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EGG-1183-1658
February 1978

AN AERIAL RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE

ROBERT EMMETT GINNA NUCLEAR POWER PLANT

ONTARIO, NEW YORK

DATE OF SURVEY: SEPTEMBER 1972

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ABSTRACT

The Aerial Measuring Systems (AMS)* was used to survey the area surrounding the Robert Emmett Ginna Nuclear Power Plant during September 1972. The survey measured terrestrial gamma-ray exposure rate and spectral data.

A high-sensitivity detection system collected gamma-ray spectral and gross count data. The data were then processed to construct a map of a 1000 km^2 area showing the spatial distribution of gamma-ray exposure rates 1 m above the ground. Exposure rates and isotopes identified are consistent with that related to normal terrestrial background radiation.

The first survey of the Ginna site was conducted in September 1970. Comparison of the 1970 and 1972 survey data shows no measurable change in the terrestrial gamma exposure rate in the intervening years, due to the Ginna Power Plant operation.

*Formerly the Aerial Radiological Measuring System (ARMS).

ACKNOWLEDGMENT

Special appreciation is given to L. J. Deal, Assistant Director for Field Operations, Division of Operational and Environmental Safety, United States Department of Energy, and B. H. Weiss, Office of Inspection and Enforcement, United States Nuclear Regulatory Commission, for their support and encouragement in this program.

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1.0 INTRODUCTION

1.1 IDENTIFICATION OF SURVEYED PLANT AND AREA

The Aerial Measuring Systems (AMS)[1] operated by EG&G, Inc. for the United States Department of Energy (DOE)* was used to survey an extensive area surrounding the Robert Emmett Ginna Nuclear Power Plant on 9 and 14 September 1972. The Ginna site is located near Ontario, New York. The size of the survey area was approximately 1000 km^2.

1.2 AMS PROGRAM

The present survey was made as part of a continuing nationwide AMS program started in 1958 to monitor radiation levels surrounding facilities producing or utilizing radioactive materials. This was the second survey of the Ginna Nuclear Power Plant. The first survey was conducted in September 1970.[2] The results of these surveys are compared in Section 5.0.

The detection system on board the aircraft collected gamma-ray gross count and energy spectral data on each flight line of the survey. The gamma radiation and aircraft position information were processed by a computer to construct a map which shows the spatial distribution of gamma-ray exposure rates 1 m above the ground.

1.3 AMS EQUIPMENT AND PROCEDURES

The AMS aircraft and its on-board radiation detection equipment were used in the survey. Since the AMS equipment and procedures have been discussed in detail elsewhere,[1] they will only be described briefly here.

*Formerly the United States Energy Research and Development Administration (ERDA).

This AMS survey was flown in a Beechcraft Twin Bonanza aircraft at an altitude of 150 m above terrain at a ground speed of about 140 knots (70 m/sec). The ground position of the aircraft, and its altitude above terrain, were measured and recorded every other second by a radar navigation computer system. The position and altitude measurements are accurate to ±100 m and ±1.5 m, respectively. The flight pattern consisted of a series of parallel lines spaced one nautical mile (1.8 km) apart, covering all of the land area within a 12-1/2 nautical mile radius of the facility. At an altitude of 150 m, the field-of-view of the detectors was approximately 400 m wide for a mean gamma energy of naturally occurring isotopes.

The aerial radiation measurements were of two distinct types, made simultaneously: (1) gross gamma count (intensity) measurements, and (2) gamma spectral measurements. The detector system consisted of an array of fourteen 4-in. x 4-in. NaI(Tℓ) scintillation crystals, each coupled to its own photomultiplier assembly. The detector system output was directed both to the gross gamma count computing system and to the multichannel spectrum analyzer. The data collecting system is shown in Fig. 1.

The gross gamma count system consisted of an amplifier-discriminator-computer unit that counted and recorded the total number of gamma rays of energy greater than 50 keV that were detected during a one second time interval. The gross gamma count rate (number of gamma rays detected per second) was digitally recorded, along with aircraft position and altitude, every other second. Aircraft position data were supplied by a track navigational computer and doppler radar. Altitude above terrain was measured with a radar altimeter. As a backup and complement to the digital recording of the gross count data, a record was made on a continuous strip chart of both gross gamma count rate and radar altitude as a function of distance. Typical gross count rates for natural background were several thousand per second.

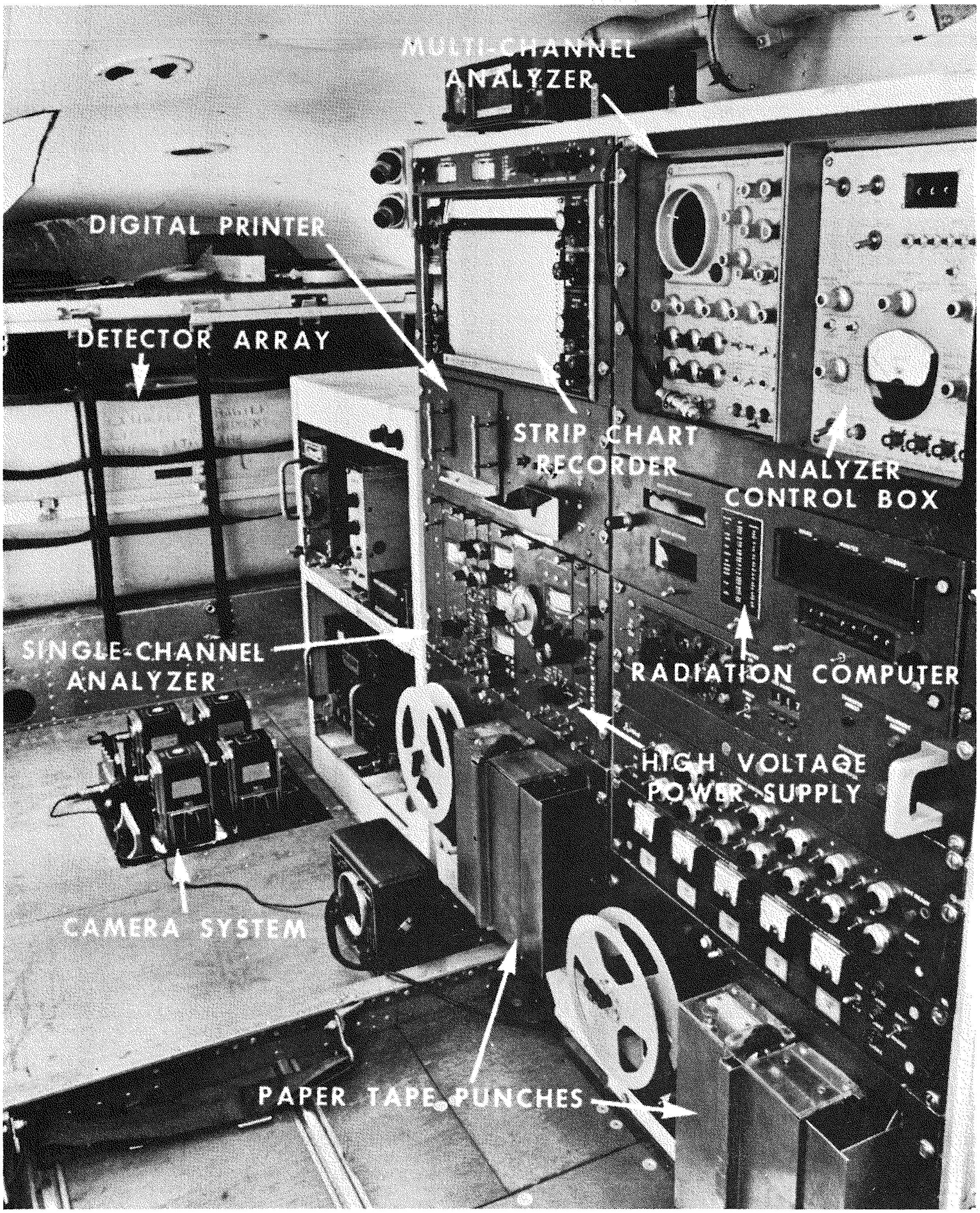

Figure 1. View of the interior of the Aerial Measuring Systems (AMS) aircraft showing detector package and electronic data collection system.

Whereas the gross gamma count data specified the intensity of radiation as a function of position, the gamma spectral data were useful in identifying particular radioactive isotopes. A pulse-height analyzer automatically sorted detected gamma rays according to energy, thereby generating a number per unit-energy versus energy spectrum. Although gamma rays occur only at well known discrete energies characteristic of the emitting species, air scattering tends to smear the detected distribution. Nevertheless, characteristic peaks that permit isotope identification were readily observable.

In wide area surveys, the typical acquisition time for a gamma-ray spectrum is several minutes; thus the spectrum represents the average radiological properties of a tract several miles in length. However, if an area of interest is indicated by an increase in the gross gamma count rate, spectral data acquisition times of only a few seconds can be used to isolate the area spatially. If further investigation is warranted, a ground mobile unit with equipment similar to that in the aircraft is available to provide greater spatial and energy resolution.

In addition to the equipment just described, the AMS aircraft also carried an air sampling and analysis system for the measurement of airborne radioactivity.

1.4 REDUCTION AND PRESENTATION OF DATA

The raw data from the gross gamma count and the gamma spectral measurements were permanently recorded on paper tape, which is computer processed and analyzed to characterize the radiological properties of the area surveyed. Using an altitude-dependent conversion factor obtained from prior calibration measurements, the corrected count rate was converted to exposure rate (μR/hr) at 1 m above ground.

The exposure rate conversion factor was obtained from repeated flights 60 m to 300 m above terrain containing known distributions of natural isotopes. Such conversion factors have proven valid over distributed fission product fields, with a variation of less than 25%. In practice, average exposure rate differences over large areas of 1 μR/hr can be reliably observed in repeated flights over the same area.

2.0 REACTOR AND SITE CHARACTERISTICS

2.1 REACTOR CHARACTERISTICS

The Robert Emmett Ginna Nuclear Power Plant is located near Ontario, Wayne County, New York, seventeen miles northeast of Rochester.

The principal nuclear contractor is Westinghouse Electric Corporation. The facility is operated by Rochester Gas and Electric Corporation.

Table 1 gives the specifications of the reactor facility at the time of the survey.

Table 1. Reactor Facility Specifications.

Reactor Unit	Reactor Type	Start-Up Date	Power Levels (Megawatts)		Status
			Electrical	Thermal	
1	Pressurized Water	1969	470	1,455	Operational

2.2 SITE AREA CHARACTERISTICS

In general, the terrain in the survey area is flat, cultivated farmland. The land area is bounded on the north by Lake Ontario.

Table 2 gives a breakdown of the population of the survey area in terms of distance and direction from the reactor site (1970 census figures).[3]

Table 2. Population Distribution Within the Robert Emmett Ginna Nuclear Power Plant Area.

Town	Direction from Power Station	Population Distance from Station (Miles)		
		0 - 5	5 - 10	10 - 15
East Rochester	SW			8,347
Fairport	SSW			6,474
Macedon	S			1,168
Palmyra	SSE			3,776
Sodus	ESE			1,812
Sodus Point	E			1,172
Webster	SW		5,037	
Williamson	SE		1,991	
TOTALS			7,028	22,749
GRAND TOTAL				29,777

3.0 SURVEY PLAN

3.1 SPECIFICATION OF FLIGHT LINES

The flight pattern for the Ginna survey consisted of twenty-three flight lines approximately 23 km long and spaced one nautical mile apart (1.8 km). The lines were oriented in a north-south direction. Radiation data, together with aircraft position and meteorological information, were collected along each flight line. The area covered by the survey was about 1000 km^2. The flight lines and survey area are shown in Fig. 2.

3.2 COORDINATION WITH LOCAL AUTHORITIES

AMS survey missions are conducted under special waiver from the Federal Aviation Administration (FAA). The survey plan was discussed with the appropriate General Aviation District Office, and public announcements were published in the local newspapers prior to the survey operation, in accordance with the FAA waiver for low-level flights.

The base of operations for the survey mission was Buffalo, New York.

4.0 RADIOLOGICAL SURVEY

4.1 SURVEY MISSIONS

The aerial survey of the Robert Emmett Ginna Nuclear Power Plant area was conducted on 9 and 14 September 1972. This survey required a total flying time of six hours.

Gross count and spectral data were simultaneously collected at an altitude of 150 m. Spectra were accumulated over the entire length of each flight line; consequently, one spectrum per line was collected.

4.2 GROSS COUNT DATA

As a first step in the analysis of the gross count data, the background due to nonterrestrial radiation was subtracted. This background consists of cosmic ray, aircraft, and airborne radioactivity contributions.[4] After correction for background, the data were normalized to a standard air mass. The resultant net count data were then converted to exposure rate in microroentgens per hour (μR/hr) at the 1 m level above the ground. The cosmic-ray exposure rate was then added back to the terrestrial exposure rate. Finally, the composite exposure rate data, together with aircraft position information, were processed into a gamma-ray exposure rate isopleth map for overlay on United States Geological Survey (USGS) topographic maps of the survey area.

An exposure rate isopleth map of the Ginna area is shown in Fig. 3. The data shown on the map include a cosmic radiation contribution of 3.09 μR/hr. Spatial resolution of the exposure rate data is determined by the field-of-view of the detector system, which is about 400 m.

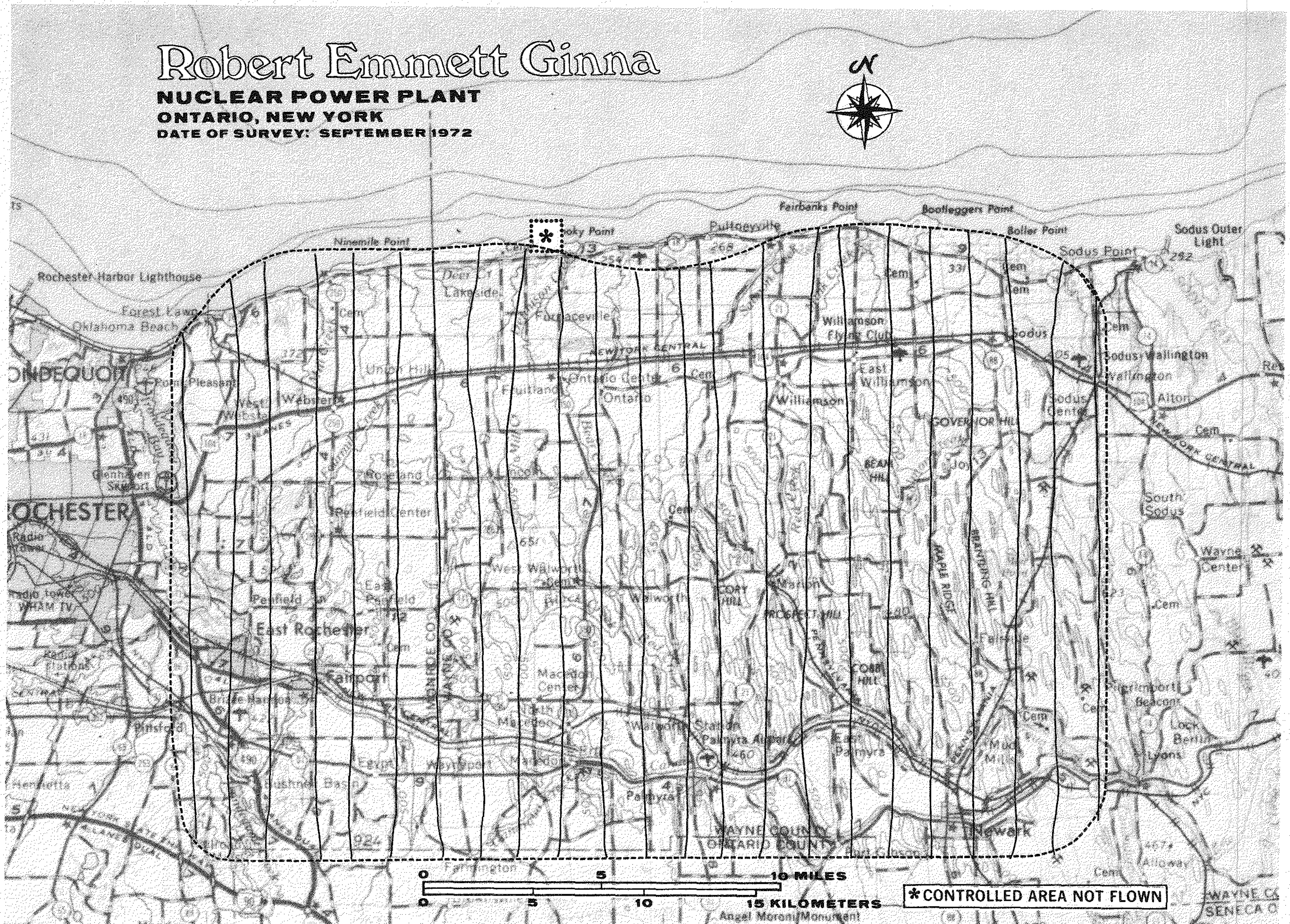

Figure 2. Flight lines and survey area superimposed on a USGS topographic map of the area surrounding the Robert Emmett Ginna Nuclear Power Plant, September 1972.

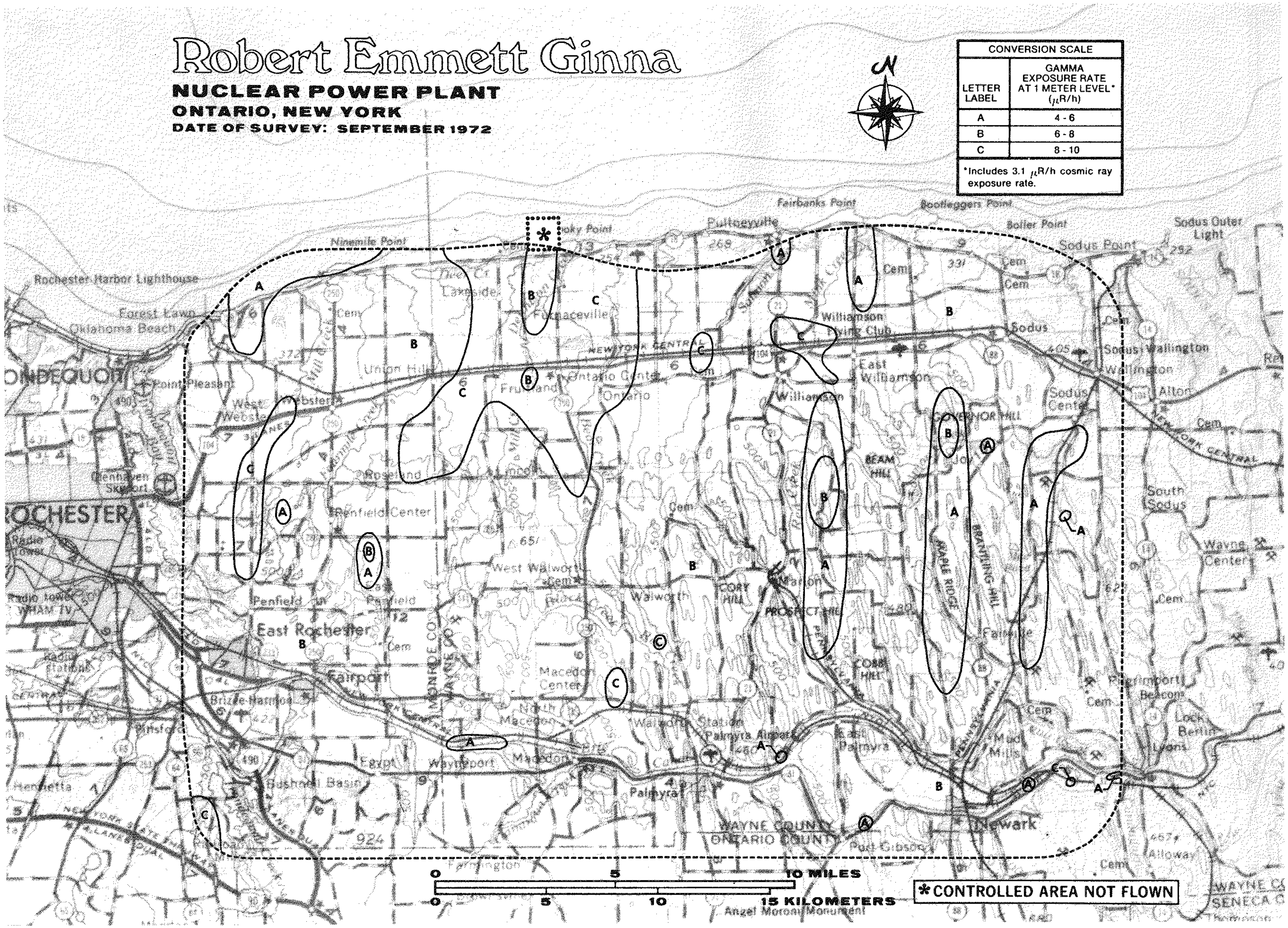

Figure 3. Exposure rate isopleths superimposed on a USGS topographic map of the area surrounding the Robert Emmett Ginna Nuclear Power Plant, September 1972.

4.3 SPECTRAL DATA

Gamma energy spectral data were recorded from about 0.05 to 3.0 MeV. The recording system was calibrated prior to airplane takeoff with an yttrium-88 source, which emits two prominent gamma rays of 0.898 and 1.836 MeV. The gain for each crystal in the 14 crystal detector array was set independently.

A pulse-height spectrum typical of those taken during the survey is shown in Fig. 4. Table 3 lists the prominent gamma-ray energies and associated source isotopes identified in the spectrum. Differences in shape between spectra taken over different portions of the survey area are minor, and the isotopes identified in all spectra are the same. Only isotopes consistent with normal background radiation are apparent.

Table 3. Gamma-Ray Energies and Isotopes Consistent with Spectral Data of Figure 4.

Observed Energy (MeV)	Radionuclides Consistent with Spectral Photopeaks		
	Fission Products	Activation Products	Terrestrial Radiation
0.51	. . . .	. . . .	Annihilation radiation
0.61	. . . .	. . . .	^{214}Bi
0.77	. . . .	. . . .	^{214}Bi
0.94	. . . .	. . . .	^{214}Bi
1.12	. . . .	. . . .	^{214}Bi
1.46	. . . .	. . . .	^{40}K
1.76	. . . .	. . . .	^{214}Bi
2.62	. . . .	. . . .	^{208}Tl

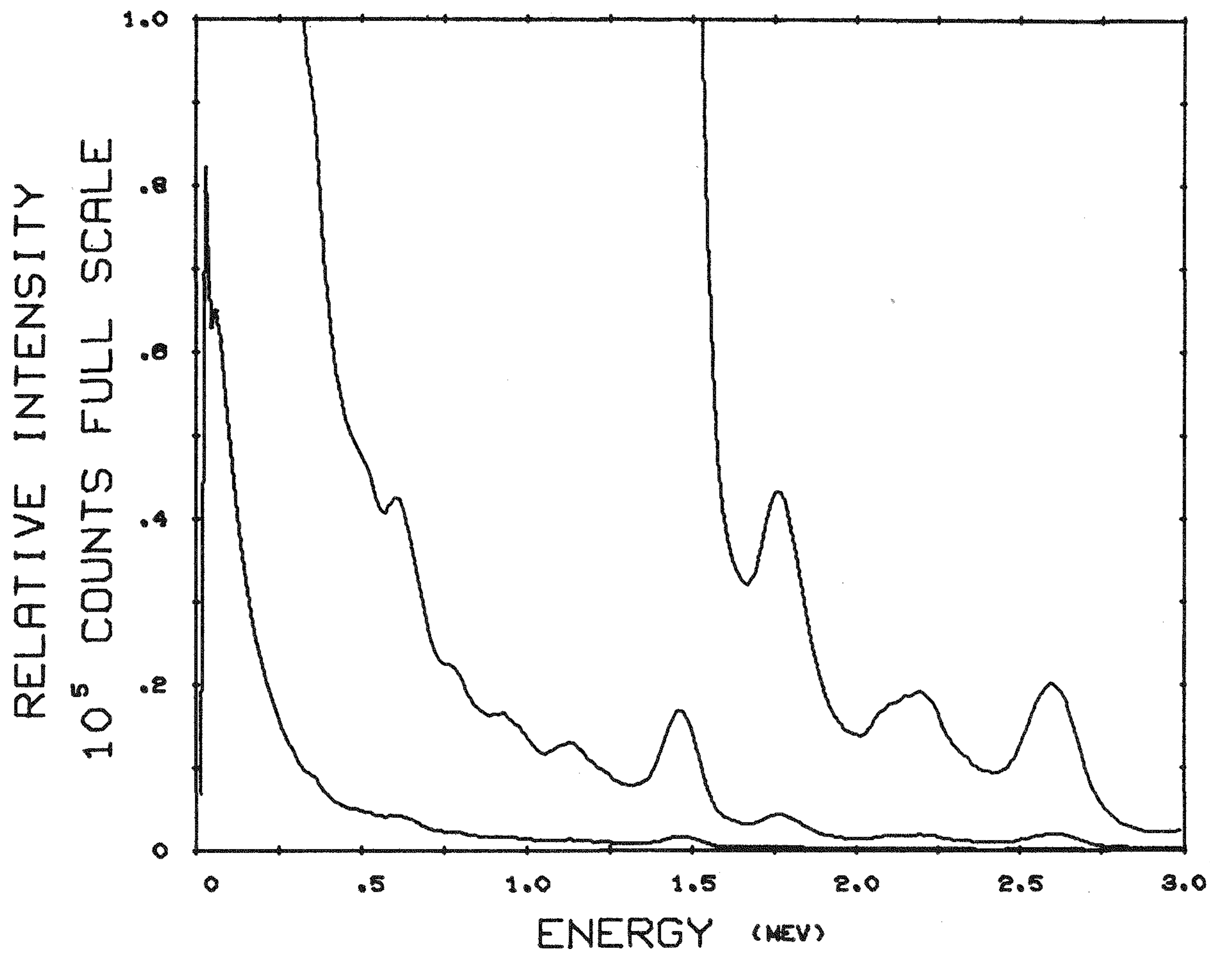

Figure 4. Typical gamma pulse-height spectrum for survey area.

5.0 SURVEY COMPARISON

5.1 PREVIOUS SURVEYS

The September 1972 survey was flown using the same programmed flight lines as the September 1970 survey. The navigator visually directed the pilot, from USGS topographic maps, along the programmed flight line. A detailed point-by-point comparison of the survey data can be made for data points collected in the same geographical area in each survey.

5.2 COMPARISON PROGRAM

Computer software has been developed to compare the data from two surveys of the same area.[5] During these two surveys, the AMS system accumulated and recorded gross count data in one second intervals. Since latitude and longitude were simultaneously recorded, each data point uniquely characterized the exposure rate directly below the aircraft. All data points were converted to the exposure rate at a level 1 m above the ground.

Whenever the survey patterns for these two surveys overlap, data points may be individually compared if they are within the field-of-view of the detector system. The field-of-view, also called the circle of investigation, is the gamma field measured by the detector, and its size is determined by using calibration sources distributed over the area below the aircraft. The size of this area depends on the altitude of the aircraft, the gamma radiation energy, and the source distribution over the terrestrial surface and with depth. The AMS system is normally flown at an altitude of 150 m. If one assumes that the gamma isotopes are uniformly distributed on the surface, one can calculate the radius of the circle measured by the detector.[6,7,8] For the range of gamma energies of interest in the present survey, the AMS field-of-view was approximately 400 m in diameter.

The computer program made a point-by-point comparison of the exposure rates (at a level 1 m above the ground) for all points within the field-of-view. The mean difference in exposure rate, the standard deviation, and a normal distribution for the exposure rate difference frequency versus measured difference, were calculated. A chi-squared test was then applied to test the statistical integrity of the data.

For all sites resurveyed to date, the exposure rate data averaged over the entire site have been reproducible within ±1.0 μR/hr. The number of matched data point pairs (those within the same 400 m field-of-view) varies for each pair of surveys compared. Even though the same flight line map is flown, the actual number of point pairs depends on navigation accuracy.

The accuracy of the comparison measurement depends on topography, the cosmic-ray exposure rates, and the concentration of airborne radionuclides on the days of the separate surveys. AMS equipment has demonstrated the ability to detect changes in the terrestrial exposure rate of less than 1.0 μR/hr. Depending on the natural terrestrial and cosmic-ray exposure rates, 1.0 μR/hr represents a 5 to 15 percent change in the terrestrial exposure rates for most areas in the United States.

5.3 COMPARISON RESULTS

Figure 5 shows the comparison results of the 1970 and 1972 Robert Emmett Ginna Nuclear Power Plant surveys. A total of 2341 overlapping data points from each survey could be directly compared. Since the mean difference in terrestrial exposure rates was 0.1485 μR/hr, and well within one standard deviation (0.7533 μR/hr), we may say there has been no measurable change in the terrestrial exposure rate over the Ginna survey area (±0.75 μR/hr at the 67% confidence level). The average exposure rate for the Ginna survey was 7.8 μR/hr. A 9% change in the exposure rate at the Ginna site could have been detected by the AMS resurvey.

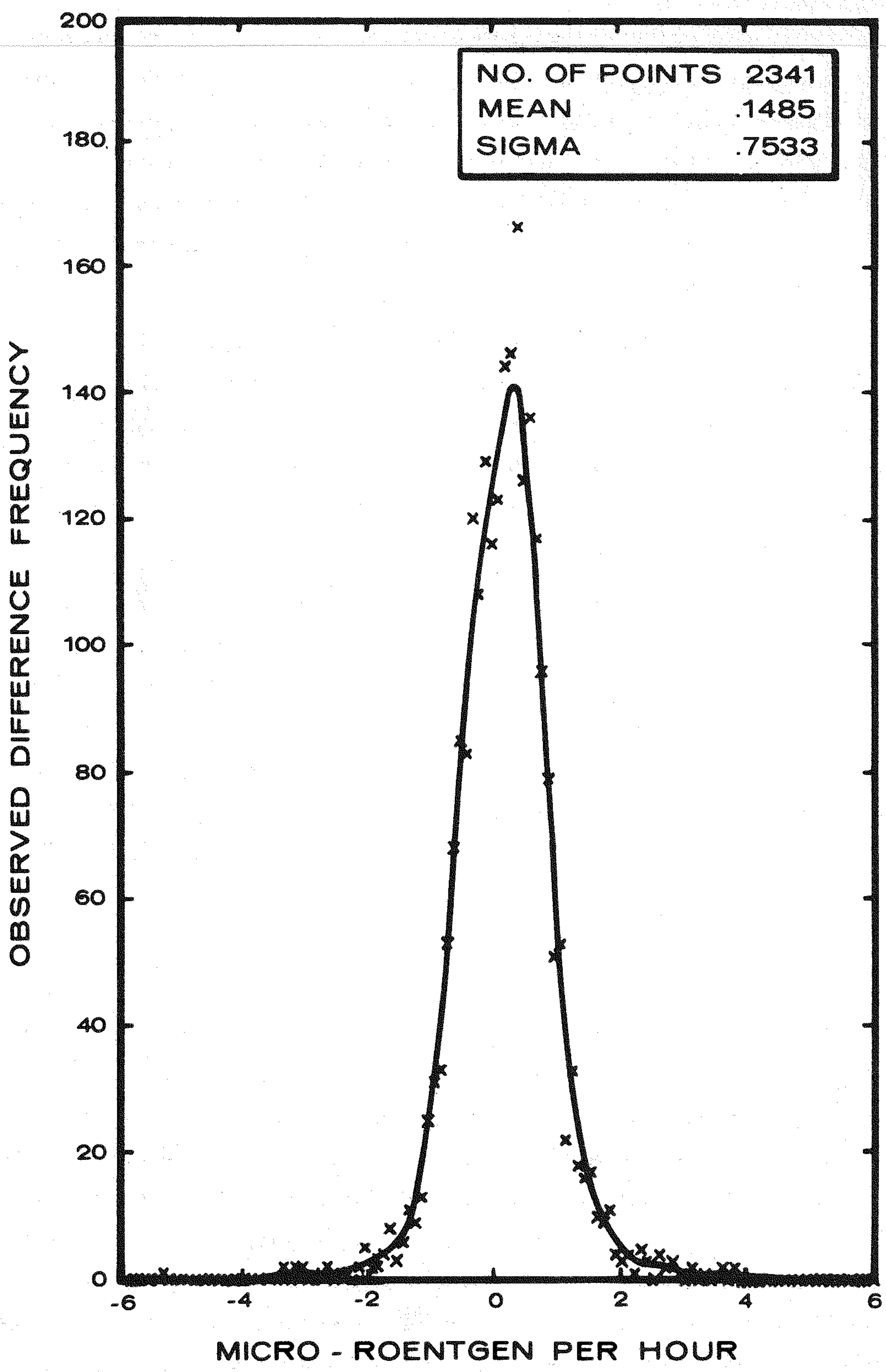

Figure 5. The exposure rate difference versus difference distribution for the 1970 and 1972 surveys of the Robert Emmett Ginna Nuclear Power Plant.

6.0 SUMMARY AND CONCLUSIONS

The 1 m level exposure rates mapped were mostly in the 4 to 10 μR/hr range. The exposure rates and radioactive isotopes revealed in the survey are consistent with normal terrestrial background. The comparison study between the two Robert Emmett Ginna Nuclear Power Plant surveys indicates that there had been no measurable change in the average exposure rate of the Ginna area within an uncertainty of ±0.75 μR/hr.

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