Luce Bay 18 lines in area Y
	13:15	16:00	1580	Background over Luce Bay 5 lines in area Y, 12 lines in area X
	16:10	17:00	560	Background over Luce Bay 5 lines in area X. Problem with aircraft
	17:45	18:55	720	5 lines in area X. IF and WG calibration (no GPS)
29/05/02	10:00	12:00	1000	Background over Luce Bay 4 lines in area X, 8 lines in area Z CK calibration
	14:00	16:15	1450	7 lines in area F
	17:00	18:40	1100	6 lines in area F
30/05/02	09:30	11:10	960	7 lines in area F
	12:00	13:10	680	5 lines in area F
	16:50	18:05	860	4 lines in area F, gap in area X free flight
31/05/02	09:20	12:10	2090	10 lines in area D (north of area X) area D south of area X free flight radar altimeter failure
	16:00	17:50	1360	9 lines of area E (1km line spacing) 1 line of area D

Table 4.1: Summary of survey flights

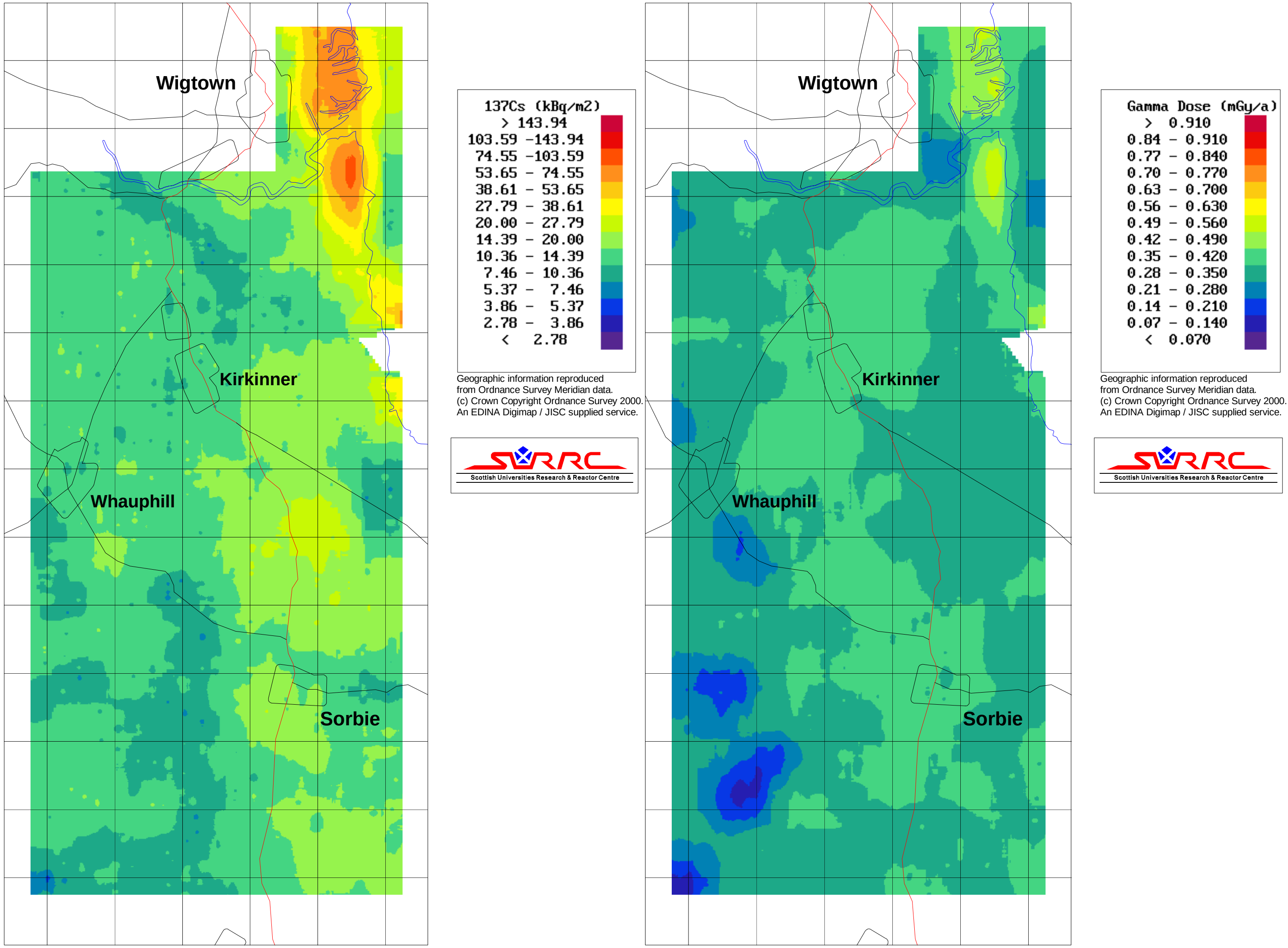


Figure 4.1: ^{137}Cs and dose rate distributions determined from NaI(Tl) data, in area X

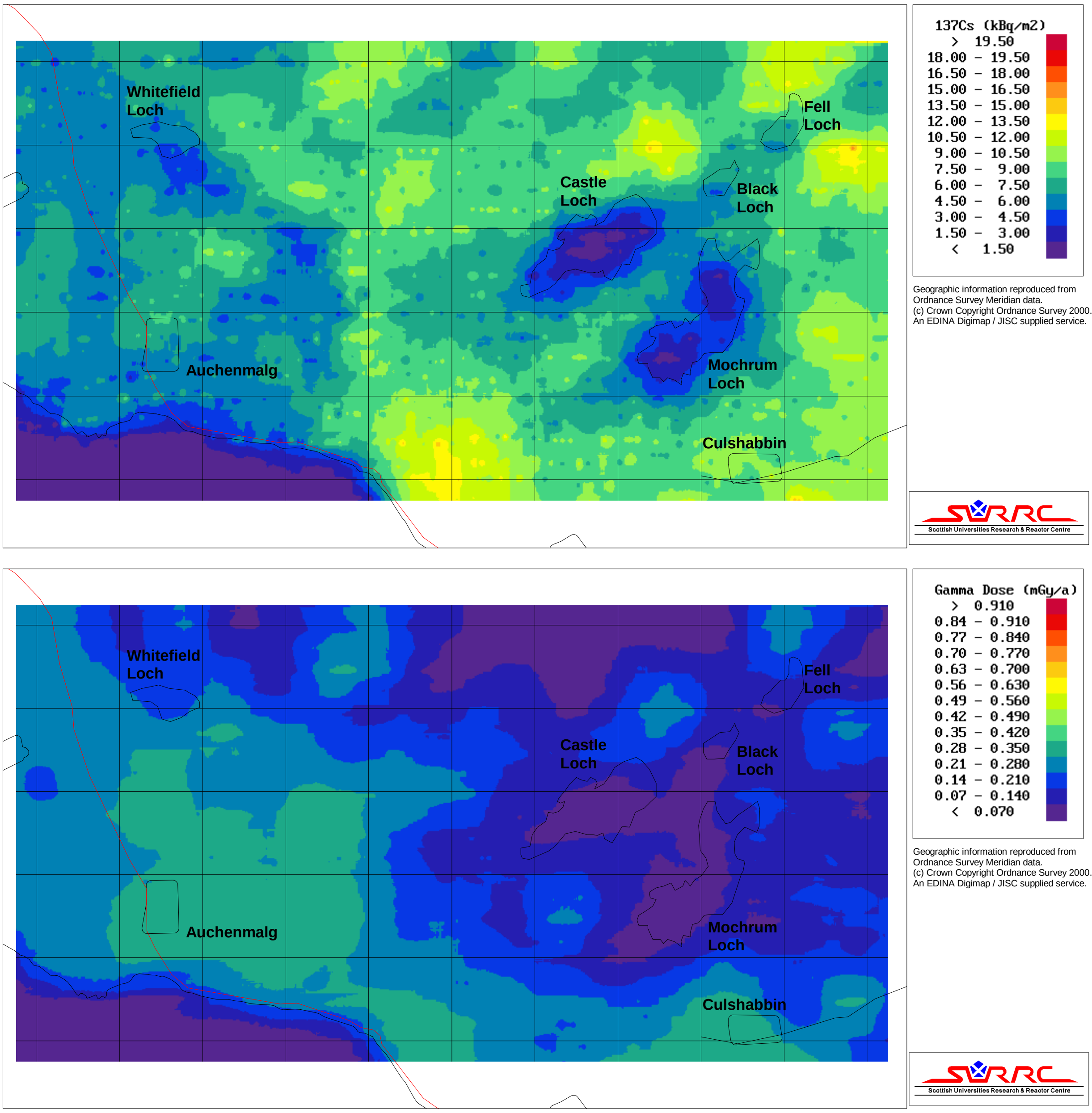
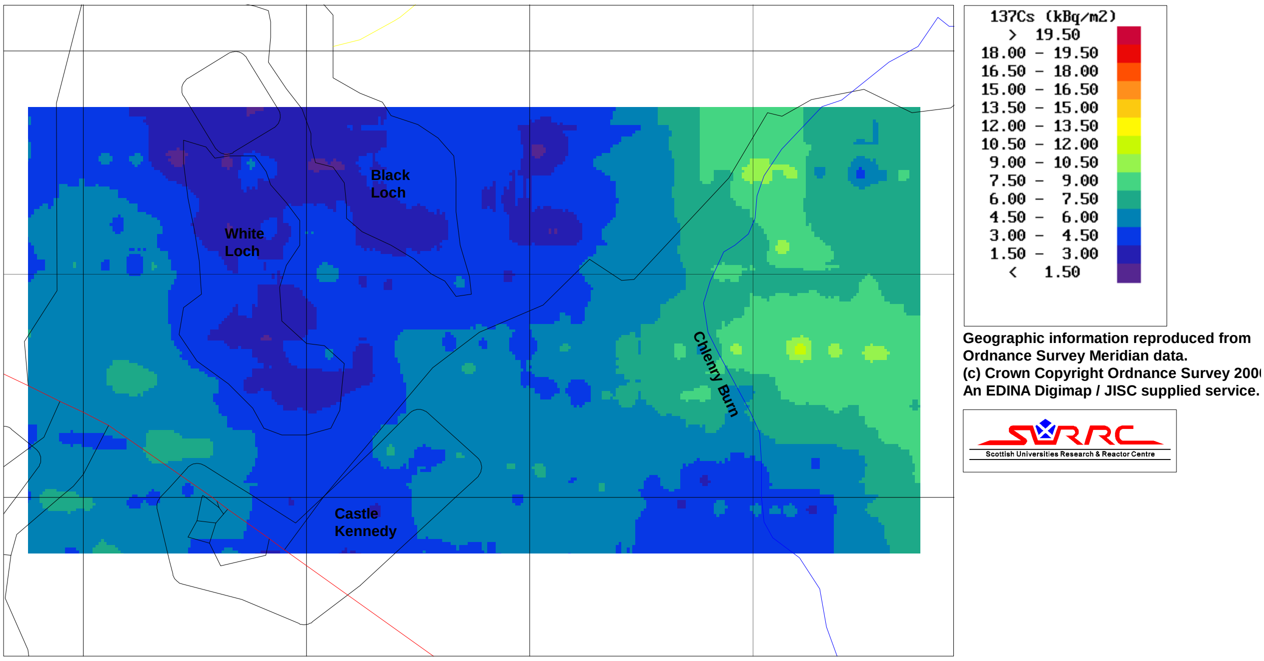


Figure 4.2: ^{137}Cs and dose rate distributions determined from NaI(Tl) data, in area Y



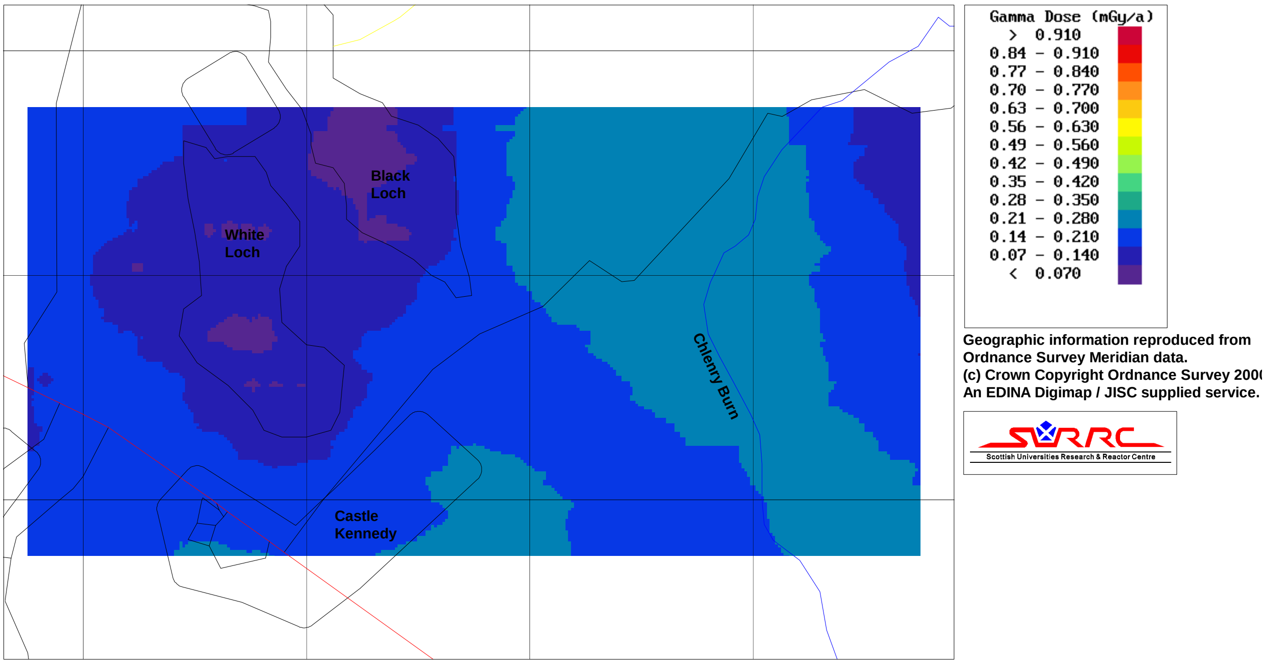


Figure 4.3: ^{137}Cs and dose rate distributions determined from NaI(Tl) data, in area Z

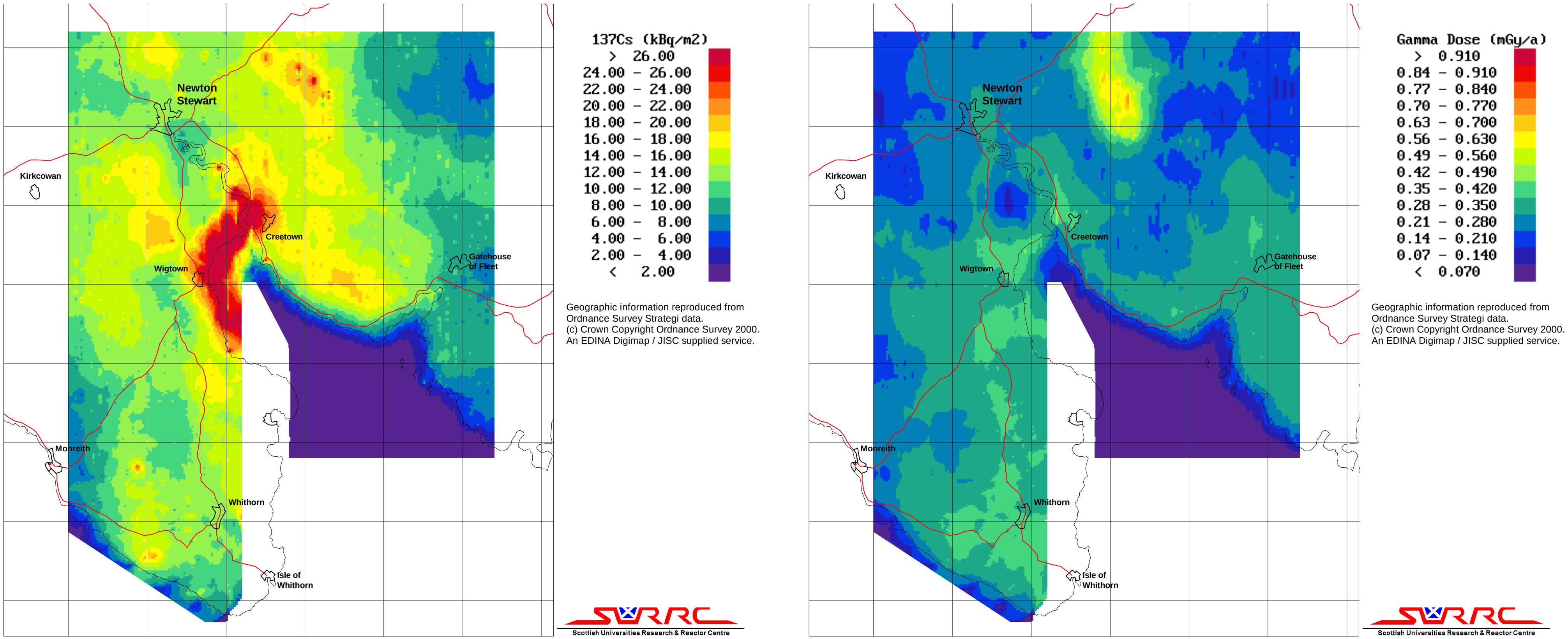


Figure 4.4: ^{137}Cs and dose rate distributions determined from NaI(Tl) data, for the composite areas

4.2 Ge data

The ^{137}Cs distributions in areas X, Y and Z determined from the Ge spectrometry data are shown in Figures 4.5-4.7. In all these areas the overall pattern of the ^{137}Cs distribution is very similar to that determined from the NaI(Tl) systems. There are, however, some noticeable differences in the levels determined. The Ge system gives significantly lower activity per unit area on the salt marsh in area X, and higher activities in areas Y and Z.

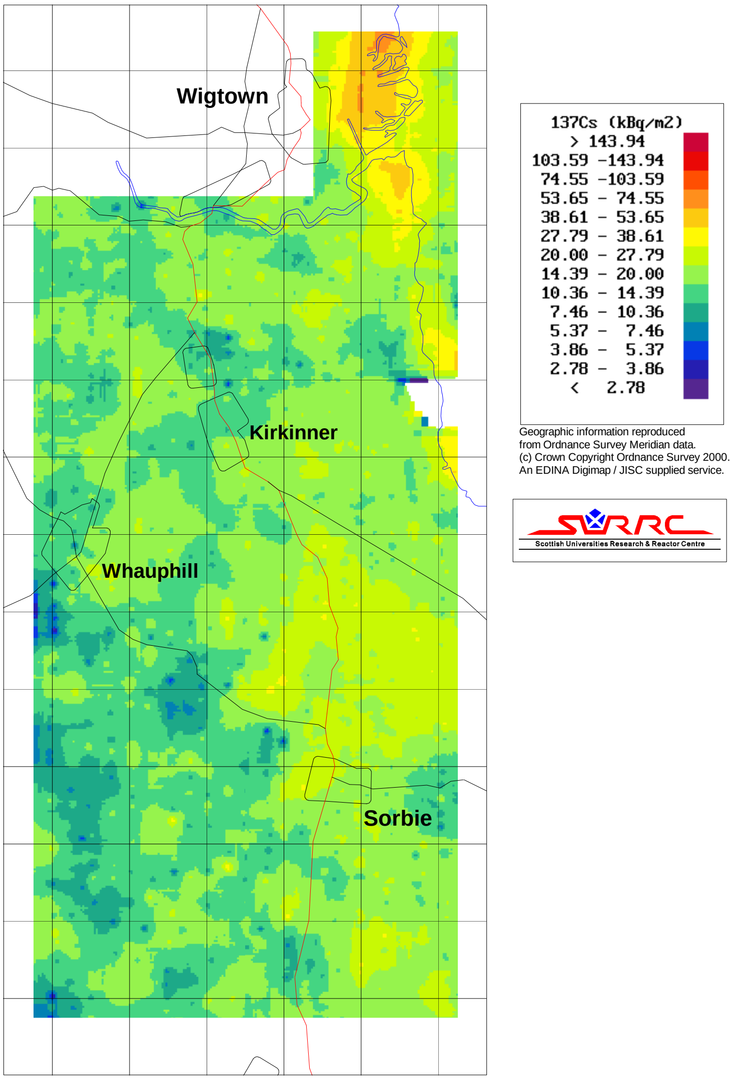


Figure 4.5: ^{137}Cs distribution in area X determined from the Ge spectrometry data.

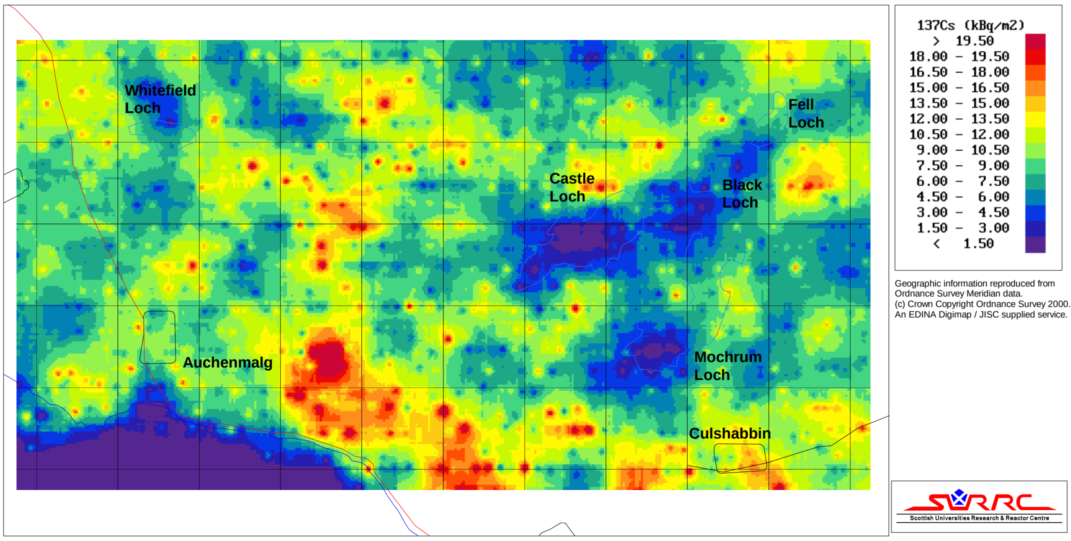


Figure 4.6: ^{137}Cs distribution in area Y determined from the Ge spectrometry data

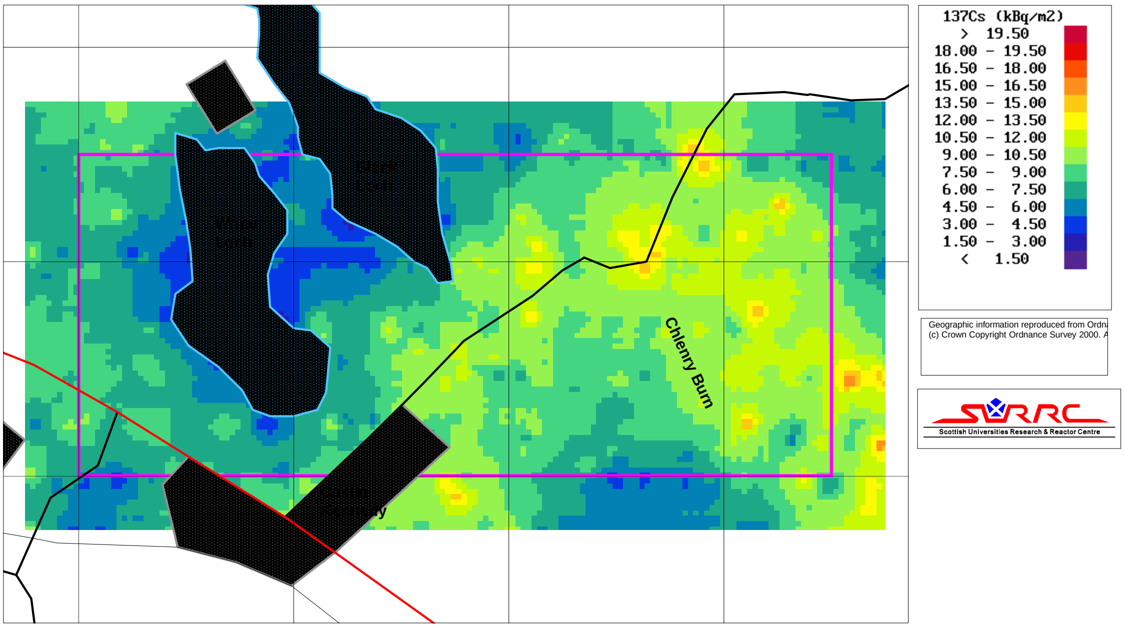


Figure 4.7: ^{137}Cs distribution in area Z determined from the Ge spectrometry data

5. Conclusions

The SURRC AGS team successfully participated in the ECCOMAGS Project Resume 2002 exercise held between 24th May and 4th June in Dumfries and Galloway, SW Scotland. During the course of the exercise, data was collected from an area of approximately 800 km^2, comprising the three calibration sites, the three common areas and 2½ of the composite mapping areas. This amounted to some 30000 NaI(Tl) and 16500 GMX spectra, collected in 22 hours of survey time.

The NaI(Tl) data were processed and mapped during the exercise, and the resulting calibrated data files for ^{137}Cs activity per unit area and dose rate along with maps and the full spectral data were submitted to the exercise coordinators prior to the end of the exercise. The GMX data were analysed after the exercise, and submitted to the coordinators in January 2003.

With the exception of a few minor bugs with the software that were fixed during the exercise, the upgraded detector system performed very well. The data produced compare very well to the other European AGS teams and the ground based measurements.

Some differences between the NaI(Tl) and GMX results have been noted, specifically in areas of low ^{137}Cs activity and localised features, reflecting differences in the angular response of the detector systems and the significantly lower efficiency of the GMX system.

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