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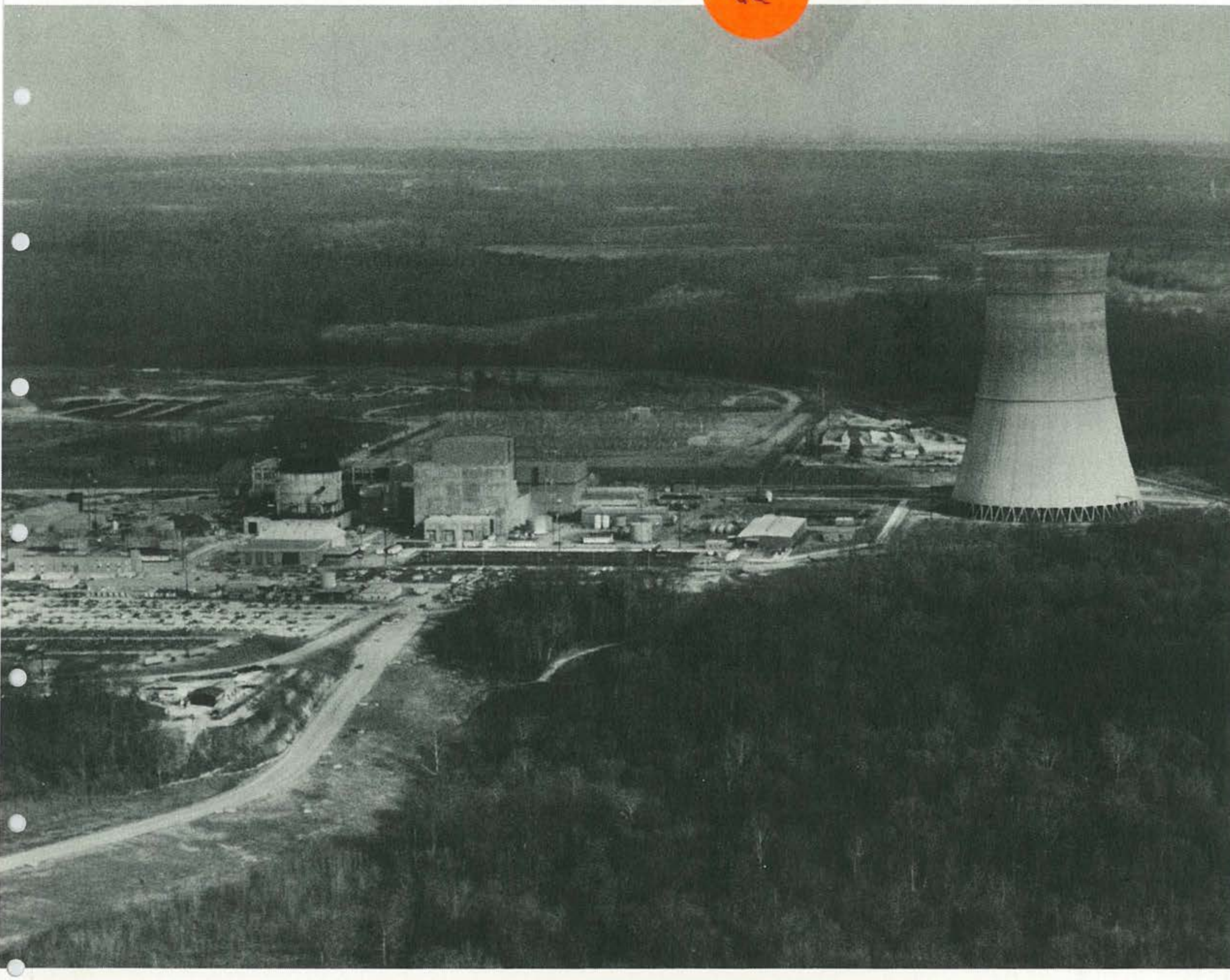

AN AERIAL RADIOLOGICAL SURVEY OF THE

GRAND GULF NUCLEAR STATION

AND SURROUNDING AREA

PORT GIBSON, MISSISSIPPI

DATE OF SURVEY: MARCH 1982

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This Document is UNCLASSIFIED

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ABSTRACT

An aerial radiological survey was performed from 11 to 20 March 1982 over a 260-square-kilometer area centered on the Grand Gulf Nuclear Station at Port Gibson, Mississippi (the station was not yet in operation at the time of the survey). All gamma ray data were collected by flying east-west lines spaced 152 meters apart at an altitude 91 meters above ground level. Processed data showed that all gamma rays detected within the survey area were those expected from naturally occurring terrestrial background emitters. Count rates obtained from the aerial platform were converted to exposure rates at 1 meter above the ground and are presented in the form of an isoradiation contour map. The observed exposure rates were between 5 and 13 microroentgens per hour (μR/h), with most of the area ranging from 9 to 10 μR/h. These values include an estimated cosmic ray contribution of 3.6 μR/h. The exposure rate obtained from soil samples and ionization chamber measurements taken from within the survey site displayed positive agreement with the aerial data.

CONTENTS

1.0 INTRODUCTION

The United States Department of Energy (DOE) maintains a Remote Sensing Laboratory (RSL) in Las Vegas, Nevada and an extension facility in Washington, D.C. The RSL is operated for the DOE by the Energy Measurements Group of EG&G, an independent contractor. One of the major functions of the RSL is to manage an aerial surveillance program called the Aerial Measuring Systems (AMS).

Since its inception in 1958, the AMS has continued a nationwide effort to document baseline radiological conditions surrounding energy-related sites of interest. These sites include nuclear power plants, manufacturing and processing plants, and research laboratories employing nuclear materials.[1] AMS aircraft have the capability of being equipped with mapping and multispectral scanners for ultraviolet, visible, and infrared imagery; a broad array of meteorological sensors; and air sampling systems for particulate and molecular gas measurements. At the request of federal or state agencies, and by direction of the DOE, AMS is deployed for various aerial survey operations.

The aerial radiological survey of the Grand Gulf Nuclear Station and surrounding area, near Port Gibson, Mississippi, was requested by the U.S. Nuclear Regulatory Commission. The purpose of the survey was to provide background information useful for future comparison when the station is operational.

2.0 NATURAL BACKGROUND RADIATION

Natural background radiation originates from radioactive elements present in the earth and cosmic rays entering the earth's atmosphere from space. The terrestrial gamma radiation originates primarily from the uranium decay chain, the thorium decay chain, and radioactive potassium. Local concentrations of these nuclides produce radiation levels typically ranging from 1 to 15 μR/h (9 to 130 mrem/y) at the surface of the earth. In the United States the higher levels are found in the western states, primarily in the Colorado Plateau area, as a result of high uranium and thorium concentrations in surface minerals. The coastal plains bordering the Atlantic Ocean and Gulf of Mexico generally display low radiation levels which are about half the U.S. average.[2]

One member of each of the uranium and thorium decay chains is a noble gas (radon) which can both diffuse through the soil and be transported through the air to other locations. Therefore, the level of airborne radiation depends on the meteorological conditions, the mineral content and permeability of the soil, and other physical conditions existing at each location at a particular time. The airborne radiation typically contributes from 1 to 10% of the natural background radiation levels.

Cosmic rays, the space component, interact in a complex manner with the elements of the earth's atmosphere and soil. These interactions produce an additional natural source of gamma radiation. Radiation levels due to cosmic rays vary with altitude and geomagnetic latitude and range from about 3.3 to 12 μR/h (up to 100 mrem/y) in the United States.[3]

The natural terrestrial radiation levels depend upon the type of soil and bedrock immediately below and surrounding the point of measurement. Within cities, the levels are also dependent upon the nature of the street and building materials.

3.0 SURVEY SITE DESCRIPTION

The AMS was employed from 11 to 20 March 1982 to survey a 260-square-kilometer area near Port Gibson, Mississippi. The Grand Gulf Nuclear Station (owned and operated by the Mississippi Power and Light Company) was at the center of the survey area. The pressurized water reactor was not yet in operation at the time of the survey.

4.0 SURVEY PROCEDURES AND EQUIPMENT

4.1 Operational Support

A Messerschmitt-Bolkow-Blohm (MBB) BO-105 helicopter (Figure 1) was used for the survey. The aircraft carried a crew of two along with a fourth generation version of a lightweight specialized data recording apparatus called the Radiation and Environmental Data Acquisition and Recorder (REDAR) system. Two gamma ray detector pods were mounted one on each side of the helicopter. Each detector pod contained 10 sodium iodide (thallium activated) crystals, 12.7 cm in diameter and 5.1 cm in height. The detectors were calibrated with americium-241 (60 keV) and sodium-22 (0.511 and 1.27 MeV) gamma ray sources. Signals from 19 of the detectors were summed in order to produce a single spectrum with high sensitivity. The remaining single tube was used to provide a spectrum with lower sensitivity for use in areas exhibiting greatly enhanced levels of radiation. Both spectra were simultaneously acquired and recorded. Hence, the count rate operating range of the data acquisition system was greatly extended. This dual spectral capability also made it possible to invoke various data integrity safeguards.

Figure 1. *MBB BO-105 HELICOPTER*

The data acquisition and recording system contained five microprocessor controlled subsystems used in the collection of survey information. The first, a control subsystem, was responsible for collecting gross count, live time, spectral, and radar altitude data. Additionally, the first microprocessor sent the data to the tape subsystem every 4 seconds for recording. Spectral data were recorded in two memories which operated in a time-share mode (i.e., one memory collected data while the other was being read). At the same time, aircraft positional data were collected and stored on magnetic tape. The second microprocessor controlled the display subsystem which collected and formatted the data for display on two cathode-ray tubes aboard the aircraft. The third microprocessor controlled the tape subsystem, composed of the processor and a dual digital cartridge recorder. The system recorded four 1-second blocks of data on magnetic tape every 4 seconds. Each data cartridge contained sufficient magnetic tape for 0.9 hours of data collection time. The fourth microprocessor controlled the steering indicator subsystem used to aid the pilot in flying straight, predetermined flight lines. The fifth microprocessor controlled a special usage subsystem not used in this survey.

4.2 Aircraft Positioning

Contiguous USGS maps were used to define the survey area. Radiological data were taken at an altitude 91 meters (300 ft) above ground level along flight lines 16 kilometers in length and spaced 152 meters apart. A total of 105 lines were flown for this survey.

Helicopter position was established by two systems: a microwave ranging system (MRS) and a radar altimeter. The MRS master unit, mounted in the aircraft, interrogated two remote transceivers which were mounted in an appropriate geometric configuration several kilometers outside the survey area. By measuring the round-trip propagation time between the master and remote units, the master unit computed the distance to each. These distances were acquired each second, recorded on magnetic tape, and in subsequent computer processing were converted to position coordinates and scaled to fit a 1:24,000 USGS topographic map.

The radar altimeter aboard the helicopter similarly measured the time lag for the return of a pulsed signal and converted this delay to aircraft altitude. These data were also recorded on magnetic tape so that variations in observed gamma count rates caused by altitude fluctuation could be adjusted.

4.3 Data Processing

The data recorded on magnetic tapes during the survey were processed with the Radiation and Environmental Data Analyzer and Computer (REDAC) system. This system consisted of a minicomputer mounted in a mobile data processing laboratory (Figure 2). An extensive inventory of software routines and supporting equipment was available for detailed data analysis.

Some of the data was processed during the actual survey period to assure complete data acquisition integrity and to provide preliminary results as soon as possible. The data processing procedures are described in detail in a separate publication.[4]

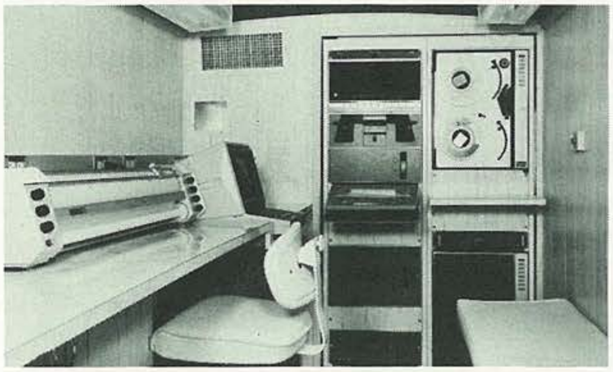

Figure 2. *MOBILE COMPUTER PROCESSING LABORATORY*

5.0 GROUND-BASED MEASUREMENTS

Soil samples in the survey area were taken from selected locations immediately before commencement of the aerial survey. A Reuter-Stokes pressurized ionization chamber (Model RSS-111) was also used to measure the level of gamma ray activity at the survey site.[5] The results of these ground-based measurements are included in Section 7.0.

It should be noted that aerial radiological detection systems average existing radiation levels, produced by gamma-emitting radionuclides, over an area of several hectares. 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.

6.0 DATA ANALYSIS

For this survey, the data analyses were directed toward producing three specific results: (1) a total gamma ray exposure rate isoradiation contour map of the survey area, (2) gamma ray spectra characterizing the overall radiation profile of the site, and (3) identification of anomalies which may have been detected.

Exposure rate contours were constructed from gross count rate numbers, which refer to integral count rates in that portion of the gamma ray energy spectrum between 0.04 and 3.00 MeV. Letter labels were used to identify discrete count rate intervals. Exposure rate isoradiation contours were then constructed by plotting the radiation data as a function of position after the positional information had been properly scaled for the particular maps desired. Before plotting the gross count rate data, the non-terrestrial contributions to the detector system were extracted. These components specifically were: (1) aircraft background, (2) cosmic radiation, and (3) airborne radon daughter contributions. These components were determined by flying over a large body of water (the Mississippi River) and assuming these values were applicable to the nearby survey area. Terrestrial exposure rate values in microroentgens per hour (μR/h) at the 1 meter level were calculated from the gross count rates using the approximate conversion factor of 730 counts per second equals 1 μR/h. A cosmic ray contribution of 3.6 μR/h was then added to the aerial data to obtain the total exposure rate values given in Figure 3.

7.0 RESULTS

An exposure rate isoradiation contour map of the Grand Gulf Nuclear Station survey area is shown in Figure 3. The exposure rates determined in this survey over the land area ranged from 5 to 13 μR/h at 1 meter above the ground. The typical background exposure rate was approximately 9 to 10 μR/h. These values include a cosmic ray contribution of 3.6 μR/h. All gamma rays detected within the survey area were from naturally occurring radioisotopes. A gamma ray pulse-height spectrum typical of the natural terrestrial background radiation detected in this survey is shown in Figure 4.

Soil samples and ion chamber measurements were taken at five locations (see Figure 3). The exposure rates measured with the pressurized ion chamber ranged from 9 to 10.5 μR/h. The soil samples were analyzed at the EG&G facilities in Santa Barbara, California. All of the spectral lines detected were associated with the decay chains of naturally occurring uranium and thorium and with radioactive potassium. The isotope concentration values were converted to 1 meter

CONVERSION SCALE	
LETTER LABEL	GAMMA EXPOSURE RATE AT 1 m LEVEL* (μR/h)
A	< 5
B	5 - 8
C	8 - 11
D	11 - 13

* Averaged over detectable field-of-view at survey altitude of 91 m (300 ft) and extrapolated to 1 m level. Includes 3.6 μR/h due to cosmic ray contributions.

Figure 3. *EXPOSURE RATE CONTOUR MAP OF THE AREA SURROUNDING THE GRAND GULF NUCLEAR STATION. Also shown are the locations of the ground-based measurements taken in support of the aerial survey.*

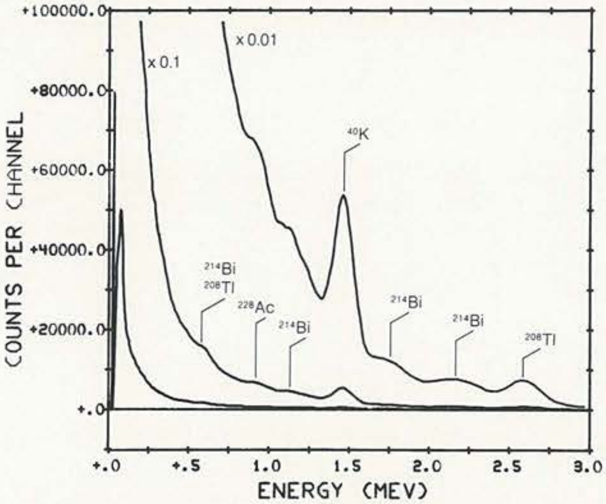

Figure 4. *BACKGROUND GAMMA RAY SPECTRUM TYPICAL OF THE AREA NEAR THE GRAND GULF NUCLEAR STATION*

above ground exposure rates and a cosmic ray contribution of 3.6 μR/h added. The exposure rates observed with the pressurized ion chamber and those obtained from the soil sample analyses agree well with the exposure rates obtained from the aerial platform (Table 1).

The primary difference between data collected with the airborne system and data obtained from ground measurements is the difference in area covered by a single measurement. Each 1-second data point obtained with the airborne platform covers an area several thousand times as large as a measurement made at 1 meter (such as with a hand-held survey meter), and several million times as large as a typical soil sample. For an ideal uniform distribution extending over a large area, each type of measurement should, in principle, lead to the same results. In practice, however, it is not unusual to find some local variation in radiation levels from point to point on the ground, even over relatively constant areas. This should be kept in mind when comparing aerial data with ground-based measurements.

In summary, the results of the aerial radiological survey of the Grand Gulf Nuclear Station and surrounding area showed only the presence of normally occurring background gamma-emitting radioisotopes.

Table 1. Comparison of Results From Aerial and Ground-Based Measurements

	Exposure Rate (μR/h at 1 meter)		
Location [1]	**Ion Chamber**	**Soil Analysis** [2]	**Aerial Data** [2]
1	10.0	12.3	8 - 11
2	9.3	11.2	8 - 11
3	9.3	11.8	8 - 11
4	10.1	11.4	8 - 11
5	10.5	11.9	8 - 11

[1] Refer to Figure 3.

[2] Includes an estimated cosmic ray contribution of 3.6 μR/h.

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