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**RESULTS OF THE
RADIOLOGICAL SURVEY
AT
6 HANCOCK STREET, LODI,
NEW JERSEY (LJ033)**

**R. D. Foley
L. M. Floyd
R. F. Carrier
J. W. Crutcher**

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HEALTH AND SAFETY RESEARCH DIVISION

Nuclear and Chemical Waste Programs
(Activity No. AH 10 05 00 0; ONLWCO1)

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ABSTRACT

Maywood Chemical Works (MCW) of Maywood, New Jersey, generated process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores from 1916 to 1956. MCW supplied rare earth metals and thorium compounds to the Atomic Energy Commission and various other government agencies from the late 1940s to the mid-1950s. Area residents used the sandlike waste from this thorium extraction process mixed with tea and cocoa leaves as mulch in their yards. Some of these contaminated wastes were also eroded from the site into Lodi Brook. At the request of the U.S. Department of Energy (DOE), a group from Oak Ridge National Laboratory conducts investigative radiological surveys of properties in the vicinity of MCW to determine whether a property is contaminated with radioactive residues, principally ^{232}Th , derived from the MCW site. The survey typically includes direct measurement of gamma radiation levels and soil sampling for radionuclide analyses. The survey of this site, 6 Hancock Street, Lodi, New Jersey (LJ033), was conducted during 1985 and 1986.

Results of the survey demonstrated radionuclide concentrations in excess of the DOE Formerly Utilized Sites Remedial Action Program criteria. The radionuclide distributions are typical of the type of material originating from the MCW site.

**RESULTS OF THE RADIOLOGICAL
SURVEY AT 6 HANCOCK STREET, LODI,
NEW JERSEY (LJ033)***

INTRODUCTION

From 1916 to 1956, process wastes and residues associated with the production and refining of thorium and thorium compounds from monazite ores were generated by the Maywood Chemical Works (MCW), Maywood, New Jersey. During the latter part of this period, MCW supplied rare earth metals and thorium compounds to various government agencies. In the 1940s and 1950s, MCW produced thorium and lithium, under contract, for the Atomic Energy Commission (AEC). These activities ceased in 1956, and, approximately three years later, the 30-acre real estate was purchased by the Stepan Company. The property is located at 100 Hunter Avenue in a highly developed area in Maywood and Rochelle Park, Bergen County, New Jersey.

During the early years of operation, MCW stored wastes and residues in low-lying areas west of the processing facilities. In the early 1930s, these areas were separated from the rest of the property by the construction of New Jersey State Highway 17. The Stepan property, the interim storage facility, and several vicinity properties have been designated for remedial action by the U.S. Department of Energy (DOE).

The waste produced by the thorium extraction process was a sandlike material containing residual amounts of thorium and its decay products, with smaller quantities of uranium and its decay products. During the years 1928 and 1944 to 1946, area residents used these process wastes mixed with tea and cocoa leaves as mulch in their lawns and gardens. In addition, some of the contaminated wastes were apparently eroded from the site into Lodi Brook and carried downstream.

Lodi Brook is a small stream flowing south from Maywood with its headwaters near the Stepan waste storage site. Approximately 150 ft after passing under State Route 17, the stream has been diverted underground through concrete or steel culverts until it merges with the Saddle River in Lodi, New Jersey. Only a small section near Interstate 80 remains uncovered. From the 1940s to the 1970s when the stream was being diverted underground, its course was altered several times. Some of these changes resulted in the movement of contaminated soil to the surface of a few properties, where it is still in evidence. In other instances, the contaminated soil was covered over or mixed with clean fill, leaving no immediate evidence on the surface. Therefore, properties in question may be drilled in search of former stream bed material, even in the absence of surface contamination.

As a result of the Energy and Water Appropriations Act of Fiscal Year 1984, the property discussed in this report and properties in its vicinity contaminated with residues from the former MCW were included as a decontamination research

*The survey was performed by members of the Measurement Applications and Development Group of the Health and Safety Research Division at Oak Ridge National Laboratory under DOE contract DE-AC05-84OF21400.

and development project under the DOE Formerly Utilized Sites Remedial Action Program. As part of this project, DCE is conducting radiological surveys in the vicinity of the site to identify properties contaminated with residues derived from the MCW. The principal radionuclide of concern is thorium-232. The radiological surveys discussed in this report are part of that effort and were conducted, at the request of DOE, by members of the Measurement Applications and Development Group of the Oak Ridge National Laboratory.

A radiological survey of the private, residential property at 6 Hancock Street, Lodi, New Jersey, was conducted during 1985 and 1986. The survey and sampling of the ground surface were carried out on October 21, 1985, and the follow-up subsurface investigation was performed on November 13-18, 1986.

SURVEY METHODS

The radiological survey of the property included: (1) a gamma scan of the entire property outdoors, (2) collection of surface and subsurface soil samples, and (3) gamma profiles of auger holes. No indoor survey measurements were performed.

Using a portable gamma scintillation meter, ranges of measurements were recorded for areas of the property surface. If the gamma readings were elevated, a biased soil sample was taken at the point showing the highest gamma radiation level. Systematic soil samples were taken at various locations on the property, irrespective of gamma radiation levels. These survey methods followed the plan outlined in Reference 1.

To define the extent of possible subsurface soil contamination, auger holes were drilled to depths of approximately 2.9 m. A plastic pipe was placed in each hole, and a NaI scintillation probe was lowered inside the pipe. The probe was encased in a lead shield with a horizontal row of collimating slits on the side. This collimation allows measurement of gamma radiation intensities resulting from contamination within small fractions of the hole depth. Measurements were usually made at 15- or 30-cm intervals. If the gamma readings in the hole were elevated, a soil sample was scraped from the wall of the auger hole at the point showing the highest gamma radiation level. The auger hole loggings were used to select locations where further soil sampling would be useful. A split-spoon sampler was used to collect subsurface samples at known depths. In some auger holes, a combination of split-spoon sampling and side-wall scraping was used to collect samples. A comprehensive description of the survey methods and instrumentation has been presented in another report.²

SURVEY RESULTS

Applicable federal guidelines are summarized in Table 1.³ The normal background radiation levels for the northern New Jersey area are presented in Table 2.⁴ These data are provided for comparison with survey results presented in this section. All direct measurement results presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background con-

centrations have not been subtracted from radionuclide concentrations measured in environmental samples.

Surface Gamma Radiation Levels

Gamma radiation levels measured during a gamma scan of the surface of the property are given in Fig. 1. Gamma exposure rates over the major portion of the property ranged from 6 to 14 $\mu\text{R}/\text{h}$. The highest gamma levels were in the northeastern corner of the property in some bricks, reading 14 $\mu\text{R}/\text{h}$. Gamma levels around the foundation of the house were 11 to 13 $\mu\text{R}/\text{h}$.

Systematic and Biased Soil Samples

Systematic and biased soil samples were taken from various locations on the property for radionuclide analyses. Locations of the systematic (S) and biased (B) samples are shown in Fig. 2, with results of laboratory analyses provided in Table 3. Concentrations of radium, thorium, and uranium in these samples ranged from 0.71 to 4.5 pCi/g, 0.56 to 0.82 pCi/g, and 0.58 to 1.2 pCi/g, respectively. All samples were below DOE guidelines for radium and thorium (Table 1).

Auger Hole Soil Samples and Gamma Logging

Varying thicknesses of subsurface soil were sampled from depths of 0 to 245 cm in auger holes (A) drilled at twelve separate locations indicated in Fig. 2. The results of analyses of these samples are given in Table 3. Concentrations of ^{226}Ra and ^{232}Th in soil samples ranged from 0.66 to 27 and 0.78 to 73 pCi/g, respectively. Radionuclide concentrations in several of the sample locations continued to increase with depth (Table 3). The highest concentrations of radium and thorium were found in sample A6D, with values of 27 and 73 pCi/g, respectively, at depths between 215 and 245 cm. At the same depths, elevated thorium levels were also found in samples A2E and A4F, with 55 and 69 pCi/g, respectively. All three of these samples were taken from the front yard of the property and were above DOE criteria (Table 1).

Gamma logging was performed in eleven of the twelve auger holes to characterize and further define the extent of possible contamination. Soil conditions in A12 prevented collecting gamma data for this hole. The logging technique used in the other eleven auger holes is not radionuclide specific. However, logging data, in conjunction with soil analyses data, may be used to estimate regions of elevated radionuclide concentrations in auger holes when compared with background levels for the area. Following a comparison of these data, it appears that any shielded scintillator readings of 1000 counts per minute (cpm) or greater generally indicate the presence of elevated concentrations of ^{226}Ra and/or ^{232}Th . Data from the gamma profiles of the logged auger holes are graphically represented in Figs. 3 through 13. Readings for auger holes A1 through A10 were all near or above 1000 cpm, beginning at ground surface or at approximately 0.3 m to depths near 3 m. Maximum readings for individual holes ranged from 1,469 cpm to 22,142 cpm, with the highest values in auger hole A4.

SIGNIFICANCE OF FINDINGS

Measurements taken at 6 Hancock Street indicate that the property contained residual radioactive material primarily from the ^{232}Th decay chain, with slight contamination from ^{226}Ra . These radionuclide distributions are typical of the type of material originating from the processing operations at the MCW site. The concentration and extent of ^{232}Th on this property were in excess of the relevant DOE criteria (Table 1). As shown in Fig. 2, this material was found at sample locations A2, A4, and A6. Based on the results of this radiological assessment, it is recommended that this site be considered for inclusion in the DOE remedial action program.

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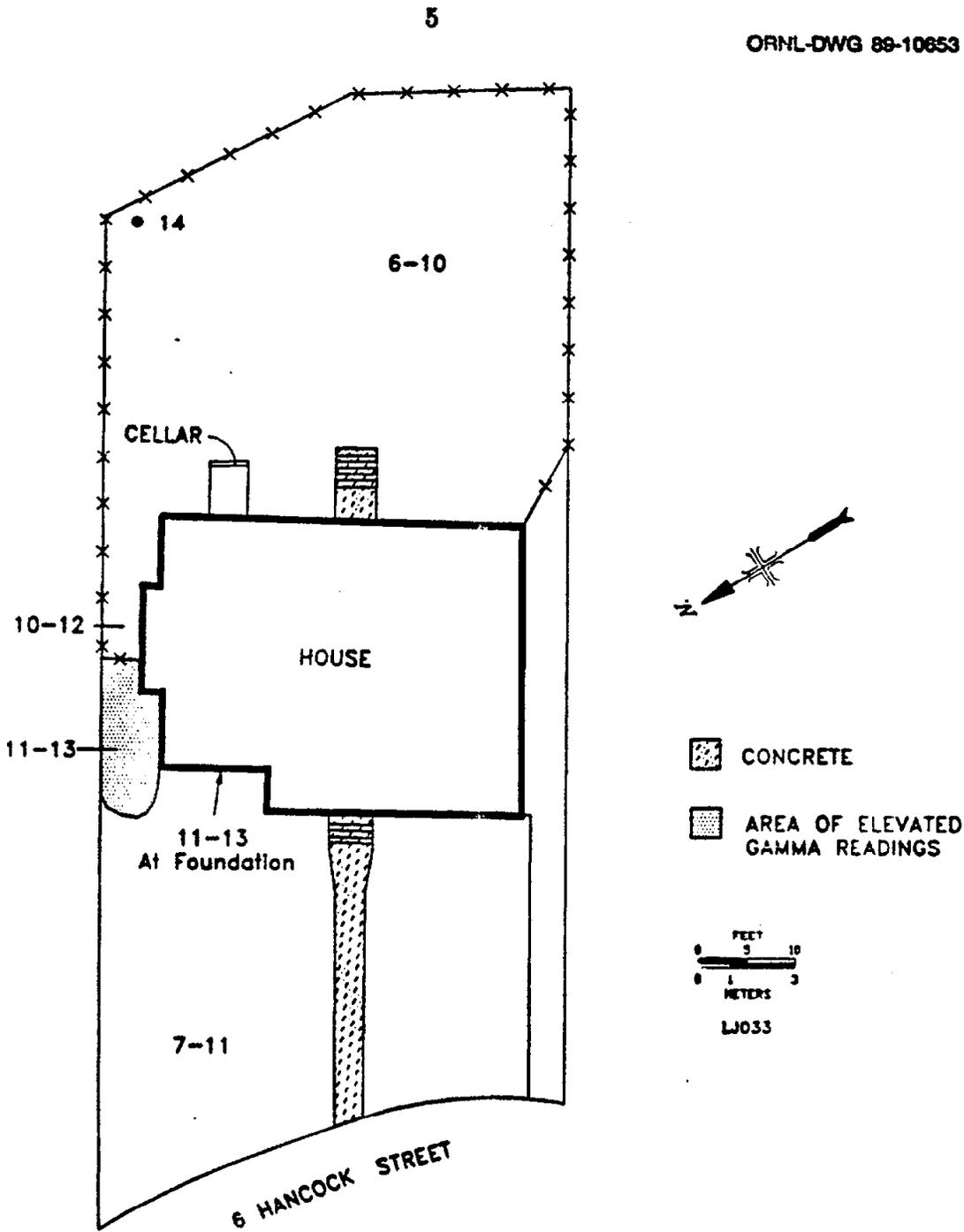


Fig. 1. Gamma radiation levels ($\mu\text{R}/\text{h}$) measured on the surface at 6 Hancock Street, Lodi, New Jersey (LJ033).

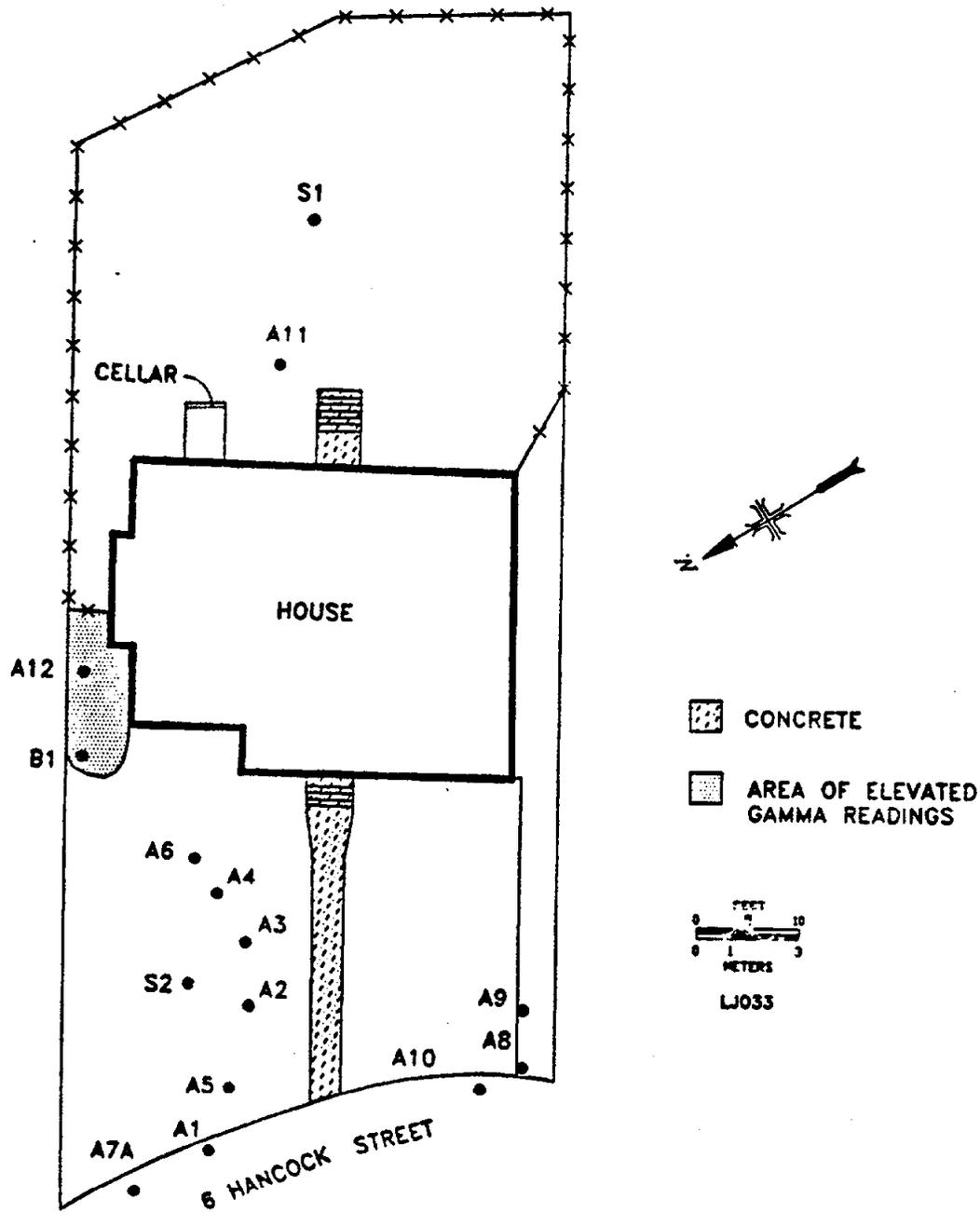
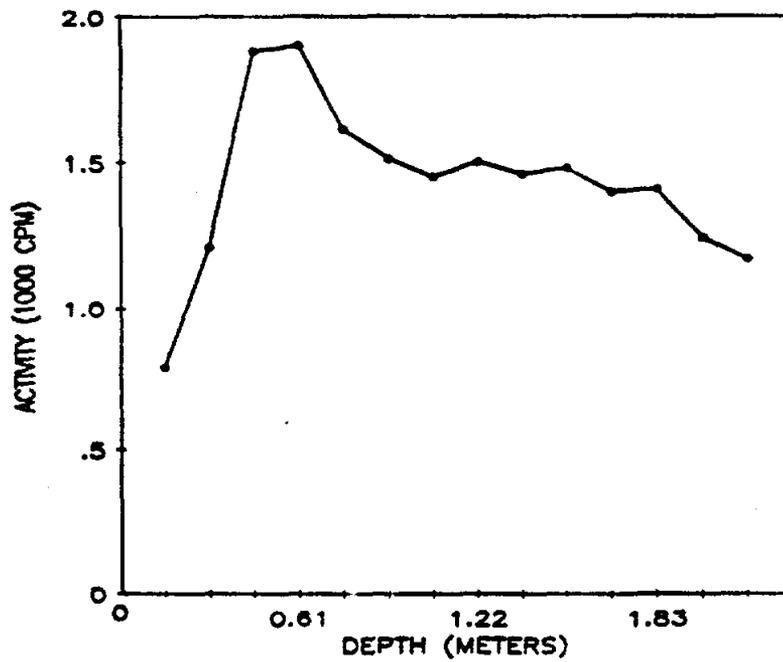


Fig. 2. Diagram showing locations of soil samples taken at 6 Hancock Street, Lodi, New Jersey (LJ033).

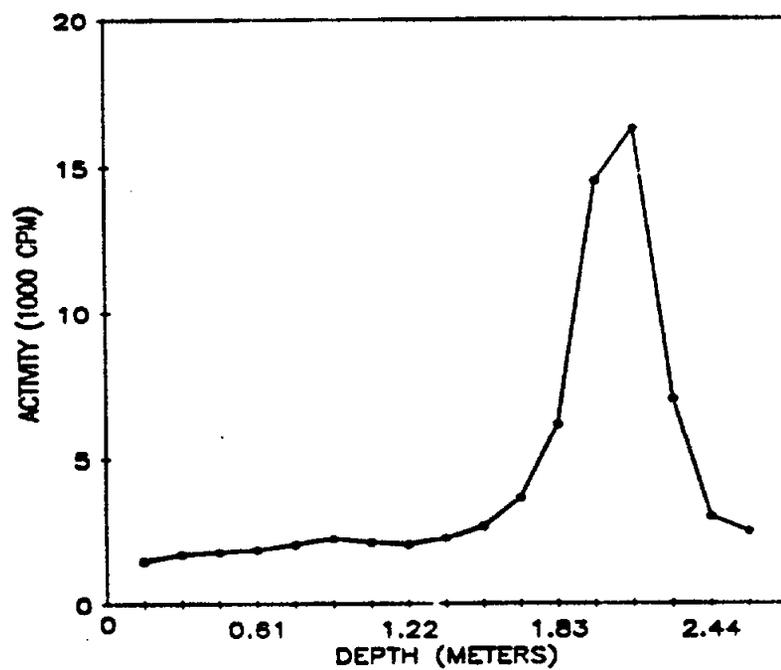
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LJ033A1

Fig. 3. Gamma profile for auger hole 1 (LJ033A1) at 6 Hancock Street, Lodi, New Jersey.

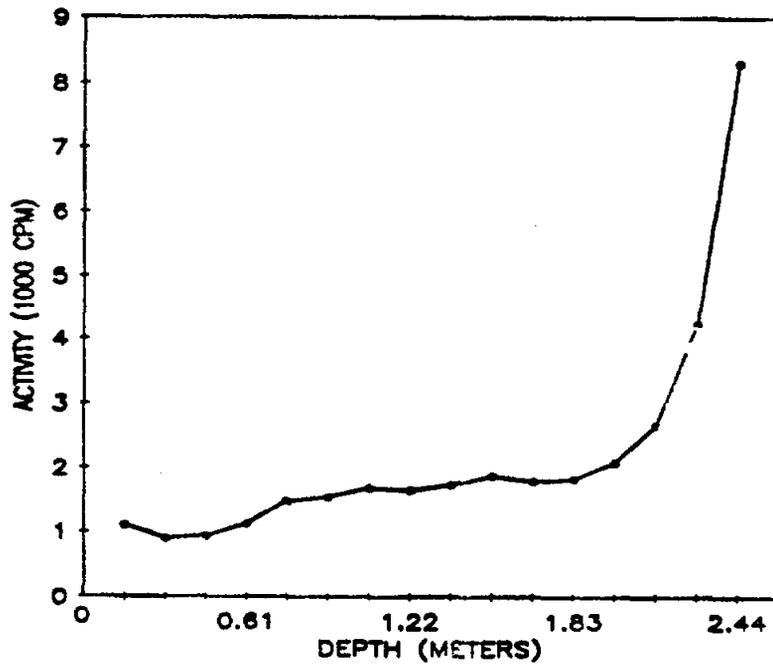
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LJ033A2

Fig. 4. Gamma profile for auger hole 2 (LJ033A2) at 6 Hancock Street, Lodi, New Jersey.

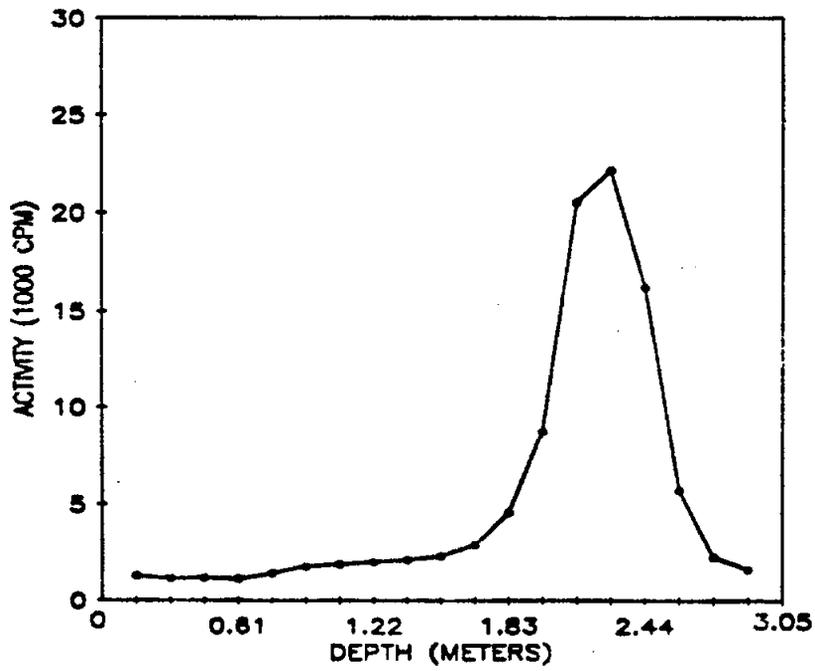
ORNL-DWG 89-10657



LJ033A3

Fig. 5. Gamma profile for auger hole 3 (LJ033A3) at 6 Hancock Street, Lodi, New Jersey.

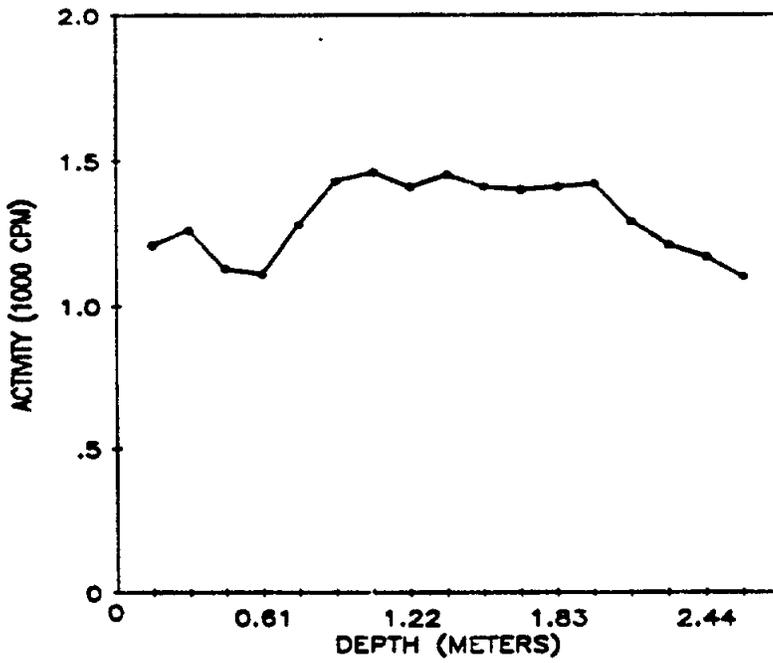
ORNL-DWG 89-10658



LJ033A4

Fig. 6. Gamma profile for auger hole 4 (LJ033A4) at 6 Hancock Street, Lodi, New Jersey.

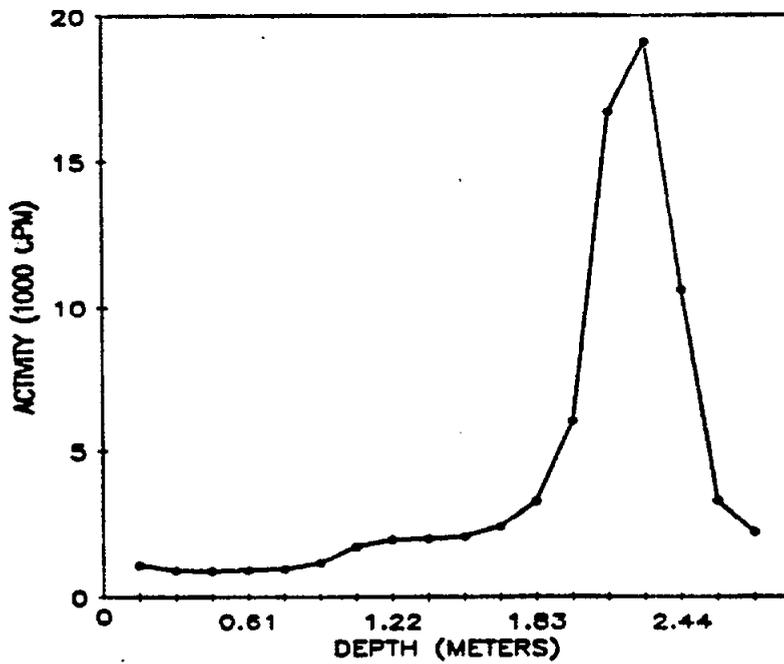
ORNL-DWG 89-10659



LJ033A5

Fig. 7. Gamma profile for auger hole 5 (LJ033A5) at 6 Hancock Street, Lodi, New Jersey.

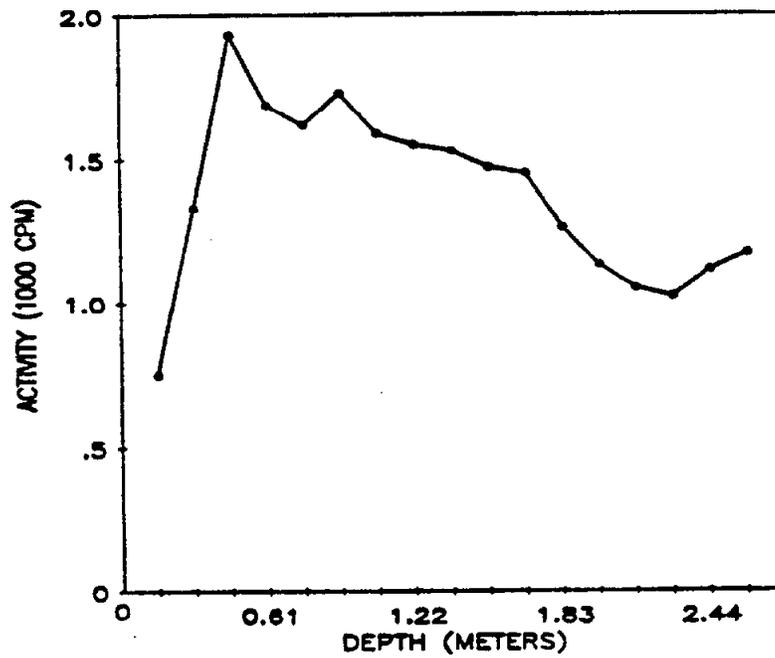
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LJ033A6

Fig. 8. Gamma profile for auger hole 6 (LJ033A6) at 6 Hancock Street, Lodi, New Jersey.

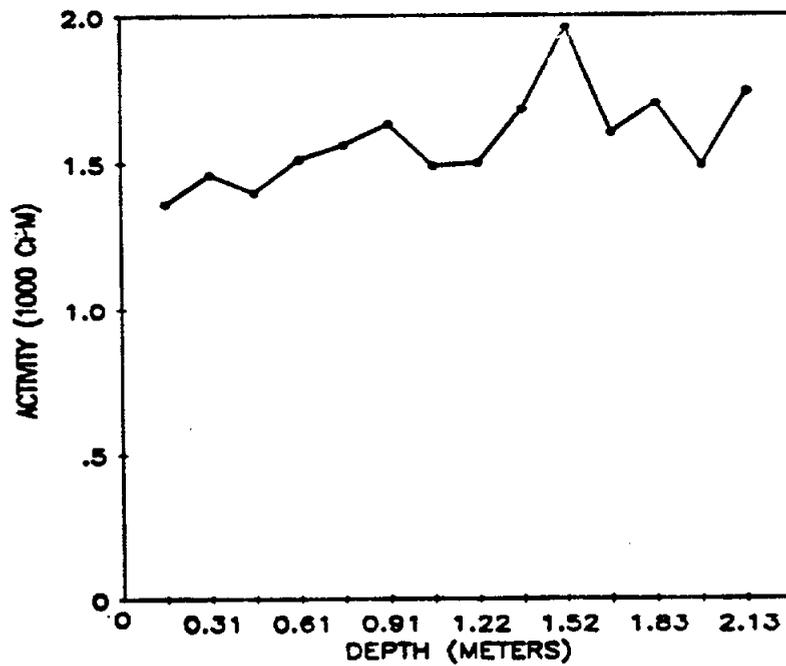
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LJ033A7

Fig. 9. Gamma profile for auger hole 7 (LJ033A7) at 6 Hancock Street, Lodi, New Jersey.

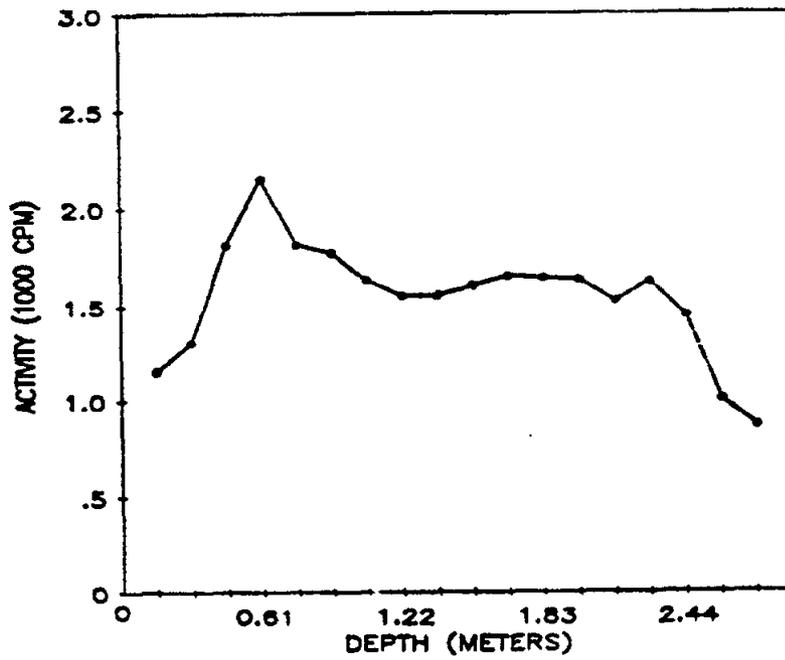
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LJ033A8

Fig. 10. Gamma profile for auger hole 8 (LJ033A8) at 6 Hancock Street, Lodi, New Jersey.

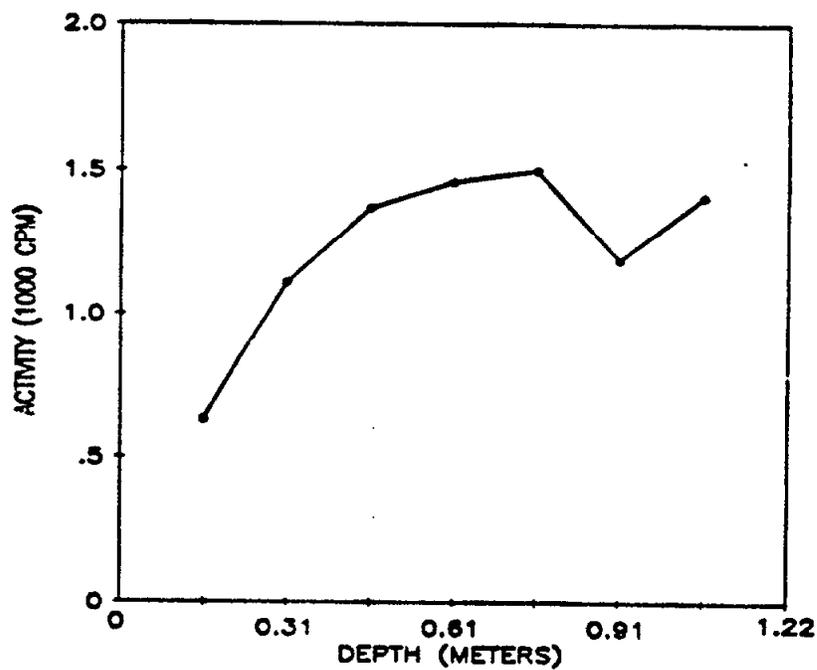
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LJ033A9

Fig. 11. Gamma profile for auger hole 9 (LJ033A9) at 6 Hancock Street, Lodi, New Jersey.

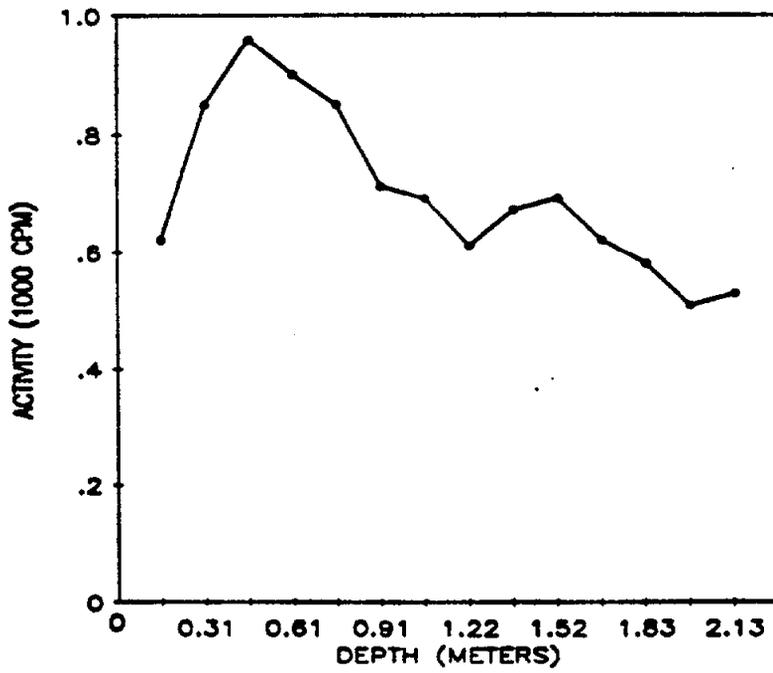
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LJ033A10

Fig. 12. Gamma profile for auger hole 10 (LJ033A10) at 6 Hancock Street, Lodi, New Jersey.

ORNL-DWG 89-10685



LJ033A11

Fig. 13. Gamma profile for auger hole 11 (LJ033A11) at 6 Hancock Street, Lodi, New Jersey.

Table 1. Applicable guidelines for protection against radiation^a

Mode of exposure	Exposure conditions	Guideline value
Radionuclide concentrations in soil	Maximum permissible concentration of the following radionuclides in soil above background levels averaged over 100 m ² area ²³² Th ²³⁰ Th ²²⁸ Ra ²²⁶ Ra	5 pCi/g averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over 15-cm thick soil layers more than 15 cm below the surface

^aReference 3.

Table 2. Background radiation levels for the northern New Jersey area

Type of radiation measurement or sample	Radiation level or radionuclide concentration
Concentration of radionuclides in soil (pCi/g)	
²³² Th	0.9 ^a
²³⁸ U	0.9 ^a
²²⁶ Ra	0.9 ^a

^aReference 4.

**Table 3. Concentrations of radionuclides in soil at
6 Hancock Street, Lodi, New Jersey (LJ033)**

Sample ^a	Depth (cm)	Radionuclide concentration (pCi/g)		
		²²⁶ Ra ^b	²³² Th ^b	²³⁸ U ^c
<i>Systematic samples^d</i>				
S1	0-15	1.0 ± 0.09	0.75 ± 0.4	1.1
S2	0-15	0.71 ± 0.06	0.56 ± 0.2	0.82
<i>Biased samples^e</i>				
B1A	0-15	4.5 ± 0.2	0.82 ± 0.3	1.2
B1B	15-30	2.1 ± 0.07	0.70 ± 0.2	0.58
<i>Auger samples^f</i>				
A1A	30-60	1.9 ± 0.1	2.3 ± 0.2	g
A1B	60-90	2.0 ± 0.07	1.8 ± 0.1	g
A1C	90-120	2.1 ± 0.08	1.7 ± 0.4	g
A1D	120-150	1.8 ± 0.2	1.6 ± 0.1	g
A1E	150-185	2.1 ± 0.3	1.7 ± 0.3	g
A2A	60-90	1.9 ± 0.09	2.0 ± 0.1	g
A2B	90-120	2.1 ± 0.1	2.4 ± 0.3	g
A2C	120-150	2.5 ± 0.1	1.9 ± 0.06	g
A2D	150-185	2.3 ± 0.1	1.8 ± 0.3	g
A2E	215-245	6.1 ± 0.2	55 ± 5	g
A3A	60-90	2.0 ± 0.08	1.7 ± 0.2	g
A3B	90-120	2.1 ± 0.2	1.7 ± 0.4	g
A3C	120-150	2.3 ± 0.05	1.8 ± 0.4	g
A3D	150-185	2.3 ± 0.1	1.8 ± 0.2	g
A3E	185-215	2.3 ± 0.1	1.7 ± 0.2	g
A3F	215-245	2.3 ± 0.05	3.1 ± 0.5	g
A4A	60-75	1.0 ± 0.09	1.0 ± 0.3	g
A4B	90-120	2.2 ± 0.2	1.7 ± 0.2	g
A4C	120-150	2.2 ± 0.06	1.8 ± 0.2	g
A4D	150-185	2.4 ± 0.2	1.7 ± 0.2	g
A4E	185-215	2.3 ± 0.1	1.9 ± 0.3	g
A4F	215-245	10 ± 0.6	69 ± 6	g

Table 3 (continued)

Sample ^a	Depth (cm)	Radionuclide concentration (pCi/g)		
		²²⁶ Ra ^b	²³² Th ^b	²³⁸ U ^c
<i>Auger samples^f</i>				
A5A	60-90	1.6 ± 0.2	1.7 ± 0.3	g
A5B	90-120	1.7 ± 0.3	1.6 ± 0.3	g
A5C	120-150	2.1 ± 0.2	1.7 ± 0.1	g
A5D	150-185	2.2 ± 0.07	1.6 ± 0.3	g
A6A	120-150	2.3 ± 0.1	1.8 ± 0.2	g
A6B	150-185	2.3 ± 0.2	1.7 ± 0.4	g
A6C	185-215	2.4 ± 0.06	3.2 ± 0.5	g
A6D	215-245	27 ± 0.6	73 ± 6	g
A7A	30-60	1.6 ± 0.08	3.0 ± 0.3	g
A8A	120-150	1.6 ± 0.08	2.9 ± 0.3	g
A9A	45-75	1.6 ± 0.1	2.0 ± 0.1	g
A10A	60-90	2.1 ± 0.1	1.8 ± 0.2	g
A11A	60-90	1.2 ± 0.04	1.1 ± 0.08	g
A11B	120-150	0.66 ± 0.03	0.92 ± 0.2	g
A11C	150-185	0.68 ± 0.07	0.8 ± 0.1	g
A12A	0-15	1.5 ± 0.03	0.78 ± 0.07	g
A12B	15-30	1.3 ± 0.06	1.1 ± 0.2	g

^aLocations of soil samples are shown on Fig. 2.

^bIndicated counting error is at the 95% confidence level ($\pm 2\sigma$).

^cTotal analytical error of measurement results is less than $\pm 5\%$ (95% confidence level).

^dSystematic samples are taken at locations irrespective of gamma exposure rates.

^eBiased samples are taken from areas shown to have elevated gamma exposure rates.

^fAuger samples are taken from holes drilled to further define the depth and extent of radioactive material. Holes are drilled where the surface may or may not be contaminated.

^gAuger sample was not analyzed for ²³⁸U.

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