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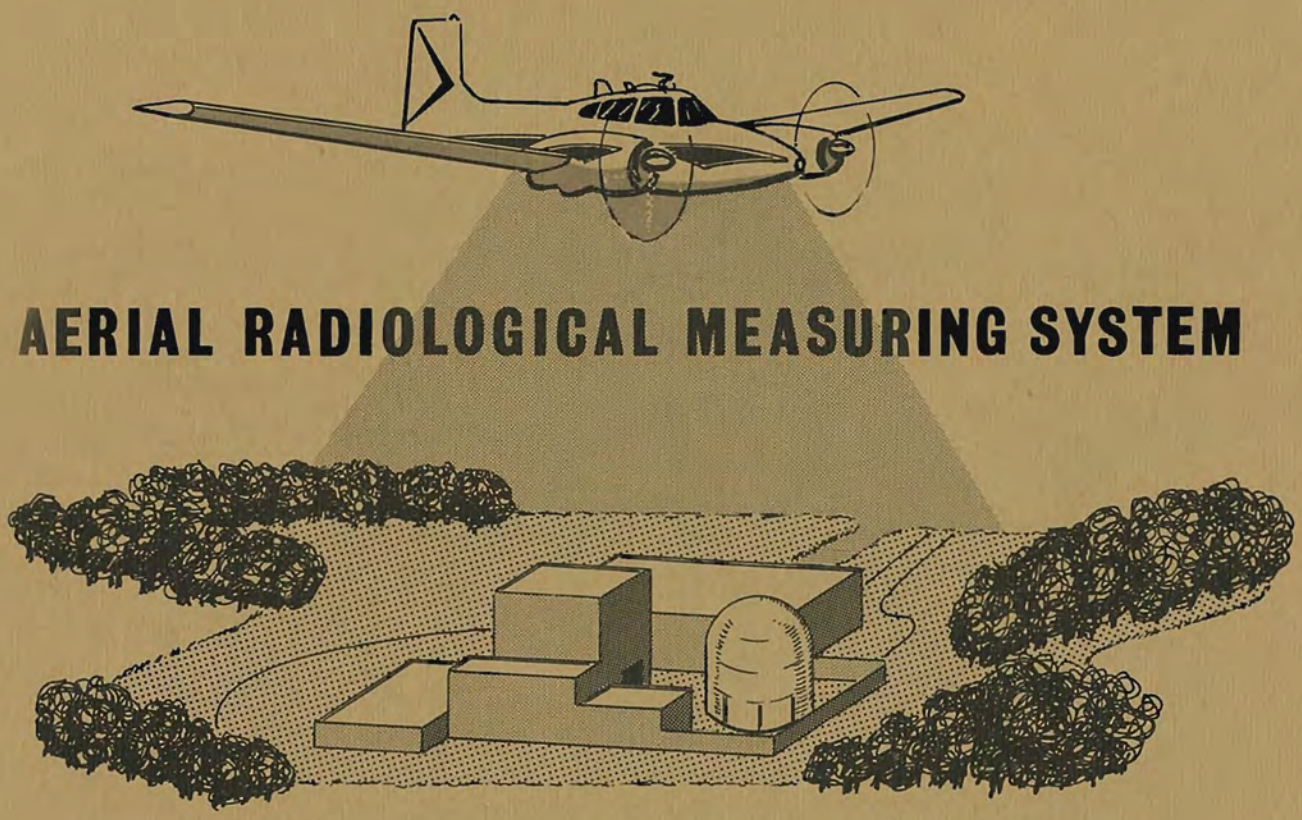
ARMS



AERIAL RADIOLOGICAL MEASURING SYSTEM

RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE PROJECT GNOME TEST SITE CARLSBAD, NEW MEXICO DATE OF SURVEY: 13 MAY 1972

14 FEBRUARY 1973

LAS VEGAS AREA OPERATIONS
EG&G, INC., 680 E. SUNSET RD.,
LAS VEGAS, NEV. 89101

NOTICE

EG&G

EGG-1183-1569
Technical Report No. L-1082
14 February 1973

RADIOLOGICAL SURVEY OF THE AREA SURROUNDING THE PROJECT GNOME TEST SITE CARLSBAD, NEW MEXICO DATE OF SURVEY: 13 MAY 1972

Approved for Publication

John F. Doyle, Manager
Aerial Surveillance Department

Clyde Jupiter, Manager Radiation and
Environmental Sciences Department

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Phil V. Betts
Classification Officer

Prepared for the U. S. Atomic Energy Commission under Contract No. AT(29-1)-1183.

WORK PERFORMED BY

Analyst

P. K. Boyns

Instrumentation Specialist

G. E. Menkel

Navigator

M. D. Sevart

Pilot

E. D. Shultz

ABSTRACT

The Aerial Radiological Measuring System (ARMS) was used to perform an aerial radiological survey of the Project Gnome Test Site and surrounding area during May 1972. The survey measured terrestrial background gamma radiation.

A high-sensitivity detection system collected gamma-ray spectral and gross-count data. The data were then computer processed into a map of a four square mile area showing gamma exposure rates three feet above the ground. Results in general indicated the presence of isotopes normally found in the background radiation throughout the United States. However, trace amounts of cesium-137 were detected over a small area, later identified as a waste dump.

ACKNOWLEDGMENTS

Special appreciation is given to L. J. Deal (Assistant Director, DOS/Health Protection, USAEC) and to D. W. Hendricks (Director, Radiological Operations Division, USAEC/NV) for their support and encouragement in this program.

CONTENTS

1. INTRODUCTION

1.1 Identification of Surveyed Plant and Area

The Aerial Radiological Measuring System (ARMS) (Ref. 1) operated by EG&G, Inc., Las Vegas, Nevada, for the U. S. Atomic Energy Commission was used to perform an aerial radiological survey of an extensive area surrounding the Project Gnome Test Site during May 1972. The Project Gnome site is operated by the United States Atomic Energy Commission. It is located near Carlsbad, New Mexico. The size of the survey area was four square miles.

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 survey is the first such performed in the Project Gnome Test Site area.

The detection system on board the aircraft collects gamma-ray gross-count and spectral data on each flight line of the survey. The gamma radiation and aircraft position information can be processed by a computer into an isoexposure contour map of the area surveyed.

1.3 ARMS Equipment and Procedures

The ARMS aircraft and its on-board radiation detection equipment were used in the survey of the Project Gnome Test Site and surrounding area. Since the ARMS equipment and procedures have been discussed in detail elsewhere (Ref. 1), they will only be described briefly here.

The ARMS surveys are flown in a Beechcraft Twin Bonanza at an altitude of 300 to 500 feet above ground level at a ground speed of about 140 knots (235 ft/sec). The ground position of the aircraft and its altitude above terrain are measured and recorded every other second by a radar navigation computer system. The position and altitude measurements are accurate to $\pm$ 350 ft and $\pm$ 5 ft, respectively.

A typical flight pattern consists of a series of parallel lines covering the survey area. At an altitude of 500 feet, the field of view

of the detectors is approximately 1/4 mile wide for a mean gamma energy of naturally occurring isotopes.

The aerial radiation measurements are of two distinct types, made simultaneously: (1) gross gamma count (intensity) measurements and (2) gamma spectral measurements. The detector system consists of an array of fourteen 4 x 4 in. NaI (Tℓ) scintillation crystals, each coupled to its own photomultiplier assembly. The detector system output is 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 consists of an amplifier-discriminator-computer unit that counts and records the total number of gamma-rays of energy greater than 50 keV that are detected during a 1-second time interval. The gross gamma count rate (number of gamma-rays detected per second) is digitally recorded along with aircraft position and altitude every other second. Aircraft position data are supplied by a track navigational computer and doppler radar. Altitude above terrain is measured with a radar altimeter. As a backup and complement to the digital recording of the gross-count data, a record is 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 are several thousand per second.

Whereas the gross gamma count data specify the intensity of radiation as a function of position, the gamma spectral data are useful in identifying particular radioactive isotopes. A pulse-height analyzer automatically sorts 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, the characteristic peaks that permit isotope identification are 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 of the gross gamma count data, spectral data acquisition times of only a few seconds are 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 carries an air sampling and analysis system, for the measurement of airborne radioactivity.

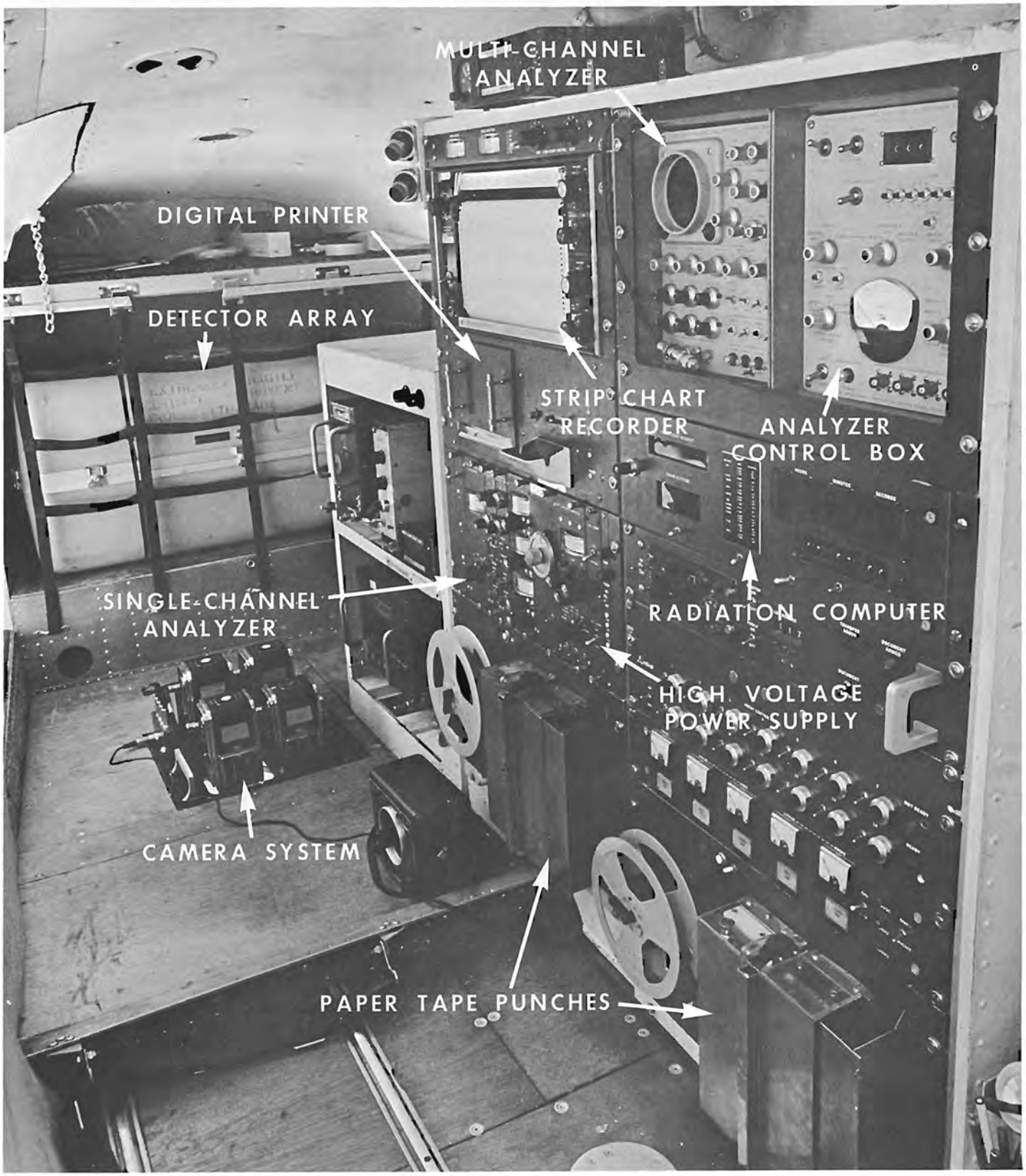


FIGURE 1. View of the interior of the Aerial Radiological Measuring System (ARMS) aircraft showing detector package and electronic data collection system.

1.4 Reduction and Presentation of Data

The raw data from the gross gamma count and the gamma spectral measurements are 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 raw gross-count rate is converted to exposure rate (μR/hr) at three feet above ground (designated as "terrestrial exposure rate").

The exposure rate conversion factor was obtained from repeated flights 200 to 1000 feet above terrain containing known distributions of natural isotopes. Such conversion factors have proved valid over distributed fission product fields, with a variation of less than 25%. In practice, variations of 2 μR/hr or greater can be reliably observed in repeated flights over the same area.

2. SITE CHARACTERISTICS

The Project Gnome Test Site is located 20 miles southeast of Carlsbad, New Mexico. The facility is operated by the U. S. Atomic Energy Commission. Figure 2 is a location map of the test site.

In general the terrain in the survey area is arid desert with little ground cover. The actual survey area is unpopulated.

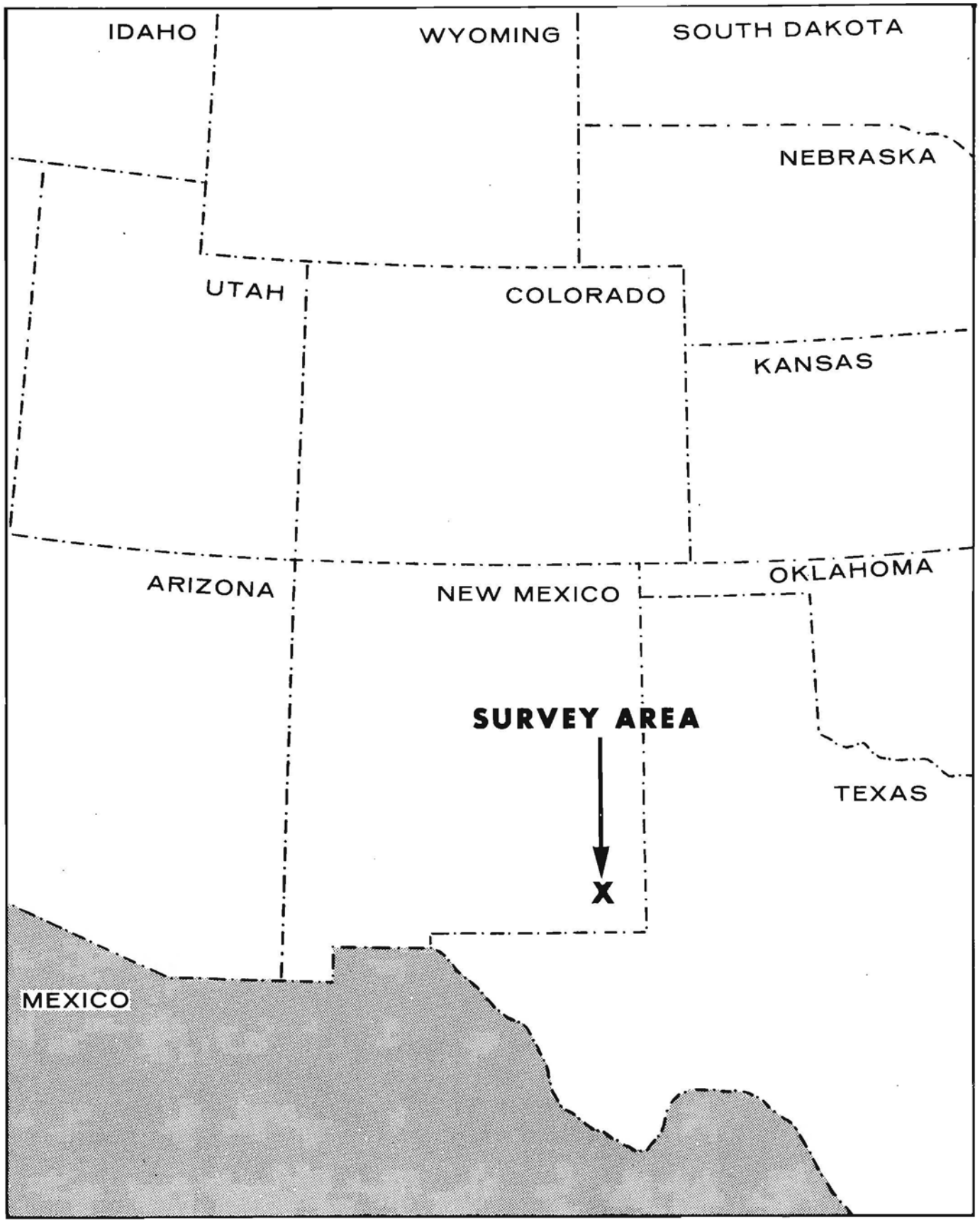


FIGURE 2. Project Gnome Test Site Location.

3. SURVEY PLAN

3.1 Specification of Flight Lines

The flight pattern for the Project Gnome Test Site survey consisted of five flight lines approximately four nautical miles long and spaced 0.20 nautical miles apart. The flight lines were oriented in an east-west direction. Radiation data together with aircraft position and meteorological information were collected along each flight line.

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 General Aviation District Office at Albuquerque, New Mexico 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 Carlsbad, New Mexico.

4. RADIOLOGICAL SURVEY

4.1 Survey Missions

The aerial survey of the Project Gnome Test Site area was conducted on May 13, 1972. This survey required a total flying time of one hour.

Gross-count and spectral data were simultaneously collected at an altitude of 500 feet. Spectral collections were accumulated over the entire length of each line. Several additional lines were flown at 300 feet over the waste dump area within the fenced perimeter of the test site to collect spectral data.

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 (Ref. 2). 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 (uR/hr) at the 3-foot 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 exposure rate map for overlay on U. S. Geological Survey topographic maps of the survey area.

An isoexposure map of the Project Gnome Test Site area is shown in Figure 3. The data shown on the map include a cosmic radiation contribution of 4.97 μR/hr. Spatial resolution of the exposure rate data is determined by the field of view of the detector system, which is about 1/4 mile.

4.3 Spectral Data

Spectral data were recorded from about 0.03 to 3.0 MeV. The recording system was calibrated prior to 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.

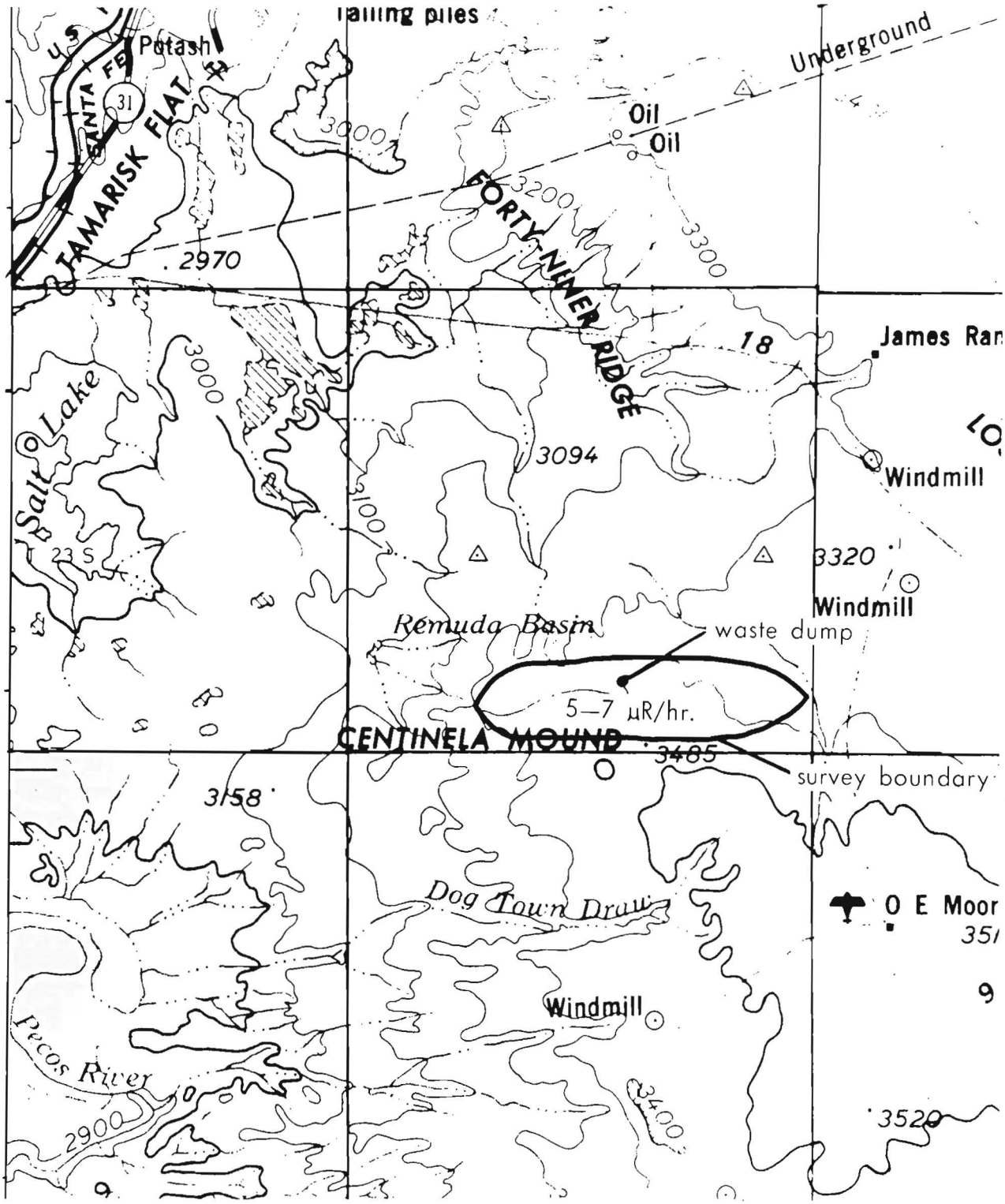
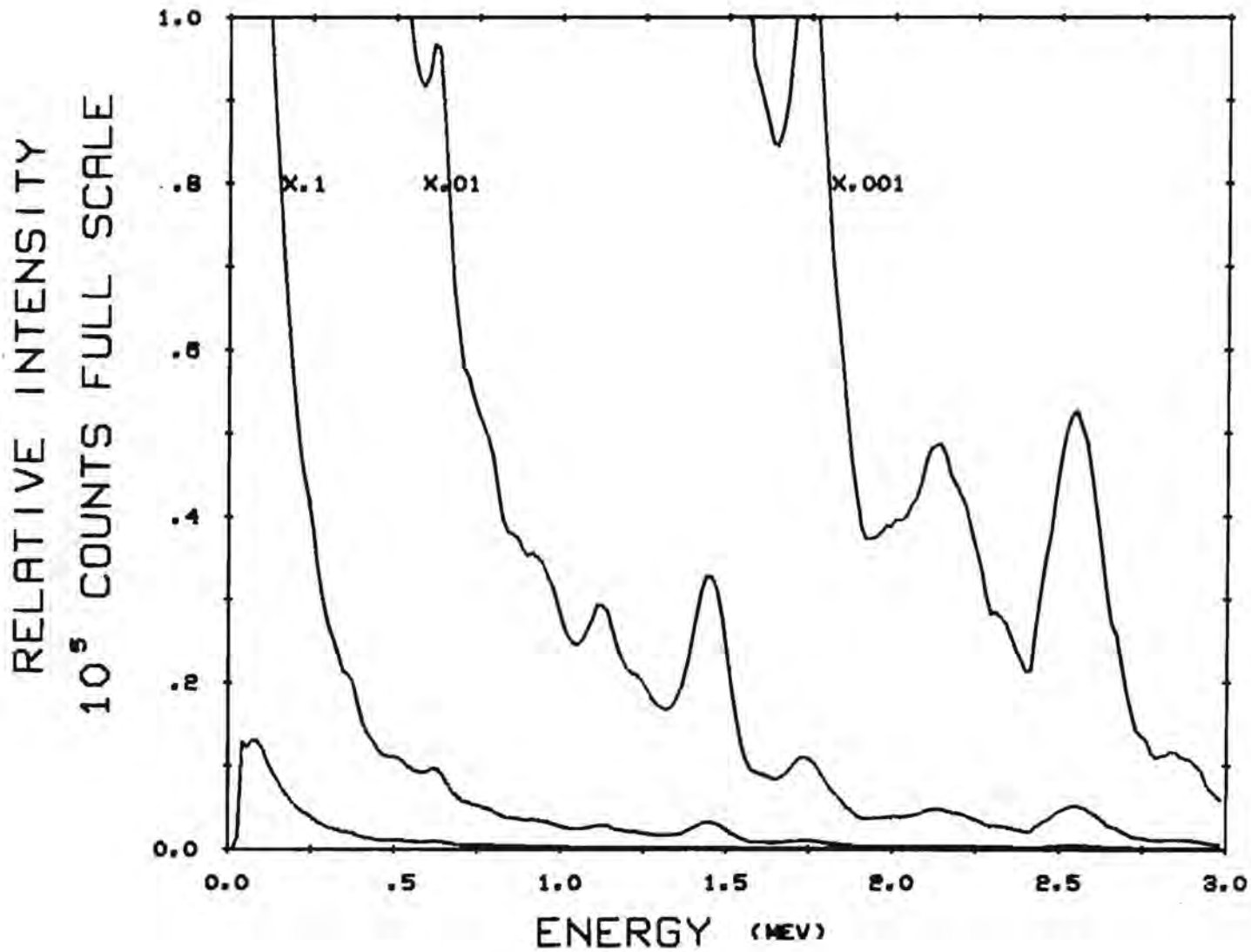


FIGURE 3. Gamma exposure rate map of the Project Gnome Test Site area, 13 May 1972.

A spectrum typical of those taken during the main survey is shown in Figure 4. Table 1 lists the prominent gamma-ray energies and associated source isotopes identified in the spectrum. Except for the waste dump area, 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 2 lists the prominent gamma ray energies and associated source isotopes identified in the spectrum.

The spectrum taken over the waste dump area indicates the additional presence of cesium-137. This spectrum is shown in Figure 5 and summarized in Table 2.



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LIVE TIME 1.46
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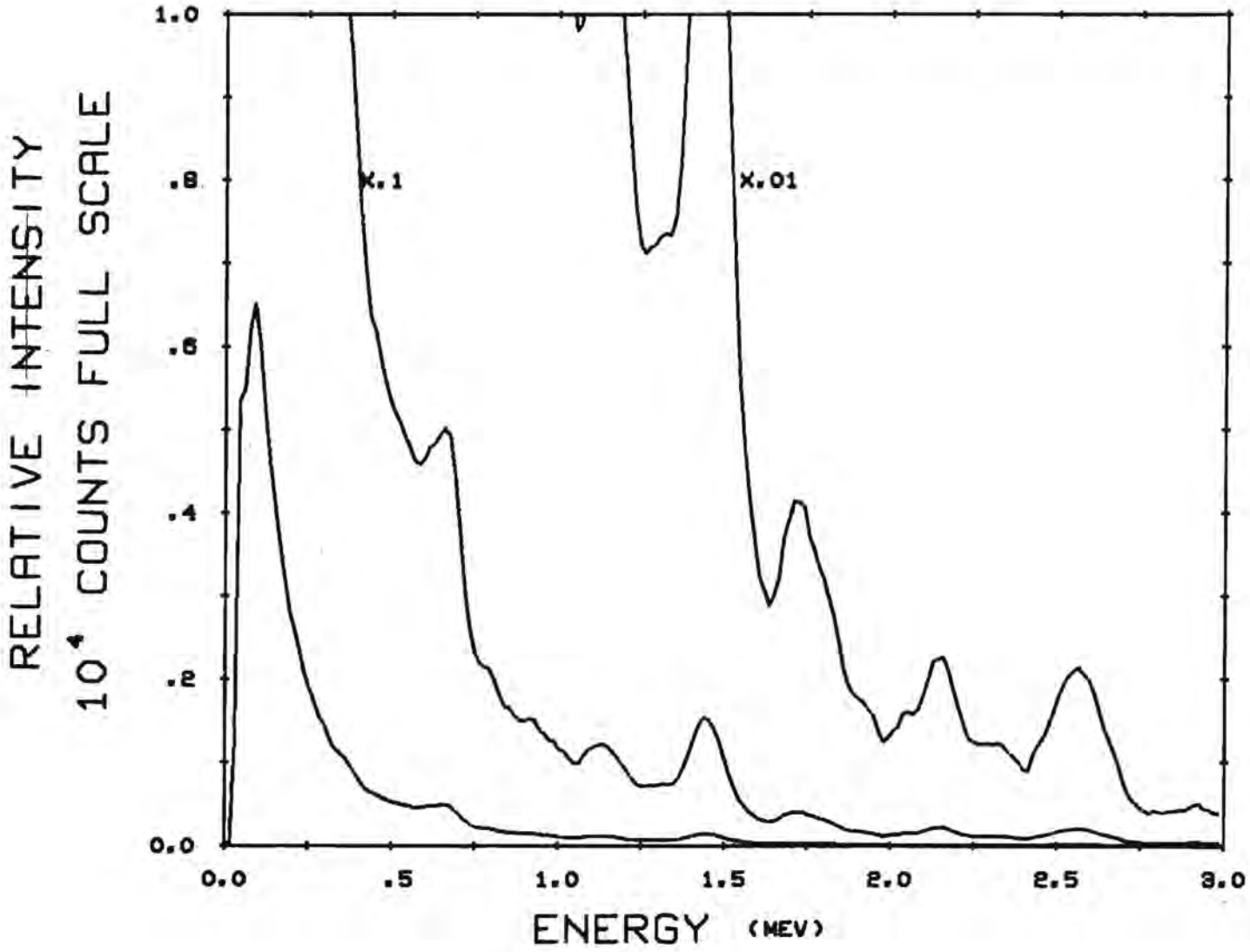
TYPE ACFT TERRAIN BKG.-GND. DEPO.
ALTITUDE 500.
AIRCRAFT (ARMS)

FIGURE 4. Typical spectrum for survey area.

TABLE 1. Gamma-ray energies and isotopes consistent with spectral data of Figure 4.

Observed Energy (MeV)	Radionuclides Consistent With Spectral Photopeaks		
	Fission Products	Activation Products	Background
0.35	. . . . .	. . . . .	Pb-214
0.61	. . . . .	. . . . .	Bi-214
0.94	. . . . .	. . . . .	Bi-214
1.12	. . . . .	. . . . .	Bi-214
1.46	. . . . .	. . . . .	K-40
1.76	. . . . .	. . . . .	Bi-214
2.20	. . . . .	. . . . .	Bi-214
2.62	. . . . .	. . . . .	Tl-208



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DATE 05-13-72
LIVE TIME 1.00
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TYPE ACFT TERRAIN BKG.-GND. DEPO.
ALTITUDE 300.
AIRCRAFT (ARMS)

FIGURE 5. Spectrum for waste dump area.

TABLE 2. Gamma-ray energies and isotopes consistent with spectral data of Figure 5.

Observed Energy (MeV)	Radionuclides Consistent With Spectral Photopeaks		
	Fission Products	Activation Products	Background
0.35	. . . . .	. . . . .	Pb-214
0.61	. . . . .	. . . . .	Bi-214
0.66	Cs-137	. . . . .	. . . . .
0.94	. . . . .	. . . . .	Bi-214
1.12	. . . . .	. . . . .	Bi-214
1.46	. . . . .	. . . . .	K-40
1.76	. . . . .	. . . . .	Bi-214
2.20	. . . . .	. . . . .	Bi-214
2.62	. . . . .	. . . . .	Tl-208

5. SUMMARY AND CONCLUSIONS

The four square mile aerial survey of the area surrounding the Project Gnome Test Site revealed that both the concentration and relative abundance of radioactive isotopes are consistent with normal background radiation. No anomalies were detected that could be attributed to the Project Gnome test, other than the trace amounts of cesium-137 detected over the waste dump area.

The 3-foot level exposure rates mapped during the survey were in the 5 to 7 μR/hr range.

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1. "Aerial Radiological Measuring Systems (ARMS) - Systems and Procedures Employed Through FY71," AEC Report No. ARMS-71.6, in preparation.

2. Burson, Z. G., Boyns, P. K., and Fritzsche, A. E., "Technical Procedures for Characterizing the Terrestrial Gamma Radiation Environment by Aerial Surveys," EG&G/LVAO Report No. 1183-1559, 1972.

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L. J. Deal (5)

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D. W. Hendricks
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AEC/TIC

P. W. Rosser (2)

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