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DEPARTMENT OF ENERGY

EG&G SURVEY REPORT
NRC—8113
NOVEMBER 1981

AN AERIAL RADIOLOGICAL SURVEY OF THE

W. R. GRACE PROPERTY

WAYNE TOWNSHIP, NEW JERSEY

Region I

DATE OF SURVEY: MAY 1981

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T. S. Dahlstrom
Project Scientist

REVIEWED BY

T P Stuart

T. P. Stuart, Manager
Nuclear Radiation Department

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G P Stobie

G. P. Stobie
Classification Officer

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ABSTRACT

During the week of 24 May 1981, an aerial radiological survey was performed over the W. R. Grace property in Wayne Township, New Jersey. The facility is occupied by a firm known as Electronucleonics, Inc. An isoradiation map was generated from the aerial data which shows increased levels of ^{208}Tl, a thorium daughter, over the burial grounds and in an area to the west believed to have resulted from subsurface water erosion of material from the burial grounds.

CONTENTS

1.0 SUMMARY

An aerial radiological survey was made during the week of 24 May 1981, of the W.R. Grace property located in Wayne Township, New Jersey. The site is occupied by Electro-nucleonics, Inc. and was formerly used to extract rare earths and thorium from monzanite sands. The property contains a 1.67 acre burial site, where building debris, sludges, and ore tailing had been buried. Average radiation levels of greater than 120 μR/h at one meter over the burial ground were inferred from the aerial data. Ground surveys over the same area indicated radiation levels of some local hot spots of 800 to 1000 μR/h. These levels were all due to the thorium daughter, ^{208}Tl.

The aerial survey data also suggests there had been some subsurface contamination to the west along a stream running adjacent to the property. The maximum levels in this area were inferred to be 60 to 120 μR/h at the one meter level. The average background levels were 8 to 12 μR/h including 3.7 μR/h cosmic radiation contribution.

2.0 INTRODUCTION

The United States Department of Energy (DOE) maintains an aerial surveillance operation called the Aerial Measuring System (AMS). AMS is operated for DOE by EG&G. This continuing nationwide program, started in 1958, involves surveys to monitor radiation levels in and around facilities producing, utilizing, or storing radioactive materials. The purpose of the surveys, in general, is to document, at a given point in time, the location of all areas containing gamma-emitting radionuclides (visible at the surface) and to aid in evaluating the magnitude and spatial extent of any radioactive contaminants released into the environment. At the request of federal and state agencies, AMS is deployed for various aerial survey operations.

Aerial radiological detection systems average the radiation levels due to gamma-emitting radionuclides existing over an area of several acres. The systems are capable of detecting anomalous gamma count rates and determining the specific radionuclides causing the anomalies; however, because of averaging, they tend to underestimate the magnitude of localized sources as compared with ground-based readings. As such, the indicated radiation levels in the vicinity of anomalies are not definitive. Ground surveys are required for accurate definition of the extent and intensity of such anomalies.

The results of the survey are reported as radiation exposure rates in microroentgens per hour (μR/h) at 1 meter above the ground surface. Approximate annual absorbed radiation dose levels expressed as millirem per year (mrem/y) are obtained by multiplying μR/h by 8.76. This conversion number applies only to the external radiation dose component.

This report is the result of a survey requested by the Environmental Protection Agency for an area centered on the former W. R. Grace Property in Wayne Township, N.J. The preparation of the report was requested by the Nuclear Regulatory Commission.

3.0 BACKGROUND

Natural background radiation originates from radioactive elements present in the earth 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. Local concentrations of these nuclides produce radiation levels at the surface of the earth in the range of 1 to 15 μR/h (9 to 130 mrem/y). Some areas with high uranium and thorium concentrations in surface minerals exhibit even higher radiation levels, especially in the western states. For example, in the Colorado Plateau area the average radiation level is above 200 mrem/y. At some locations in Brazil and India, the natural radiation level is above 1000 mrem/y. One member of each of the uranium and thorium decay chains is an isotope of the noble gas, radon, which can diffuse through soil and be borne by air to other locations. Thus, the level of this airborne radiation depends on the meteorological conditions, the mineral content of the soil, the soil permeability, and other conditions existing at each location at any particular time. The airborne radiation contributes from 1 to 10% of the natural background radiation levels.

Cosmic rays (the space component) interact in a complicated manner with the elements of the earth's atmosphere and the soil. These interactions produce an additional natural source of gamma radiation. Radiation levels due to cosmic rays vary with altitude and geomagnetic latitude: they range from 3.7 to 23 μR/h (up to 200 mrem/y).[1] The cosmic ray contribution in Wayne Township is estimated to 3.7μR/h.

4.0 DISCUSSION AND RESULTS

The results of the aerial survey are shown in Figure 1 as exposure rate isoradiation contours. These contours are derived from gross gamma count rates at survey altitude. The contours are overlaid on a combination of an aerial photograph and a USGS map (a single photograph of the entire survey area was unavailable). Data analysis details are given in Appendix A.

As shown in Figure 1, the natural background radiation levels generally ranged from 8 to 12 μR/h. Lower radiation levels are evident over large bodies of water where cosmic radiation dominates the background levels.

Radiation levels higher than background were found over the burial ground and over an area west of the property. These contours are shown in blue in Figure 1.

The highest radiation levels inferred from the gross gamma count rates from the aerial survey data were above 120 μR/h. However, these numbers represent levels averaged over the total field-of-view of the detector system and do not reflect small localized hot spots. Measurements taken on the ground with hand-held survey meters gave exposure rates from 800 to 1000μR/h in one area (about two feet in diameter) on the western boundary of the burial ground.

The spread of contamination to the west of the plant is most likely due to subsurface erosion along the outer boundaries of a stream which runs along the eastern and southern boundaries of the property and then flows west on the opposite side of Black Oak Ridge road. The highest levels in this region (inferred from the aerial survey data) were 60 to 120 μR/h.

The blue E level contour surrounding the burial ground and the area to the west does not accurately define the boundaries of the higher radiation levels at ground level. Because the burial ground and stream exhibit relatively high level activity and are concentrated in small areas, the detectors "see" the radiation from these areas, both before the helicopter reaches them and after it has passed them.

There are additional E level contours to the west and south of the contaminated areas. However, these are most likely due to natural radiation anomalies and are not associated with the burial grounds.

A gamma ray energy spectrum was extracted from the aerial data taken over the burial ground (see appendix A). The photopeaks of the ^{208}Tl and other isotopes in the thorium decay chain dominated the spectrum.

The survey data were also processed by another method to identify those areas that contained ^{208}Tl in excess of its natural abundance. The results showed only the area contained within the blue contours. The existence of ^{208}Tl identifies the presence of thorium, which was expected to be present in the residue of monzanite sands used in the production of rare earths and thorium compounds at this facility.

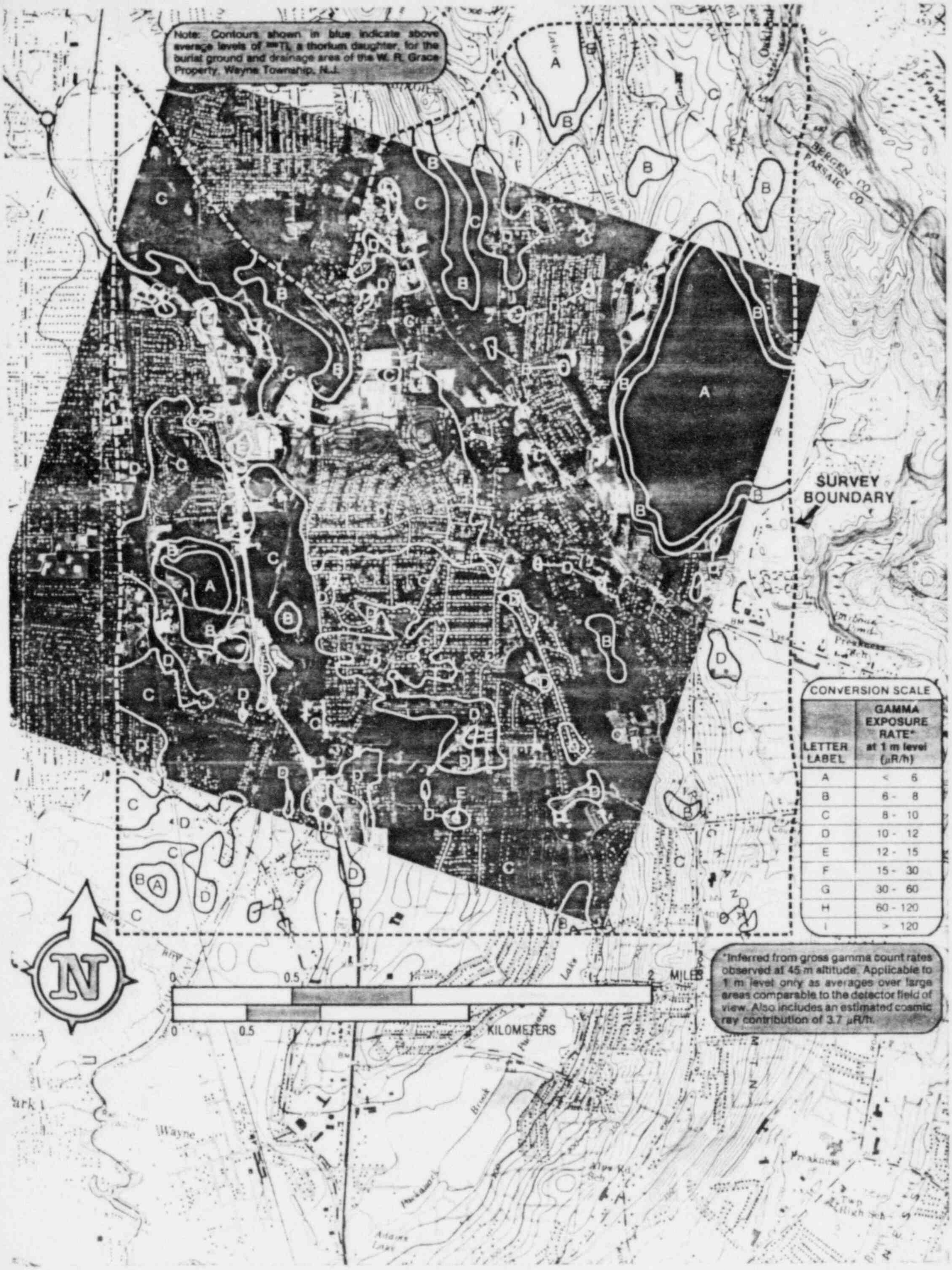

Figure 1. *EXPOSURE RATE ISORADIATION CONTOURS*

APPENDIX A. SURVEY METHOD, DATA ANALYSIS EQUIPMENT, DATA PROCESSING METHODS AND RESULTS

The data reported here were generated from measurements taken with an airborne system during the week of 24 May 1981. Gamma rays were detected in 12.7-cm diameter by 5.1-cm thick NaI (T*l*) crystals arranged in two arrays of ten crystals each. To cover the area of interest the system was flown in a BO-105 helicopter at 45 m altitude along a series of parallel lines. Position information from a microwave ranging system was recorded on magnetic tape along with the radiation data. Correlations between the two and extractions of specific types of nuclides were effected with a computer data processing system. A description of the equipment and operating procedures can be found in References 2 and 3.

Gross Counting Rates

The gamma ray energy spectrum measured during this survey covers the range between 0.05 million electron volts (MeV) and 3 MeV. This spectrum is useful for identifying specific nuclides contributing to the total activity. The most active areas in Figure 1 were singled out for spectral examination. The nuclides responsible for the increased activity were sought by comparing background spectral data with spectral data accumulated while the aircraft was over the anomalous area. The background was taken from data gathered at positions just before or just after the anomaly (Figure 1). A typical background spectrum is shown in Figure A-1. Figure A-2 presents channel-by-channel differences between anomalous and background data. The predominant peaks are due to ^{208}T*l*, a daughter of thorium.

The gross count rate isopleths (Figure 1) are based on the sum of all counts in that portion of the gamma ray energy spectrum between 0.05 MeV and 3 MeV. The terrestrial component of gross count rate and the sum of exposure rates due to soil and cosmic ray activity were produced as follows:

1. Overflight of a body of water at the survey altitude to measure the sum of count rates due to aircraft background, cosmic rays, and airborne radon daughter radionuclides.
2. Measurement of count rate over the survey area.
3. Subtraction of Item 1 from Item 2.
4. A predetermined factor obtained over a calibration range near Lake Mead was then applied to convert Item 3 above to exposure rate.

Dependent on (a) the proximity of the survey area to the body of water overflown in Step 2, (b) the differences in topography and meteorological conditions between the areas, and (c) the differences in time between execution of the two flights, the counts resulting from Step 3 and the isopleths shown in Figure 1 may be either rich or poor in airborne radon daughter content. Daily variations in airborne radon daughter concentrations can lead to discontinuities in isopleths across boundaries between areas flown on different days. When necessary, corrections were made for this effect. The correction, based on data from a single cross-track flight, adjusted counting rates to a constant component due to the airborne radon daughter levels. Although not precisely known, this airborne radon daughter component is estimated to contribute an uncertainty of no more than 10% to the exposure rate.

The calibration described in Step 4 was done over an area containing a typical mix of naturally occurring radionuclides. The conversion factor will be in error where the mix is atypical, where man-made nuclides exist, or when airborne radon daughter contributions are not completely subtracted. The conversion factor used was 987 counts per second per μR/h one meter above the ground.

It should be stressed that inherent spatial resolution in any remote sensing survey that uses uncollimated detectors (such as the airborne system) is one to two times the distance between the surveyed surface and the detector. Therefore, ground surveys using detectors at the one meter level will not compare well with an aerial survey over areas that contain sources whose lateral dimensions are small relative to the aircraft altitude. Isopleths constructed from a ground survey over a point source will indicate a source width of one to two meters, whereas aerial survey isopleths over the same source will indictate a source width of at least several tens of meters.

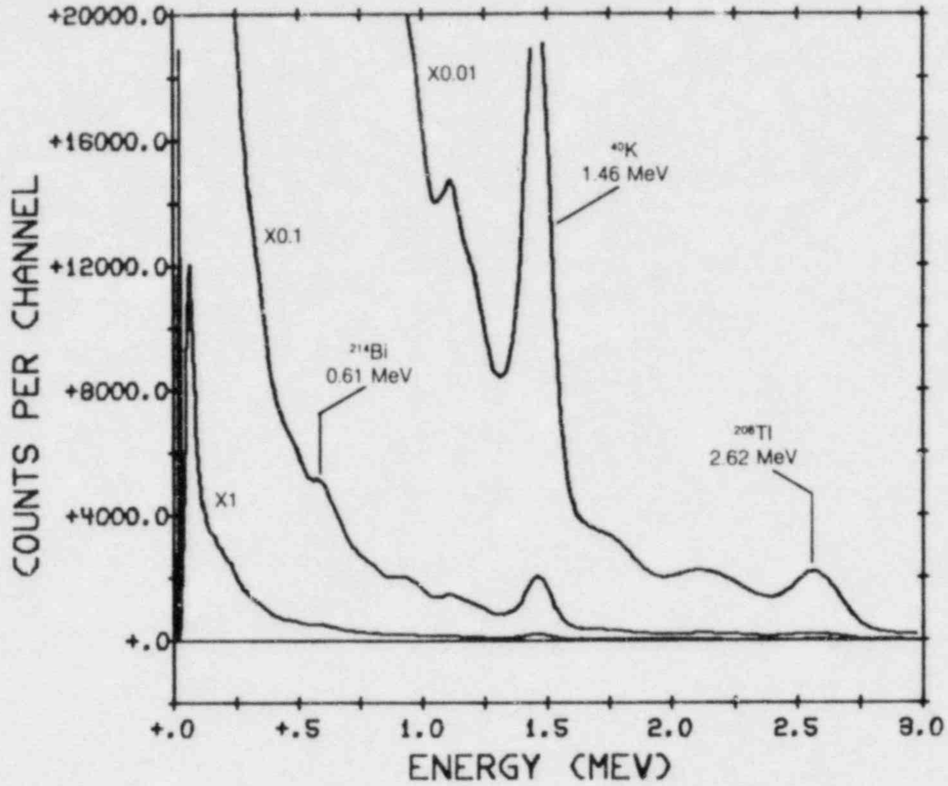

Figure A-1. *GAMMA PULSE-HEIGHT SPECTRUM OF TYPICAL BACKGROUND AREA*

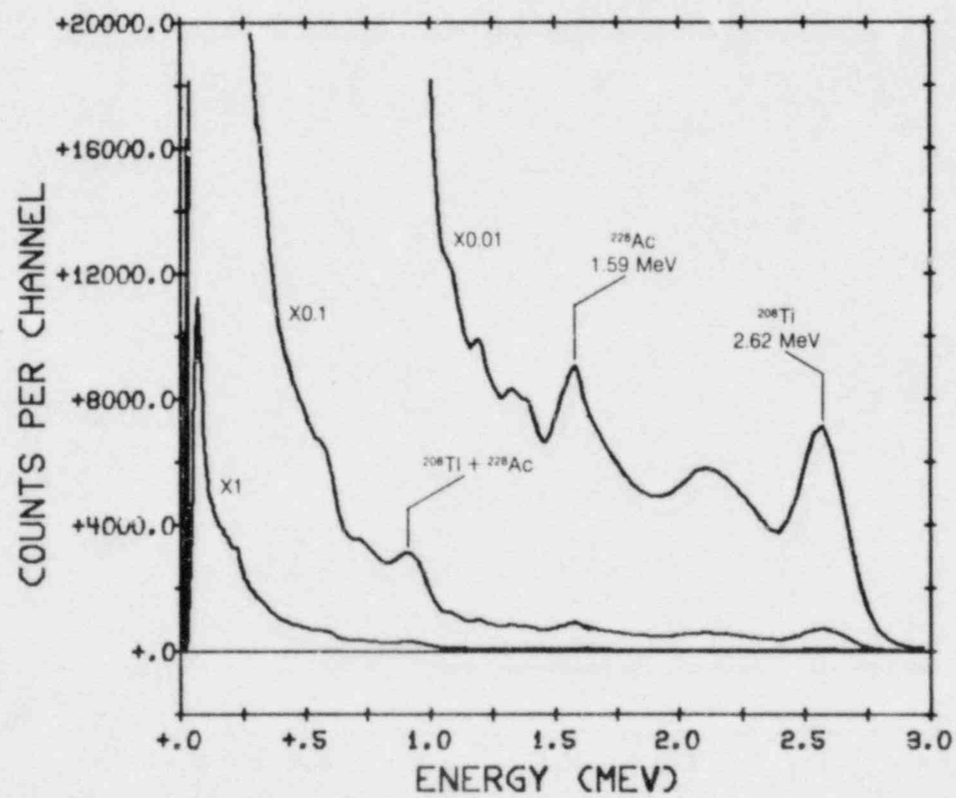

Figure A-2. *NET SPECTRUM OF ELEVATED ACTIVITY OVER THE BURIAL GROUND*

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