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RESULTS OF THE RADIOLOGICAL SURVEY AT INTERSTATE 80, NORTH RIGHT OF WAY AT LODI BROOK, LODI, NEW JERSEY (LJ077)

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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, on the North Right of Way of Interstate 80 at Lodi Brook, Lodi, New Jersey (LJ077), was conducted during 1988.

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 INTERSTATE 80, NORTH RIGHT OF WAY AT LODI BROOK, LODI, NEW JERSEY (LJ077)*

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-AC05-84OR21400.

and development project under the DOE Formerly Utilized Sites Remedial Action Program. As part of this project, DOE 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 public North Right of Way of Interstate 80 at Lodi Brook, Lodi, New Jersey, was conducted during 1988. The survey and sampling of the ground surface were carried out on March 10 and May 3, 1988, and the follow-up subsurface investigation was performed on June 9, 1988.

SURVEY METHODS

The radiological survey of the property included: (1) a gamma scan of the entire property outdoors, both at the surface and one meter above the surface, (2) collection of surface and subsurface soil samples, and (3) gamma profiles of auger holes. The survey methods followed the plan outlined in Reference 1. No indoor survey measurements were performed.

Using a portable gamma scintillation meter, ranges of measurements were recorded for areas of the property surface and one meter above the 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.

To define the extent of possible subsurface soil contamination, auger holes were drilled to depths of approximately 3.2 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. 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 radiomuclide concentrations measured in environmental samples.

Gamma Radiation Levels

Gamma radiation levels measured during a gamma scan of the surface of the property are given in Fig. 1, with corresponding measurements one meter above the surface where indicated. Gamma exposure rates over the major portion of the property ranged from 5 to 11 μR/h. One-meter readings were between 7 and 15 μR/h; the normal background level at one meter is 8 μR/h for the northern New Jersey area (Table 2). The highest gamma levels were found in an eastern corner of the Right of Way, just west of the exposed section of Lodi Brook; measurements ranged from 13 to 26 μR/h at the surface and 15 μR/h at one meter above ground (Fig. 1). Three other areas of elevated gamma readings were found on the site. Two were east of the Lodi Brook, reading 12 and 13 μR/h. The third was east of the closed parking area, reading 13 μR/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 0.60 to 2.4 pCi/g, 1.0 to 21 pCi/g, and <0.81 to <11 pCi/g, respectively. All systematic samples and biased radium samples were near or above normal background levels for the northern New Jersey area (Table 2). Biased samples B1A, B4A, and B5A&C were above DOE guidelines for ^{232}Th (Table 1).

Auger Hole Soil Samples and Gamma Logging

Varying thicknesses of subsurface soil were sampled from depths of 15 to 305 cm in auger holes (A) drilled at two separate locations indicated in Fig. 2. The results of analyses of these samples are given in Table 3. Concentrations of ^{226}Ra, ^{232}Th, and ^{238}U in soil samples ranged from 0.67 to 2.05, 0.73 to 7.3, and 0.88 to <8.2 pCi/g, respectively. All auger samples were below DOE guideline values for thorium, though most were above normal background for the northern New Jersey area (Tables 1 and 2).

Gamma logging was performed in each auger hole to characterize and further define the extent of possible contamination. The logging technique used here 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 and 4. Readings in auger hole 1 were elevated from the surface to 1.4 m, with a maximum of 2618 cpm at 0.8 m. Elevated readings in hole 2 extended from 0.15 m to 1.2 m, with a maximum of 1750 cpm at 0.3 m.

The areas of elevated gamma readings correspond to the greatest concentrations of radionuclides shown in Table 3.

SIGNIFICANCE OF FINDINGS

Measurements taken on the North Right of Way of Interstate 80 at Lodi Brook indicate that the property contained residual radioactive material primarily from the ^{232}Th and ^{238}U decay chains, with slight contamination from ^{226}Ra. These radionuclide distributions are typical of the type of material originating from the MCW site. The concentration and extent of ^{232}Th on this property were in excess of the applicable DOE criteria (Table 1). As shown in Fig. 2, this material was found at sample locations B1, B4, and B5, consistent with the elevated gamma radiation measurements in those areas. Results of this radiological assessment indicate that the property contains residual radioactivity derived from MCW in concentrations that exceed remedial action guidelines.

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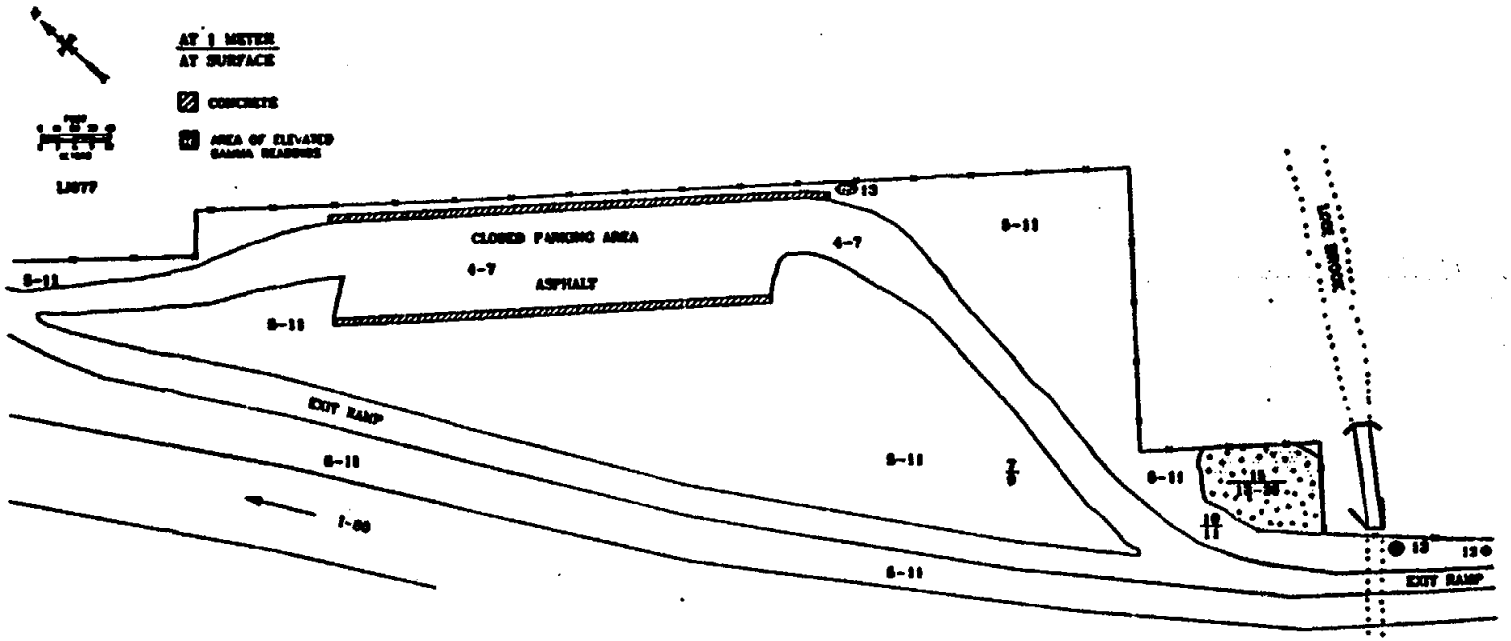

Fig. 1. Gamma radiation levels (μR/h) measured on the surface at Interstate 80, North Right of Way at Lodi Brook, Lodi, New Jersey (LJ077), with corresponding measurements one meter above the surface where indicated.

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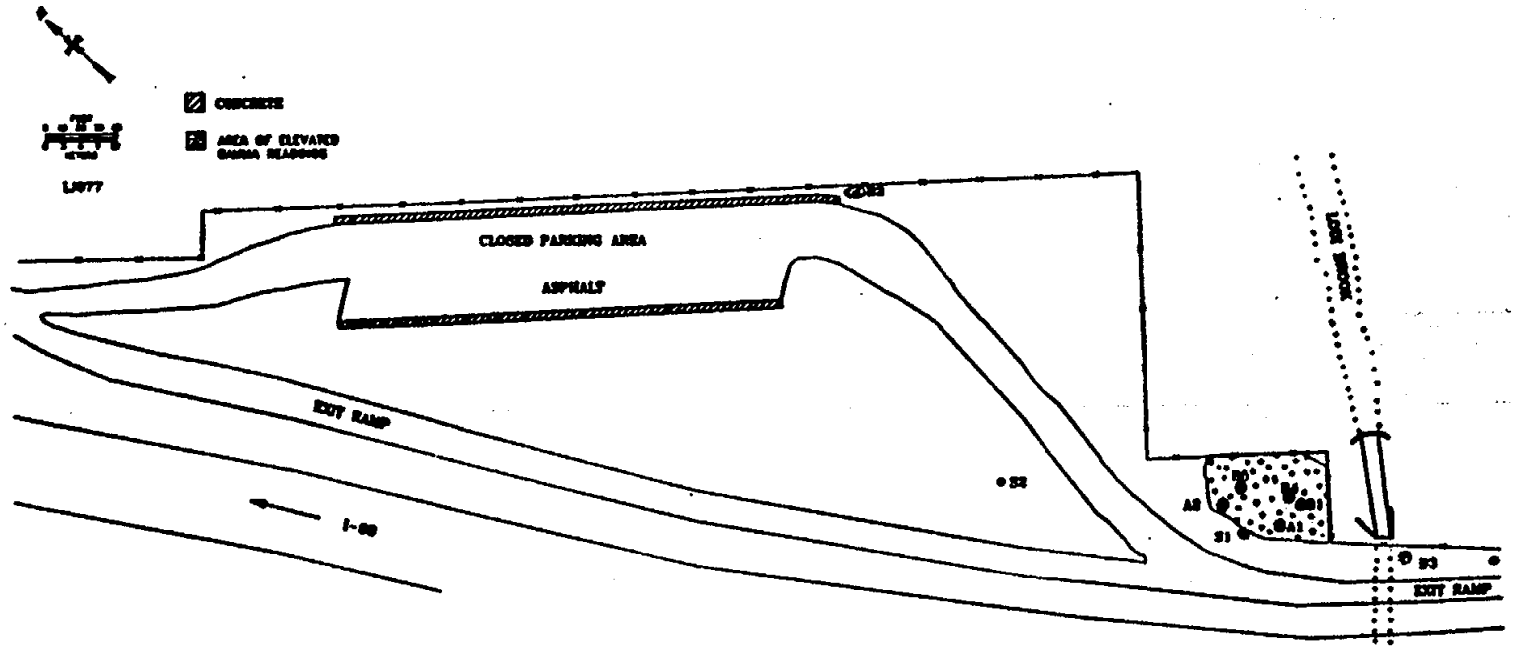

Fig. 2. Diagram showing locations of soil samples taken at Interstate 80, North Right of Way at Lodi Brook, Lodi, New Jersey (LJ077).

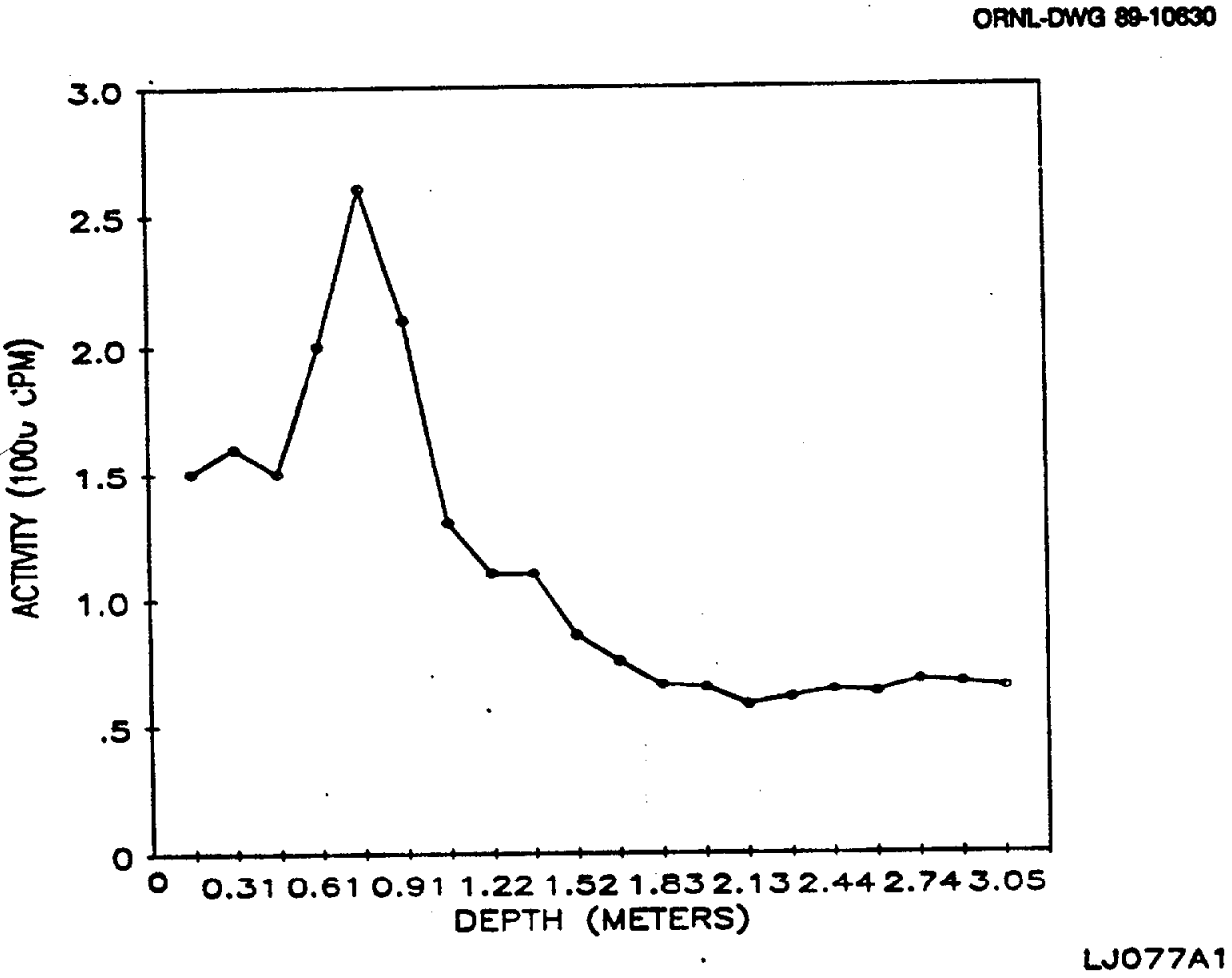

Fig. 3. Gamma profile for auger hole 1 (LJ077A1) at Interstate 80, North Right of Way at Lodi Brook, Lodi, New Jersey.

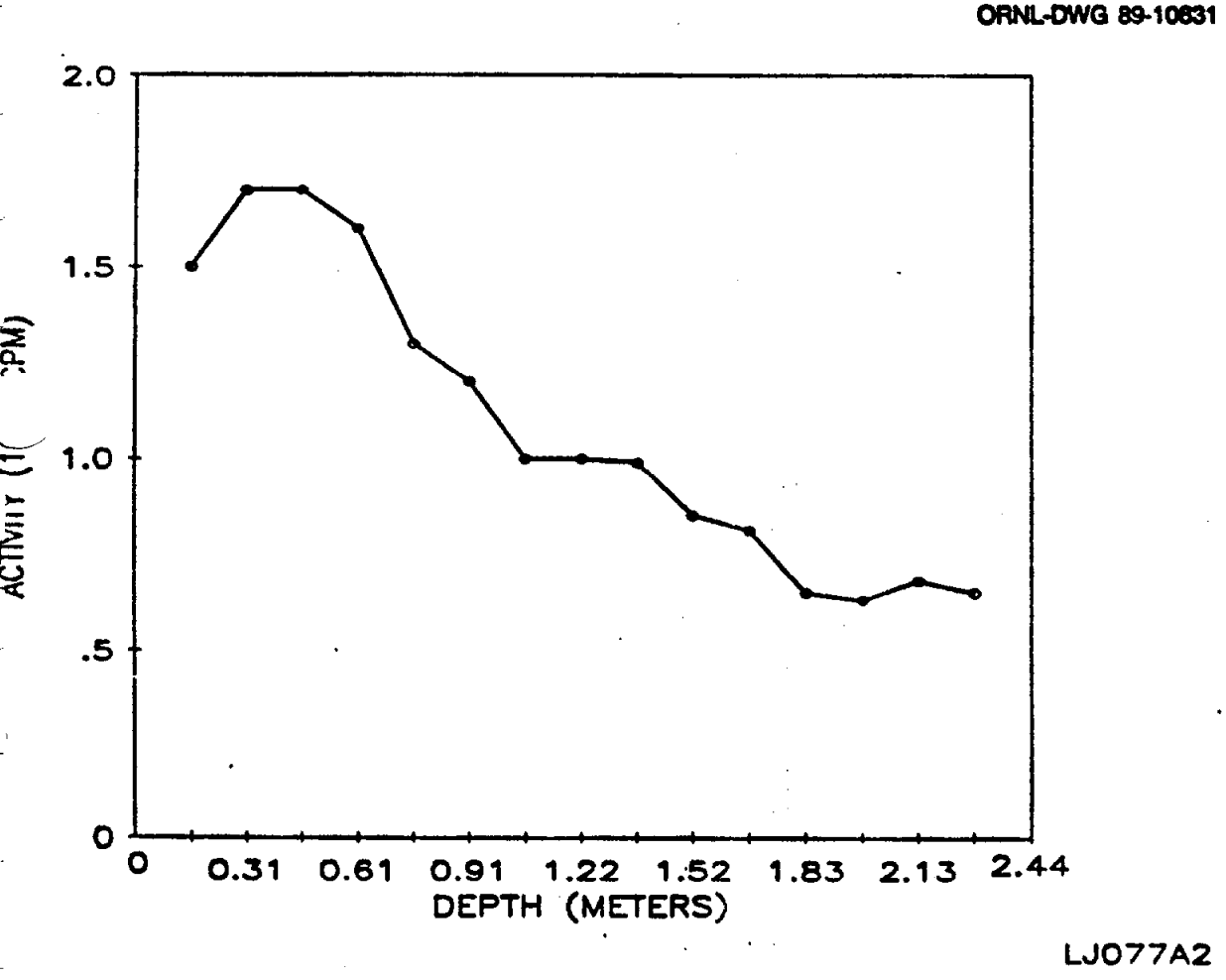

Fig. 4. Gamma profile for auger hole 2 (LJ077A2) at Interstate 80, North Right of Way at Lodi Brook, Lodi, New Jersey.

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

[a]Reference 3.

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

Type of radiation measurement or sample	Radiation level or radionuclide concentration
Gamma exposure at 1 m above ground surface (μR/h)	8[a]
Concentration of radionuclides in soil (pCi/g)	
^{232}Th	0.9[b]
^{238}U	0.9[b]
^{226}Ra	0.9[b]

[a]Reference 4.
[b]Reference 5.

Table 3. Concentrations of radionuclides in soil at Interstate 80, North Right of Way at Lodi Brook, Lodi, New Jersey (LJ077)

Sample[a]	Depth (cm)	Radionuclide concentration (pCi/g)		
		^{226}Ra[b]	^{232}Th[b]	^{238}U[b]
		Systematic samples[c]		
S1A	0–15	1.1 ±0.05	2.6 ±0.07	<3.5
S1B	15–30	0.88±0.06	2.3 ±0.2	<1.7
S1C	30–45	0.79±0.1	2.1 ±0.2	4.3 ±2
S1D	45–60	0.82±0.02	1.2 ±0.02	<2.1
S2A	0–15	0.78±0.05	1.8 ±0.06	<1.9
S2B	15–30	0.60±0.08	1.0 ±0.06	<0.81
		Biased samples[d]		
B1A	0–15	2.0 ±0.2	9.5 ±1.2	4.7 ±1
B1B	15–30	2.1 ±0.12	11 ±0.14	2.7 ±0.7
B2A	0–15	0.83±0.03	4.0 ±0.2	<2.0
B2B	15–30	1.0 ±0.1	5.6 ±0.2	<2.7
B2C	30–45	0.76±0.2	1.9 ±0.4	<3.2
B3A	0–15	0.92±0.02	4.1 ±0.04	<2.6
B3B	15–30	0.75±0.07	2.0 ±0.05	<0.95
B3C	30–45	0.77±0.1	1.7 ±0.05	0.99±1
B4A	0–15	1.3 ±0.07	8.5 ±0.2	<11
B4B	15–30	1.3 ±0.4	9.7 ±0.3	<7.0
B4C	30–45	1.2 ±0.1	7.9 ±0.2	3.0 ±3
B4D	45–60	1.3 ±0.05	7.9 ±0.1	<8.0
B4E	60–75	1.1 ±0.09	4.6 ±0.2	<1.4
B5A	0–15	1.1 ±0.04	6.1 ±0.08	<6.0
B5B	15–30	1.2 ±0.1	6.9 ±0.3	<2.5
B5C	30–45	2.4 ±0.4	21 ±0.7	<9.0
B5D	45–60	1.4 ±0.05	8.2 ±0.1	<8.0
B5E	60–75	1.1 ±0.1	4.9 ±0.09	<3.5
B5F	75–85	1.1 ±0.07	5.4 ±2	2.1 ±2
		Auger samples[e]		
A1A	60–75	1.3 ±0.1	6.0 ±0.2	1.8 ±3
A1B	75–90	1.2 ±0.18	5.9 ±0.42	<4.5
A1C	90–105	1.2 ±0.08	5.0 ±0.08	7.2 ±3.9
A1D	105–120	1.4 ±0.10	7.3 ±0.43	<2.4
A1E	120–135	1.1 ±0.03	2.3 ±0.07	4.0 ±1.3
A1F	135–150	0.99±0.04	4.2 ±0.36	6.7 ±2.2
A1G	150–165	1.35±0.04	5.47±0.09	<8.2
A1H	165–185	1.1 ±0.08	2.98±0.05	2.9 ±2.6

Table 3. (Continued)

Sample[a]	Depth (cm)	Radionuclide concentration (pCi/g)		
		^{226}Ra[b]	^{232}Th[b]	^{238}U[b]
A1I	185–195	1.4 ±0.01	1.05±0.02	2.7 ±0.5
A1J	195–215	1.5 ±0.009	1.08±0.02	2.1 ±0.4
A1K	215–225	1.37±0.02	1.63±0.04	3.20±0.2
A1L	225–245	0.67±0.01	0.73±0.03	1.16±0.4
A1M	245–255	0.77±0.008	1.01±0.01	1.03±0.29
A1N	275–290	0.82±0.007	1.36±0.03	0.96±0.2
A1P	290–305	0.76±0.02	1.02±0.03	<2.8
A2A	60–75	1.3 ±0.06	5.5 ±0.29	<6.3
A2B	105–120	1.34±0.03	4.04±0.06	<4.9
A2C	120–135	1.14±0.06	2.7 ±0.05	2.9 ±0.56
A2D	135–150	2.05±0.03	1.25±0.04	6.43±1.2
A2E	150–165	1.3 ±0.01	2.6 ±0.02	2.7 ±0.45
A2F	165–185	1.5 ±0.02	1.2 ±0.006	2.5 ±0.83
A2G	185–195	1.6 ±0.01	1.1 ±0.02	0.88±0.45
A2H	195–215	1.4 ±0.009	1.2 ±0.02	1.9 ±0.27
A2I	215–225	1.31±0.02	1.03±0.03	1.81±0.46
A2J	225–245	0.75±0.007	0.96±0.01	1.43±0.49
A2K	45–60	1.2 ±0.04	3.2 ±0.09	<7.0
A2L	30–45	1.2 ±0.04	4.3 ±0.09	<6.8
A2M	15–30	1.3 ±0.1	3.7 ±0.4	<4.5

[a]Locations of soil samples are shown on Fig. 2.

[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).

[c]Systematic samples are taken at locations irrespective of gamma exposure.

[d]Biased samples are taken from areas shown to have elevated gamma exposure rates.

[e]Auger samples are those 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.

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