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ENERGY MEASUREMENTS GROUP

THE
REMOTE
SENSING
LABORATORY
OF THE UNITED STATES
DEPARTMENT OF ENERGY

EG&G SURVEY REPORT
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AN AERIAL RADIOLOGICAL SURVEY OF AN AREA SURROUNDING
THE FORMER MIDDLESEX SAMPLING PLANT IN

MIDDLESEX, NEW JERSEY

DATE OF SURVEY: MAY 1978

DISCLAIMER

AN AERIAL RADIOLOGICAL SURVEY OF AN AREA SURROUNDING THE FORMER MIDDLESEX SAMPLING PLANT IN MIDDLESEX, NEW JERSEY

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1.0 SUMMARY OF RESULTS

An aerial radiological measuring system was used to survey the area surrounding the former Middlesex Sampling Plant in Middlesex, New Jersey during the month of May 1978. The survey was conducted for the U.S. Department of Energy's (DOE) Office of Operational Safety by the Department's Remote Sensing Laboratory, operated for the DOE by the Energy Measurements Group of EG&G.

The highest radiation exposure rates were measured over the plant site. Average radiation levels of 30 to 45 microroentgens per hour (μR/h), normalized to 3 feet above the ground, were inferred from the aerial data. Elevated radiation levels were also observed over some church property and over a residential lot. The source of the elevated activity in each case was radium.

Natural background radiation exposure rates measured by the airborne system within the survey area typically ranged from 6 to 8 μR/h.

2.0 INTRODUCTION

An aerial radiological survey was flown over a 1-3/4-mile by 2-mile area surrounding the former uranium ore sampling plant located in Middlesex, New Jersey. This survey was conducted for the Department of Energy's (DOE) Office of Operational Safety (OOS) by the Energy Measurements Group of EG&G. The Middlesex Sampling Plant was used during the 1940's and 1950's for assaying and storing uranium ores. The purpose of this aerial survey was to provide information to help guide the planning of ground-based surveys in the same vicinity.

An MBB BO-105 helicopter, equipped with aerial radiological detection systems, was used for the survey. The helicopter altitude above ground level was 150 feet with 300-foot line spacings.

Aerial radiological detection systems average the radiation levels produced by gamma-emitting radionuclides existing over an area of several acres. These detection systems are capable of determining specific radionuclides causing radiological anomalies. However, because of averaging, airborne systems, as compared to ground-based measurements, tend to underestimate the magnitude of localized sources. Details of the systems and procedures employed in obtaining and processing aerial radiation data are presented in References 1 and 2.

In aerial radiological surveys, the gamma ray energies, source concentrations, and relative distribution are measured by specialized instrumentation. The results are reported as radiation exposure rates in μR/h at 3 feet above the ground. The maximum annual radiation dose that could be absorbed through continuous exposure (24 hours a day for 365 days to a constant exposure rate), expressed in millirem per year (mrem/y) is approximated by multiplying the exposure rate in microroentgen per hour (μR/h) by 8.76.* These results apply to external radiation only and do not account for inhalation or ingestion of radioactive materials. The actual amount of radiation absorbed depends on the duration and circumstances of exposure.

3.0 BACKGROUND RADIATION

Background gamma radiation originates from naturally occurring radioactive elements present in the earth (terrestrial radiation) and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma rays originate primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Variable concentrations of these nuclides produce estimated annual radiation doses ranging from 15 to 140 mrem/y (1.7 to 16 μR/h) at the surface of the earth in the United States. The higher

*$\frac{\mu R}{h} \times 24 \frac{h}{day} \times 365 \frac{day}{y} \times \frac{1}{1000} \frac{mrem}{\mu R} = \frac{mrem}{y}$ (using the approximate conversion from μR to mrem)

background radiation dose levels (up to 140 mrem/y) are typically found in the western states, primarily in the Colorado Plateau area, and are a result of high uranium and thorium concentrations in surface minerals and increased cosmic radiation because of higher elevation.

The uranium decay chain includes radium-226 and its daughter, radon, which is a noble gas, i.e., it will not combine chemically with other elements. The radionuclide radon can both diffuse through the soil and move through the air to other locations. Thus, the level of radiation contributed by this noble gas depends upon the meteorological conditions, mineral and moisture content and permeability of the soil, and other physical conditions existing at each location at any particular time. Airborne radon typically contributes from 1 to 10 percent of the natural background radiation levels.

Cosmic rays, the space component of the natural radiological background, interact in a complex manner with the elements of the earth's atmosphere and soil. These cosmic ray interactions produce additional background radiation dose rates which vary slightly with latitude and directly with altitude, increasing from 26 mrem/y (3 μR/h) at sea level in Florida to 107 mrem/y (12 μR/h) at 10,000 feet above sea level at some locations in Colorado. The cosmic ray dose rate in Denver, Colorado (1 mile above sea level), contributes about 50 mrem/y to the total background dose rate of about 125 mrem/y.

The aerial survey results include the terrestrial gamma radiation measured throughout the surveyed area and an estimated cosmic ray exposure rate, but the results do not include the contribution from airborne radon.

4.0 SURVEY BOUNDARIES

This survey covered an area of approximately 3-3/4 square miles including parts of Middlesex and Piscataway, New Jersey. The boundaries of the survey are shown in Figure 1.

5.0 SURVEY RESULTS

The results of this aerial survey are presented in Figure 1 as closed contour curves of total radiation exposure rates (isoradiation contours) overlaid on an aerial photograph of Middlesex, New Jersey. The results are reported in units of μR/h at 3 feet above ground and include a cosmic ray contribution estimated at 4.0 μR/h.

The highest radiation exposure rates were measured over the plant site (Area 1 in Figure 1). Average radiation levels ranging from 30 to 45 μR/h were inferred from the aerial data. Natural background radiation exposure rates within the survey area typically ranged from 6 to 8 μR/h.

A special data processing technique was used to help identify areas containing radium-226 (an isotope of radium) greater than that present in typical background soils. Excess radium-226 activity generally indicates the presence of uranium ore or uranium tailings. (Details of the data processing technique are given in Reference 2.) The results of this special analysis are shown as blue contours in Figure 1. Excess radium-226 areas are indicated, as expected, over the plant site. The contours are larger than would be expected if all the material were confined on-site. This suggests that some material has been distributed to the area surrounding the site, probably by wind and/or water erosion.

Area 2 in Figure 1 shows elevated radiation levels averaging 12 to 17 μR/h 3 feet above the ground. This is the location of the Rectory of the Church of Our Lady of Mount Virgin in Middlesex. Material from the plant site was probably used as fill material at this location.

The lot at 432 William Street in Piscataway (Area 3) shows elevated radiation levels as well as excess radium-226 concentration. Again, material from the plant site was probably used as fill material at this location.

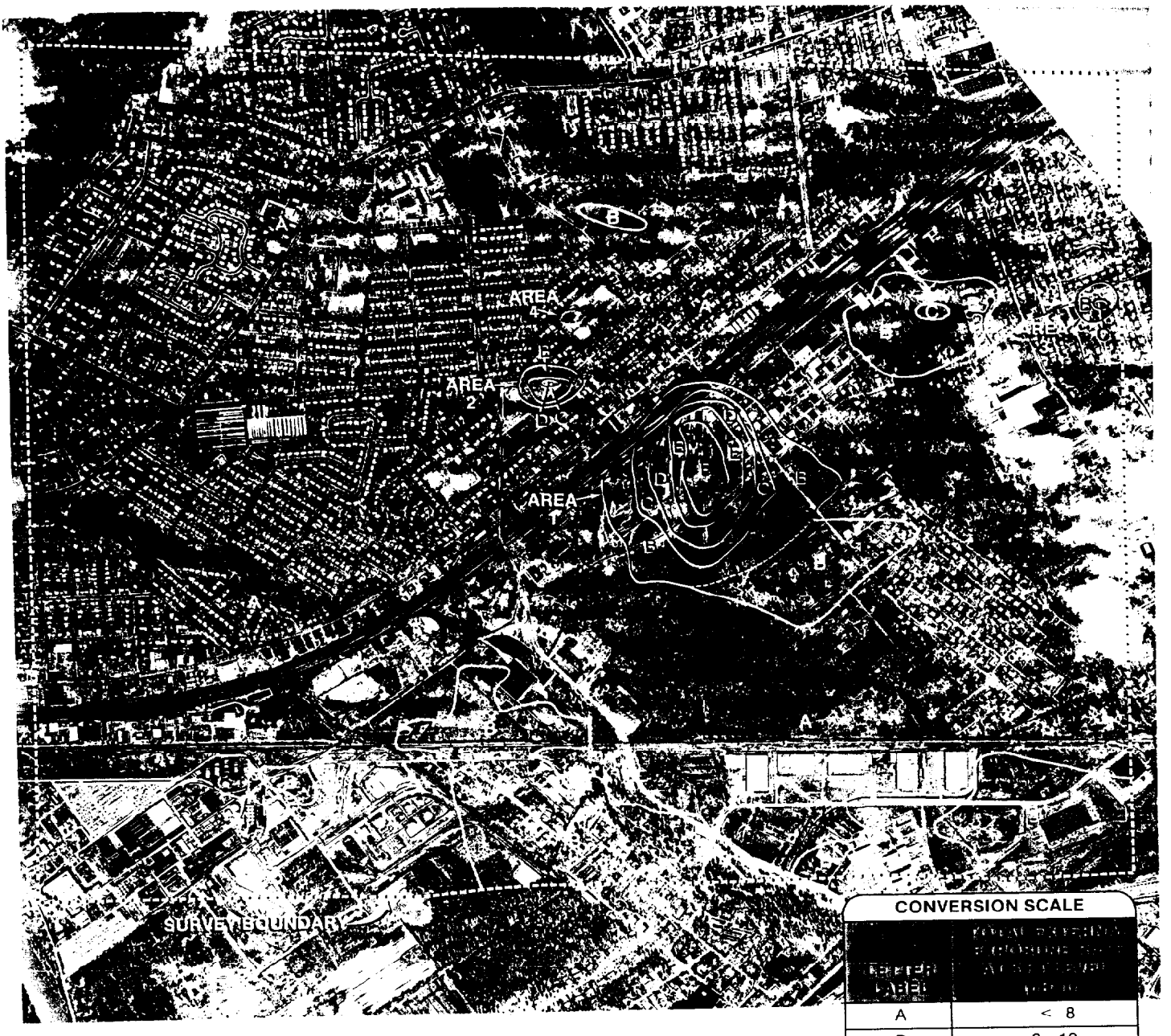
Area 4 shows elevated radium-226 concentration but does not show elevated radiation levels. This location is a recreational area. The slight increase in radium-226 concentration could be a statistical anomaly,

or it could be caused by soil at the location having a natural concentration of radium-226 slightly higher than the surrounding area. There is also a possibility that material from the plant site was used as fill dirt at this location. Ground-based measurements would be required to determine the cause of this anomaly.

REFERENCES

1. Boyns, P.K. July 1976. The Aerial Radiological Measuring System (ARMS): Systems, Procedures, and Sensitivity (1976). Report No. EGG-1183-1691. Las Vegas, Nevada: EG&G.

2. Jobst, J.E. 1979. "The Aerial Measuring Systems Program." Nuclear Safety, March/April 1979, 20:136-147.



CONVERSION SCALE	
CONTOUR LABEL	TOTAL EXPOSURE RATE (FOOTNOTE) AT 3 FT (μR/h)
A	< 8
B	8 - 10
C	10 - 12
D	12 - 17
E	17 - 30
F	30 - 45

* Inferred from gamma gross count rate observed at 150 ft above the ground. Applicable to the 3 ft level only as averages over large areas comparable to the detector's field-of-view. Also includes an estimated cosmic ray contribution of 4 μR/h.

Figure 1. *TOTAL EXPOSURE RATE ISORADIATION CONTOURS SUPERIMPOSED ON AN AERIAL PHOTOGRAPH OF THE FORMER MIDDLESEX SAMPLING PLANT, MIDDLESEX, NEW JERSEY. Natural background levels are represented by contours indicated in white. Blue contours indicate the presence of excess ^{226}Ra.*