

# British nuclear bomb tests at Emu Field, South Australia: using legacy geophysical datasets to map radioactive fallout

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## SUMMARY

The British government conducted twelve atomic bomb tests in Australia during the 1950s. The best known are the seven tests conducted at Maralinga in South Australia, but these followed three earlier tests at the Montebello Islands in Western Australia and two tests at Emu Field in South Australia, about 170 km north of Maralinga.

The tests at Emu Field, known as TOTEM-1 and TOTEM-2, were the second and third atomic tests conducted by the British government, and less documentation is available about these tests compared to the later ones at Maralinga. Details about the radioactive fallout from the tests are very limited, and many of the documents relating to all aspects of the tests remain confidential in the British government archives more than seventy years later.

In this study, we show that the distribution of radionuclides following the nuclear tests at Emu Field in 1953 can be extracted from publicly available conventional airborne gamma-ray spectrometry data acquired in 1994 and 2001. Only the 4-channel data is available, so we use ratios of the existing channels to extract the  $^{137}\text{Cs}$  signature. Our results show that the radioactive plumes are still readily detected without complex processing, although a more detailed picture would be possible with a properly calibrated survey.

This study highlights the importance of high-resolution airborne geophysical surveys, both for ongoing monitoring of potential health hazards from radioactive fallout, and to answer some ongoing questions about the type of nuclear testing conducted at Emu Field in 1953.

Key words: airborne gamma-ray spectrometry, radiometrics, airborne, Maralinga, Emu Field, nuclear tests,  $^{137}\text{Cs}$  (Caesium 137),  $^{239}\text{Pu}$  (Plutonium 239),  $^{240}\text{Pu}$  (Plutonium 240),

## INTRODUCTION

The British government conducted twelve atomic bomb tests in Australia during the 1950s. The best known are the seven tests conducted at Maralinga in South Australia, but these followed three earlier tests at the Montebello Islands in Western Australia and two tests at Emu Field in South Australia, about 170 km north of Maralinga.

The tests at Emu Field, known as TOTEM-1 and TOTEM-2, were probably designed to experiment with the ratios of  $^{240}\text{Pu}$  and  $^{239}\text{Pu}$ , as a higher proportion of  $^{240}\text{Pu}$  could make the bomb very unstable. However, the composition of the bombs was never made public (Tynan, 2022).

The first test, TOTEM-1, was conducted despite the wind conditions being considered unsuitable from a safety perspective, sending a plume of radioactive fallout across the continent towards the NE coast near Townsville. No detailed ground mapping of the plumes was done. TOTEM-2 was conducted under more suitable wind conditions, but the direction and extent of fallout was not measured. Following the TOTEM-2 test, the Emu Field test site was abandoned, and no significant rehabilitation has been conducted.

During a cleanup in 1967, larger pieces of material were collected by hand, and circular regions of about 125 m radius around each ground zero were tilled or covered with soil (Maclagan et al., 1979). No further clean up was considered necessary during the 1980s and 1990s when extensive rehabilitation was undertaken at Maralinga (MARTAC, 2003)

In the past thirty years, several airborne geophysical surveys for mineral exploration have been conducted

over the TOTEM sites; however, the raw data has not been preserved, and only four-channel radiometric data is available. In this study, we have used two radiometric surveys acquired in 1994 and 2001, and extracted a signature for the man-made radioactive nuclides, likely representing the  $^{137}\text{Cs}$  plume from the nuclear bomb blasts. We also present maps showing the calculated dispersion of radioactive clouds across Australia, which concur with the limited measurements of radioactive fallout available from the time.

## DATA

The TOTEM blast sites were separated by about 1600 m, with TOTEM-2 to the SSE of TOTEM-1. The blast zone is at the junction of several airborne radiometric surveys, with the unfortunate result that no single survey completely covers both radioactive plumes. The TOTEM-1 plume is imaged by a 1994 survey, and the TOTEM-2 plume is imaged by a 2001 survey (Table 1).

	<b>1994SA003</b>	<b>TEISA Officer</b>
<b>Geoscience Project</b>	SAEI A9 -Project 717	Officer Basin – Project 476
<b>Survey Company</b>	World Geoscience Corporation	Tesla Airborne Geoscience
<b>Client</b>	Mines & Energy SA (MESA)	PIRSA
<b>Survey Type</b>	Magnetic and Radiometric	Magnetic and Radiometric
<b>Area Name</b>		Officer Basin
<b>Flown</b>	1994	2001
<b>Datum / Projection</b>	WGS84	GDA94 / MGA52
<b>Survey Line Spacing</b>	400 metres	400 metres
<b>Survey Line Direction</b>	N-S	N-S
<b>Nominal Terrain Clearance</b>	60 metres	80 metres
<b>256 channel data available</b>	No	No

Table 1. Survey specifications for two airborne radiometric surveys over Emu Field between 1994 and 2001.

We also constructed simple trajectory models and models of the atmospheric dispersion of the radioactive cloud following the blasts, using a web-based modelling developed by the National Oceanic and Atmospheric Administration (NOAA) Air Resources Laboratory (Stein et al., 2015).

## METHOD AND RESULTS

The 256-channel data was no longer available to separate  $^{137}\text{Cs}$  signature from natural sources, so ratios of the 4-channel datasets were used, following the method described in Minty and Brodie, (1994). In addition to the 4-channel datasets, the 1994SA003 survey data included a “uranium-low” channel, which may have been intended to image the  $^{214}\text{Bi}$  signature at 0.61 MeV, although there is no documentation with the survey data which defines this channel.

The most effective ratio to image the  $^{137}\text{Cs}$  plumes was achieved by dividing the sum of the K, Th and U channels by the total count channel. The results are poorly constrained due to the lack of information about the naturally-occurring spectra and the lack of ground calibration, but they nevertheless show a clear NE-trending plume from the TOTEM-1 test extending for at least 25 km, and a stronger but less extensive south-trending plume from the TOTEM-2 test.

Maps of the bomb trajectories and atmospheric dispersion of the radioactive clouds match with the limited documentation of the TOTEM tests and suggest that the dispersion cloud for TOTEM-1 reached the east coast of Australia near Townsville after about 72 hours, and the dispersion cloud for TOTEM-2 was directed south over Adelaide and then Melbourne.

## CONCLUSIONS

We show that the radioactive plumes from atomic tests conducted at Emu Field in 1953 can be readily detected from 4-channel airborne gamma-ray spectrometry data acquired in 1994 and 2001. However, higher-resolution data, such as that described in Cunneen et al. (2024) for Maralinga, would better constrain the spatial distribution of nuclear fallout at Emu Field, and may provide detail about the nature of the atomic tests.

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## REFERENCES

Cunneen, J., Cunneen, J.P., Jurza, P., Kita, J., & Street, G., 2024. The plumes of Maralinga: Mapping nuclear fallout patterns over sixty years after atomic bomb testing. Australian Society of Exploration Geophysicists Extended Abstracts, Volume 2024, 1st ASEG DISCOVER Symposium, Hobart.

Maclagan, D., Cooper, M.B., and Duggleby, J.C., 1979 "Residual Radioactive Contamination of the Test Site at Emu from Nuclear Weapons Tests conducted in 1953", Australian Radiation Laboratory Report TR012.

MARTAC (Maralinga Rehabilitation Technical Advisory Committee), 2003. Rehabilitation of the Former Nuclear Test Sites at Emu and Maralinga (Australia). Commonwealth of Australia, Canberra, Australia. <http://www.dest.gov.au/radwaste/martac/default.htm>

Minty, B.R.S., and Brodie, R.C., 1994. Mapping <sup>137</sup>CS at Maralinga nuclear test site, South Australia, using conventional 4-channel airborne gamma-ray spectrometry. AGSO Journal of Australian Geology and Geophysics, 15 (2/3), 217-222.

Stein, A.F., Draxler, R.R., Rolph, G.D., Stunder, B.J.B., Cohen, M.D., Ngan, F., 2015. NOAA's HYSPLIT atmospheric transport and dispersion modeling system. Bull. Am. Meteorol. Soc. 96 (12), 2059–2077. <https://doi.org/10.1175/bams-d-14-00110.1>.

Tynan, E., 2022. The Secret of Emu Field (Sydney: NewSouth Books, 2022) 384 pp, ISBN: 9781742236957