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AN AERIAL RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE

NINE MILE POINT NUCLEAR POWER STATION

SCRIBA, NEW YORK

DATE OF SURVEY: SEPTEMBER 1972

P. K. Boyns
Project Leader

APPROVED FOR PUBLICATION

T. P. Stuart, Manager
Remote Sensing Sciences
Department

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G. P. Stobie
Classification Officer

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ABSTRACT

The Aerial Radiological Measuring System (ARMS)* was used to survey the area surrounding the Nine Mile Point Nuclear Power Station 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 determine the spatial distribution of gamma-ray exposure rates one meter above the ground. Exposure rates and isotopes identified are consistent with that related to normal terrestrial background radiation.

The first survey of the Nine Mile Point area was conducted in September 1969. Comparison of the 1969 and 1972 survey data shows no measurable change in the terrestrial gamma exposure rate in the intervening years, due to the Nine Mile Point Nuclear Power Station.

*Changed to EG&G Aerial Measuring Systems (AMS) in January 1976.

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1.0 INTRODUCTION

1.1 IDENTIFICATION OF SURVEYED PLANT AND AREA

The Aerial Radiological Measuring System (ARMS)[1] operated by EG&G, Inc., Las Vegas, Nevada, for the United States Energy Research and Development Administration (ERDA) was used to survey an extensive area surrounding the Nine Mile Point Nuclear Power Station in September 1972. The Nine Mile Point site is located near Scriba, New York. The size of the survey area was approximately 2000 km^2.

1.2 ARMS PROGRAM

The present survey was made as part of a continuing nationwide ARMS program started in 1958 to monitor radiation levels surrounding facilities producing or utilizing radioactive materials.* This was the second survey of the Nine Mile Point Nuclear Power Station. The first survey was conducted in September 1969.[2] The results of these surveys are compared in Section 5.0.

The detection system onboard the aircraft collected gamma-ray gross-count and energy spectral data on each flight line of the survey.

1.3 ARMS EQUIPMENT AND PROCEDURES

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

*Special appreciation is given to L. J. Deal, Assistant Director for Health Protection, Division of Safety, Standards and Compliance, United States Energy Research and Development Administration, for his support and encouragement in this program.

This ARMS survey was flown in a Beechcraft Twin Bonanza aircraft at an altitude of 150m above terrain at a ground speed of about 140 knots (70m/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 ±100m and ±1.5m, 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 23 km radius of the facility. At an altitude of 150m, the field-of-view of the detectors was approximately 400m 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-by-4-inch 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 Figure 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 1-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.

Whereas the gross gamma count data specified the intensity of radiation as a function of position, the gamma spectral data were

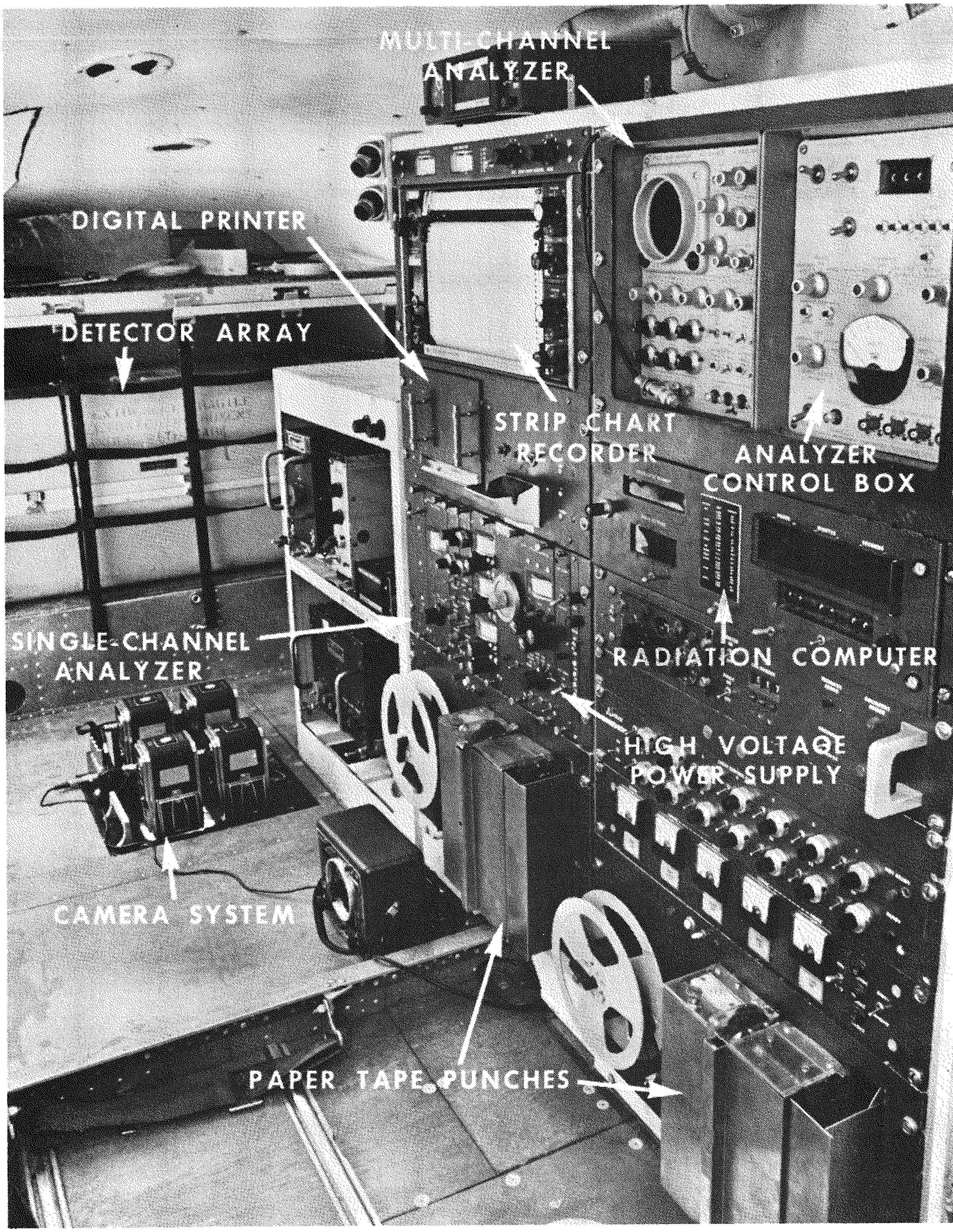

Figure 1. View of the interior of the Aerial Radiological Measuring System (ARMS) aircraft showing detector package and electronic data collection system.

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 ARMS 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 an exposure rate in microroentgens per hours (μR/hr) at one meter above ground.

The exposure rate conversion factor was obtained from repeated flights 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 Nine Mile Point Nuclear Power Stations's Reactor is located in Oswego County, New York, five miles northeast of the town of Scriba.

The principal nuclear contractor is the General Electric Company. The facility is operated by the Niagara Mohawk Power Corp.

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	Boiling Water	1969	625	1,850	Operational

2.2 SITE AREA CHARACTERISTICS

The shore of Lake Ontario forms the northwest boundary of the survey area. The terrain is mainly rolling hills covered by a mixture of forest, brushwoods, and orchards. Numerous small lakes and marshes occur throughout the area.

Table 2 lists the towns in the survey area with significant populations, by distance and direction from the reactor site (1970 census figures).[3]

Table 2. Principal Population Centers Within the Nine Mile Point Area.

Town	Direction from Power Station	Population* Distance from Station (Miles) 0-5	5-10	10-15
Fernwood	E			3,659
Fulton	S			14,003
Lakeview	W	5,471		
Mexico	ESE		1,555	
Oswego	WSW		23,844	
Parish	SE			634
Pulaski	ENE			2,480
TOTALS		5,471	25,399	20,776
GRAND TOTAL				51,646

*1970 census figures.

3.0 SURVEY PLAN

3.1 SPECIFICATION OF FLIGHT LINES

The flight pattern for the Nine Mile Point Nuclear Power Station survey consisted of twenty-five flight lines 11 km to 46 km long and spaced 1.8 km apart. The lines were oriented in a north-south direction and terminated on the shore of Lake Ontario. Radiation data together with aircraft position and meteorological information were collected along each flight line. The area covered by the survey was about 2000 km^2.

3.2 COORDINATION WITH LOCAL AUTHORITIES

ARMS survey missions are conducted under special waiver from the Federal Aviation Administration. 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 Rochester, New York.

4.0 RADIOLOGICAL SURVEY

4.1 SURVEY MISSIONS

The aerial survey of the Nine Mile Point area was conducted on 15, 16, and 19 September 1972. This survey required a total flying time of nine hours.

Gross-count and spectral data were simultaneously collected at an altitude of 150m. 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 one meter above the ground. The cosmic-ray exposure rate was then added back to the terrestrial exposure rate.

Spatial resolution of the exposure rate data is determined by the field-of-view of the detector system, which is about 400m.

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 Figure 2. Table 3 lists the prominent gamma-ray

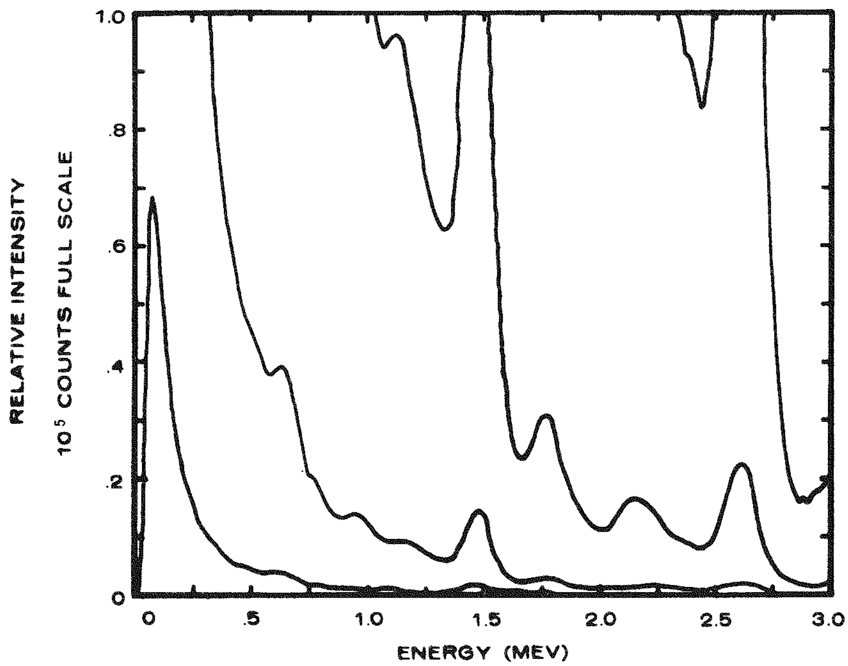

Figure 2. Typical **gamma pulse-height** spectrum for survey area.

Observed Energy (MeV)	Radionuclides Consistent with Spectral Photopeaks		
	Fission Products	Activation Products	Terrestrial Radiation
0.51	. . . .	. . . . . .	Annihilation Radiation
0.61	. . . .	. . . . . .	^{214}Bi
0.76	. . . .	. . . . . .	^{214}Bi
0.93	. . . .	. . . . . .	^{214}Bi
1.12	. . . .	. . . . . .	^{214}Bi
1.46	. . . .	. . . . . .	^{40}K
1.76	. . . .	. . . . . .	^{214}Bi
2.62	. . . .	. . . . . .	^{208}Tℓ

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

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.

5.0 SURVEY COMPARISON

5.1 PREVIOUS SURVEYS

The September 1972 survey was flown using the same programmed flight lines as the September 1969 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 ARMS system accumulated and recorded gross count data in 2-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 meter 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. The ARMS system is normally flown at an altitude of 150m. 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 surveys, the ARMS field-of-view was approximately 450m in diameter.

The computer program made a point-by-point comparison of the exposure rates (at a level of one meter 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.

For all sites re-surveyed 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 450m 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. ARMS equipment has demonstrated the ability to detect changes in the terrestrial and cosmic-ray 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 3 shows the comparison results of the 1969 and 1972 Nine Mile Point surveys. There was a total of 1688 overlapping data points from each survey which could be directly compared. Since the mean difference in terrestrial exposure rates was 0.34 μR/hr and well within one standard deviation (0.85 μR/hr), we may say there has been no measurable change in the terrestrial exposure rate over the Nine Mile Point survey area (±0.85 μR/hr at the 67% confidence level). The average exposure rate for the Nine Mile Point Nuclear Power Station survey was approximately 7 μR/hr. A 12% change in the exposure rate at the Nine Mile Point site could have been detected by the ARMS resurvey.

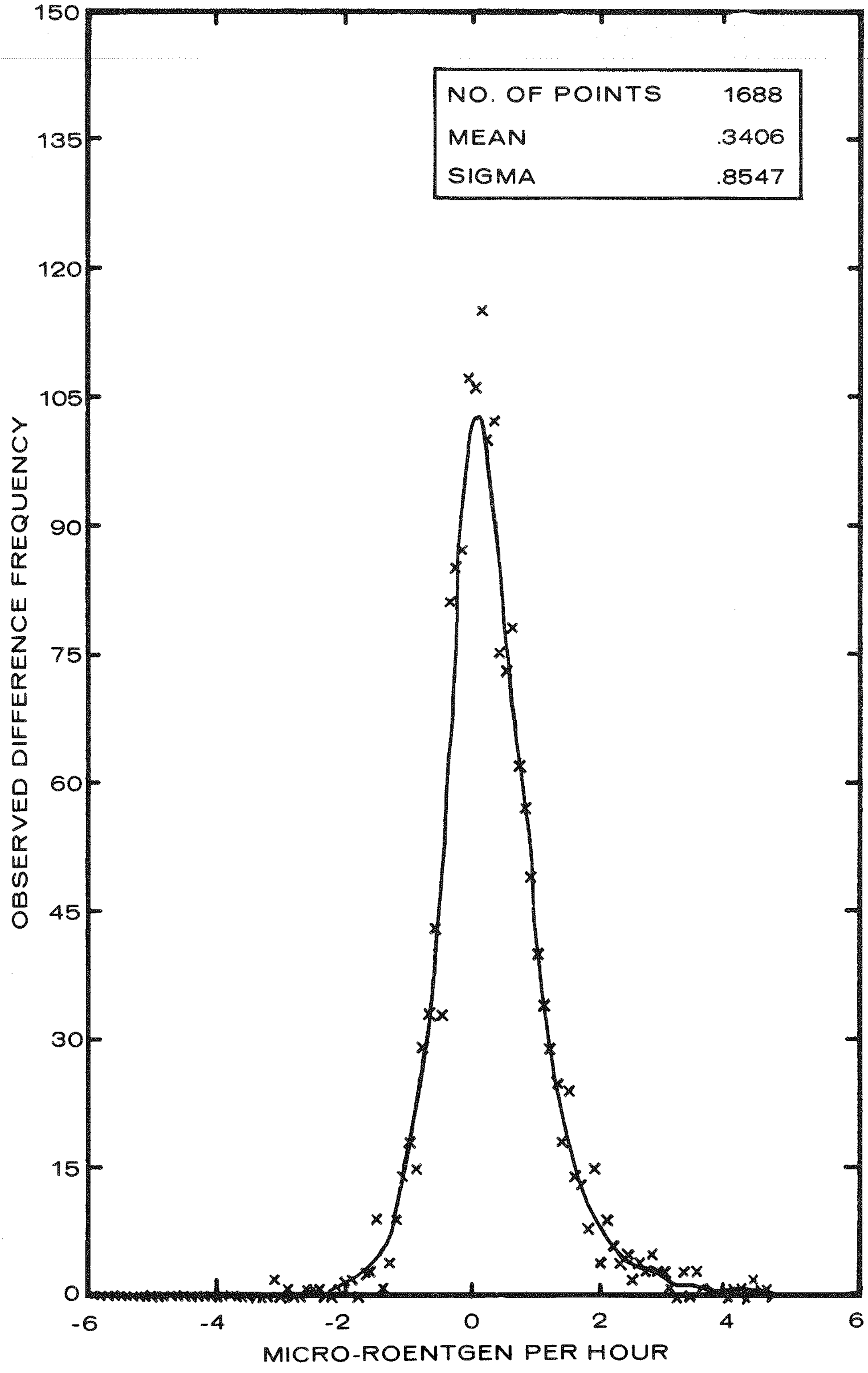

Figure 3. The exposure rate difference versus difference distribution for the 1969 and 1972 surveys of the Nine Mile Point Nuclear Power Station.

6.0 SUMMARY AND CONCLUSIONS

The one meter level exposure rates mapped were mostly in the 4 to 8 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 Nine Mile Point surveys indicates that there had been no measurable change in the average exposure rate of the area within an uncertainty of ±0.85 μR/hr.

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