MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES

3 4456 0351873 5

ornl

ORNL/TM-11817

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

Radiological Characterization Survey of the Former Diamond Magnesium Company Site, 720 Fairport–Nursery Road, Painesville, Ohio (DMP001, DMP002)

R. D. Foley
R. F. Carrier

OAK RIDGE NATIONAL LABORATORY
CENTRAL RESEARCH LIBRARY
CIRCULATION SECTION
4500N ROOM 175
LIBRARY LOAN COPY
DO NOT TRANSFER TO ANOTHER PERSON
If you wish someone else to see this report, send in name with report and the library will arrange a loan.
ORNL-2568 (11-67)

MANAGED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

This report has been reproduced directly from the best available copy.

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, Oak Ridge, TN 37831; prices available from (615) 576-8401, FTS 626-8401.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Rd., Springfield, VA 22161.

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

ORNL/TM-11817

HEALTH AND SAFETY RESEARCH DIVISION

Environmental Restoration and Waste Management Non-Defense Programs
(Activity No. EX 20 20 01 0; ADS3170000)

Radiological Characterization Survey of the Former Diamond Magnesium Company Site, 720 Fairport-Nursery Road, Painesville, Ohio (DMP001, DMP002)

R. D. Foley and R. F. Carrier

Publication issued — December 1991

Investigation Team

R. E. Swaja — Measurement Applications and Development Manager
W. D. Cottrell — FUSRAP Project Director

Survey Team Members

J. F. Allred
S. N. Burman
A. C. Butler*
R. L. Coleman
L. M. Floyd
R. D. Foley
L. C. Johnson*
R. E. Rodriguez
D. A. Rose
W. H. Shinpaugh*
W. Winton

*D. R. Stone Associates, Inc.

Work performed by the
MEASUREMENT APPLICATIONS AND DEVELOPMENT GROUP

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831-6285
managed by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U. S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

MARTIN MARIETTA ENERGY SYSTEMS LIBRARIES

3 4456 0351873 5

CONTENTS

LIST OF FIGURES v

LIST OF TABLES vii

ACKNOWLEDGMENTS ix

ABSTRACT xi

INTRODUCTION 1

SITE DESCRIPTION 2

SCOPE OF THE SURVEY 2

SURVEY METHODS 3

GAMMA MEASUREMENTS 3

SOIL SAMPLING AND ANALYSIS 4

SURVEY RESULTS 4

UNIROYAL PROPERTY, OUTDOOR SURVEY 4

Gamma Measurements 4

Systematic Soil Samples 5

Biased Soil Samples 5

Auger Hole Soil Samples and Gamma Logging of Auger Holes 6

Additional Analysis 7

UNIROYAL PROPERTY, INDOOR SURVEY 7

LONZA PROPERTY 7

Gamma Measurements 7

Systematic Samples 7

Biased Samples 8

SIGNIFICANCE OF FINDINGS 8

REFERENCES 9

APPENDIX 47

LIST OF FIGURES

1 Plot plan of the former Diamond Magnesium Company, 720 Fairport-Nursery Road, Painesville, Ohio (DMP001; DMP002) 10

2 Plot plan of the present Uniroyal Chemical Company, 720 Fairport-Nursery Road (DMP001) and the Lonza Chemical Company, 679 Hardy Road (DMP002), Painesville, Ohio 11

3 Aerial view of the former Diamond Magnesium Company site, Painesville, Ohio, as it appeared in the 1950s, looking southeast 12

4 View of the butadiene storage tank west of the buildings at the Uniroyal Chemical Company, 720 Fairport-Nursery Road, Painesville, Ohio 13

5 Diagram showing the Uniroyal Chemical Company property, Painesville, Ohio, grid system used by ORNL to locate measurements and samples 14

6 Ranges of gamma exposure rates (μR/h) measured over the surface at the Uniroyal and Lonza Chemical Company properties, Painesville, Ohio 15

7 Areas of elevated gamma radiation levels on the Uniroyal and Lonza Chemical Company properties, Painesville, Ohio 16

8 View of the south end of the contaminated spill containment area (A) at the Uniroyal Chemical Company property, 720 Fairport-Nursery Road, Painesville, Ohio 17

9 Photograph of the spill containment basin on the Uniroyal Chemical Company property, looking south 18

10 View of the contaminated area (B) along the railroad tracks in the southeastern corner of the Uniroyal property, looking north 19

11 View of the extreme northern portion of the contaminated area (B) along the railroad tracks in the southeastern corner of the Uniroyal property, looking north 20

12 View looking south from contaminated area D on the eastern side of the Uniroyal property 21

13 Locations of biased (B) and systematic (S) soil samples collected from the Uniroyal and Lonza Chemical Company properties 22

14 Locations of auger holes (A) drilled on the Uniroyal Chemical Company property 23

15 View looking toward the Lonza Chemical Company property across the contaminated railroad tracks (area B) on the Uniroyal property 24

LIST OF TABLES

1 Applicable guidelines for protection against radiation 25

2 Background radiation levels and concentrations of selected radionuclides in soil in the Painesville, Ohio, area 26

3 Gamma exposure rate measurements outdoors at the Uniroyal Chemical Plant, Painesville, Ohio (DMP001) 27

4 Radionuclide concentrations in soil samples collected from the Uniroyal Chemical Company property at 720 Fairport-Nursery Road, Painesville, Ohio (DMP001) 32

5 Concentrations of ^{230}Th, ^{226}Ra, and ^{238}U in soil samples from the Uniroyal Chemical Company property, Painesville, Ohio (DMP001) 44

6 Radionuclide concentrations in soil samples collected from the Lonza Chemical Company property bordering Uniroyal property at 679 Hardy Road, Painesville, Ohio (DMP002) 45

ACKNOWLEDGMENTS

Research for this project was sponsored by the U. S. Department of Energy's Office of Environmental Restoration under contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc. The authors wish to acknowledge the contributions of J. F. Allred, S. N. Burman, R. L. Coleman, L. M. Floyd, D. A. Roberts, R. E. Rodriguez, D. A. Rose, T. R. Stewart, and W. Winton of the Measurement Applications and Development Group and A. C. Butler, L. C. Johnson, and W. H. Shinpaugh of D. R. Stone & Associates, Inc., for their participation in the collection, analyses, and reporting of data for this survey. Thanks are due to C. A. Johnson for helpful suggestions.

ABSTRACT

At the request of the U.S. Department of Energy (DOE), a group from Oak Ridge National Laboratory performed an investigative radiological survey at the former Diamond Magnesium Company (DMC) site at 720 Fairport-Nursery Road, Painesville, Ohio, in September 1990. The purpose of the survey was to determine if the site is contaminated with radioactive residues as a result of federal government operation in the development of nuclear energy for defense-related projects. The survey of the site, separate parcels of which are currently owned by the Uniroyal Chemical Company (DMP001) and the Lonza Chemical Company (DMP002), included a gamma scan over the ground surface, determination of gamma exposure rates at the surface and at 1 m above the surface at grid points, collection and radionuclide analysis of soil samples, and directly measured radiation levels inside three buildings used during original DMC processing.

Results of the survey revealed widespread radiological contamination outdoors on the Uniroyal property and several isolated spots of elevated radiation levels on the Lonza property. The contaminants consisted of radium, uranium, and thorium in surface and subsurface soil in concentrations exceeding DOE guidelines for the release of property for unrestricted use.

RADIOLOGICAL CHARACTERIZATION SURVEY OF THE FORMER DIAMOND MAGNESIUM COMPANY SITE, 720 FAIRPORT-NURSERY ROAD, PAINESVILLE, OHIO (DMP001, DMP002)*

INTRODUCTION

For periods during the early 1940s through the 1960s, the Diamond Magnesium Company (DMC) operated a magnesium reduction facility at 720 Fairport-Nursery Road, Painesville, Ohio, for the General Services Administration (GSA). In 1953, radioactively contaminated scrap steel was released to the facility by the Atomic Energy Commission (AEC) from the Lake Ontario Storage Area (LOSA) for use in the magnesium production process. It is the policy of the U.S. Department of Energy (DOE) to verify that radiological conditions at facilities having handled radioactive materials for which DOE predecessor agencies [i.e., Manhattan Engineer District (MED) and AEC] were responsible comply with existing guidelines.[1] The Formerly Utilized Sites Remedial Action Program (FUSRAP) was established by DOE to assist in assessment and cleanup activities at these sites. The work detailed in this report was performed under that program.

In the early 1960s, the DMC facility was excessed and sold by GSA in separate parcels to the Uniroyal Chemical Company and the Lonza Chemical Company as commercial property. A review of historical records relating to the former DMC site revealed that the approximately 800 tons of "slightly" radioactively contaminated scrap metal had been transported to the Fairport-Nursery Road facility by railroad to the western side of the property. According to former employees, the material was also delivered onto the property via the east tracks. Figures 1 and 2 show the previous DMC property layout and the present Uniroyal/Lonza layout, respectively. Scrap metal not immediately used was stored in an area on the west side of the Uniroyal buildings near the railroad tracks, and possibly in other locations on the property. The radiological contamination was incidental to the use of the scrap metal which had been produced from discarded iron drums and other items previously used to store uranium compounds involved with pitchblende operations. The photo reproduced in Fig. 3 is an aerial view of the site as it existed in the 1950s. An area apparently used for scrap metal storage can be observed in the location indicated by the arrows superimposed on the photograph.

To determine whether further DOE action would be required, a team from Oak Ridge National Laboratory (ORNL) conducted a preliminary radiological survey of the Uniroyal property.[2] The results of that October 1988 survey demonstrated that the soil in some locations

---

*The survey was performed by the members of the Measurement and Applications Group of the Health and Safety Division at Oak Ridge National Laboratory under DOE contract DE-AC05-842100.

on the property contains ^{238}U and ^{226}Ra in concentrations exceeding currently used site-specific guidelines previously applied at similar sites. In accordance with the recommendation generated as a result of that survey, a second, comprehensive radiological characterization was conducted by members of the Measurement Applications and Development Group of ORNL in September 1990. The results are detailed in this report. Both the Uniroyal and Lonza Chemical companies were in operation on the site at the time of the survey. The properties are designated DMP001 and DMP002 (Uniroyal and Lonza, respectively) for data analysis identification.

SITE DESCRIPTION

The Uniroyal Company currently uses some of the original plant facilities, including Buildings 420, 421, and 422. They installed a butadiene tank west of the buildings and constructed an earthen dike around it (Fig. 4). The bottom of this dike was lined with stone. An overhead pipe rack system extends eastward from the butadiene tank to the railroad tank cars and then to the storage tanks closer to the buildings. Uniroyal also installed a spill containment area with a spill retention basin in the area midway between the butadiene tank and the sewer ditch. The basin is lined with asphalt and was designed to contain possible spills during the unloading of railroad tank cars. Fire water lines were buried approximately three feet deep in the grassy area between the dike and the spill containment area and around the circumference of the butadiene tank.

The Lonza Chemical Company, 679 Hardy Road, is adjacent to the eastern property line of Uniroyal. The properties are separated by a chain-link fence topped with barbed wire.

SCOPE OF THE SURVEY

The survey included the following measurements:

- A gamma scan of the ground surface in accessible areas throughout the Uniroyal property and over a 50-ft wide strip of land on the Lonza property at the adjoining property lines.
- Measurements of gamma radiation levels at 1 m above the ground and at the ground surface at grid line intersections.
- Collection and radionuclide analysis of systematic and biased soil samples collected from both surface and subsurface depths.
- Collection and analysis of soil samples from auger holes and gamma logging of the holes.

- Determination of directly measured radiation levels inside three buildings originally used during the time the magnesium reduction process was being conducted by DMC (Buildings 420, 421, and 422).

- Analysis by thermal emission mass spectrometry was performed on a radioactive "rock" sample.

SURVEY METHODS

A comprehensive description of the survey methods and instrumentation is presented in *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, Martin Marietta Energy Systems, Inc., Oak Ridge National Laboratory, ORNL/TM-8600 (April 1987).[3]

GAMMA MEASUREMENTS

Outdoor gamma radiation levels were determined using a portable NaI gamma scintillation meter. Because NaI gamma scintillators are energy dependent, measurements of gamma radiation levels are normalized to pressurized ionization chamber (PIC) measurements to estimate gamma exposure rates.

A Ludlum Model 239-1F gas flow proportional floor monitor was used to scan floor surfaces inside Buildings 420, 421, and 422 for the presence of alpha and/or beta-emitting radionuclide contamination. The monitor expedites the survey process by providing an efficient method for covering large, easily accessible areas of floor surface. The Ludlum instrument is not calibrated to obtain quantitative measurements but provides only an estimate of the type and degree of contamination above a precisely determined detection limit.[4] In confined spaces and in areas identified as elevated by the floor monitor, the relatively small, portable alpha- and beta-detecting meters are employed to obtain precise measurements.

In reporting outdoor survey results for the Uniroyal property, locations of measurements and samples were identified by use of a grid system previously established by the company within its property boundaries (Fig. 5). Gamma exposure rates at the ground surface were recorded by range and average for each 100-ft grid block in all areas having gamma levels near background. Wherever elevated gamma levels were detected, the gamma measurements were recorded for individual 50-ft grid blocks. The ungridded remainder of the Uniroyal property was scanned at the ground surface. To determine whether or not the Lonza Chemical Company property is radiologically contaminated, a strip of land approximately 50-ft wide along the adjoining east property lines was scanned at the ground surface.

SOIL SAMPLING AND ANALYSES

Surface and subsurface soil samples were systematically collected as close as possible to the center of each block in the gridded portion of the surveyed area without regard to gamma radiation levels. Surface and subsurface soil samples were also collected in areas of elevated exposure rates. Such samples are referred to as biased samples and are more likely to contain elevated concentrations of radionuclides than are systematically chosen samples. All soil samples were analyzed to determine ^{238}U, ^{232}Th, and ^{226}Ra concentrations.

To define the extent of possible subsurface soil radioactivity, auger holes were drilled to depths ranging from <15 to 300 cm. 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 radioactivity within small fractions of the hole depth. The auger hole loggings were used to select locations where further soil sampling would be useful. A combination of split-spoon sampling and side-wall scraping was used to collect samples from the auger holes at known depths below the surface. Surface (0-15 cm) samples and samples of side-wall scrapings were collected at maximum gamma levels in holes having no elevated readings. Selected samples were subjected to radionuclide analysis.

SURVEY RESULTS

Current guidelines for sites included within the FUSRAP are summarized in Table 1 (ref. 5). Typical background radiation levels for the Ohio area are presented in Table 2 (ref. 6). These data are provided for comparison with the survey results presented in this section. All direct measurements presented in this report are gross readings; background radiation levels have not been subtracted. Similarly, background concentrations have not been subtracted from radionuclide concentrations in soil, debris, and other samples.

UNIROYAL PROPERTY, OUTDOOR SURVEY

Gamma Measurements

Results of gamma scanning over the ground surface of the site are shown on Fig. 6 and listed in Table 3. With the exception of two isolated hot spots scanning 90 and 200 μR/h between the dirt road and the railroad tracks west of the gridded area, exposure rates over the ground surface of the ungridded portion of the Uniroyal property were 8 to 13 μR/h. These values are comparable to the typical average background for the area (9 μR/h, Table 2). Surface scan measurements over the gridded portion of the Uniroyal property ranged from 4 to 1400 μR/h and averaged from 8 to 60 μR/h within individual grid blocks (Table 3). Grid point measurements were 5 to 180 μR/h at the ground surface and 4 to 96 μR/h at 1 m above the surface. Large areas

and numerous spots of elevated gamma radiation both isolated and clustered were measured throughout the gridded portion of the site. For the purposes of discussion, four of the regions have been designated A through D (Fig. 7). The two largest regions, A and B, roughly coincide with areas where the contaminated scrap metal was known to have been used and/or stored. Exposure rates were 6 to 1400 μR/h over area A measuring approximately 38,500 ft^2 (3600 m^2) of ground surface under and around the butadiene tank (Figs. 8 and 9). Scan measurements were 6 to 850 μR/h over the surface of a ~22,000 ft^2 (2000 m^2) area (B) extending along and beside the railroad tracks in the southeast corner of the property (Fig. 10). The northern end of that contaminated area is shown in the foreground of Fig. 11. Approximately 2500 ft^2 (230 m^2) of ground surface between railroad tracks south of Building 428 had gamma exposure rates of 8 to 20 μR/h (Area C). A fourth contaminated region measuring ~5000 ft^2 (460 m^2) in size (Area D) had gamma levels ranging from 21 to 120 μR/h. The southern end of that region lies in the foreground of Fig. 12. Exposure rates on contact with brick walls of buildings were generally 14 to 16 μR/h. These slightly elevated values are consistent with those frequently measured on contact with bricks and other structural materials containing technologically enhanced concentrations of naturally occurring radionuclides.

Systematic Soil Samples

Locations of systematic soil samples are diagrammed in Fig. 13 and results of analyses are listed in Table 4. Maximum concentrations of ^{238}U, ^{232}Th, and ^{226}Ra in surface soil (0-15 cm) were 33, 1.3, and 180 pCi/g, respectively. In subsurface soil, maximum values were 130 pCi/g for ^{238}U, 1.5 pCi/g for ^{232}Th, and 190 pCi/g for ^{226}Ra. The analyses demonstrate concentrations of ^{226}Ra exceeding the guidelines. The surface soil guideline (Table 1) is exceeded in sample S22 by a factor of approximately 35, and the subsurface soil guideline by a factor of ~13 (S79B). Although no specific guideline for uranium concentrations has been derived for this site, concentrations of 35 to 40 pCi/g ^{238}U have been applied at FUSRAP sites elsewhere (Table 1). Uranium-238 concentrations in some systematic subsurface samples exceed those values. Typical Painesville area background concentrations average 1.2, 1.1, and 1.1 pCi/ g, for ^{238}U, ^{232}Th, and ^{226}Ra, respectively (Table 2).

Biased Soil Samples

Biased soil sample locations are shown on Fig. 13. Gamma exposure rates on contact with 13 biased samples were 110,000 to 630,000 counts per minute (cpm) using the NaI detector indicating radionuclide concentrations significantly in excess of guidelines. It was unnecessary, therefore, to analyze those samples for precise values. Rough estimates of concentrations of radionuclides in these samples were achieved by comparing gamma exposure rates on contact with the samples to exposure rates measured on contact with analyzed samples and extrapolating from analysis results. On this basis, estimated concentrations of ^{226}Ra in those samples range from 1500 to 9800 pCi/g. Sample B22A contained the maximum estimated value. Surface, subsurface, and hot spot DOE guidelines are exceeded (Table 1). Analysis of a highly radioactive

rock-like specimen collected from the site showed that it contained 5 ppm of radium. Extrapolation indicates that the specimen contains a ^{226}Ra concentration of approximately 5 μCi/g.

Results of radionuclide analyses of samples from the Uniroyal property are detailed in Table 4. Maximum concentrations of ^{238}U, ^{232}Th, and ^{226}Ra in analyzed biased surface soil samples are 87, 1.9, and 860 pCi/g, respectively (Table 4). In subsurface samples, highest analysis results are 210 (^{238}U), 5.1 (^{232}Th), and 1500 (^{226}Ra) pCi/g. Guidelines are exceeded in both surface and subsurface biased soil samples. Samples taken from some isolated spots (e.g., B62, B65, and B71) contained concentrations of ^{226}Ra in excess of the hot spot guideline as shown in Table 1. Uranium-238 concentrations in surface and subsurface soil at maxima of 87 and 210 pCi/g, respectively, are higher than concentrations that have been applied at other sites (35 to 40 pCi/g, Table 1). Sampling analysis confirms the presence of widespread contamination over the Uniroyal property in the general locations as would be expected from the results of the gamma scan.

Auger Hole Soil Samples and Gamma Logging of Auger Holes

Auger hole locations are shown on Fig. 14 and radionuclide concentrations are given in Table 4. Analysis results reveal maximum concentrations of ^{238}U, ^{232}Th, and ^{226}Ra in samples from the top 15 cm of soil to be 41, 2.5 and 370 pCi/g, respectively. Maximum concentrations in samples collected from 15 cm and below were 63 (^{238}U), 1.5 (^{232}Th), and 230 (^{226}Ra) pCi/g. Concentrations of ^{226}Ra exceed guidelines in both surface and subsurface soil (Table 1). Furthermore, concentrations of ^{226}Ra in some auger hole samples are a factor of 30 higher than the authorized limit for non-homogeneous contamination (Table 1). FUSRAP guidelines state that "In addition," (to the 5 and 15-pCi/g guidelines) "every reasonable effort will be made to remove any source of radionuclide that exceeds 30 times the Authorized Limit irrespective of the average concentration in the soil." Uranium–238 concentrations in auger hole samples are elevated above background as well as above guideline concentrations used elsewhere (Table 1).

Gamma logging was performed in each of 71 auger holes to characterize and further define the extent of possible subsurface radioactivity. Data from the gamma profiles of the logged auger holes are graphically represented in Appendix A, Figs. A.1 through A.72. 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 1200 to 1500 cpm or greater generally indicate the presence of elevated concentrations of gamma emitters.

Gamma readings for the logged holes ranged from 360 to 94,000 cpm. The maximum gamma level measured was ~94,000 cpm in hole A9 where soil sample B19B contained the maximum concentration of ^{226}Ra on the site as demonstrated by analysis (1500 pCi/g). Thirty-six holes had

readings of ≥1500 cpm. Soil samples at these locations contained concentrations of ^{226}Ra exceeding either the surface or subsurface DOE guideline (Table 1). In general, the areas of highest gamma readings approximately correspond to the greatest concentrations of radionuclides shown in Table 4.

Additional Analysis

Historical information indicates that waste streams from former processing activities involving the scrap metal may have resulted in contamination by ^{230}Th. Analysis of several biased samples and two auger hole samples from the Uniroyal property (Table 5) revealed concentrations of ^{230}Th exceeding guidelines in surface and subsurface soil. The elevated concentrations of ^{230}Th were found in samples B9B and A51F in the absence of elevated concentrations of ^{226}Ra or ^{238}U. The reverse ratios (i.e., thorium/radium and radium/thorium) are consistent with the reported composition of the former waste streams.

The results of mass spectrometry analysis of a sample containing 100 pCi/g ^{226}Ra showed that it also contained 11.7% (by weight) lead. This finding is consistent with the typical composition of pitchblende from which the residues originated.

UNIROYAL PROPERTY, INDOOR SURVEY

A gamma scan of accessible areas inside Buildings 420, 421, and 422 revealed exposure rates ranging from 8 to 16 μR/h. Results are well below the DOE guideline of 20 μR/h above background (Table 1).

LONZA PROPERTY

Gamma Measurements

Gamma exposure rates were generally 4 to 16 μR/h over the ground surface of the surveyed 50–ft wide strip of the Lonza Property adjacent to Uniroyal (Fig. 6). These values are not significantly different from typical background (Table 1). Small, isolated spots of elevated exposure rates, 48 and 260 μR/h, were found at grid locations 4+25, 627R and 4+08, 626R, respectively.

Systematic Samples

Results of radionuclide analysis of samples collected from the Lonza property are given in Table 6. Concentrations of ^{238}U, ^{232}Th, and ^{226}Ra in two systematic surface (0-15 cm) soil samples collected from the locations shown on Fig. 11 were 1.1 and 1.7 pCi/g for ^{238}U, 0.67 and 0.78 pCi/g for ^{232}Th, and 1.6 and 1.7 pCi/g for ^{226}Ra. All results are near background concentrations and well within DOE guidelines (Tables 1 and 2).

Biased Samples

Six biased soil samples were collected from two different depths at each of three different locations near the fence separating the two properties (Fig. 13). The photograph reproduced in Fig. 15 shows the general area from which the biased samples were collected. Concentrations of ^{232}Th ranged from 0.32 to 0.83 pCi/g in the six samples (Table 6). Uranium-238 concentrations ranged from 5.5 to 310 pCi/g in surface samples and from 4.7 to 63 pCi/g in subsurface samples. Concentrations of ^{226}Ra ranged from 8 to 1000 pCi/g in surface soil samples and from 4.2 to 170 pCi/g in subsurface soil samples. Radium-226 concentrations exceed DOE hot spot guidelines for surface and subsurface soil (Table 1). Uranium results exceed site-specific guidelines used at other sites (Table 1) in samples B1A, B2A, and B2B. The gamma scanning results demonstrate that contamination on the Lonza property is probably confined to the general area of the sample locations.

SIGNIFICANCE OF FINDINGS

The results of the radiological characterization survey of the former DMC site demonstrate widespread radiological contamination outdoors within Uniroyal property boundaries and elevated radionuclide concentrations in a small area on the Lonza property. The contamination on the Uniroyal property is present in two large, generally contaminated regions where scrap metal had reportedly been stored, and in numerous smaller regions and isolated spots in scattered locations throughout the site. Elevated concentrations of radionuclides in excess of DOE guidelines were found in both surface and subsurface soil on both properties. The maximum depth of contamination was identified at 320-335 cm and is located on the Uniroyal property. The major contaminants are ^{226}Ra and ^{230}Th. Although no ^{238}U guideline has been derived for this site, concentrations of uranium in some of the samples exceed site-specific guidelines previously applied at other FUSRAP sites. The relatively high concentration of lead found in a soil sample also containing elevated concentrations of ^{226}Ra is typical of residues from pitchblende operations and is consistent with the historical source of the contaminating material.

REFERENCES

1. U.S. Department of Energy, *A Background Report for the Formerly Utilized Manhattan Engineer District/Atomic Energy Commission Sites Program*, DOE/EV-0097, September 1980.

2. R. D. Foley and L. M. Floyd, *Preliminary Site Survey Report for the Uniroyal Chemical Company, Formerly the Diamond Magnesium Company, 720 Fairport-Nursery Road, Painesville, Ohio (DMP001)*, ORNL/TM-1119, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., March 1990.

3. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the ORNL Radiological Survey Activities (RASA) Program*, ORNL/TM-8600, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., April 1987.

4. R. L. Coleman, Health and Safety Research Division, ORNL, personal communication to R. F. Carrier, Health and Safety Research Division, ORNL.

5. U.S. Department of Energy, *Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites* (Revision 2) March 1987.

6. T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Levels: Results of Measurements Taken During 1975-1979*, ORNL/TM-7343, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Nov. 1981.

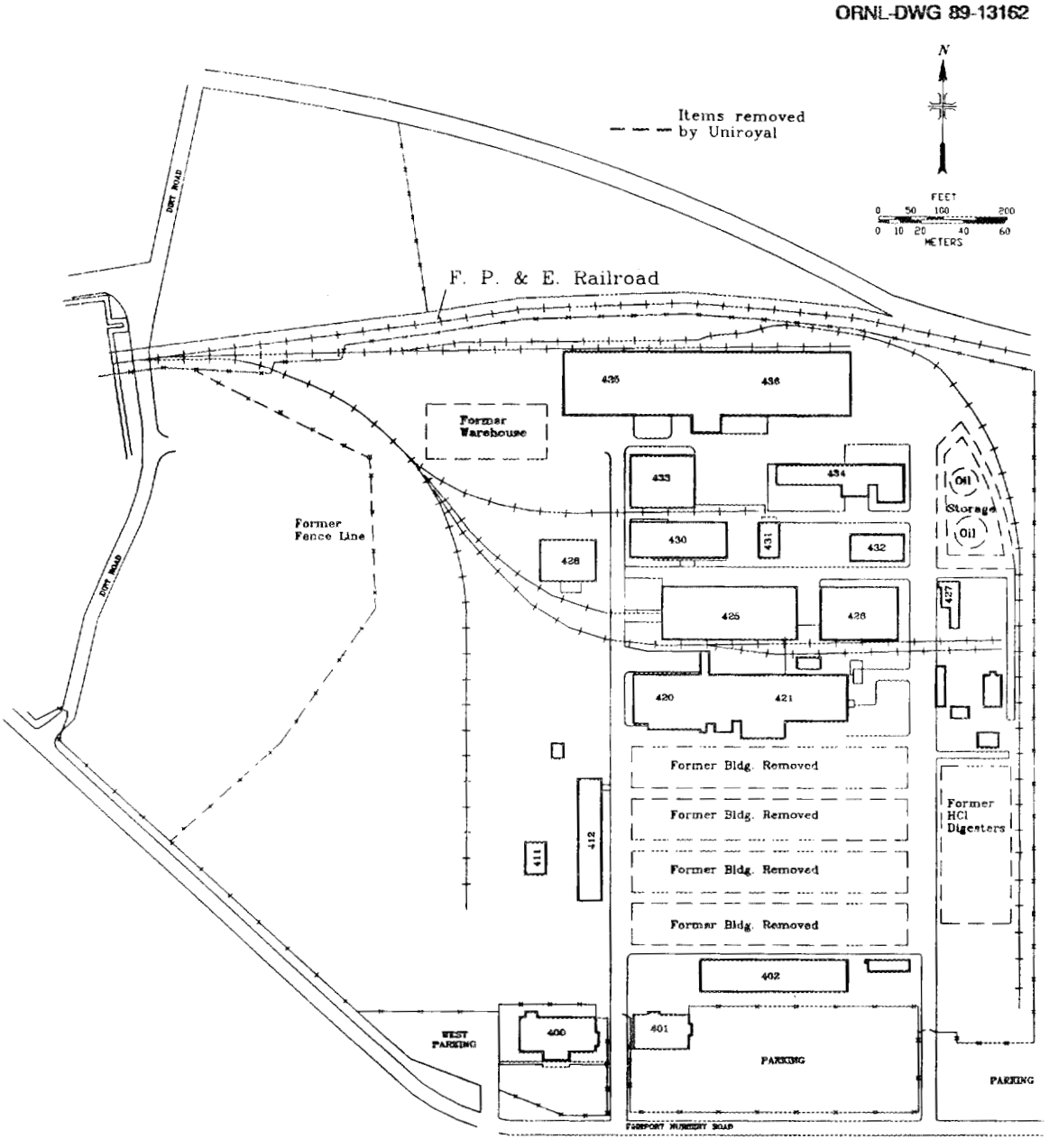

Fig. 1. Plot plan of the former Diamond Magnesium Company, 720 Fairport-Nursery Road, Painesville, Ohio (DMP001; DMP002). This drawing is limited to the portion of the property where the majority of processing activities reportedly took place.

ORNL-DWG 89-13119

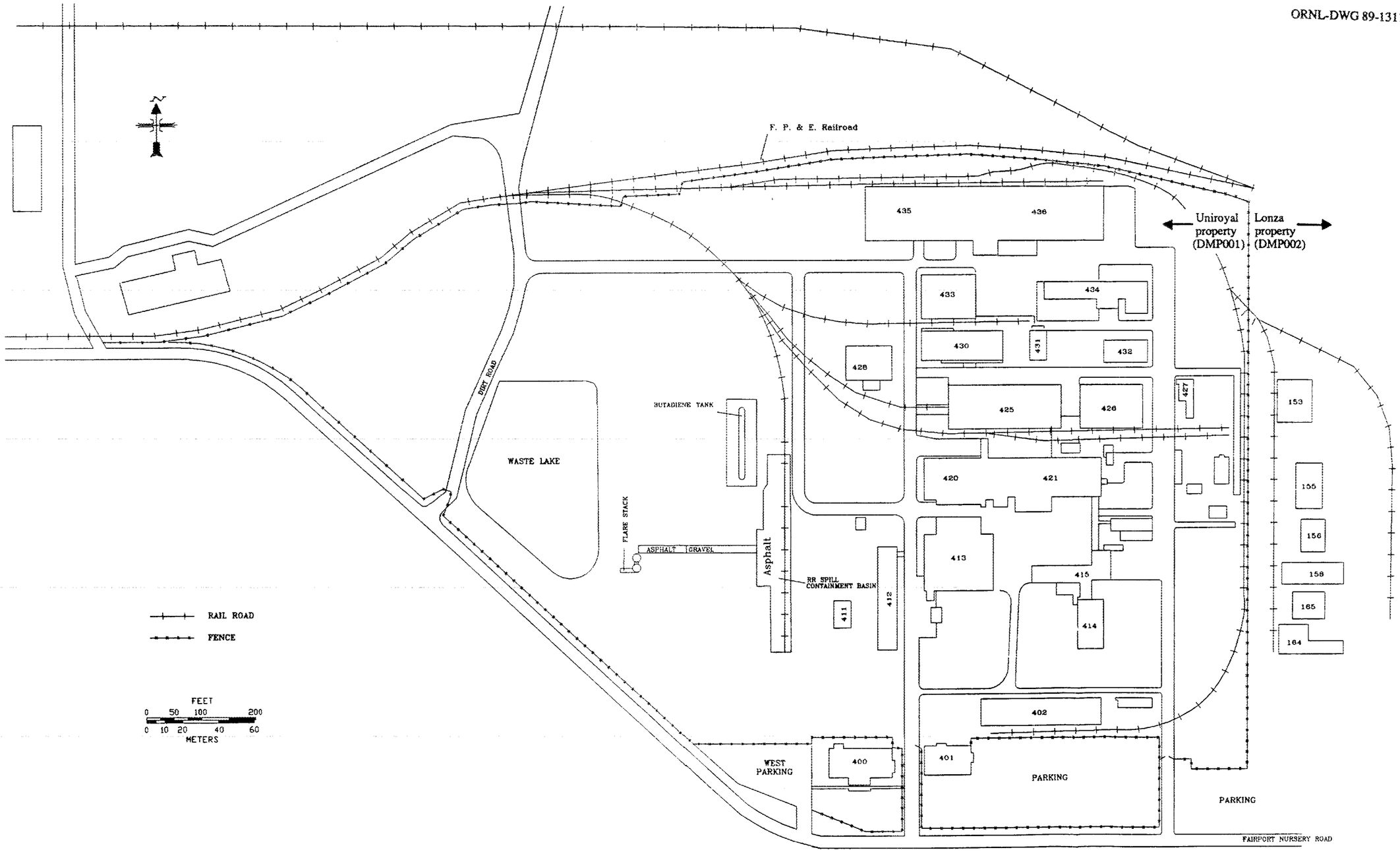

Fig. 2. Plot plan of the present Uniroyal Chemical Company, 720 Fairport-Nursery Road (DMP001) and the Lonza Chemical Company, 679 Hardy Road (DMP002), Painesville, Ohio. The fence on the east side of the drawing divides the properties.

ORNL-PHOTO 10050-91

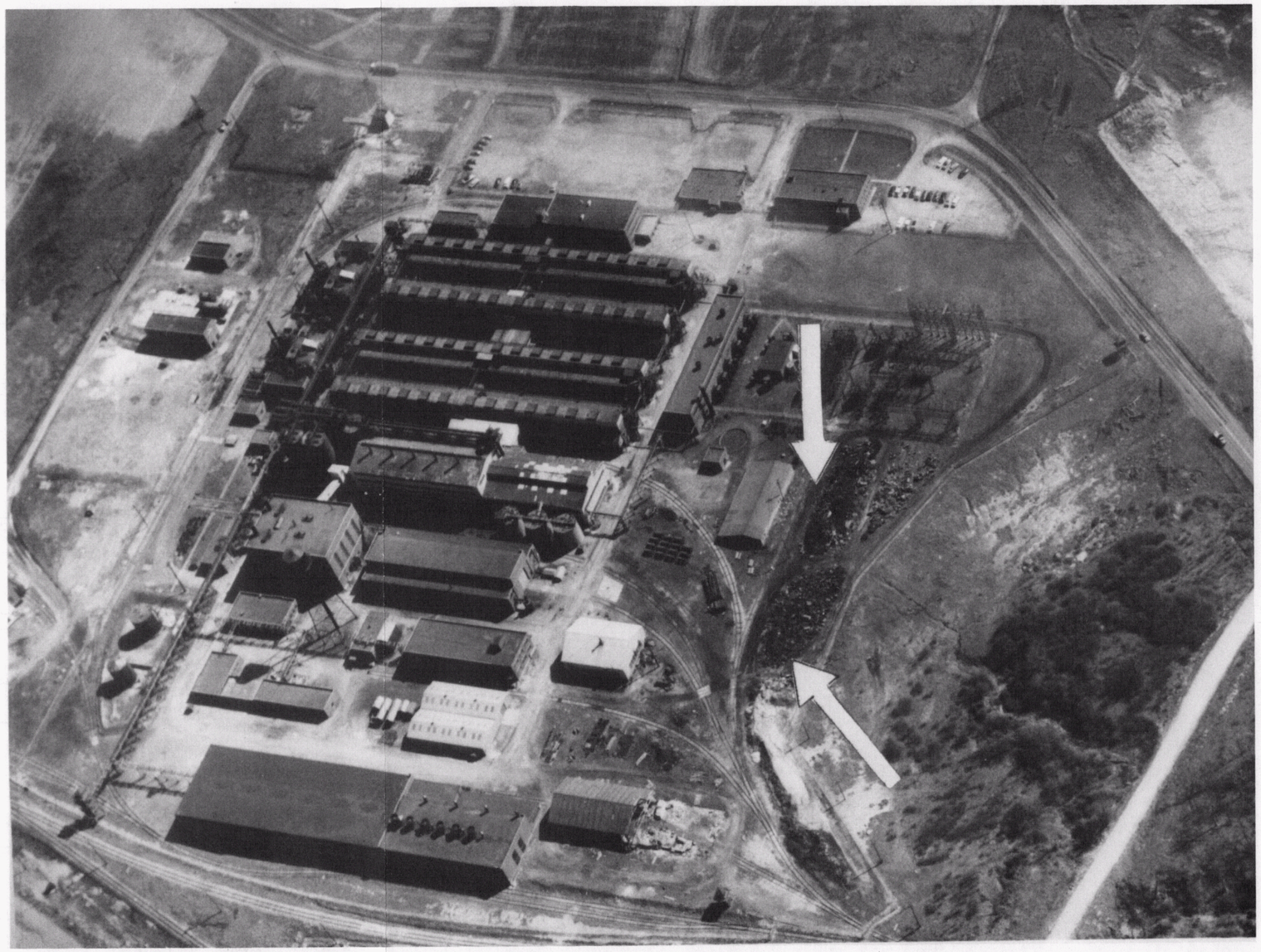

Fig. 3. Aerial view of the former Diamond Magnesium Company site, Painesville, Ohio, as it appeared in the 1950s, looking southeast. One of the major areas believed to have been used for storage of the contaminated scrap metal lies between the white arrows.

ORNL-PHOTO 3210-89

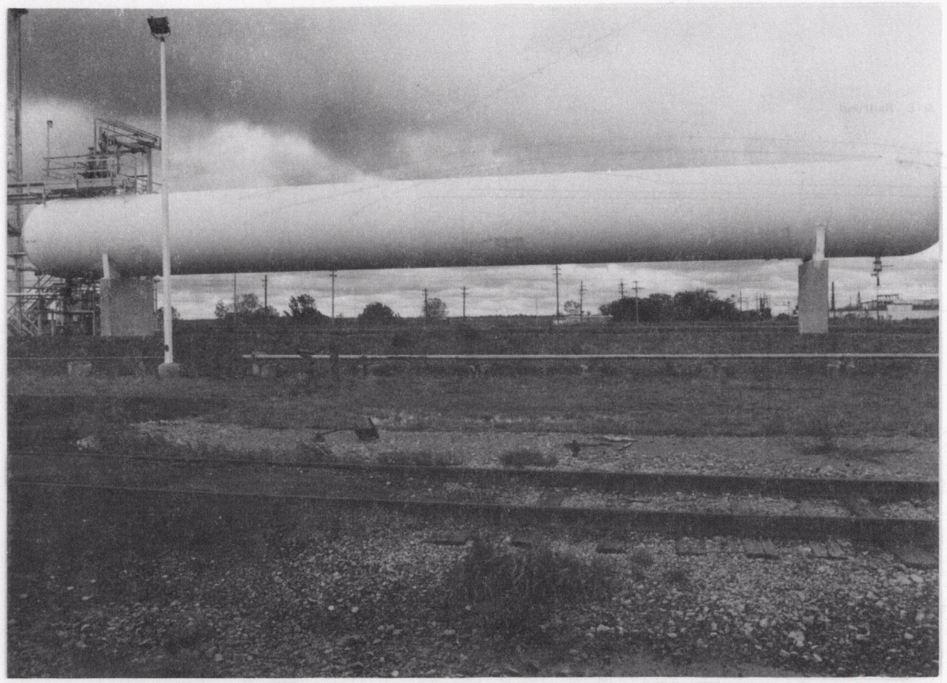

Fig. 4. View of the butadiene storage tank west of the buildings at the Uniroyal Chemical Company, 720 Fairport-Nursery Road, Painesville, Ohio.

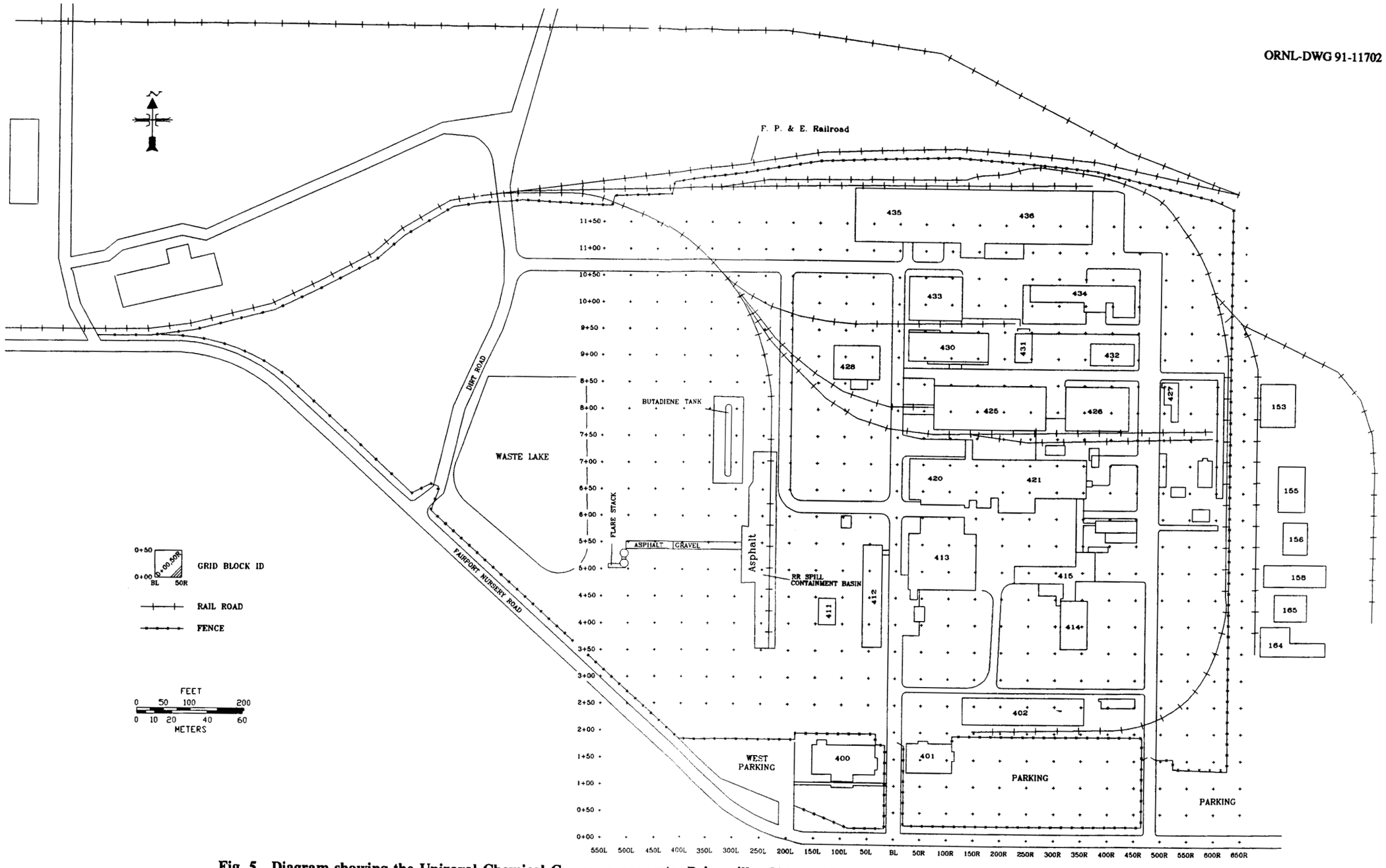

Fig. 5. Diagram showing the Uniroyal Chemical Company property, Painesville, Ohio, grid system used by ORNL to locate measurements and samples.

ORNL-DWG 91-11697

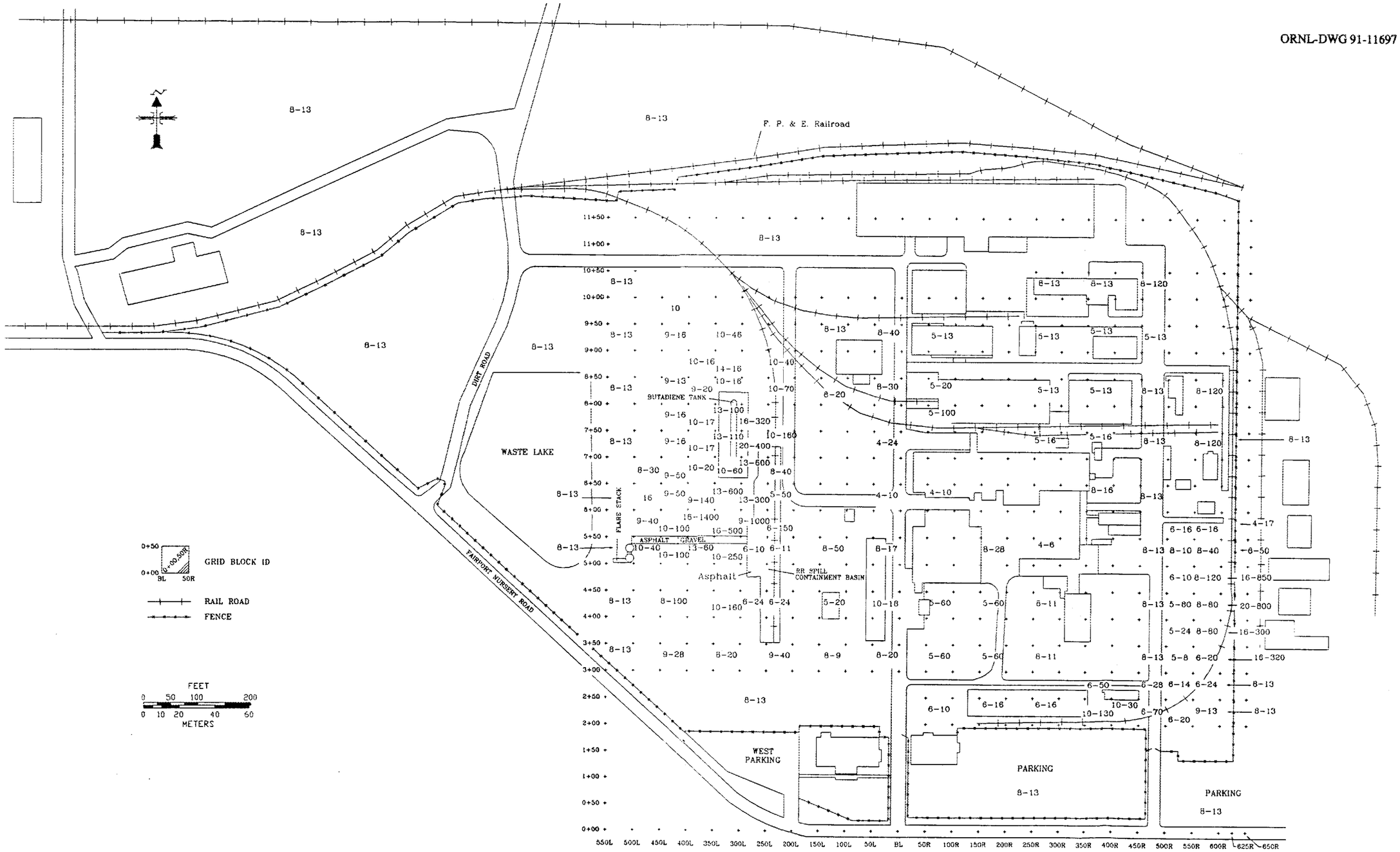

Fig. 6. Ranges of gamma exposure rates (μR/h) measured over the surface at the Uniroyal and Lonza Chemical Company properties, Painesville, Ohio.

ORNL-DWG 91-11698

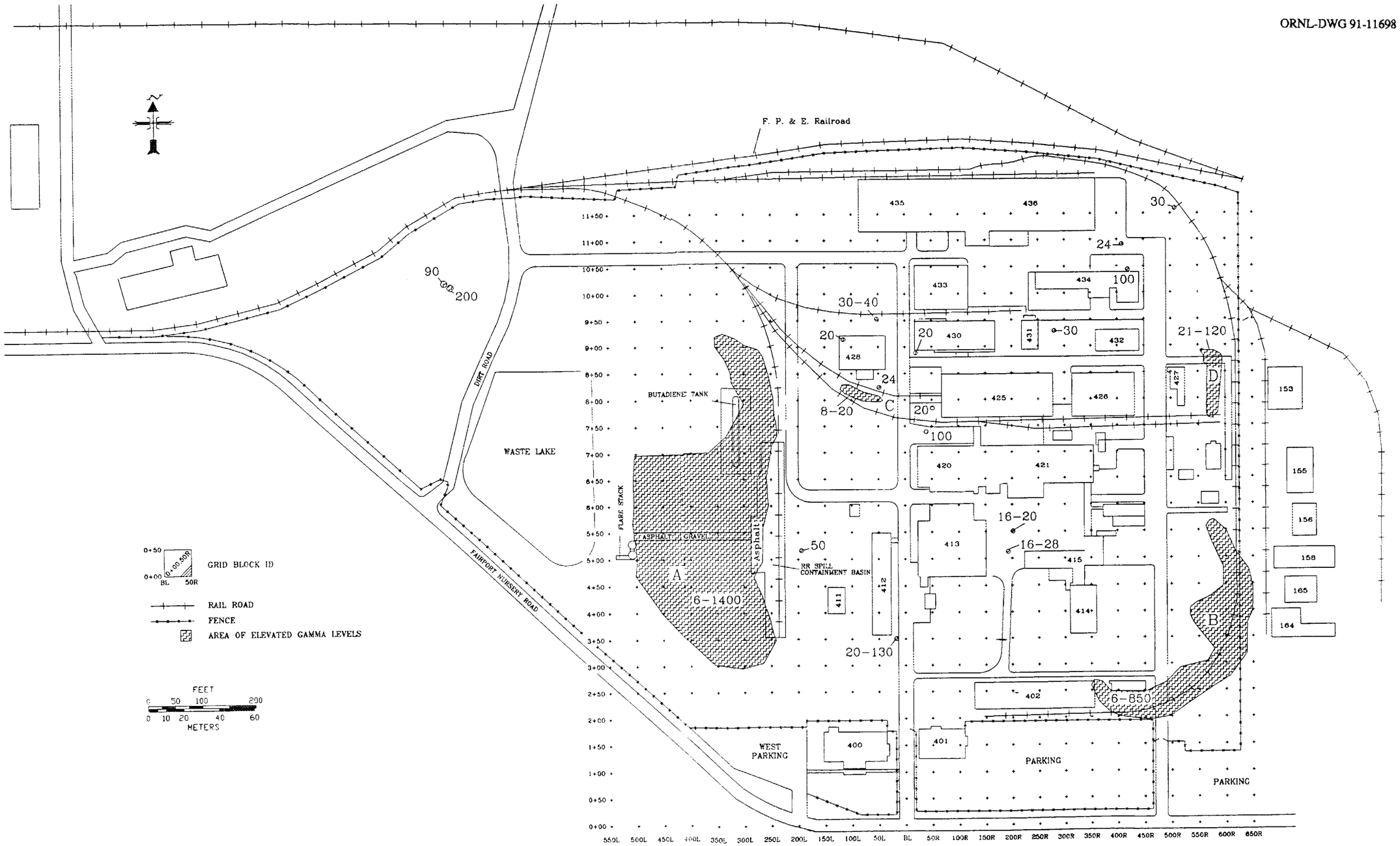

Fig. 7. Areas of elevated gamma radiation levels on the Uniroyal and Lonza Chemical Company properties, Painesville, Ohio.

ORNL-PHOTO 9762-91

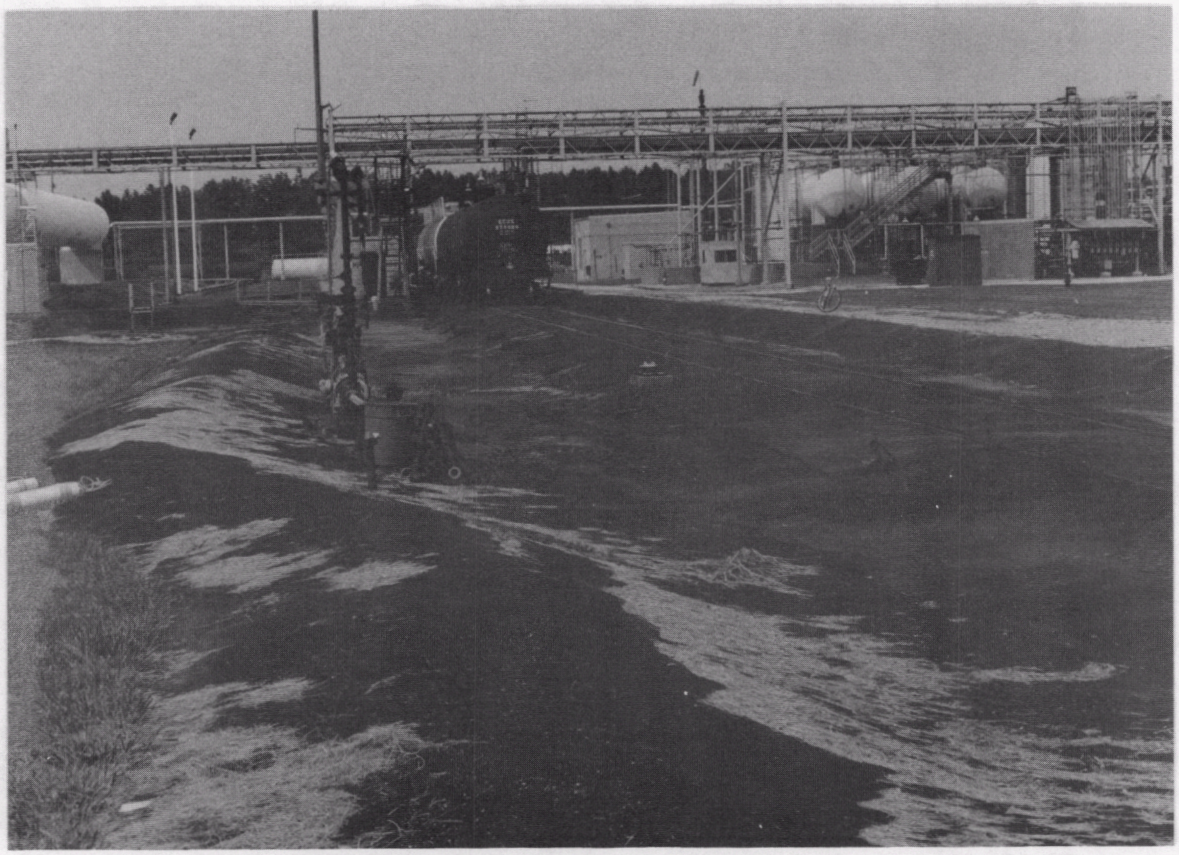

Fig. 8. View of the south end of the contaminated spill containment area (A) at the Uniroyal Chemical Company property, 720 Fairport-Nursery Road, Painesville, Ohio.

ORNL-PHOTO 9761-91

Fig. 9. Photograph of the spill containment basin on the Uniroyal Chemical Company property, looking south.

ORNL-PHOTO 9759-91

Fig. 10. View of the contaminated area (B) along the railroad tracks in the southeastern corner of the Uniroyal property, looking north.

ORNL-PHOTO 9760-91

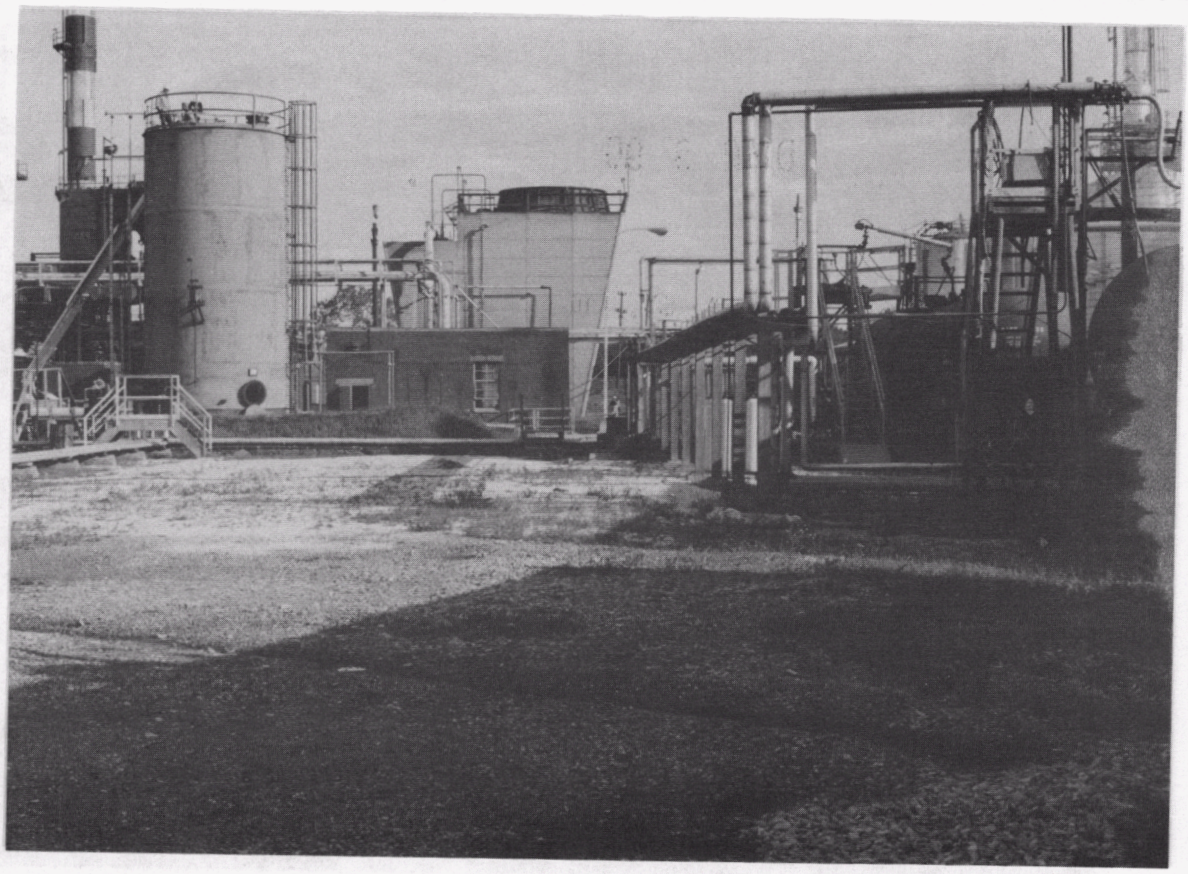

Fig. 11. View of the extreme northern portion of the contaminated area (B) along the railroad tracks in the southeastern corner of the Uniroyal property, looking north.

ORNL-PHOTO 9763-91

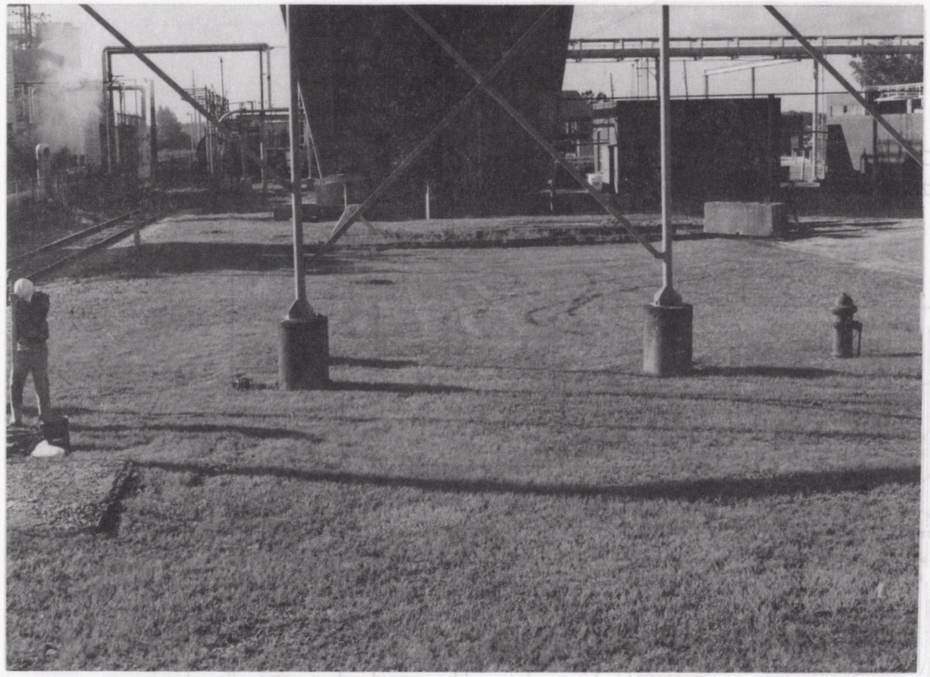

Fig. 12. View looking south from contaminated area D on the eastern side of the Uniroyal property.

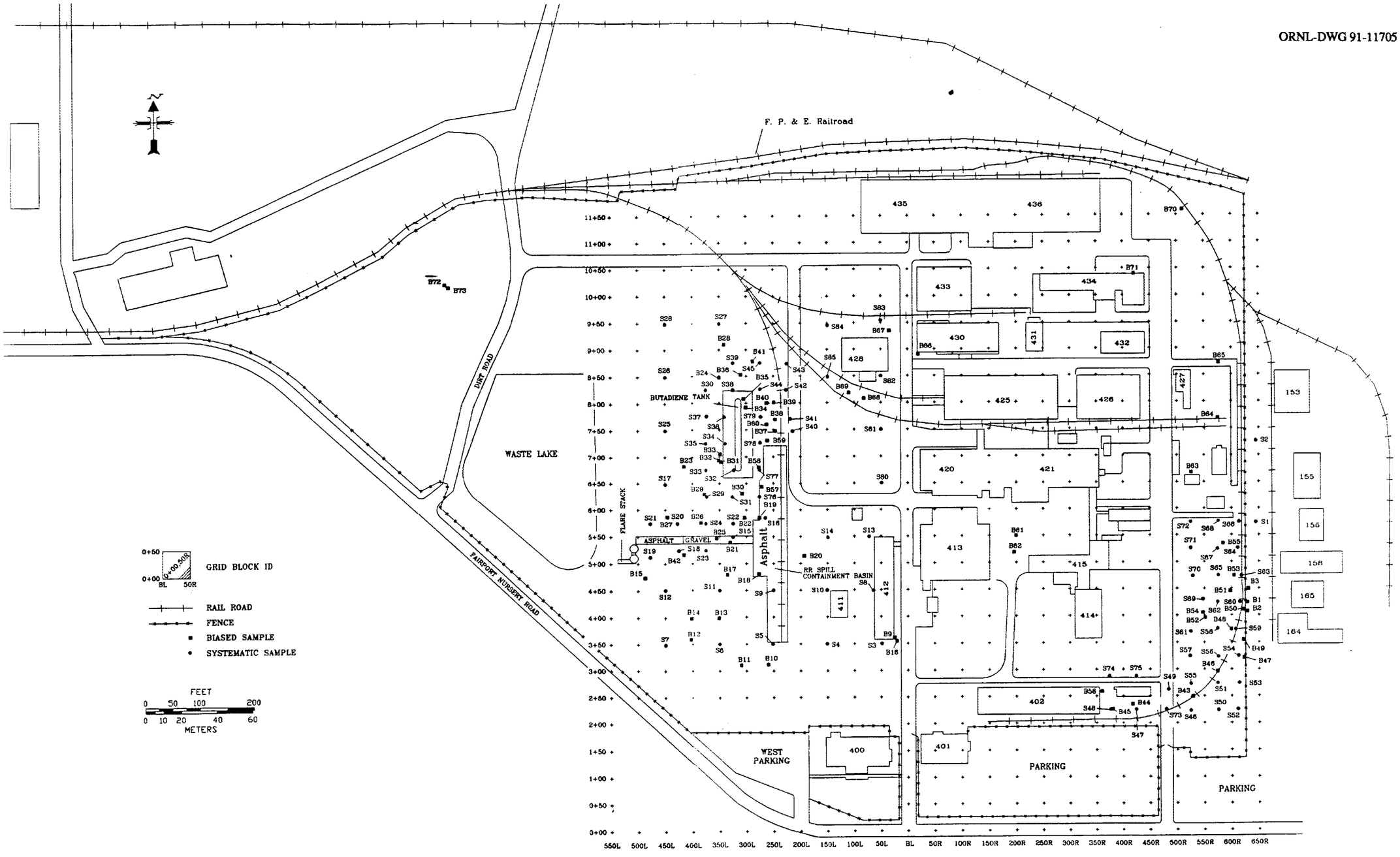

Fig. 13. Locations of biased (B) and systematic (S) soil samples collected from the Uniroyal and Lonza Chemical Company properties.

ORNL-PHOTO 9764-91

Fig. 15. View looking toward the Lonza Chemical Company property across the contaminated railroad tracks (area B) on the Uniroyal property.

ORNL-DWG 91-11699

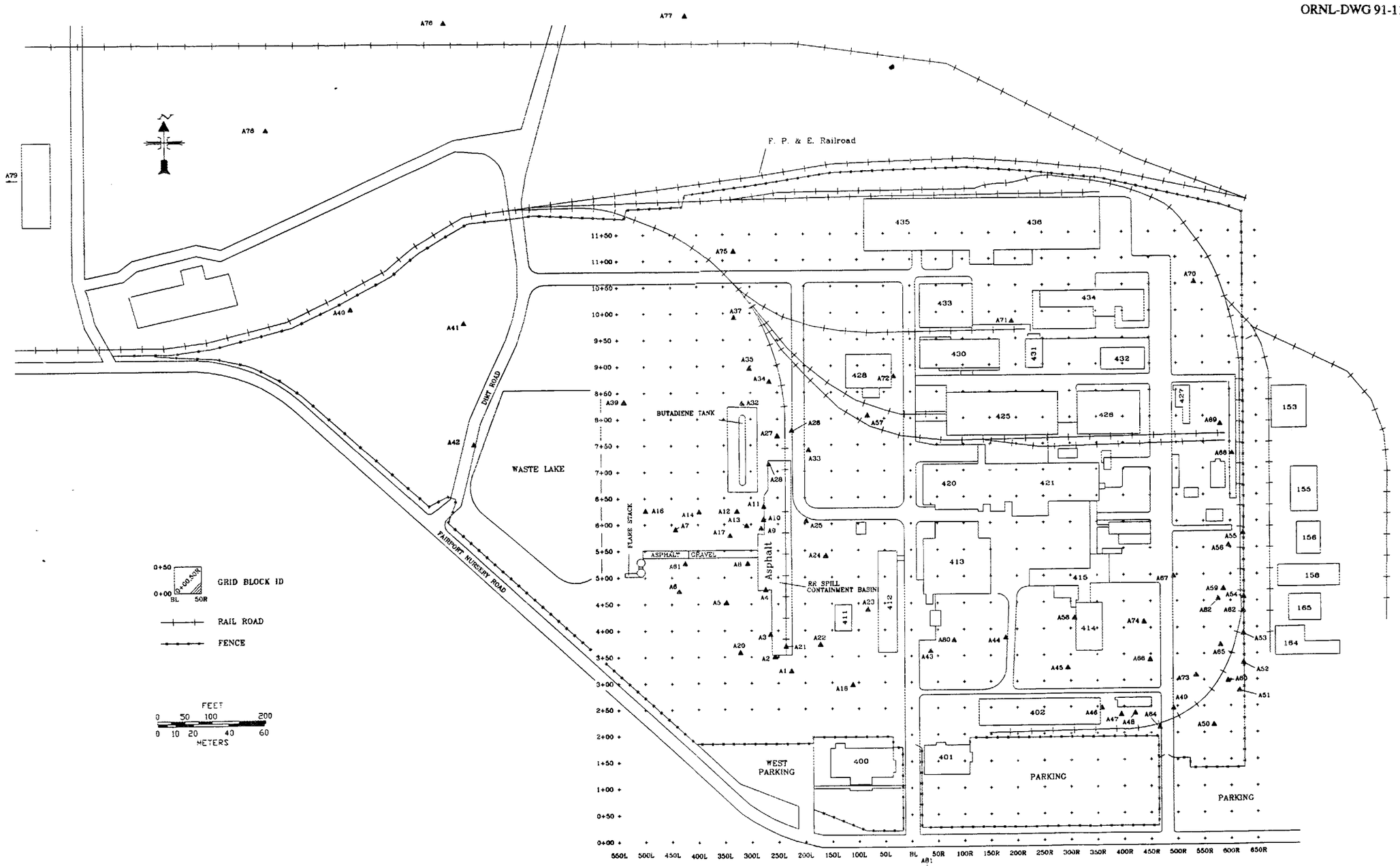

Fig. 14. Locations of auger holes (A) drilled on the Uniroyal Chemical Company property.

Table 1. Applicable guidelines for protection against radiation
(Limits for release without radiological restrictions)

Mode of exposure	Exposure conditions	Guideline value
Gamma radiation (above background)	Indoor gamma radiation level	20 μR/h[a]
Radionuclide concentrations in soil (generic)	Maximum permissible concentration of the following radionuclides in soil above background levels, averaged over a 100-cm^2 area ^{226}Ra ^{232}Th ^{230}Th ^{238}U	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
Derived concentrations		Site specific[b]
Guideline for nonhomogeneous contamination (used in addition to the 100-m^2 guideline)[c]	Applicable to locations with an area ≤25 m^2, with significantly elevated concentrations of radionuclides ("hot spots")	$G_A = G_i\ (100/A)^{1/2}$ where G_A= guideline for "hot spot" of area (A) G_i=guideline averaged over a 100-m^2 area

[a]The 20 μR/h shall comply with the basic dose limit (100 mrem/yr) when an appropriate-use scenario is considered.

[b]DOE guidelines for uranium are derived on a site-specific basis. Guidelines of 35-40 pCi/g have been applied at other FUSRAP sites. *Sources*: J. L. Marley and R. F. Carrier, *Results of the Radiological Survey at 4 Elmhurst Avenue, Colonie, New York (AL219)*, ORNL/RASA-87/117, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1988; B. A. Berven et. al., *Radiological Survey of the Former Kellex Research Facility, Jersey City, New Jersey*, DOE/EV-0005/29, ORNL-5734, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., February 1982.

[c]DOE guidelines specify that every reasonable effort shall be made to identify and to remove any source which has a concentration exceeding 30 times the guideline value, irrespective of area. *Source:* Adapted from *Revised Guidelines for Residual Radioactive Material at FUSRAP and Remote SFMP Sites*, April 1987.

Source: Adapted from *U.S. Department of Energy*, DOE Order 5400.5, April 1990.

Table 2. Background radiation levels and concentrations of selected radionuclides in soil in the Painesville, Ohio, area

Type of radiation measurement or sample	Radiation level or radionuclide concentration[a]
Gamma exposure rate at 1 m above ground surface (μR/h)	9
Concentration of radionuclide in soil (pCi/g dry wt)[b]	
^{232}Th	1.1 ± 0.10
^{226}Ra	1.1 ± 0.04
^{238}U	1.2

[a]Gamma exposure rate is the average of 3 to 4 measurements taken as reported in T. E. Myrick, B. A. Berven, and F. F. Haywood, *State Background Radiation Levels: Results of Measurements Taken During 1975–1979*, ORNL/TM-7343, Martin Marietta Energy Systems, Inc., Oak Ridge Natl. Lab., Nov. 1981.

[b]The total error of measurement results for ^{226}Ra and ^{232}Th is $\pm 2\sigma$ (95% confidence level). Error for the ^{238}U measurement is ≤5%.

Table 3. Gamma exposure rate measurements outdoors at the Uniroyal Chemical Plant, Painesville, Ohio (DMP001)

Grid location[a]	Grid point measurements[b] (μR/h)		Range of gamma exposure rates from scan of grid block[c] (μR/h)	Average gamma exposure rate at surface[c] (μR/h)
	Gamma exposure rate at 1 m	Gamma exposure rate at the surface		
2+00, BL	8	8	*d*	*d*
3+00, BL	8	9	8-20	10-13
4+00, BL	11	12	10-18	13-16
5+00, BL	9	10	8-17	13
6+00, BL	6	7	4-10	8
7+00, BL	6	6	4-24	13
8+00, BL	6	6	8-30	*d*
9+00, BL	9	9	8-40	*d*
10+00, BL	6	6	*d*	*d*
10+50, BL	8	10	*d*	*d*
2+00, 100L	12	14	*d*	*d*
3+00, 100L	13	13	8-9	*d*
4+00, 100L	14	14	5-20	8-13
5+00, 100L	14	14	8-50	8-13
6+00, 100L	11	11	*d*	*d*
7+00, 100L	7	8	*d*	*d*
8+00, 100L	12	12	8-20	*d*
9+00, 100L	9	10	8-13	*d*
10+00, 100L	12	12	*d*	*d*
10+50, 100L	7	7	*d*	*d*
2+00, 200L	10	12	*d*	*d*
3+00, 200L	13	13	9-40	9-13
4+00, 200L	10	9	6-24	10-16
5+00, 200L	10	10	6-11	9
5+50, 200L	*d*	*d*	6-150	*d*
6+00, 200L	9	9	5-50	20
6+50, 200L	*d*	*d*	8-40	14
7+00, 200L	10	10	10-160	16
8+00, 200L	12	10	10-70	16
8+50, 200L	*d*	*d*	10-40	16
9+00, 200L	12	12	*d*	*d*
10+00, 200L	8	9	*d*	*d*
10+50, 200L	7	8	*d*	*d*
2+50, 250L	11	12	*d*	*d*
3+00, 250L	12	12	*d*	*d*
3+50, 250L	10	11	*d*	*d*
4+00, 250L	9	9	6-24	*d*
4+50, 250L	9	9	*d*	*d*
5+00, 250L	10	9	6-10	8
5+50, 250L	10	9	9-1000	*d*
6+00, 250L	24	16	13-300	40
6+50, 250L	18	14	13-600	50
7+00, 250L	38	24	20-400	50
7+50, 250L	96	110	16-320	50
8+00, 250L	60	76	20-140	40
8+50, 250L	36	40	16-300	20-40

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h) Gamma exposure rate at 1 m	Gamma exposure rate at the surface	Range of gamma exposure rates from scan of grid block[c] (μR/h)	Average gamma exposure rate at surface[c] (μR/h)
9+00, 250L	17	19	*d*	*d*
9+50, 250L	11	10	*d*	*d*
10+00, 250L	12	13	*d*	*d*
10+50, 250L	9	8	*d*	*d*
2+00, 300L	10	12	*d*	*d*
3+00, 300L	10	11	8-20	11
4+00, 300L	14	14	10-160	13-16
5+00, 300L	10	10	10-250	18
5+50, 300L	*d*	*d*	16-500	60
6+00, 300L	44	44	13-600	40
6+50, 300L	*d*	*d*	10-60	20
7+00, 300L	52	48	13-110	20
7+50, 300L	*d*	*d*	13-100	16-20
8+00, 300L	20	19	10-16	17
8+50, 300L	*d*	*d*	14-16	17
9+00, 300L	14	15	10-46	12-16
10+00, 300L	8	8	*d*	*d*
10+50, 300L	8	8	*d*	*d*
2+00, 350L	11	12	*d*	*d*
2+50, 350L	12	12	*d*	*d*
3+00, 350L	12	12	*d*	*d*
3+50, 350L	13	14	*d*	*d*
4+00, 350L	13	13	*d*	*d*
4+50, 350L	14	14	*d*	*d*
5+00, 350L	14	15	13-60	18
5+50, 350L	34	38	16-1400	40
6+00, 350L	24	20	9-140	20
6+50, 350L	15	16	10-20	16
7+00, 350L	17	17	10-17	13
7+50, 350L	16	16	10-17	13
8+00, 350L	14	14	9-20	10
8+50, 350L	16	18	10-16	*d*
9+00, 350L	12	12	*d*	*d*
9+50, 350L	12	14	*d*	*d*
10+00, 350L	12	12	*d*	*d*
10+50, 350L	10	10	*d*	*d*
2+00, 400L	10	11	*d*	*d*
2+50, 400L	11	11	*d*	*d*
3+00, 400L	11	11	9-28	9-13
3+50, 400L	10	11	*d*	*d*
4+00, 400L	13	14	8-100	9-14
4+50, 400L	11	14	*d*	*d*
5+00, 400L	14	14	10-100	10-17
5+50, 400L	14	18	10-100	16-24
6+00, 400L	14	16	9-50	10-16
6+50, 400L	14	14	9-50	*d*
7+00, 400L	13	14	9-16	10-14

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h) Gamma exposure rate at 1 m	Gamma exposure rate at the surface	Range of gamma exposure rates from scan of grid block[c] (μR/h)	Average gamma exposure rate at surface[c] (μR/h)
7+50, 400L	13	13	9-16	*d*
8+00, 400L	14	14	9-13	10
8+50, 400L	13	14	*d*	*d*
9+00, 400L	12	13	9-16	10
9+50, 400L	12	13	10	*d*
10+00, 400L	12	12	*d*	*d*
10+50, 400L	9	9	*d*	*d*
2+50, 450L	12	12	*d*	*d*
3+00, 450L	11	12	*d*	*d*
3+50, 450L	11	12	*d*	*d*
4+00, 450L	13	14	*d*	*d*
4+50, 450L	12	12	*d*	*d*
5+00, 450L	13	13	10-40	10-16
5+50, 450L	15	15	9-40	9-16
6+00, 450L	13	13	*d*	*d*
6+50, 450L	13	15	*d*	*d*
7+00, 450L	12	13	*d*	*d*
7+50, 450L	13	13	*d*	*d*
8+00, 450L	14	14	*d*	*d*
8+50, 450L	13	14	*d*	*d*
9+00, 450L	12	12	*d*	*d*
9+50, 450L	12	12	*d*	*d*
10+00, 450L	12	13	*d*	*d*
10+50, 450L	9	10	*d*	*d*
3+00, 500L	11	11	8-13	*d*
3+50, 500L	11	12	*d*	*d*
4+00, 500L	10	11	8-13	*d*
4+50, 500L	10	9	*d*	*d*
5+00, 500L	8	8	8-13	*d*
5+50, 500L	14	15	*d*	*d*
6+00, 500L	12	13	8-13	*d*
6+50, 500L	13	16	*d*	*d*
7+00, 500L	12	13	8-13	*d*
7+50, 500L	12	13	*d*	*d*
8+00, 500L	12	13	8-13	*d*
8+50, 500L	12	12	*d*	*d*
9+00, 500L	12	13	8-13	*d*
9+50, 500L	12	14	*d*	*d*
10+00, 500L	12	12	8-13	*d*
10+50, 500L	8	8	*d*	*d*
2+00, 100R	10	10	6-10	*d*
3+00, 100R	*d*	*d*	5-60	*d*
4+00, 100R	*d*	*d*	5-60	*d*
6+00, 100R	*d*	*d*	4-10	*d*
7+50, 100R	*d*	*d*	5-100	*d*
8+00, 100R	10	10	5-20	*d*
9+00, 100R	*d*	*d*	5-13	*d*
2+00, 150R	11	12	*d*	*d*

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h) Gamma exposure rate at 1 m	Gamma exposure rate at the surface	Range of gamma exposure rates from scan of grid block[c] (μR/h)	Average gamma exposure rate at surface[c] (μR/h)
2+00, 200R	10	11	6-16	*d*
3+00, 200R	*d*	*d*	5-60	*d*
4+00, 200R	*d*	*d*	5-60	*d*
5+00, 200R	*d*	*d*	8-28	*d*
3+00, 250R	7	6	*d*	*d*
2+00, 300R	10	10	6-16	*d*
3+00, 300R	9	9	8-11	*d*
4+00, 300R	*d*	*d*	8-11	*d*
5+00, 300R	*d*	*d*	4-6	*d*
7+00, 300R	*d*	*d*	5-16	*d*
8+00, 300R	*d*	*d*	5-13	*d*
9+00, 300R	*d*	*d*	5-13	*d*
10+00, 300R	*d*	*d*	8-13	*d*
2+00, 350R	9	10	*d*	*d*
2+50, 350R	19	20	*d*	*d*
3+00, 350R	6	6	*d*	*d*
2+50, 380R	18	18	*d*	*d*
2+00, 400R	10	9	10-130	20-40
2+50, 400R	*d*	*d*	6-50	9
3+00, 400R	6	6	*d*	*d*
6+00, 400R	*d*	*d*	8-16	9
7+00, 400R	*d*	*d*	5-16	9
8+00, 400R	*d*	*d*	5-13	9
9+00, 400R	*d*	*d*	5-13	9
10+00, 400R	*d*	*d*	8-13	9
2+00, 450R	10	11	10-30	16-20
2+50, 450R	16	19	*d*	*d*
3+00, 450R	6	5	*d*	*d*
3+50, 450R	4	4	*d*	*d*
4+00, 450R	4	5	*d*	*d*
4+50, 450R	5	6	*d*	*d*
5+00, 450R	6	6	*d*	*d*
5+50, 450R	5	6	*d*	*d*
6+00, 450R	7	7	*d*	*d*
6+23, 450R	12	14	*d*	*d*
2+00, 500R	10	11	6-70	10-16
2+50, 500R	11	12	6-28	10-16
3+00, 500R	6	5	8-13	*d*
3+50, 500R	5	6	*d*	*d*
4+00, 500R	5	5	8-13	*d*
4+50, 500R	10	12	*d*	*d*
5+00, 500R	8	9	8-13	*d*
5+50, 500R	6	7	*d*	*d*
6+00, 500R	7	8	8-13	*d*
7+00, 500R	*d*	*d*	8-13	9
8+00, 500R	*d*	*d*	8-13	9
9+00, 500R	*d*	*d*	5-13	9
10+00, 500R	*d*	*d*	8-120	9

Table 3 (continued)

Grid location[a]	Grid point measurements[b] (μR/h) Gamma exposure rate at 1 m	Gamma exposure rate at the surface	Range of gamma exposure rates from scan of grid block[c] (μR/h)	Average gamma exposure rate at surface[c] (μR/h)
2+00, 550R	9	9	6-20	10
2+50, 550R	9	10	6-14	10
3+00, 550R	6	5	5-8	6
3+50, 550R	7	7	5-24	6
4+00, 550R	11	14	5-80	8-10
4+50, 550R	7	6	6-10	8
5+00, 550R	9	11	8-10	8
5+50, 550R	8	9	6-16	9
2+00, 600R	8	9	9-13	10
2+50, 600R	8	10	6-24	10
3+00, 600R	10	10	6-20	9
3+50, 600R	16	12	8-80	20
4+00, 600R	19	20	8-80	13
4+50, 600R	20	22	8-120	20
5+00, 600R	24	30	8-40	8
5+50, 600R	12	16	6-16	9
6+00, 600R	6	7	*d*	*d*
7+00, 600R	*d*	*d*	8-120	*d*
8+00, 600R	*d*	*d*	8-12	*d*
5+50, 624R	6	7	*d*	*d*
6+00, 624R	6	7	*d*	*d*
2+00, 625R	8	9	8-13	10
2+50, 625R	9	10	8-13	10
3+00, 625R	9	11	16-320	20-30
3+50, 625R	68	140	16-300	*d*
4+00, 625R	60	180	20-800	*d*
4+50, 625R	19	20	16-850	40
5+00, 625R	7	9	6-50	13
5+50, 625R	*d*	*d*	4-17	8

[a]Location shown on Fig. 5.
[b]Grid point measurements are taken at intersections of grid lines.
[c]Ranges and average gamma exposure rates are obtained by scanning the entire block.
[d]Measurement was not determined.

Table 4. Radionuclide concentrations in soil samples collected from the Uniroyal Chemical Company property at 720 Fairport-Nursery Road, Painesville, Ohio (DMP001)

Sample ID	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
			Systematic samples[c]		
S3	3+50, 50L	0-15	1.8 ± 0.59	0.28 ± 0.02	0.66 ± 0.01
S4	3+50, 150L	0-15	1.6 ± 0.93	1.2 ± 0.03	1.5 ± 0.02
S5	3+50, 250L	0-15	1.3 ± 0.35	0.91 ± 0.03	1.2 ± 0.02
S6	3+50, 350L	0-15	1.6 ± 0.93	1.2 ± 0.04	1.7 ± 0.03
S7	3+50, 450L	0-15	1.5 ± 0.51	1.0 ± 0.03	1.1 ± 0.02
S8	4+50, 65L	0-15	1.6 ± 0.43	1.1 ± 0.03	1.3 ± 0.02
S9	4+50, 250L	0-15	2.7 ± 0.98	0.69 ± 0.03	2.1 ± 0.03
S10	4+50, 150L	0-15	2.6 ± 1.2	1.3 ± 0.04	1.3 ± 0.02
S11	4+50, 350L	0-15	2.4 ± 0.55	1.2 ± 0.04	1.6 ± 0.03
S12	4+50, 450L	0-15	2.3 ± 0.50	1.1 ± 0.04	1.5 ± 0.02
S13	5+50, 72L	0-15	1.3 ± 0.63	0.84 ± 0.03	0.87 ± 0.02
S14	5+50, 150L	0-15	2.4 ± 1.1	1.1 ± 0.05	2.1 ± 0.03
S15	5+50, 325L	0-15	6.0 ± 2.3	0.92 ± 0.07	5.7 ± 0.08
S16	5+84, 265L	0-15	2.6 ± 1.6	0.32 ± 0.04	3.9 ± 0.05
S17	6+50, 450L	0-15	1.6 ± 0.42	1.3 ± 0.04	1.3 ± 0.02
S18	5+25, 425L	0-15	2.4 ± 1.1	1.3 ± 0.04	5.0 ± 0.04
S19A	5+15, 475L	0-15	3.6 ± 1.1	1.2 ± 0.04	2.9 ± 0.03
S19B	5+15, 475L	15-30	2.0 ± 1.2	1.2 ± 0.05	3.9 ± 0.04
S20A	5+75, 426L	0-15	2.5 ± 1.1	1.1 ± 0.04	2.5 ± 0.04
S20B	5+75, 426L	15-30	5.1 ± 1.1	1.1 ± 0.06	31 ± 0.09
S21	5+75, 476L	0-15	2.9 ± 1.3	0.86 ± 0.04	4.1 ± 0.04
S22	5+75, 325L	0-15	26 ± 7.4	0.80 ± 0.13	180 ± 0.53
S23	5+25, 375L	0-15	4.5 ± 1.8	1.2 ± 0.07	4.4 ± 0.07
S24A	5+75, 375L	0-15	3.9 ± 1.8	0.22 ± 0.05	7.8 ± 0.10
S24B	5+75, 375L	15-30	14 ± 3.9	0.72 ± 0.06	51 ± 0.25
S25	7+50, 450L	0-15	1.7 ± 0.93	1.2 ± 0.04	1.2 ± 0.02
S26	8+50, 450L	0-15	2.4 ± 1.1	1.3 ± 0.03	1.3 ± 0.02
S27	9+50, 350L	0-15	2.3 ± 1.2	1.1 ± 0.05	1.4 ± 0.03
S28	9+50, 450L	0-15	2.7 ± 1.1	1.2 ± 0.05	1.2 ± 0.03
S29	6+25, 375L	0-15	1.7 ± 0.63	0.52 ± 0.02	1.0 ± 0.02
S30	8+25, 375L	0-15	1.9 ± 0.64	1.2 ± 0.03	1.2 ± 0.02
S31	6+25, 325L	0-15	4.2 ± 2.8	0.84 ± 0.08	7.6 ± 0.11
S32A	6+75, 325L	0-15	2.4 ± 0.48	1.1 ± 0.03	2.4 ± 0.03
S32B	6+75, 325L	15-30	4.7 ± 2.1	0.90 ± 0.09	11 ± 0.13
S33	6+75, 375L	0-15	1.8 ± 0.86	1.1 ± 0.05	1.3 ± 0.03
S34	7+25, 340L	0-15	2.0 ± 0.99	1.1 ± 0.03	1.8 ± 0.03
S35	7+25, 375L	0-15	2.6 ± 1.1	1.2 ± 0.03	1.4 ± 0.02
S36	7+75, 340L	0-15	2.4 ± 1.1	1.1 ± 0.04	1.7 ± 0.03
S37	7+75, 375L	0-15	1.0 ± 0.76	1.1 ± 0.04	2.1 ± 0.03
S38	8+25, 325L	0-15	1.9 ± 0.57	1.2 ± 0.03	1.3 ± 0.02

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
S39	8+75, 325L	0-15	1.7 ± 1.1	1.0 ± 0.05	1.7 ± 0.03
S40	7+49, 215L	0-15	1.8 ± 0.67	0.19 ± 0.03	2.0 ± 0.03
S41	7+70, 218L	0-15	2.4 ± 1.4	0.59 ± 0.08	3.5 ± 0.08
S42	8+25, 227L	0-15	3.5 ± 1.3	0.38 ± 0.04	3.6 ± 0.05
S43	8+75, 225L	0-15	2.0 ± 1.3	0.39 ± 0.04	3.1 ± 0.05
S44	8+25, 275L	0-15	33 ± 6.2	0.89 ± 0.11	93 ± 1.0
S45	8+75, 275L	0-15	6.3 ± 1.2	1.0 ± 0.04	7.2 ± 0.05
S46	2+25, 525R	0-15	2.8 ± 0.62	0.99 ± 0.03	1.4 ± 0.02
S47	2+25, 425R	0-15	2.4 ± 0.76	0.76 ± 0.04	4.2 ± 0.05
S48	2+25, 375R	0-15	2.0 ± 0.39	0.91 ± 0.03	3.1 ± 0.03
S49	2+65, 484R	0-15	1.2 ± 0.57	0.31 ± 0.02	0.90 ± 0.02
S50	2+25, 575R	0-15	1.8 ± 0.54	0.99 ± 0.03	1.1 ± 0.02
S51	2+75, 575R	0-15	1.6 ± 0.90	1.0 ± 0.03	2.0 ± 0.03
S52	2+25, 612R	0-15	1.2 ± 0.78	1.1 ± 0.05	1.2 ± 0.03
S53	2+75, 612R	0-15	1.3 ± 0.53	1.1 ± 0.03	1.2 ± 0.02
S54	3+25, 612R	0-15	10 ± 2.4	0.73 ± 0.05	19 ± 0.08
S55A	2+75, 525R	0-15	2.0 ± 1.0	0.74 ± 0.03	2.1 ± 0.03
S55B	2+75, 525R	15-30	2.2 ± 1.7	0.89 ± 0.05	16 ± 0.14
S55C	2+75, 525R	30-45	4.4 ± 1.0	0.82 ± 0.05	24 ± 0.09
S56	3+25, 575R	0-15	0.77 ± 0.49	0.16 ± 0.02	0.71 ± 0.02
S57	3+25, 525R	0-15	1.2 ± 0.51	0.13 ± 0.02	0.68 ± 0.02
S58A	3+75, 575R	0-15	2.9 ± 0.85	0.73 ± 0.03	3.3 ± 0.03
S58B	3+75, 575R	15-30	4.2 ± 1.8	0.86 ± 0.04	12 ± 0.07
S58C	3+75, 575R	30-45	7.6 ± 2.9	1.2 ± 0.18	26 ± 0.23
S59	3+75, 608R	0-15	8.4 ± 3.6	1.0 ± 0.12	19 ± 0.18
S60A	4+25, 615R	0-15	19 ± 8.3	0.49 ± 0.13	35 ± 0.21
S60B	4+25, 615R	15-30	25 ± 7.5	0.98 ± 0.27	31 ± 0.38
S61	3+70, 525R	0-15	1.5 ± 0.38	0.27 ± 0.02	2.9 ± 0.03
S62	4+25, 575R	0-15	1.2 ± 0.48	0.16 ± 0.02	1.2 ± 0.02
S63A	4+75, 620R	0-15	3.0 ± 1.2	0.45 ± 0.05	15 ± 0.06
S63B	4+75, 620R	15-30	4.3 ± 2.6	1.1 ± 0.09	6.2 ± 0.08
S64	5+25, 612R	0-15	1.1 ± 0.55	0.18 ± 0.02	1.2 ± 0.02
S65	4+75, 575R	0-15	1.1 ± 0.47	0.23 ± 0.01	1.0 ± 0.02
S66	5+75, 612R	0-15	1.2 ± 0.68	0.23 ± 0.02	1.3 ± 0.02
S67A	5+25, 575R	0-15	1.8 ± 0.72	0.54 ± 0.03	0.91 ± 0.02
S67B	5+25, 575R	15-30	2.4 ± 1.1	1.1 ± 0.04	3.1 ± 0.04
S67C	5+25, 575R	30-45	2.9 ± 1.3	1.0 ± 0.07	4.4 ± 0.07
S68	5+75, 575R	0-15	0.87 ± 0.49	0.08 ± 0.02	0.74 ± 0.02
S69A	4+30, 547R	0-15	1.7 ± 1.1	0.33 ± 0.05	3.4 ± 0.07
S69B	4+30, 547R	15-30	6.2 ± 1.4	0.92 ± 0.05	13 ± 0.07
S70A	4+75, 530R	0-15	0.94 ± 0.46	0.22 ± 0.03	1.3 ± 0.03
S70B	4+75, 530R	15-30	1.7 ± 0.83	0.75 ± 0.03	4.8 ± 0.05
S70C	4+75, 530R	30-45	3.9 ± 1.0	1.1 ± 0.03	5.7 ± 0.04
S71	5+25, 525R	0-15	1.1 ± 0.59	0.80 ± 0.03	1.1 ± 0.02
S72	5+75, 525R	0-15	1.3 ± 0.50	0.11 ± 0.01	0.73 ± 0.01
S73	2+25, 480R	0-15	1.0 ± 0.70	0.48 ± 0.02	1.5 ± 0.02

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
S74A	2+90, 375R	0-15	1.0 ± 0.50	0.20 ± 0.02	0.75 ± 0.02
S74B	2+90, 375R	15-30	3.0 ± 0.93	0.70 ± 0.03	2.3 ± 0.03
S74C	2+90, 375R	30-45	1.9 ± 0.51	0.86 ± 0.03	1.9 ± 0.03
S75	2+90, 424R	0-15	1.2 ± 0.96	0.20 ± 0.02	0.58 ± 0.01
S76A	6+25, 275L	0-15	17 ± 3.2	0.71 ± 0.12	28 ± 0.20
S76B	6+25, 275L	15-30	20 ± 4.4	0.78 ± 0.13	31 ± 0.21
S76C	6+25, 275L	30-45	19 ± 7.2	0.87 ± 0.21	32 ± 0.28
S77A	6+75, 275L	0-15	31 ± 7.9	<0.54	78 ± 0.54
S77B	6+75, 275L	15-30	21 ± 4.2	1.3 ± 0.14	36 ± 0.18
S77C	6+75, 275L	30-45	27 ± 3.9	1.0 ± 0.18	19 ± 0.19
S78A	7+25, 275L	0-15	17 ± 1.8	0.97 ± 0.06	57 ± 0.25
S78B	7+25, 275L	15-30	32 ± 14	1.5 ± 0.38	110 ± 0.69
S79A	7+75, 275L	0-15	30 ± 1.7	0.95 ± 0.07	37 ± 0.23
S79B	7+75, 275L	15-30	120 ± 23	<0.70	190 ± 0.82
S79C	7+75, 275L	30-45	130 ± 24	1.4 ± 0.87	100 ± 1.4
S80	6+50, 50L	0-15	0.80 ± 0.33	0.11 ± 0.02	0.47 ± 0.02
S81	7+50, 50L	0-15	0.93 ± 0.55	0.63 ± 0.03	0.80 ± 0.02
S82	8+50, 50L	0-15	0.87 ± 0.46	0.21 ± 0.02	0.88 ± 0.02
S83	9+55, 50L	0-15	1.3 ± 0.73	0.53 ± 0.02	0.70 ± 0.02
S84	9+45, 150L	0-15	0.91 ± 0.68	0.97 ± 0.04	1.7 ± 0.03
S85	8+50, 150L	0-15	5.8 ± 2.5	1.1 ± 0.11	3.9 ± 0.08
			Biased samples[d]		
B9A	3+60, 25L	0-15	3.1 ± 1.6	0.35 ± 0.05	12 ± 0.08
B9B	3+60, 25L	15-30	2.8 ± 0.70	0.86 ± 0.04	7.3 ± 0.05
B9C	3+60, 25L	30-45	2.0 ± 0.43	1.1 ± 0.03	2.8 ± 0.03
B10A	3+15, 260L	0-15	6.8 ± 1.4	0.94 ± 0.25	130 ± 0.49
B10B	3+15, 260L	15-30	1.4 ± 1.1	1.2 ± 0.03	1.9 ± 0.02
B11A	3+12, 310L	0-15	2.2 ± 0.58	1.2 ± 0.03	2.9 ± 0.03
B11B	3+12, 310L	15-30	3.6 ± 1.9	1.2 ± 0.06	28 ± 0.10
B11C	3+12, 310L	30-45	2.7 ± 0.97	1.0 ± 0.03	3.8 ± 0.05
B12A	3+60, 402L	0-15	4.4 ± 2.3	0.68 ± 0.06	24 ± 0.20
B12B	3+60, 402L	15-30	4.5 ± 1.6	1.1 ± 0.07	5.2 ± 0.07
B12C	3+60, 402L	30-45	2.9 ± 0.99	1.2 ± 0.08	1.4 ± 0.05
B13A	3+99, 351L	0-15	1.9 ± 0.96	1.1 ± 0.03	3.6 ± 0.03
B13B	3+99, 351L	15-30	1.9 ± 0.87	0.98 ± 0.04	2.6 ± 0.03
B14A	3+99, 400L	0-15	1.7 ± 0.46	1.1 ± 0.03	1.9 ± 0.03
B14B	3+99, 400L	15-30	3.0 ± 1.8	1.2 ± 0.06	18 ± 0.07
B14C	3+99, 400L	30-45	2.3 ± 0.89	1.2 ± 0.03	3.5 ± 0.03
B15B	4+75, 485L	15-30	2.2 ± 0.84	1.2 ± 0.05	4.3 ± 0.06
B17A	4+80, 335L	0-15	2.3 ± 0.72	1.0 ± 0.04	14 ± 0.06
B17B	4+80, 335L	15-30	1.2 ± 0.70	0.76 ± 0.03	2.1 ± 0.03
B18A	4+80, 275L	0-15	4.5 ± 1.5	0.90 ± 0.04	12 ± 0.07
B18B	4+80, 275L	15-30	3.2 ± 0.96	1.0 ± 0.06	4.7 ± 0.06

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
B19B	5+85, 275L	15-30	99 ± 14	<2.8	1500 ± 3.5
B20B	5+15, 192L	15-30	2.6 ± 1.4	1.3 ± 0.08	3.8 ± 0.09
B20C	5+15, 192L	30-45	2.2 ± 0.73	1.2 ± 0.07	1.9 ± 0.05
B21B	5+38, 330L	15-30	1.2 ± 0.68	0.72 ± 0.04	2.6 ± 0.04
B22B	5+85, 301L	15-30	14 ± 6.1	0.98 ± 0.14	42 ± 0.25
B23B	6+85, 415L	15-30	1.7 ± 0.51	1.2 ± 0.03	1.6 ± 0.03
B24A	8+47, 351L	0-15	3.6 ± 1.5	1.3 ± 0.08	3.6 ± 0.07
B24B	8+47, 351L	15-30	4.6 ± 2.6	1.1 ± 0.08	7.4 ± 0.09
B24C	8+47, 351L	30-45	5.1 ± 1.4	1.0 ± 0.07	5.2 ± 0.07
B25B	5+48, 355L	15-30	2.6 ± 1.1	1.0 ± 0.03	4.0 ± 0.04
B26A	5+77, 385L	0-15	14 ± 1.9	0.74 ± 0.13	66 ± 0.26
B26B	5+77, 385L	15-30	<5.5	1.2 ± 0.13	12 ± 0.13
B27A	5+85, 445L	0-15	3.8 ± 1.5	1.1 ± 0.07	4.1 ± 0.07
B27B	5+85, 445L	15-30	5.3 ± 2.2	1.1 ± 0.08	18 ± 0.17
B27C	5+85, 445L	30-45	12 ± 26	<0.98	410 ± 2.3
B28A	9+10, 340L	0-15	2.0 ± 1.1	1.1 ± 0.09	4.5 ± 0.08
B29B	6+30, 379L	15-30	2.4 ± 1.3	1.1 ± 0.04	5.0 ± 0.04
B30A	6+32, 308L	0-15	5.2 ± 3.9	0.94 ± 0.11	96 ± 0.47
B30B	6+32, 308L	15-30	6.7 ± 2.3	0.68 ± 0.12	22 ± 0.12
B30C	6+32, 308L	30-45	8.1 ± 3.9	0.84 ± 0.11	30 ± 0.20
B31A	6+93, 350L	0-15	3.8 ± 1.8	1.1 ± 0.04	17 ± 0.07
B31B	6+93, 350L	15-30	5.0 ± 0.79	1.1 ± 0.05	24 ± 0.15
B32A	6+94, 351L	0-15	5.0 ± 2.6	1.1 ± 0.08	7.2 ± 0.09
B32B	6+94, 351L	15-30	3.0 ± 1.1	1.1 ± 0.06	2.5 ± 0.05
B33A	7+05, 349L	0-15	11 ± 7.2	<1.1	470 ± 2.7
B33B	7+05, 349L	15-30	3.8 ± 2.3	<0.19	2.9 ± 0.07
B34A	7+90, 300L	0-15	11 ± 1.7	1.0 ± 0.05	7.0 ± 0.05
B34B	7+90, 300L	15-30	29 ± 4.4	5.1 ± 1.7	770 ± 2.3
B35A	8+08, 303L	0-15	3.2 ± 1.2	1.0 ± 0.04	2.3 ± 0.04
B35B	8+08, 303L	15-30	4.5 ± 1.2	1.1 ± 0.08	2.5 ± 0.06
B35C	8+08, 3031	30-45	56 ± 7.6	0.82 ± 0.20	110 ± 0.36
B35D	8+08, 303L	45-60	35 ± 3.2	1.0 ± 0.37	91 ± 0.73
B36A	8+52, 310L	0-15	5.7 ± 2.5	1.1 ± 0.09	4.7 ± 0.08
B36B	8+52, 310L	15-30	8.2 ± 3.5	0.97 ± 0.08	19 ± 0.14
B36C	8+52, 310L	30-45	14 ± 3.2	1.1 ± 0.14	16 ± 0.14
B37A	7+47, 247L	0-15	30 ± 13	0.86 ± 0.26	90 ± 0.69
B37B	7+47, 247L	15-30	42 ± 9.3	<0.46	250 ± 1.0
B38A	7+71, 248L	0-15	19 ± 4.9	1.1 ± 0.19	99 ± 0.57
B38B	7+71, 248L	15-30	17 ± 7.5	0.93 ± 0.21	43 ± 0.39
B38C	7+71, 248L	30-45	31 ± 14	1.0 ± 0.33	140 ± 0.69
B39A	8+01, 250L	0-15	33 ± 8.2	0.88 ± 0.15	35 ± 0.34
B39B	8+01, 250L	15-30	66 ± 8.2	<0.77	170 ± 0.69
B39C	8+01, 250L	30-45	53 ± 3.7	1.2 ± 0.08	77 ± 0.15
B40A	8+00, 258L	0-15	49 ± 5.3	0.87 ± 0.36	140 ± 1.5
B40B	8+00, 258L	15-30	88 ± 5.5	<0.76	210 ± 0.85
B40C	8+00, 258L	30-45	21 ± 4.8	1.2 ± 0.16	58 ± 0.68

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
B42B	5+16, 415L	15-30	2.6 ± 1.3	1.0 ± 0.05	2.4 ± 0.05
B43A	2+48, 526R	0-15	3.1 ± 1.3	0.95 ± 0.12	40 ± 0.23
B43B	2+48, 526R	15-30	11 ± 3.7	0.92 ± 0.11	120 ± 0.21
B43C	2+48, 526R	30-45	4.1 ± 2.5	1.1 ± 0.07	78 ± 0.28
B44A	2+34, 419R	0-15	5.3 ± 2.9	0.70 ± 0.08	70 ± 0.22
B44B	2+34, 419R	15-30	2.8 ± 1.2	0.99 ± 0.04	13 ± 0.07
B44C	2+34, 419R	30-45	2.2 ± 0.69	0.93 ± 0.04	3.4 ± 0.03
B45A	2+25, 381R	0-15	15 ± 1.8	1.1 ± 0.69	130 ± 0.87
B45B	2+25, 381R	15-30	2.5 ± 1.5	0.99 ± 0.05	13 ± 0.10
B45C	2+25, 381R	30-45	2.2 ± 0.66	0.98 ± 0.04	11 ± 0.05
B46	2+95, 575R	0-15	2.6 ± 1.5	0.42 ± 0.03	21 ± 0.19
B47B	3+20, 624R	15-30	14 ± 5.6	0.62 ± 0.10	39 ± 0.26
B48	3+74, 599R	0-15	12 ± 4.8	0.82 ± 0.12	56 ± 0.27
B49A	3+55, 622R	0-15	79 ± 13	<1.1	220 ± 1.3
B49B	3+55, 622R	15-30	5.5 ± 1.3	0.79 ± 0.07	18 ± 0.11
B50A	4+10, 625R	0-15	87 ± 13	<0.59	280 ± 0.99
B50B	4+10, 625R	15-30	14 ± 5.0	<0.24	28 ± 0.24
B51A	4+48, 598R	0-15	29 ± 8.5	<0.38	110 ± 0.65
B51B	4+48, 598R	15-30	35 ± 12	<0.60	120 ± 0.71
B52A	3+95, 550R	0-15	4.9 ± 1.9	0.45 ± 0.10	5.7 ± 0.12
B52B	3+95, 550R	15-30	9.4 ± 2.8	0.81 ± 0.28	56 ± 0.21
B53	4+76, 604R	0-15	34 ± 11	<0.50	84 ± 0.41
B54A	4+05, 547R	0-15	1.6 ± 0.75	0.31 ± 0.04	4.6 ± 0.05
B55A	5+35, 585R	0-15	19 ± 7.0	0.72 ± 0.25	55 ± 0.37
B55B	5+35, 585R	15-30	25 ± 8.4	1.5 ± 0.71	120 ± 0.36
B56A	2+58, 360R	0-15	32 ± 13	<0.52	92 ± 0.68
B56B	2+58, 360R	15-30	5.0 ± 2.7	0.72 ± 0.06	14 ± 0.10
B57A	6+44, 270L	0-15	83 ± 16	<0.64	350 ± 0.77
B57B	6+44, 270L	15-30	210 ± 7.1	<0.75	180 ± 0.70
B57C	6+44, 270L	30-45	200 ± 8.7	0.83 ± 0.20	17 ± 0.23
B58A	6+80, 276L	0-15	63 ± 34	<1.6	860 ± 1.9
B58C	6+80, 276L	30-45	150 ± 23	<1.2	1000 ± 7.0
B58D	6+80, 276L	45-60	130 ± 12	<1.1	320 ± 2.1
B59A	7+32, 260L	0-15	<30	<0.90	260 ± 0.83
B60A	7+59, 262L	0-15	29 ± 5.2	0.95 ± 0.14	41 ± 0.23
B60B	7+59, 262L	15-30	130 ± 12	<1.7	840 ± 3.3
B60C	7+59, 262L	30-45	35 ± 3.1	2.0 ± 1.5	220 ± 1.6
B60D	7+59, 262L	45-60	53 ± 8.1	1.4 ± 0.15	53 ± 0.27
B61A	5+50, 200R	0-15	5.1 ± 2.0	0.46 ± 0.08	7.0 ± 0.13
B61B	5+50, 200R	15-30	1.4 ± 0.40	0.30 ± 0.02	1.5 ± 0.02
B62A	5+20, 195R	0-15	6.1 ± 2.8	0.66 ± 0.11	7.7 ± 0.15
B62B	5+20, 195R	15-30	15 ± 6.4	0.80 ± 0.63	74 ± 0.36
B62C	5+20, 195R	30-45	20 ± 5.9	0.81 ± 0.12	42 ± 0.31
B63A	6+70, 525R	0-15	1.6 ± 0.80	1.2 ± 0.04	1.5 ± 0.02
B63B	6+70, 525R	15-30	1.8 ± 0.76	0.99 ± 0.03	1.6 ± 0.02
B64A	7+70, 575R	0-15	4.5 ± 2.3	0.72 ± 0.04	22 ± 0.14

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b] ^{238}U	^{232}Th	^{226}Ra
B64B	7+70, 575R	15-30	2.5 ± 1.1	1.0 ± 0.04	3.6 ± 0.04
B65A	8+75, 575R	0-15	30 ± 2.2	<0.66	180 ± 1.1
B65B	8+75, 575R	15-30	9.2 ± 3.0	0.93 ± 0.14	43 ± 0.27
B66A	8+90, 20R	0-15	<1.5	0.51 ± 0.20	48 ± 0.15
B66B	8+90, 20R	15-30	3.2 ± 1.8	0.83 ± 0.05	28 ± 0.18
B67	9+35, 35L	0-15	3.2 ± 0.86	0.50 ± 0.03	18 ± 0.06
B68A	8+10, 82L	0-15	6.1 ± 3.0	0.92 ± 0.07	16 ± 0.11
B68B	8+10, 82L	15-30	2.3 ± 1.3	1.1 ± 0.04	4.7 ± 0.04
B69A	8+20, 109L	0-15	6.4 ± 0.68	0.91 ± 0.09	33 ± 0.30
B69B	8+20, 109L	15-30	4.0 ± 1.1	1.1 ± 0.04	6.3 ± 0.04
B70A	11+60, 510R	0-15	3.9 ± 4.6	1.0 ± 0.13	120 ± 1.2
B70B	11+60, 510R	15-30	2.2 ± 0.92	1.1 ± 0.03	2.5 ± 0.03
B71	10+35, 420R	0-15	18 ± 6.6	0.36 ± 0.15	25 ± 0.24
B72A	10+25, 855L	0-15	27 ± 26	<1.3	310 ± 1.5
B72B	10+25, 855L	15-30	54 ± 16	<0.69	270 ± 2.8
B72C	10+25, 855L	30-45	42 ± 14	<0.77	170 ± 1.3
B72D	10+25, 855L	45-60	16 ± 4.4	0.76 ± 0.10	27 ± 0.16
B73A	10+20, 850L	0-15	13 ± 4.9	1.2 ± 0.13	70 ± 0.43
B73B	10+20, 850L	15-30	36 ± 10	0.81 ± 0.23	200 ± 1.9
B73C	10+20, 850L	30-45	20 ± 3.8	<0.52	130 ± 0.86
B74A	*e*	0-15	2.9 ± 1.6	1.9 ± 0.05	3.6 ± 0.04
B74B	*e*	15-30	1.7 ± 1.0	1.2 ± 0.06	1.8 ± 0.13
B75A	*e*	0-15	6.0 ± 3.2	1.4 ± 0.10	7.6 ± 0.23
B75B	*e*	15-30	2.9 ± 0.72	1.5 ± 0.05	7.3 ± 0.13
B75C	*e*	30-45	2.4 ± 1.3	1.3 ± 0.07	3.6 ± 0.18
			Auger hole samples[f]		
A1A	3+18, 228L	0-15	<1.7	1.1 ± 0.04	1.3 ± 0.03
A2A	3+45, 267L	0-15	2.0 ± 0.83	1.1 ± 0.04	1.3 ± 0.02
A3A	3+87, 228L	0-15	2.6 ± 0.97	1.1 ± 0.03	2.4 ± 0.03
A3B	3+87, 228L	15-30	1.5 ± 0.88	1.2 ± 0.05	1.2 ± 0.03
A3C	3+87, 228L	30-45	1.7 ± 0.39	1.2 ± 0.03	1.2 ± 0.02
A3D	3+87, 228L	45-60	2.0 ± 1.1	1.2 ± 0.03	1.2 ± 0.02
A3E	3+87, 228L	60-75	1.7 ± 0.95	1.3 ± 0.03	1.3 ± 0.02
A3F	3+87, 228L	75-90	2.1 ± 1.0	1.2 ± 0.04	1.5 ± 0.03
A3G	3+87, 228L	90-105	1.6 ± 0.85	1.1 ± 0.05	1.1 ± 0.03
A3H	3+87, 228L	105-120	1.3 ± 0.43	1.1 ± 0.03	1.3 ± 0.02
A4A	4+74, 275L	0-15	3.9 ± 0.73	1.0 ± 0.07	7.7 ± 0.09
A4B	4+74, 275L	15-30	3.3 ± 2.0	1.0 ± 0.06	3.2 ± 0.05
A4C	4+74, 275	30-45	2.1 ± 1.1	0.82 ± 0.06	2.5 ± 0.05
A5A	4+48, 349L	0-15	3.0 ± 1.1	1.3 ± 0.05	1.7 ± 0.04
A5B	4+48, 349L	30-45	1.2 ± 1.1	1.2 ± 0.05	1.2 ± 0.03
A5C	4+48, 349L	30-45	1.6 ± 0.50	1.3 ± 0.04	1.3 ± 0.02
A5D	4+48, 349L	45-60	1.6 ± 0.54	1.5 ± 0.03	1.5 ± 0.02
A5E	4+48, 349L	60-75	1.6 ± 0.98	1.3 ± 0.05	1.8 ± 0.03

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
A6A	4+70, 438L	0-15	2.1 ± 0.97	1.0 ± 0.04	1.2 ± 0.02
A7A	5+86, 445L	0-15	4.2 ± 1.4	1.1 ± 0.04	4.7 ± 0.04
A7B	5+86, 445L	15-30	6.1 ± 2.0	1.1 ± 0.11	24 ± 0.18
A7C	5+86, 445L	30-45	11 ± 5.4	1.0 ± 0.14	52 ± 0.30
A7D	5+86, 445L	45-60	9.3 ± 3.2	0.98 ± 0.17	89 ± 0.50
A7E	5+86, 445L	60-75	2.8 ± 1.1	1.3 ± 0.04	3.1 ± 0.04
A7F	5+86, 445L	75-90	8.1 ± 1.8	1.2 ± 0.07	1.4 ± 0.04
A7I	5+86, 445L	120-135	7.1 ± 1.7	1.2 ± 0.11	8.3 ± 0.11
A7J	5+86, 445L	135-150	3.8 ± 1.1	1.3 ± 0.07	1.7 ± 0.05
A7K	5+86, 445L	150-170	3.7 ± 1.8	1.3 ± 0.05	1.4 ± 0.03
A8A	5+22, 308L	0-15	6.0 ± 1.8	0.94 ± 0.05	16 ± 0.06
A8B	5+22, 308L	15-30	7.2 ± 1.8	0.87 ± 0.05	13 ± 0.06
A8C	5+22, 308L	30-45	5.8 ± 0.76	0.92 ± 0.04	12 ± 0.05
A8D	5+22, 308L	45-60	5.2 ± 2.4	1.0 ± 0.07	3.9 ± 0.06
A8E	5+22, 308L	60-75	2.1 ± 0.51	1.3 ± 0.03	1.4 ± 0.02
A8G	5+22, 308L	90-105	3.5 ± 1.4	1.2 ± 0.04	5.3 ± 0.05
A9A	5+88, 284L	30-45	12 ± 5.7	0.90 ± 0.14	120 ± 0.45
A9B	5+88, 284L	45-60	1.5 ± 1.1	1.1 ± 0.05	1.4 ± 0.03
A9C	5+88, 284L	60-75	2.0 ± 1.1	1.1 ± 0.05	1.5 ± 0.04
A9D	5+88, 284L	75-90	1.4 ± 0.50	1.0 ± 0.03	1.1 ± 0.02
A10A	6+10, 267L	0-15	27 ± 6.2	<0.80	370 ± 1.2
A10B	6+10, 267L	15-30	47 ± 2.5	1.1 ± 0.17	14 ± 0.25
A10C	6+10, 267L	30-45	63 ± 5.8	1.0 ± 0.27	31 ± 0.51
A10D	6+10, 267L	45-60	20 ± 1.8	1.1 ± 0.19	6.7 ± 0.17
A10E	6+10, 267L	60-75	13 ± 2.9	0.97 ± 0.17	50 ± 0.27
A10F	6+10, 267L	75-90	4.9 ± 1.1	1.2 ± 0.07	2.8 ± 0.06
A10G	6+10, 267L	90-105	3.7 ± 0.87	1.4 ± 0.09	1.3 ± 0.05
A10H	6+10, 267L	105-120	2.3 ± 0.30	1.3 ± 0.03	1.5 ± 0.02
A10I	6+10, 267L	120-135	14 ± 2.3	1.3 ± 0.14	17 ± 0.20
A10J	6+10, 267L	135-150	3.1 ± 0.57	1.3 ± 0.08	2.5 ± 0.06
A10K	6+10, 267L	150-170	4.1 ± 0.56	1.3 ± 0.07	6.6 ± 0.08
A10L	6+10, 267L	170-185	2.2 ± 0.45	1.2 ± 0.03	2.2 ± 0.03
A10M	6+10, 267L	185-200	9.5 ± 0.91	1.2 ± 0.14	22 ± 0.22
A10N	6+10, 267L	200-215	3.2 ± 0.41	1.3 ± 0.12	14 ± 0.14
A10O	6+10, 267L	215-230	1.7 ± 0.30	1.2 ± 0.05	1.6 ± 0.03
A10P	6+10, 267L	230-245	3.4 ± 0.97	1.2 ± 0.04	3.6 ± 0.04
A10U	6+10, 267L	305-320	4.5 ± 0.71	1.1 ± 0.08	11 ± 0.11
A10V	6+10, 267L	320-335	11 ± 1.1	1.1 ± 0.10	18 ± 0.16
A10W	6+10, 267L	335-350	2.1 ± 0.35	1.2 ± 0.04	2.3 ± 0.03
A11A	6+29, 279L	0-15	35 ± 6.9	0.91 ± 0.16	69 ± 0.31
A12A	6+19, 328L	0-15	3.2 ± 0.51	0.93 ± 0.03	3.6 ± 0.03
A12B	6+19, 328L	15-30	1.5 ± 0.45	1.1 ± 0.03	1.4 ± 0.02
A12C	6+19, 328L	30-45	1.9 ± 0.81	1.1 ± 0.04	2.0 ± 0.03
A12E	6+19, 328L	45-60	2.6 ± 0.68	1.1 ± 0.08	2.4 ± 0.07
A12F	6+19, 328L	60-75	1.9 ± 0.63	1.1 ± 0.03	1.3 ± 0.02

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
A12G	6+19, 328L	75-90	2.5 ± 0.94	1.1 ± 0.05	1.3 ± 0.03
A12H	6+19, 328L	90-105	1.7 ± 0.56	1.1 ± 0.04	1.2 ± 0.02
A12I	6+19, 328L	105-120	2.1 ± 0.78	1.1 ± 0.03	2.0 ± 0.03
A13A	5+92, 311L	0-15	21 ± 1.2	0.76 ± 0.21	90 ± 0.39
A13B	5+92, 311L	15-30	6.1 ± 0.89	1.0 ± 0.04	1.2 ± 0.02
A13C	5+92, 311L	30-45	0.98 ± 0.30	0.76 ± 0.03	0.85 ± 0.02
A13D	5+92, 311L	45-60	1.5 ± 0.88	1.0 ± 0.04	1.1 ± 0.02
A13E	5+92, 311L	60-75	11 ± 2.6	0.98 ± 0.06	39 ± 0.10
A13F	5+92, 311L	75-90	1.5 ± 0.81	1.1 ± 0.03	1.4 ± 0.02
A13G	5+92, 311L	90-105	1.3 ± 0.73	1.0 ± 0.04	1.1 ± 0.02
A13H	5+92, 311L	105-120	1.5 ± 0.49	0.77 ± 0.03	1.0 ± 0.02
A14A	6+20, 400L	0-15	2.2 ± 0.98	1.1 ± 0.05	1.4 ± 0.03
A14B	6+20, 400L	15-30	2.2 ± 0.97	1.0 ± 0.04	1.7 ± 0.03
A14C	6+20, 400L	30-45	2.5 ± 1.0	1.1 ± 0.05	3.1 ± 0.04
A14E	6+20, 400L	60-75	1.9 ± 0.57	1.2 ± 0.04	1.5 ± 0.02
A14F	6+20, 400L	75-90	1.6 ± 1.1	1.3 ± 0.07	1.2 ± 0.04
A14G	6+20, 400L	90-105	1.7 ± 0.84	1.3 ± 0.04	1.2 ± 0.02
A14H	6+20, 400L	105-120	1.3 ± 0.78	1.1 ± 0.04	1.2 ± 0.02
A16A	6+21, 500L	0-15	1.8 ± 0.78	1.1 ± 0.04	1.4 ± 0.02
A17A	5+74, 341L	0-15	12 ± 1.0	0.93 ± 0.23	73 ± 0.41
A18A	2+90,115L	0-15	2.7 ± 1.1	1.5 ± 0.04	1.9 ± 0.03
A20B	3+57, 323L	15-30	3.2 ± 1.7	1.1 ± 0.06	3.6 ± 0.06
A21C	3+65, 238L	30-45	1.8 ± 0.46	1.1 ± 0.03	1.5 ± 0.02
A21D	3+65, 238L	45-60	2.0 ± 1.0	1.2 ± 0.03	1.3 ± 0.02
A22A	3+69, 174L	0-15	2.3 ± 0.72	0.95 ± 0.04	3.0 ± 0.04
A23A	4+36, 85L	0-15	1.8 ± 0.78	0.44 ± 0.02	0.87 ± 0.02
A24A	5+35, 165L	0-15	1.8 ± 0.55	1.1 ± 0.04	1.7 ± 0.02
A25C	6+00, 200L	30-45	1.6 ± 0.41	1.2 ± 0.04	1.2 ± 0.02
A25E	6+00, 200L	45-60	2.0 ± 0.70	1.4 ± 0.07	1.5 ± 0.04
A25F	6+00, 200L	60-75	2.0 ± 0.97	1.5 ± 0.05	1.6 ± 0.03
A25G	6+00, 200L	75-90	1.6 ± 0.57	1.4 ± 0.04	1.5 ± 0.02
A25I	6+00, 200L	120-135	1.8 ± 1.1	1.2 ± 0.05	1.4 ± 0.03
A25J	6+00, 200L	135-150	1.8 ± 0.43	1.4 ± 0.04	1.3 ± 0.02
A26A	7+73, 224L	0-15	1.9 ± 0.76	0.16 ± 0.02	2.9 ± 0.03
A27A	7+62, 252L	0-15	25 ± 3.0	0.95 ± 0.23	68 ± 0.40
A27C	7+62, 252L	30-45	50 ± 3.4	1.1 ± 0.46	230 ± 1.8
A28A	7+11, 262L	0-15	41 ± 21	2.5 ± 0.82	200 ± 1.1
A28B	7+11, 262L	15-30	43 ± 8.6	<1.4	230 ± 1.5
A28C	7+11, 262L	30-45	12 ± 3.1	0.95 ± 0.08	6.6 ± 0.11
A28E	7+11, 262L	60-75	13 ± 4.3	1.3 ± 0.11	32 ± 0.17
A28F	7+11, 262L	75-90	1.7 ± 1.1	1.5 ± 0.06	1.7 ± 0.03
A28G	7+11, 262L	90-105	2.2 ± 0.98	1.2 ± 0.08	1.3 ± 0.03
A28H	7+11, 262L	105-120	1.9 ± 1.1	1.3 ± 0.05	1.3 ± 0.03
A28I	7+11, 262L	120-135	4.8 ± 1.8	1.3 ± 0.05	15 ± 0.08
A28J	7+11, 262L	135-150	1.5 ± 0.55	1.2 ± 0.04	1.2 ± 0.02
A28K	7+11, 262L	150-170	1.5 ± 0.50	1.4 ± 0.04	1.3 ± 0.02
A28L	7+11, 262L	170-185	1.8 ± 1.1	1.5 ± 0.05	1.4 ± 0.03

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	232Th	^{226}Ra
A32A	8+25, 318L	0-15	11 ± 2.2	1.0 ± 0.05	15 ± 0.07
A32B	8+25, 318L	15-30	2.8 ± 1.2	1.3 ± 0.06	1.7 ± 0.03
A32C	8+25, 318L	30-45	1.8 ± 0.78	1.3 ± 0.06	2.3 ± 0.04
A32D	8+25, 318L	45-60	4.4 ± 1.4	1.2 ± 0.06	3.6 ± 0.06
A32E	8+25, 318L	60-75	6.3 ± 2.9	1.2 ± 0.10	5.0 ± 0.08
A32F	8+25, 318L	75-90	1.2 ± 0.66	1.2 ± 0.03	1.8 ± 0.02
A32G	8+25, 318L	90-105	2.4 ± 1.1	1.3 ± 0.04	1.4 ± 0.02
A32H	8+25, 318L	105-120	1.8 ± 1.1	1.3 ± 0.04	1.3 ± 0.02
A32I	8+25, 318L	120-135	2.0 ± 1.1	1.2 ± 0.05	2.6 ± 0.04
A32J	8+25, 318L	135-150	1.9 ± 1.0	1.3 ± 0.04	1.3 ± 0.02
A33A	8+40, 192L	0-15	1.2 ± 0.68	0.48 ± 0.02	0.81 ± 0.02
A34A	8+69, 264L	0-15	14 ± 1.5	1.1 ± 0.21	33 ± 0.27
A35A	8+93, 301L	0-15	2.8 ± 0.61	0.97 ± 0.04	3.6 ± 0.04
A37A	9+91, 331L	0-15	2.5 ± 1.3	1.1 ± 0.05	1.5 ± 0.03
A39A	8+28, 540L	0-15	1.4 ± 0.55	1.2 ± 0.04	1.5 ± 0.02
A40A	10+10, 1052L	0-15	1.3 ± 0.73	1.0 ± 0.04	1.2 ± 0.02
A41A	9+80, 838L	0-15	2.1 ± 1.1	1.0 ± 0.05	1.4 ± 0.03
A42A	7+50, 820L	0-15	0.73 ± 0.36	0.76 ± 0.03	0.87 ± 0.02
A43A	3+56, 34R	0-15	2.2 ± 1.1	1.1 ± 0.04	1.8 ± 0.03
A43C	3+56, 34R	30-45	1.5 ± 0.42	0.74 ± 0.02	1.4 ± 0.02
A43D	3+56, 34R	45-60	2.7 ± 1.9	0.99 ± 0.05	2.1 ± 0.04
A43E	3+56, 34R	60-75	1.5 ± 0.52	1.1 ± 0.03	1.3 ± 0.02
A43F	3+56, 34R	75-90	1.6 ± 0.38	1.1 ± 0.03	1.2 ± 0.02
A43G	3+56, 34R	90-105	1.9 ± 1.0	1.4 ± 0.04	1.4 ± 0.02
A43H	3+56, 34R	105-120	1.4 ± 0.97	1.4 ± 0.04	1.4 ± 0.02
A43I	3+56, 34R	120-135	1.9 ± 0.87	1.3 ± 0.04	1.3 ± 0.02
A43J	3+56, 34R	135-150	2.4 ± 1.6	1.4 ± 0.06	1.4 ± 0.04
A43K	3+56, 34R	150-170	2.4 ± 1.1	1.2 ± 0.06	1.3 ± 0.04
A43L	3+56, 34R	170-185	2.8 ± 1.6	1.3 ± 0.08	1.3 ± 0.05
A44A	3+80, 175R	0-15	2.1 ± 0.87	0.83 ± 0.06	1.5 ± 0.04
A45A	3+20, 292R	0-15	1.2 ± 0.57	0.55 ± 0.03	0.80 ± 0.02
A46A	2+44, 357R	0-15	2.8 ± 1.5	0.76 ± 0.05	5.4 ± 0.06
A46B	2+44, 357R	15-30	2.8 ± 1.2	1.2 ± 0.05	2.6 ± 0.03
A46C	2+44, 357R	30-45	0.79 ± 0.53	0.93 ± 0.03	1.7 ± 0.02
A46E	2+44, 357R	60-75	2.1 ± 1.4	0.80 ± 0.04	10 ± 0.05
A46F	2+44, 357R	75-90	1.3 ± 0.95	1.0 ± 0.05	1.2 ± 0.03
A46G	2+44, 357R	90-105	2.5 ± 1.0	0.81 ± 0.04	1.4 ± 0.03
A46H	2+44, 357R	105-120	1.5 ± 1.1	0.89 ± 0.04	1.1 ± 0.02
A46I	2+44, 357R	120-135	3.5 ± 1.4	1.0 ± 0.06	1.4 ± 0.04
A46J	2+44, 357R	135-150	2.2 ± 1.4	1.3 ± 0.05	1.3 ± 0.03
A46K	2+44, 357R	150-170	1.2 ± 0.95	1.1 ± 0.04	1.1 ± 0.02
A46L	2+44, 357R	170-185	1.8 ± 1.1	1.2 ± 0.04	1.2 ± 0.02
A47A	2+31, 393R	0-15	2.0 ± 1.1	0.75 ± 0.05	4.6 ± 0.06
A47B	2+31, 393R	15-30	1.5 ± 0.91	1.0 ± 0.04	1.2 ± 0.02
A47C	2+31, 393R	30-45	1.1 ± 0.59	0.92 ± 0.03	1.1 ± 0.02
A47D	2+31, 393R	45-60	1.0 ± 0.44	0.90 ± 0.03	1.0 ± 0.02
A47E	2+31, 393R	60-75	2.1 ± 1.2	0.89 ± 0.06	2.2 ± 0.04

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
A47F	2+31, 393R	75-90	1.8 ± 1.2	0.89 ± 0.06	0.95 ± 0.03
A47I	2+31, 393R	120-135	1.4 ± 0.61	0.85 ± 0.03	3.0 ± 0.04
A48A	2+35, 416R	0-15	3.1 ± 1.9	0.96 ± 0.05	29 ± 0.10
A48B	2+35, 416R	15-30	3.1 ± 2.8	0.85 ± 0.06	38 ± 0.39
A48C	2+35, 416R	30-45	1.3 ± 0.45	0.84 ± 0.03	1.4 ± 0.02
A48E	2+35, 416R	60-75	4.7 ± 2.2	0.89 ± 0.09	28 ± 0.17
A48F	2+35, 416R	75-90	3.0 ± 1.6	0.81 ± 0.03	10 ± 0.05
A48G	2+35, 416R	90-105	1.9 ± 0.43	0.84 ± 0.03	1.0 ± 0.02
A48H	2+35, 416R	105-120	1.6 ± 1.0	0.69 ± 0.03	0.78 ± 0.02
A48I	2+35, 416R	120-135	1.5 ± 0.52	0.86 ± 0.03	5.8 ± 0.04
A48J	2+35, 416R	135-150	1.2 ± 0.76	1.0 ± 0.04	1.1 ± 0.03
A48K	2+35, 416R	150-170	1.4 ± 0.77	1.0 ± 0.03	1.1 ± 0.02
A48L	2+35, 416R	170-185	2.2 ± 0.95	1.3 ± 0.04	1.4 ± 0.02
A49A	2+40, 488R	0-15	1.3 ± 0.45	0.48 ± 0.02	2.5 ± 0.03
A50A	2+12, 566R	0-15	6.8 ± 1.9	0.94 ± 0.06	1.5 ± 0.04
A51A	2+80, 615R	0-15	1.7 ± 0.90	1.0 ± 0.03	1.3 ± 0.02
A51B	2+80, 615R	15-30	2.9 ± 0.97	1.2 ± 0.04	1.9 ± 0.03
A51C	2+80, 615R	30-45	3.3 ± 1.1	1.3 ± 0.05	3.2 ± 0.05
A51D	2+80, 615R	45-60	3.5 ± 0.45	1.2 ± 0.03	3.5 ± 0.03
A51E	2+80, 615R	60-75	4.9 ± 2.5	1.2 ± 0.06	9.0 ± 0.09
A51F	2+80, 615R	75-90	3.6 ± 2.3	1.0 ± 0.06	5.8 ± 0.07
A51I	2+80, 615R	120-135	2.8 ± 1.2	1.3 ± 0.05	2.7 ± 0.04
A52A	3+33, 623R	0-15	13 ± 4.5	0.42 ± 0.25	99 ± 0.43
A52C	3+33, 623R	30-45	1.8 ± 0.47	1.4 ± 0.03	1.9 ± 0.03
A52D	3+33, 623R	45-60	2.1 ± 1.0	1.4 ± 0.06	1.5 ± 0.04
A52E	3+33, 623R	60-75	18 ± 8.4	1.0 ± 0.14	42 ± 0.44
A52F	3+33, 623R	75-90	1.3 ± 0.48	1.3 ± 0.04	1.4 ± 0.02
A52G	3+33, 623R	90-105	1.5 ± 0.53	1.2 ± 0.04	1.3 ± 0.02
A52H	3+33, 623R	105-120	1.4 ± 1.0	1.2 ± 0.04	1.3 ± 0.03
A52I	3+33, 623R	120-135	1.9 ± 1.1	1.3 ± 0.05	2.3 ± 0.04
A52J	3+33, 623R	135-150	1.6 ± 0.98	1.2 ± 0.03	1.3 ± 0.02
A52K	3+33, 623R	150-170	1.5 ± 0.44	1.2 ± 0.03	1.2 ± 0.02
A52L	3+33, 623R	170-185	1.6 ± 0.73	1.3 ± 0.08	1.3 ± 0.04
A53A	3+84, 622R	0-15	3.5 ± 1.1	0.96 ± 0.04	9.2 ± 0.05
A53B	3+84, 622R	15-30	4.1 ± 0.57	1.0 ± 0.06	5.6 ± 0.07
A53C	3+84, 622R	30-45	2.0 ± 1.0	1.3 ± 0.04	1.5 ± 0.03
A53D	3+84, 622R	45-60	1.9 ± 0.93	1.3 ± 0.04	1.4 ± 0.02
A53G	3+84, 622R	90-105	1.9 ± 0.95	1.3 ± 0.04	1.9 ± 0.03
A53H	3+84, 622R	105-120	1.3 ± 0.54	1.3 ± 0.03	1.4 ± 0.02
A53I	3+84, 622R	120-135	1.6 ± 0.90	1.3 ± 0.04	1.4 ± 0.02
A53J	3+84, 622R	135-150	1.6 ± 0.88	1.3 ± 0.03	1.3 ± 0.02
A53K	3+84, 622R	150-170	1.8 ± 0.95	1.2 ± 0.04	1.5 ± 0.03
A53L	3+84, 622R	170-185	1.2 ± 0.85	1.3 ± 0.03	1.3 ± 0.02
A53M	3+84, 622R	185-200	2.1 ± 0.98	1.2 ± 0.07	1.2 ± 0.04
A53N	3+84, 622R	200-215	2.6 ± 0.92	1.2 ± 0.04	1.3 ± 0.03
A54A	4+53, 623R	0-15	10 ± 1.9	1.1 ± 0.05	11 ± 0.06
A55E	5+74, 621R	60-75	1.5 ± 0.79	1.3 ± 0.06	1.4 ± 0.03

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
A56A	5+50, 594R	0-15	7.0 ± 1.9	0.68 ± 0.05	18 ± 0.09
A56B	5+50, 594R	15-30	6.6 ± 0.54	1.0 ± 0.03	3.8 ± 0.03
A56C	5+50, 594R	30-45	1.9 ± 1.1	1.2 ± 0.06	2.4 ± 0.05
A56E	5+50, 594R	60-75	1.9 ± 0.76	1.0 ± 0.06	1.1 ± 0.04
A56I	5+50, 594R	120-135	2.3 ± 0.72	1.3 ± 0.04	1.4 ± 0.02
A56J	5+50, 594R	135-150	2.2 ± 0.54	1.1 ± 0.03	1.1 ± 0.02
A56K	5+50, 594R	150-170	1.1 ± 0.76	1.2 ± 0.03	1.2 ± 0.02
A56L	5+50, 594R	170-185	1.2 ± 0.82	1.2 ± 0.05	1.1 ± 0.03
A57A	8+00, 81L	0-15	3.1 ± 1.7	0.48 ± 0.05	5.2 ± 0.06
A58A	4+15, 305R	0-15	1.1 ± 0.48	0.25 ± 0.03	0.56 ± 0.02
A59A	4+68, 582R	0-15	3.0 ± 1.3	0.53 ± 0.05	4.4 ± 0.06
A60A	3+00, 597R	0-15	1.9 ± 0.92	1.1 ± 0.05	2.2 ± 0.04
A61A	5+22, 427L	0-15	2.4 ± 1.1	1.1 ± 0.04	3.3 ± 0.04
A61B	5+22, 427L	15-30	2.9 ± 0.69	1.1 ± 0.06	3.1 ± 0.06
A61C	5+22, 427L	30-45	2.5 ± 0.95	0.97 ± 0.06	1.0 ± 0.04
A61D	5+22, 427L	45-60	2.4 ± 1.0	1.5 ± 0.03	1.4 ± 0.02
A61E	5+22, 427L	60-75	2.8 ± 0.85	1.1 ± 0.05	2.7 ± 0.04
A61F	5+22, 427L	75-90	1.0 ± 1.0	1.3 ± 0.04	1.3 ± 0.02
A61G	5+22, 427L	90-105	2.7 ± 1.5	1.3 ± 0.07	1.3 ± 0.04
A61H	5+22, 427L	105-120	2.0 ± 0.96	1.3 ± 0.05	1.2 ± 0.03
A61I	5+22, 427L	120-135	3.1 ± 0.56	1.3 ± 0.11	1.5 ± 0.06
A61J	5+22, 427L	135-150	1.1 ± 0.61	1.4 ± 0.04	1.4 ± 0.02
A61K	5+22, 427L	150-170	1.5 ± 0.58	1.3 ± 0.04	1.3 ± 0.02
A61L	5+22, 427L	170-185	1.1 ± 0.82	1.3 ± 0.04	1.4 ± 0.03
A62A	4+26, 621R	0-15	19 ± 3.4	<0.54	190 ± 0.51
A62B	4+26, 621R	15-30	4.6 ± 0.96	1.1 ± 0.06	41 ± 0.12
A62C	4+26, 621R	30-45	1.6 ± 0.99	1.3 ± 0.04	2.1 ± 0.03
A62D	4+26, 621R	45-60	2.3 ± 0.71	1.3 ± 0.06	1.4 ± 0.04
A62E	4+26, 621R	60-75	1.8 ± 0.93	1.2 ± 0.03	1.3 ± 0.02
A62F	4+26, 621R	75-90	2.0 ± 0.55	1.2 ± 0.04	1.9 ± 0.02
A62G	4+26, 621R	90-105	2.1 ± 0.98	1.3 ± 0.06	1.4 ± 0.04
A62H	4+26, 621R	105-120	1.2 ± 0.94	1.3 ± 0.04	1.3 ± 0.02
A64A	2+06, 463R	0-15	15 ± 1.3	0.93 ± 0.10	20 ± 0.16
A64B	2+06, 463R	15-30	8.7 ± 0.78	1.1 ± 0.08	8.4 ± 0.11
A64C	2+06, 463R	30-45	2.1 ± 0.86	0.96 ± 0.04	2.0 ± 0.03
A64D	2+06, 463R	45-60	1.9 ± 0.45	0.98 ± 0.03	1.1 ± 0.02
A64E	2+06, 463R	60-75	2.1 ± 1.2	0.94 ± 0.07	1.3 ± 0.05
A64G	2+06, 463R	90-105	6.1 ± 1.6	0.91 ± 0.09	17 ± 0.13
A64H	2+06, 463R	105-120	2.2 ± 1.3	0.84 ± 0.06	3.5 ± 0.06
A64K	2+06, 463R	150-170	1.3 ± 0.89	0.94 ± 0.03	3.9 ± 0.03
A64L	2+06, 463R	170-185	1.5 ± 0.88	0.99 ± 0.04	2.8 ± 0.04
A64M	2+06, 463R	185-200	2.4 ± 1.1	1.3 ± 0.12	3.7 ± 0.09
A64N	2+06, 463R	200-215	2.1 ± 0.89	1.2 ± 0.04	1.7 ± 0.02
A65A	3+62, 578R	0-15	1.7 ± 0.89	0.13 ± 0.03	2.7 ± 0.03
A65B	3+62, 578R	15-30	1.7 ± 0.46	1.3 ± 0.04	2.7 ± 0.03
A65C	3+62, 578R	30-45	1.7 ± 0.57	1.3 ± 0.04	3.6 ± 0.03

Table 4 (continued)

Sample	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
A66A	3+35, 445R	0-15	1.1 ± 0.58	0.12 ± 0.02	0.83 ± 0.02
A67A	4+92, 490R	0-15	1.1 ± 0.65	0.26 ± 0.02	0.72 ± 0.02
A67E	4+92, 490R	60-75	0.78 ± 0.36	0.70 ± 0.02	0.82 ± 0.02
A67F	4+92, 490R	75-90	0.93 ± 0.42	0.76 ± 0.02	0.91 ± 0.01
A67G	4+92, 490R	90-105	0.93 ± 0.49	0.70 ± 0.04	0.72 ± 0.02
A67H	4+92, 490R	105-120	1.7 ± 0.57	1.0 ± 0.03	1.2 ± 0.02
A67I	4+92, 490R	120-135	1.2 ± 0.72	0.96 ± 0.03	1.1 ± 0.02
A67J	4+92, 490R	135-150	1.7 ± 1.2	1.4 ± 0.06	1.4 ± 0.03
A67K	4+92, 490R	150-170	1.7 ± 0.46	1.3 ± 0.03	1.3 ± 0.02
A68A	7+23, 600R	0-15	2.3 ± 0.87	0.15 ± 0.03	1.0 ± 0.02
A69A	7+84, 580R	0-15	2.2 ± 1.5	0.82 ± 0.04	6.9 ± 0.07
A70C	10+50, 532R	30-45	1.6 ± 0.90	0.58 ± 0.04	0.78 ± 0.03
A71B	9+81, 193R	15-30	1.5 ± 0.91	0.91 ± 0.04	1.3 ± 0.02
A72A	8+75, 50L	0-15	1.9 ± 1.2	0.85 ± 0.05	1.4 ± 0.03
A73A	3+05, 533R	0-15	0.84 ± 0.50	0.30 ± 0.02	1.0 ± 0.02
A74A	4+08, 435R	0-15	0.78 ± 0.39	0.24 ± 0.02	0.71 ± 0.01
A75A	11+15, 330L	0-15	1.6 ± 1.2	1.1 ± 0.06	1.8 ± 0.04
A76A	15+50, 870L	0-15	1.6 ± 0.79	1.4 ± 0.03	1.5 ± 0.02
A77A	15+60, 420L	0-15	1.3 ± 0.64	0.78 ± 0.03	0.96 ± 0.02
A78A	13+50, 1210L	0-15	2.6 ± 1.4	1.1 ± 0.06	1.3 ± 0.04
A79A	12+65, 1770L	0-15	1.1 ± 0.38	0.23 ± 0.02	0.91 ± 0.02
A80A	3+76, 79R	0-15	1.4 ± 1.1	1.0 ± 0.03	2.8 ± 0.03
A80B	3+76, 79R	15-30	1.7 ± 0.66	0.81 ± 0.04	1.6 ± 0.03
A80C	3+76, 79R	30-45	1.5 ± 0.67	0.73 ± 0.03	1.1 ± 0.02
A80D	3+76, 79R	45-60	2.3 ± 0.89	0.88 ± 0.04	1.2 ± 0.03
A80E	3+76, 79R	60-75	1.4 ± 1.2	1.1 ± 0.04	1.3 ± 0.03
A80F	3+76, 79R	75-90	3.1 ± 1.0	1.1 ± 0.05	2.7 ± 0.05
A80I	3+76, 79R	120-135	1.8 ± 0.49	1.2 ± 0.04	1.6 ± 0.02
A80J	3+76, 79R	135-150	1.7 ± 0.55	1.4 ± 0.04	1.4 ± 0.02
A80K	3+76, 79R	150-170	1.4 ± 0.42	1.4 ± 0.03	1.4 ± 0.02
A81A	-2-21, 28R	0-15	2.4 ± 1.2	1.4 ± 0.04	2.3 ± 0.03
A81B	-2-21, 28R	15-30	1.7 ± 0.83	0.95 ± 0.05	1.2 ± 0.03
A81C	-2-21, 28R	30-45	1.4 ± 0.69	0.94 ± 0.05	1.0 ± 0.03
A81E	-2-21, 28R	60-75	1.2 ± 0.62	0.98 ± 0.03	1.1 ± 0.02
A81F	-2-21, 28R	75-90	1.4 ± 0.56	0.98 ± 0.04	1.0 ± 0.02
A81G	-2-21, 28R	90-105	1.7 ± 0.95	1.1 ± 0.07	1.1 ± 0.04
A82A	4+50, 574R	0-15	1.9 ± 0.67	0.21 ± 0.03	4.6 ± 0.04

[a]Locations are shown on Figs. 13 and 14.

[b]Indicated counting error is at the 95% confidence level (± 2σ).

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

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

[e]Sample B74 was taken from 309 ft south of Highway 535 from the east side of the gravel road in front of the main plant building. Sample B75 was collected from 258 ft south of Highway 535 from the west side of that same road.

[f]Auger samples are taken from holes drilled to further define the depth and extent of radioactive material. Holes are drilled where surface measurements may or may not have been elevated.

Table 5. Concentrations of ^{230}Th, ^{226}Ra, and ^{238}U in soil samples from the Uniroyal Chemical Company property, Painesville, Ohio (DMP001)

Sample ID	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{230}Th	^{226}Ra	^{238}U
			Biased samples		
B3C	See prelim. report	30-45	5.9 ± 0.81	6.7 ± 0.06	6.4 ± 1.7
B9B	3+60, 25L	15-30	27 ± 2.7	7.3 ± 0.05	2.8 ± 0.7
B10A	3+15, 260L	0-15	38 ± 2.7	130 ± 0.49	6.8 ± 1.4
B26B	5+77, 385L	15-30	14 ± 2.7	12 ± 0.13	<5.5
B29B	6+30, 379L	15-30	1.9 ± 0.54	5.0 ± 0.04	2.4 ± 1.3
B34B	7+90, 300L	15-30	43 ± 2.7	770 ± 2.3	29 ± 4.4
B40B	8+00, 258L	15-30	35 ± 2.7	210 ± 0.85	88 ± 5.5
B43A	2+48, 526R	0-15	62 ± 2.7	40 ± 0.23	3.1 ± 1.3
B45A	2+25, 381R	0-15	76 ± 2.7	130 ± 0.87	15 ± 1.8
			Auger hole samples		
A46I	2+44, 357R	120-135	5.1 ± 0.81	1.4 ± 0.04	3.5 ± 1.4
A51F	2+80, 615R	75-90	35 ± 2.7	5.8 ± 0.07	3.6 ± 2.3

[a]Locations are shown on Figs. 13 and 14.

[b]Indicated counting error is at the 95% confidence level (± 2σ).

Table 6. Radionuclide concentrations in soil samples collected from the Lonza Chemical Company property bordering Uniroyal property at 679 Hardy Road, Painesville, Ohio (DMP002)

Sample ID	Location[a]	Depth (cm)	Radionuclide concentration (pCi/g)[b]		
			^{238}U	^{232}Th	^{226}Ra
			Systematic samples[c]		
S1A	5+75, 630R	0-15	1.7 ± 0.49	0.67 ± 0.02	1.7 ± 0.02
S2A	7+25, 628R	0-15	1.1 ± 0.43	0.78 ± 0.03	1.6 ±0.02
			Biased samples[d]		
B1A	4+25, 627R	0-15	18 ± 6.8	0.32 ± 0.18	91 ± 0.45
B1B	4+25, 627R	15-30	9.5 ± 2.1	0.53 ± 0.08	28 ± 0.15
B2A	4+08, 626R	0-15	310 ± 32	<1.2	1000 ± 7.3
B2B	4+08, 626R	15-30	63 ± 31	<1.1	170 ± 1.4
B3A	4+50, 627R	0-15	5.5 ± 2.7	0.83 ± 0.11	8.0 ± 0.12
B3B	4+50, 627R	15-30	4.7 ± 1.4	0.74 ± 0.05	4.2 ± 0.06

[a]Locations shown on Fig. 13.
[b]Indicated counting error is at the 95% confidence level (± 2σ).
[c]Systematic samples are taken at selected locations irrespective of gamma exposure rates.
[d]Biased samples are taken from areas shown to have elevated gamma exposure rates.

APPENDIX

Gamma Profile Graphs of Auger Holes

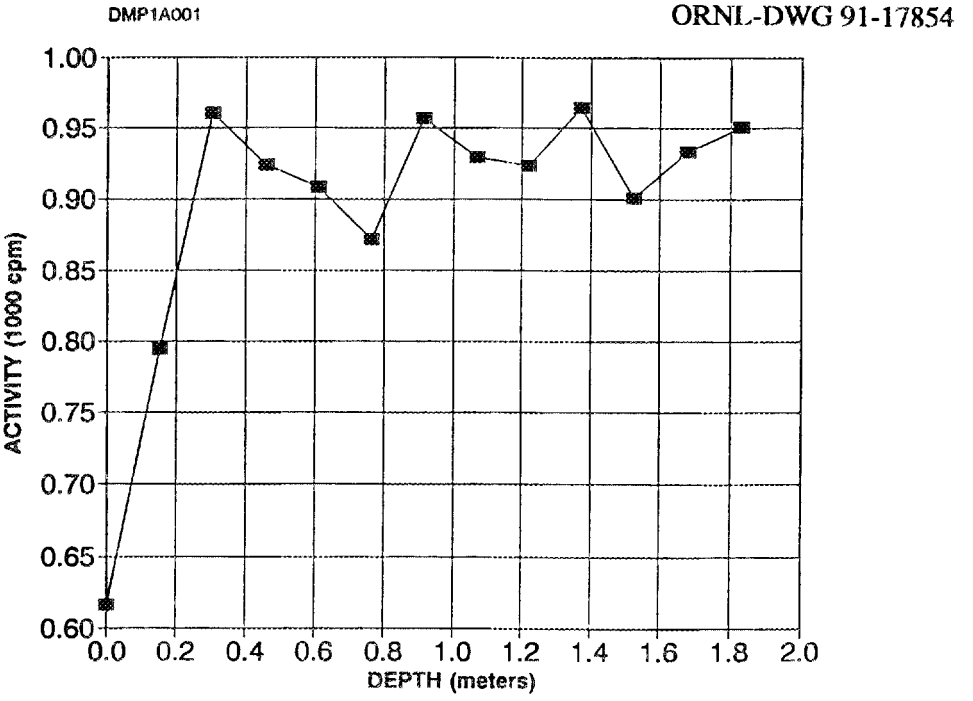

Fig. A.1. Gamma profile of auger hole A1.

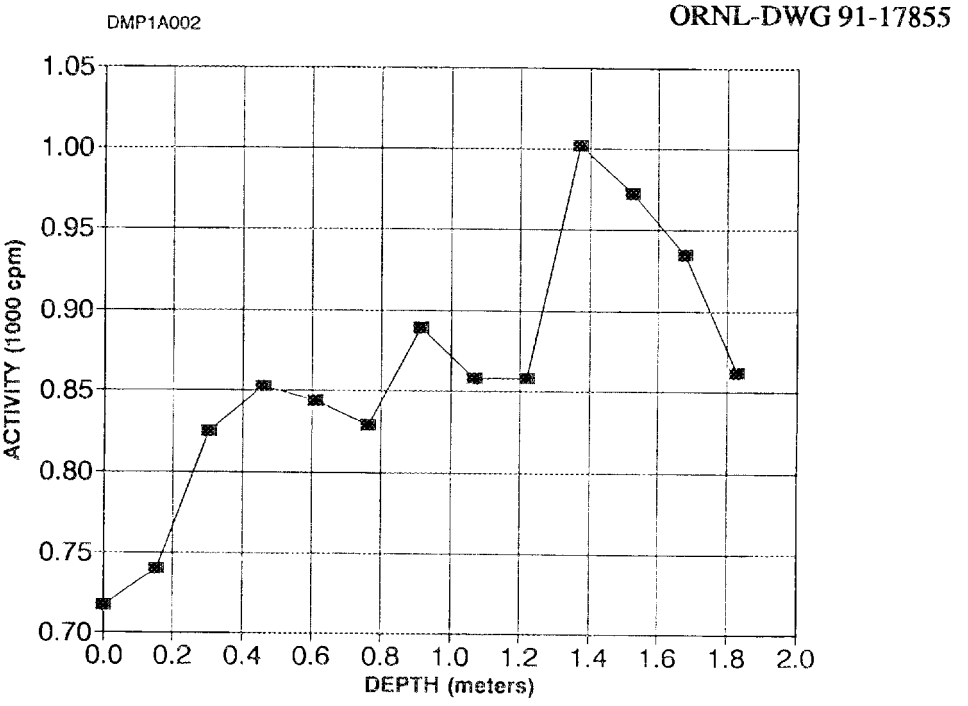

Fig. A.2. Gamma profile of auger hole A2.

ORNL-DWG 91-17856

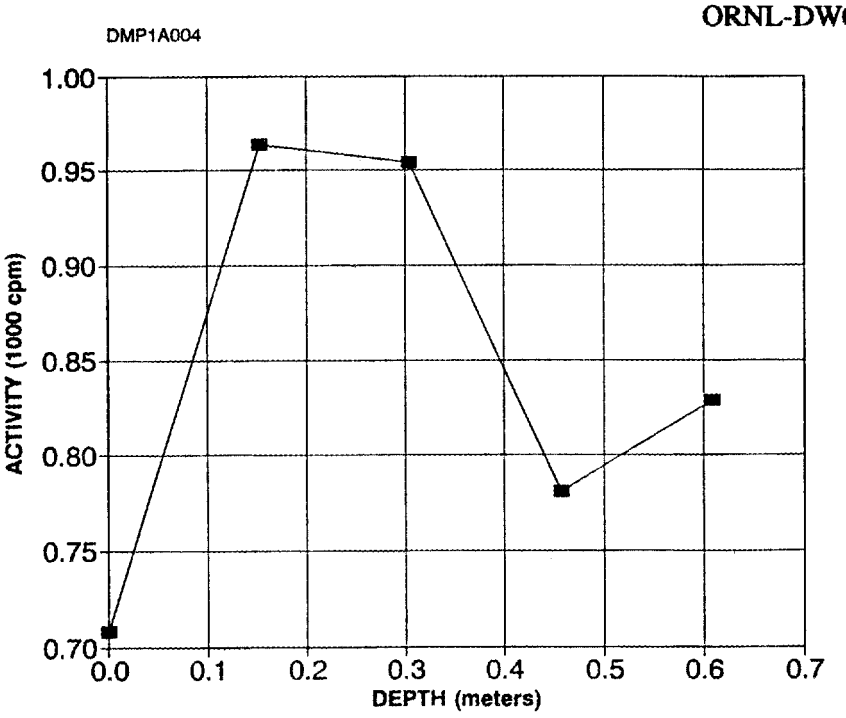

Fig. A.3. Gamma profile of auger hole A3.

ORNL-DWG 91-17857

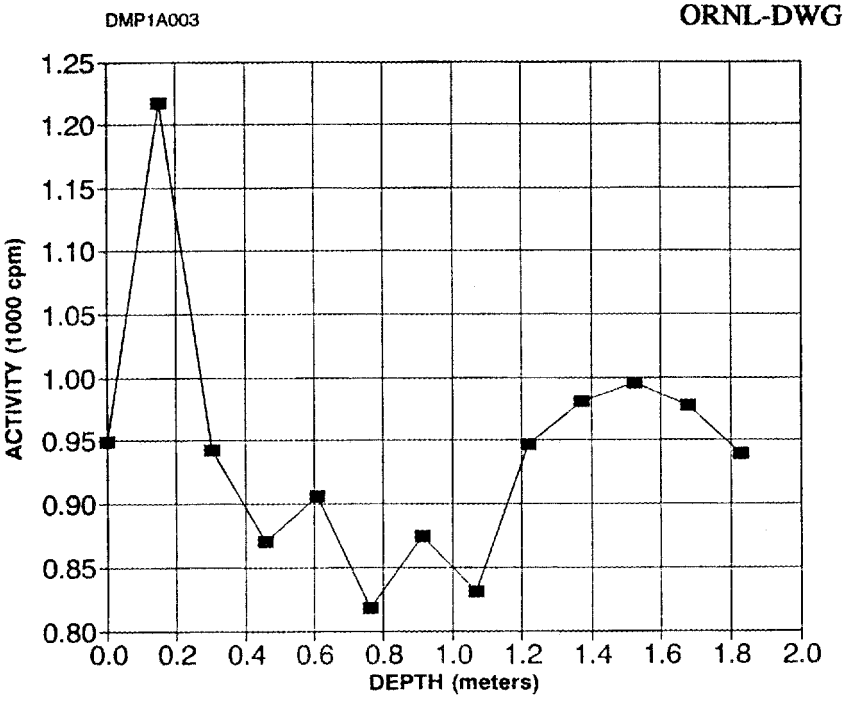

Fig. A.4. Gamma profile of auger hole A4.

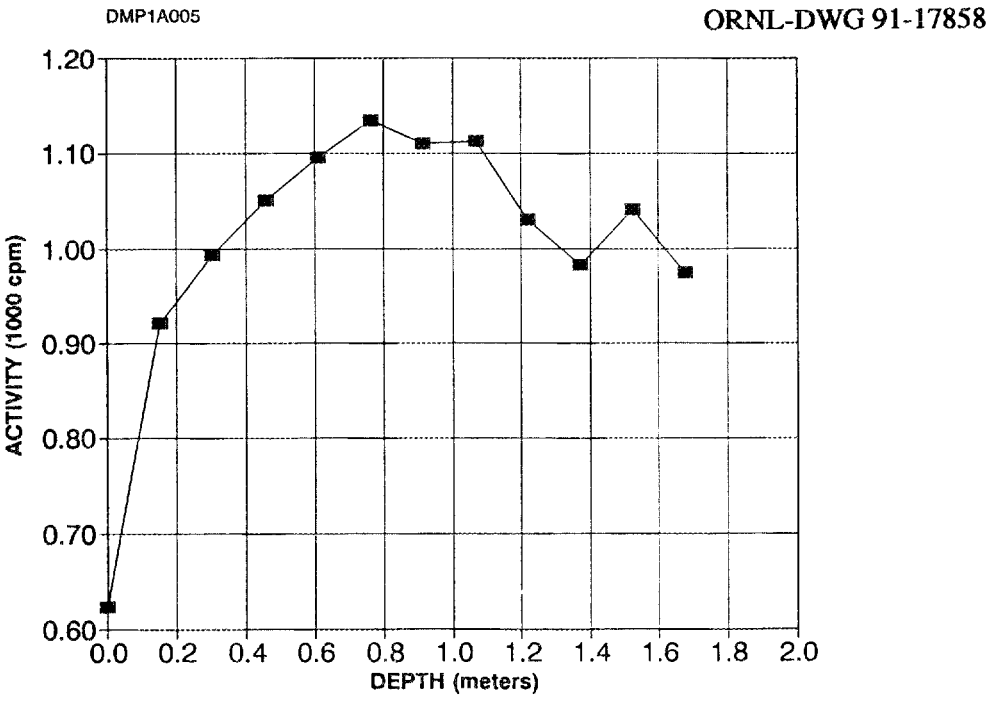

Fig. A.5. Gamma profile of auger hole A5.

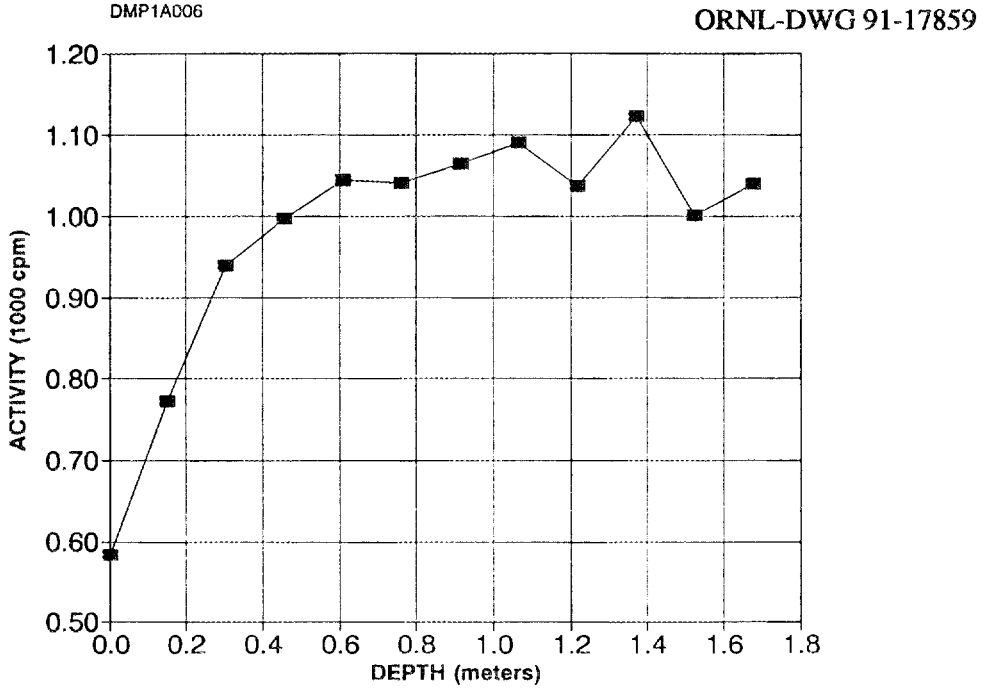

Fig. A.6. Gamma profile of auger hole A6.

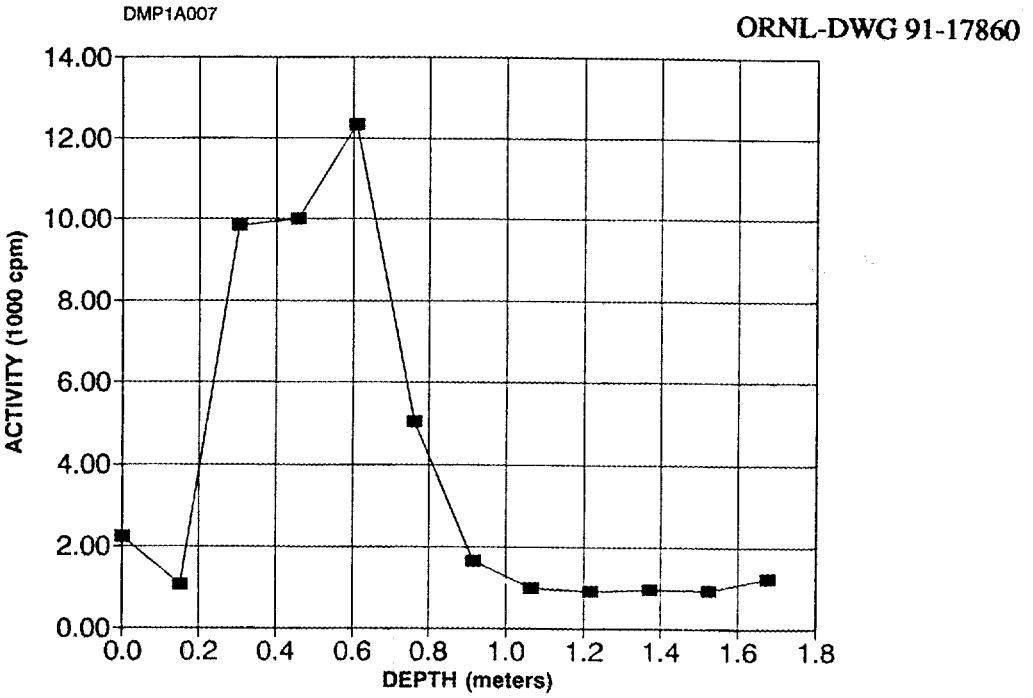

Fig. A.7. Gamma profile of auger hole A7.

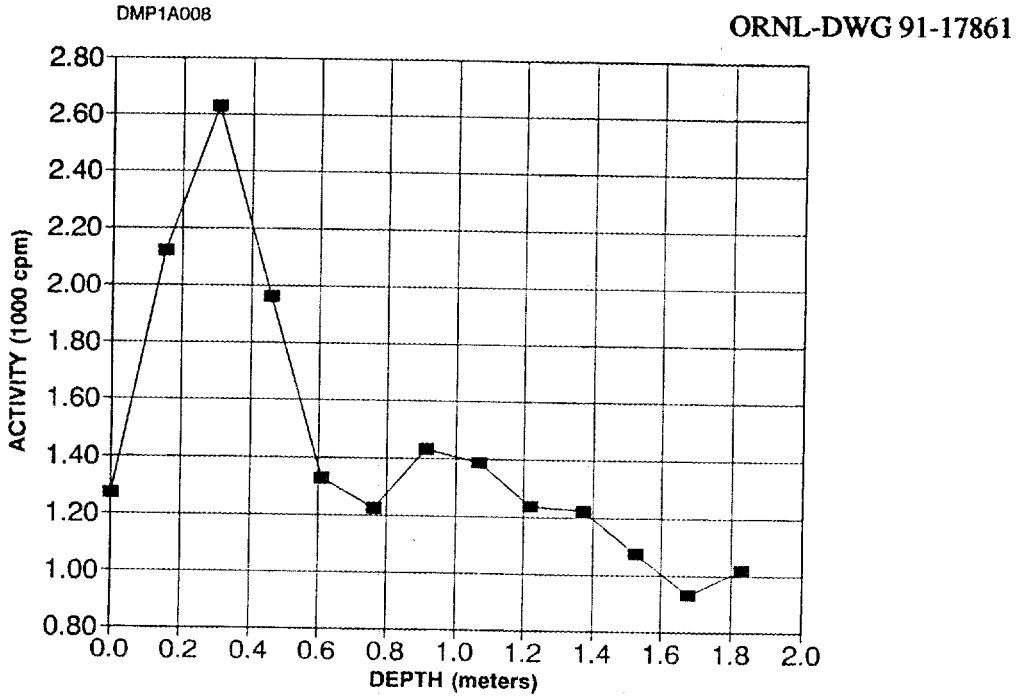

Fig. A.8. Gamma profile of auger hole A8.

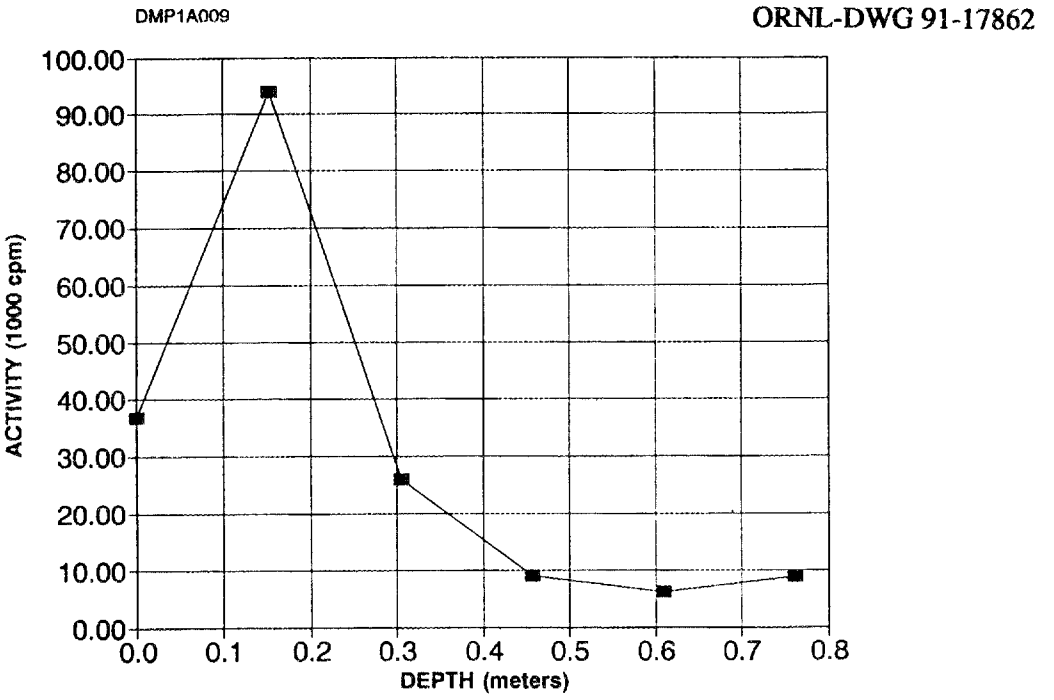

Fig. A.9. Gamma profile of auger hole A9.

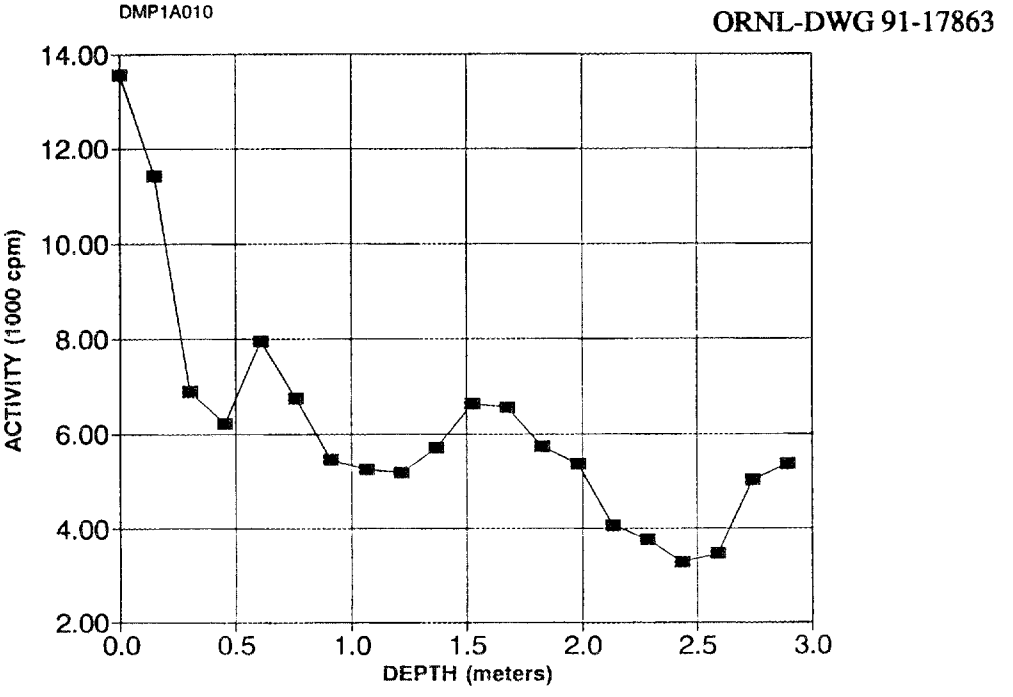

Fig. A.10. Gamma profile of auger hole A10.

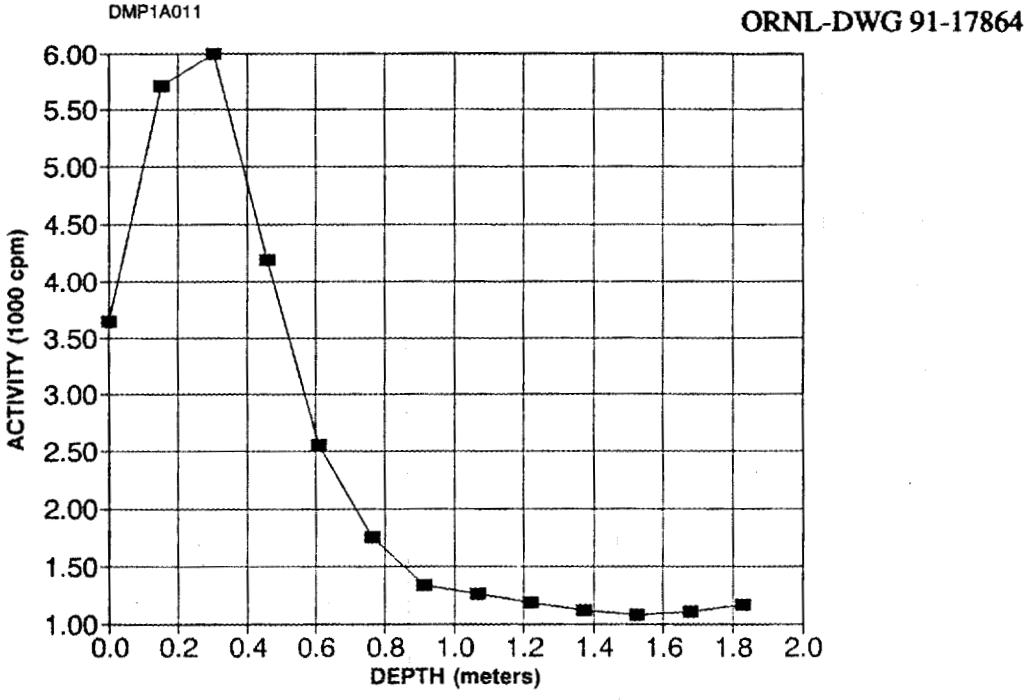

Fig. A.11. Gamma profile of auger hole A11.

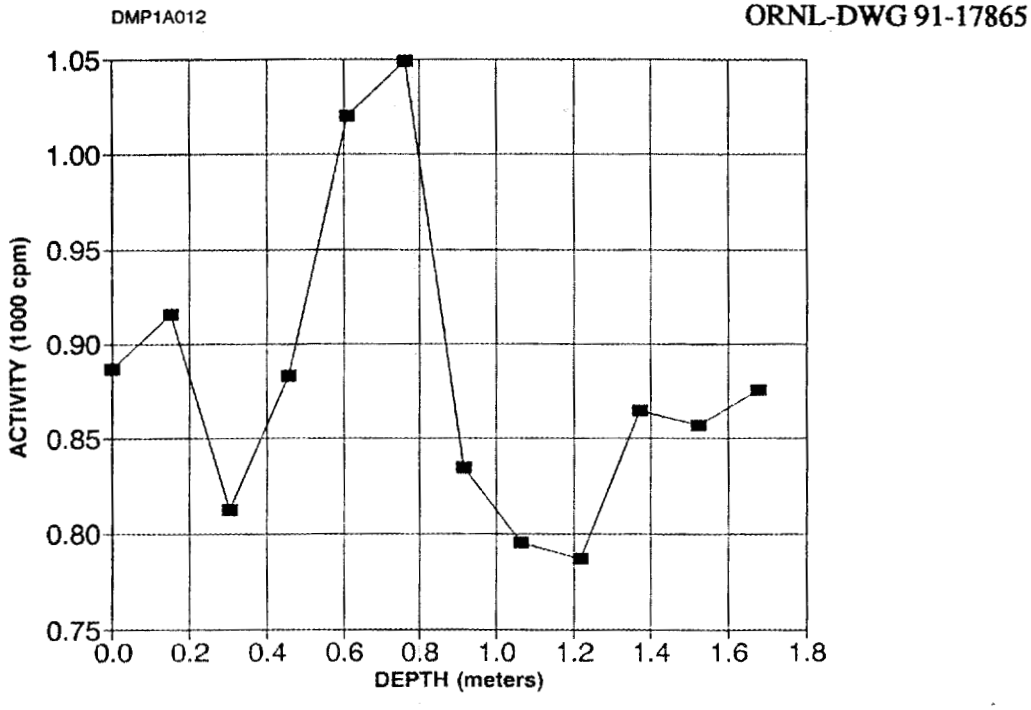

Fig. A.12. Gamma profile of auger hole A12.

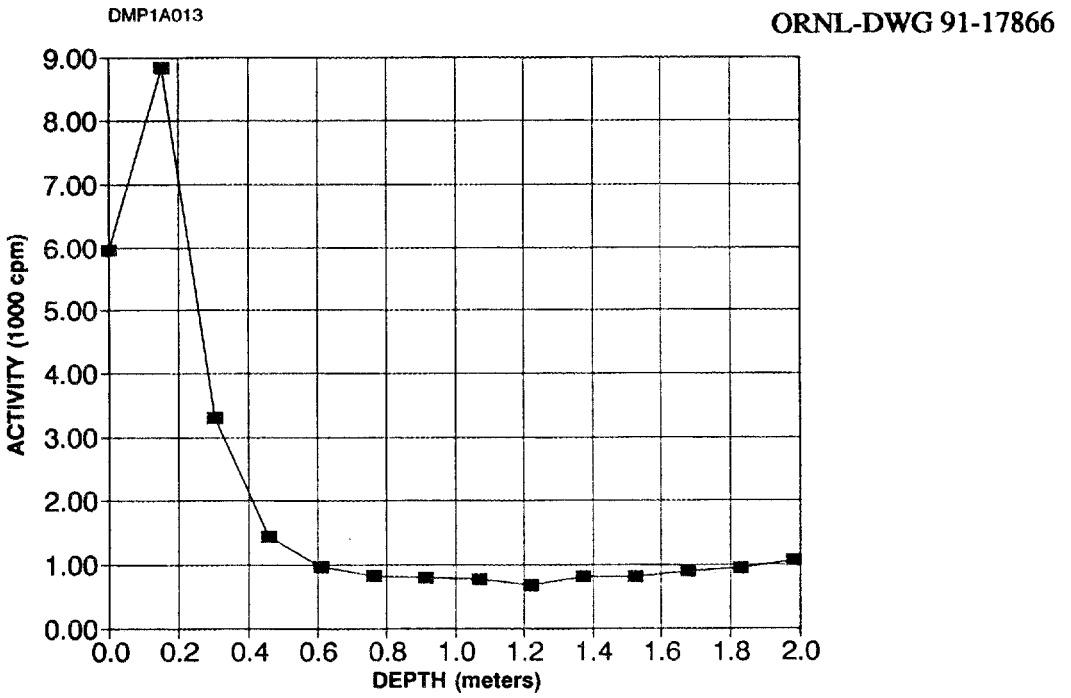

Fig. A.13. Gamma profile of auger hole A13.

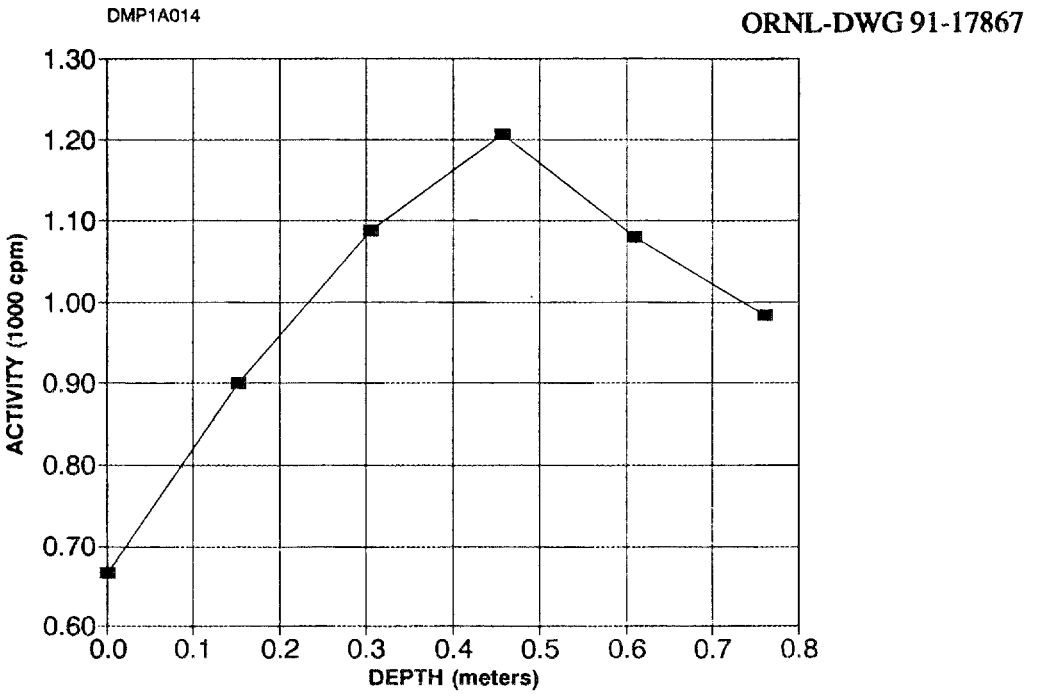

Fig. A.14. Gamma profile of auger hole A14.

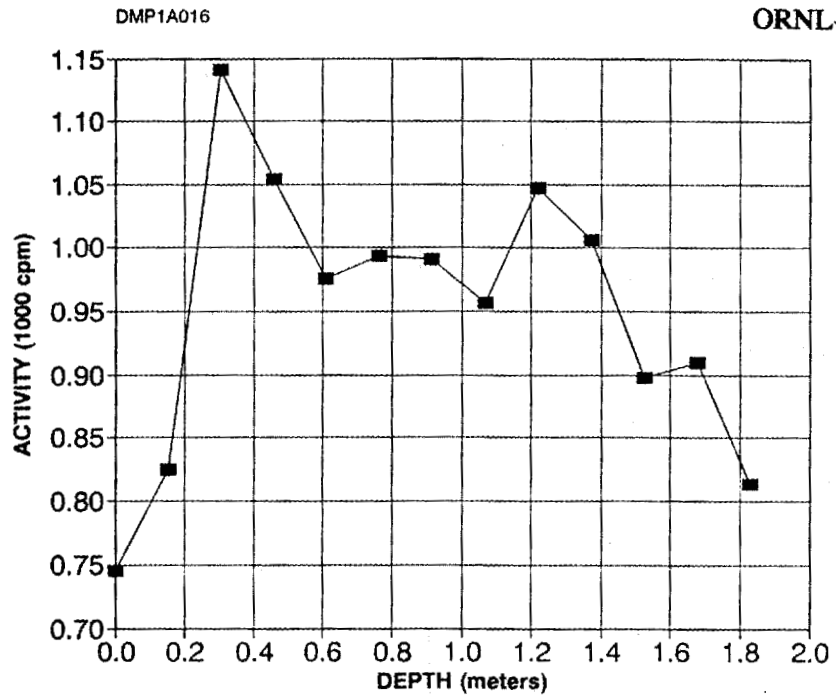

Fig. A.15. Gamma profile of auger hole A16.

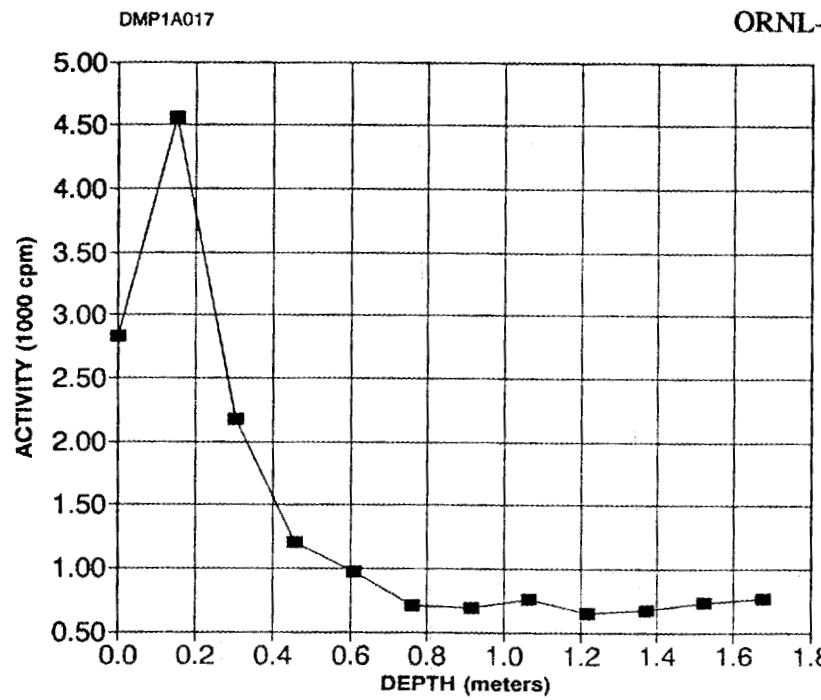

Fig. A.16. Gamma profile of auger hole A17.

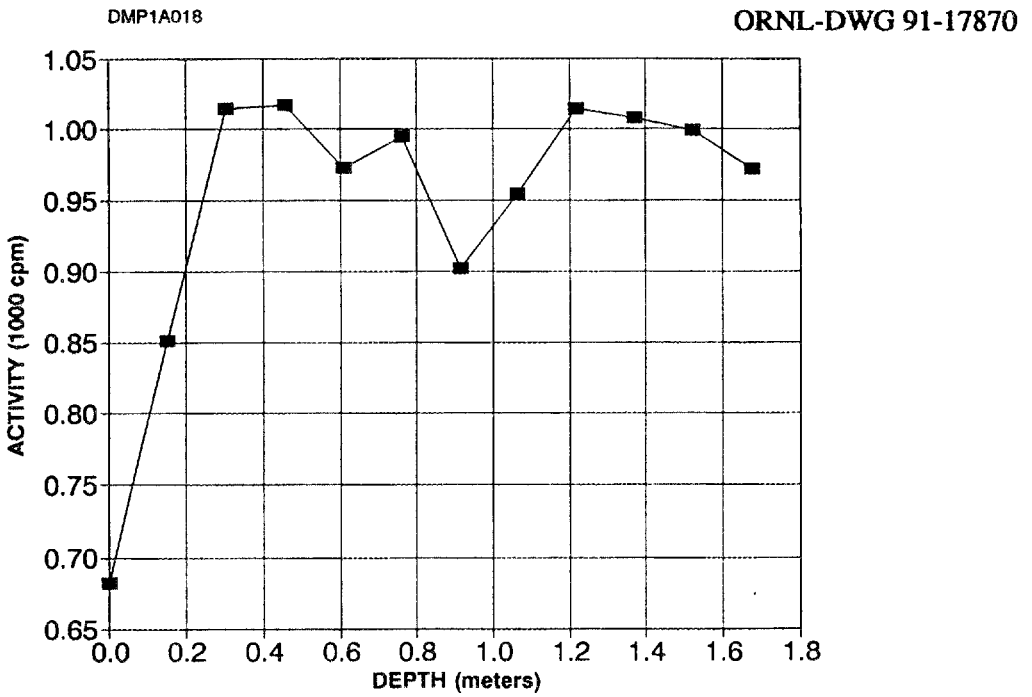

Fig. A.17. Gamma profile of auger hole A18.

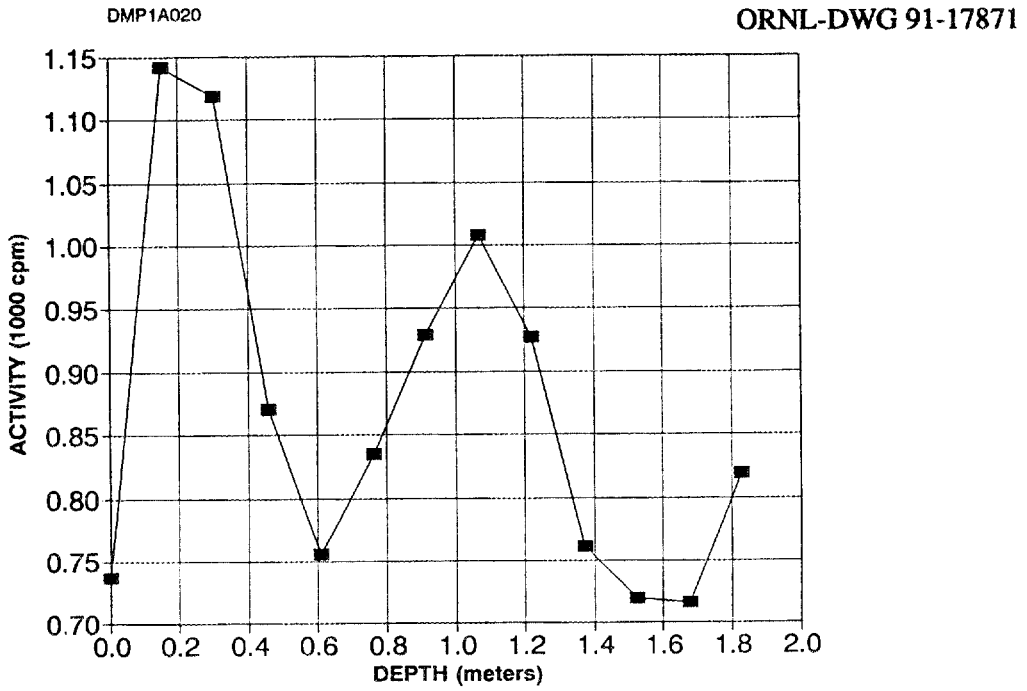

Fig. A.18. Gamma profile of auger hole A20.

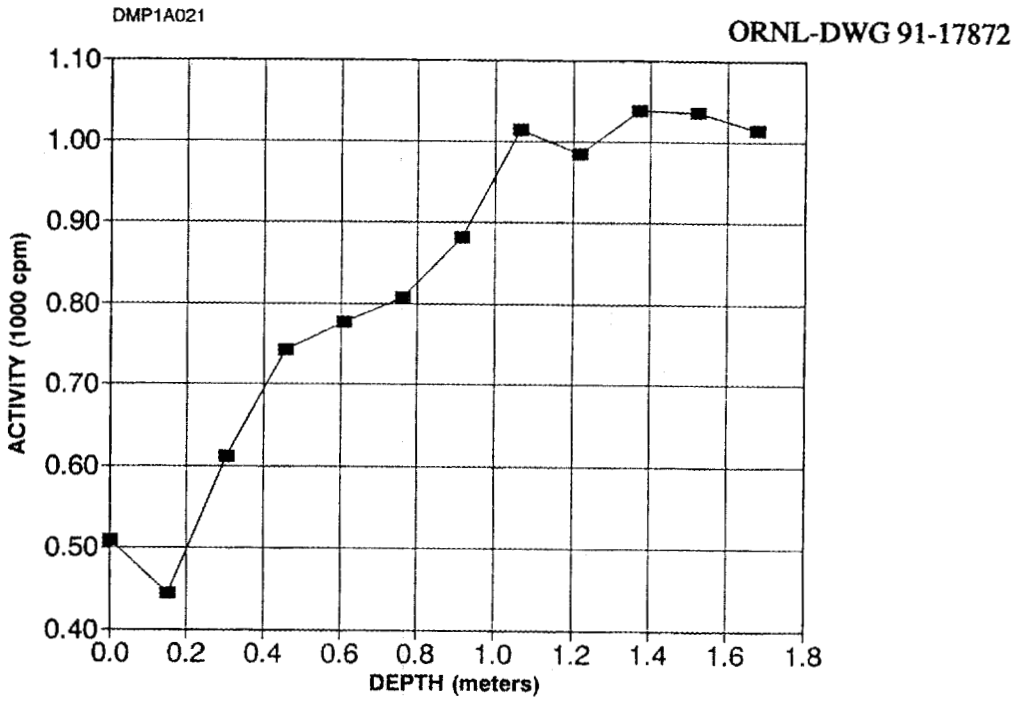

Fig. A.19. Gamma profile of auger hole A21.

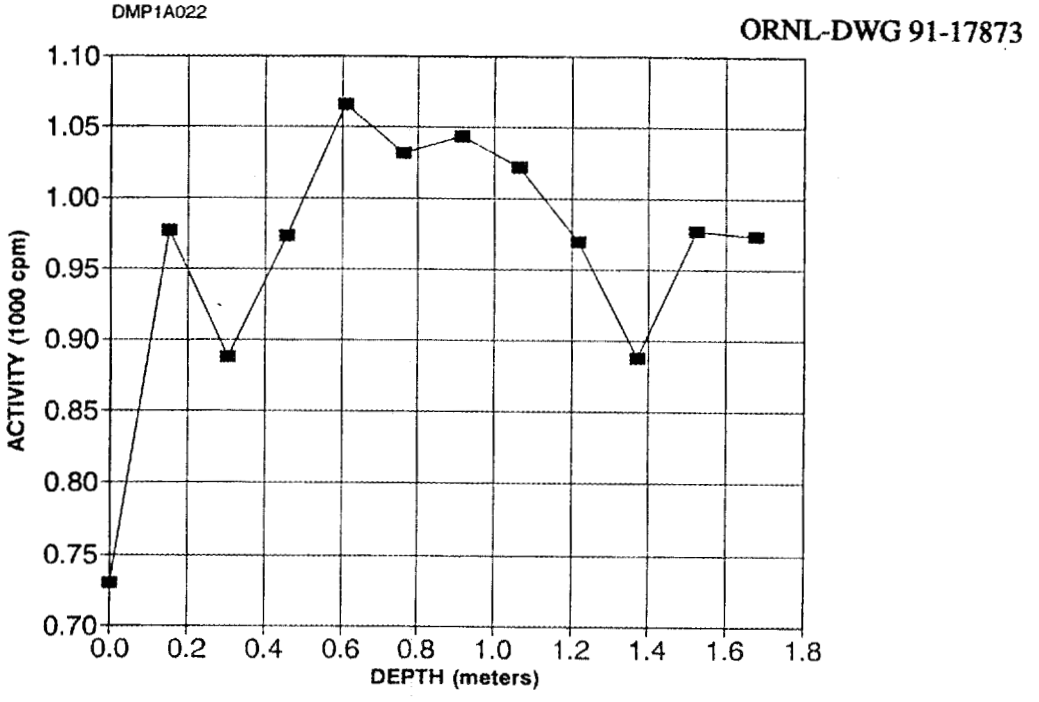

Fig. A.20. Gamma profile of auger hole A22.

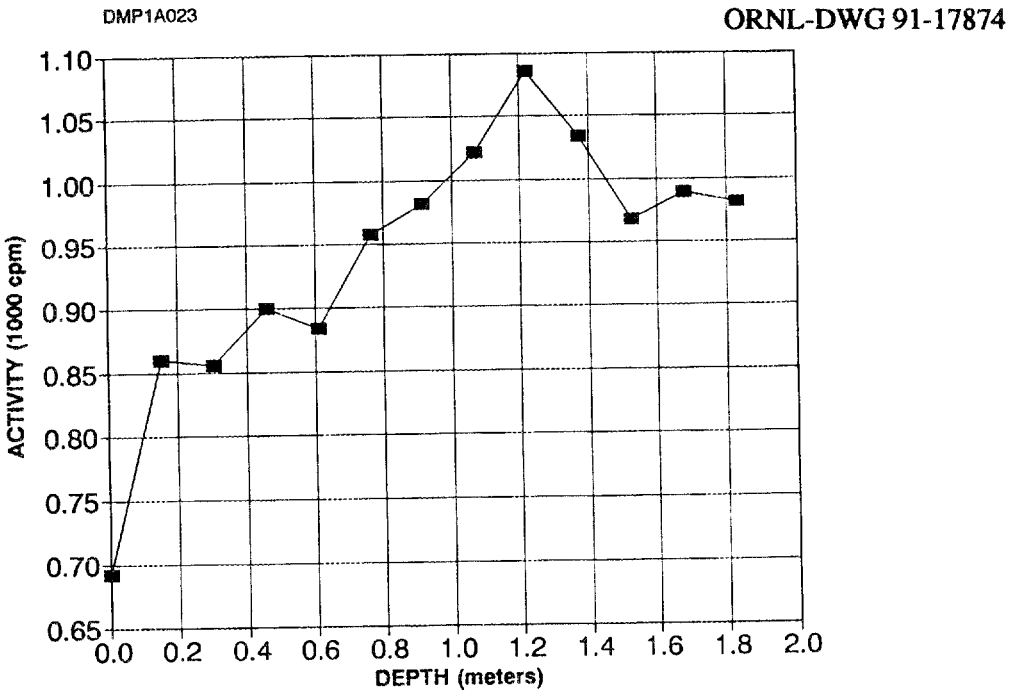

Fig. A.21. Gamma profile of auger hole A23.

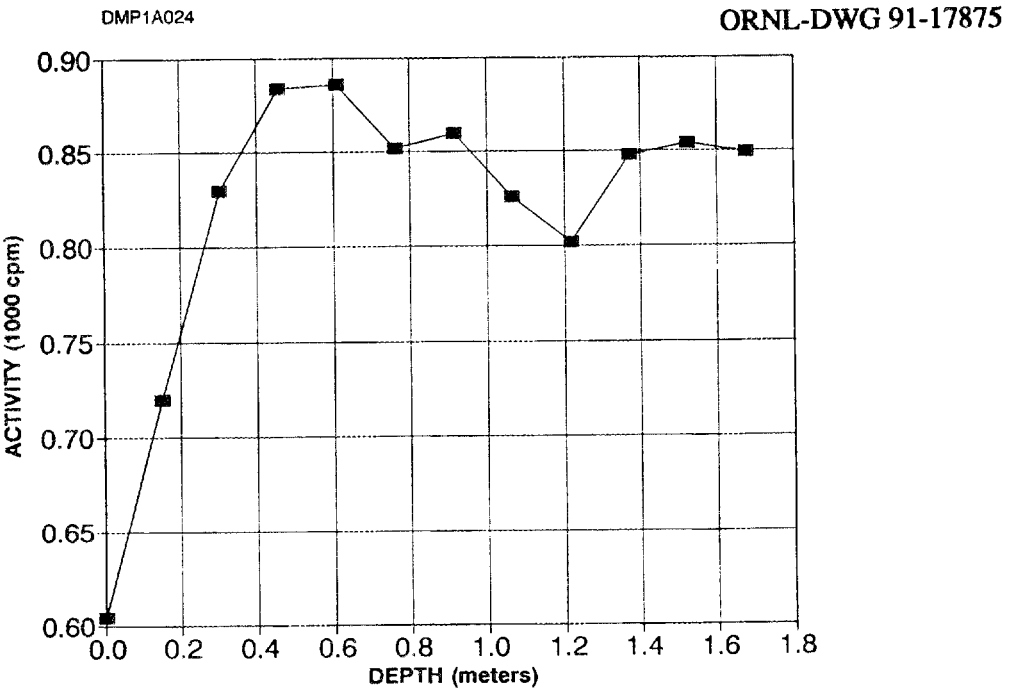

Fig. A.22. Gamma profile of auger hole A24.

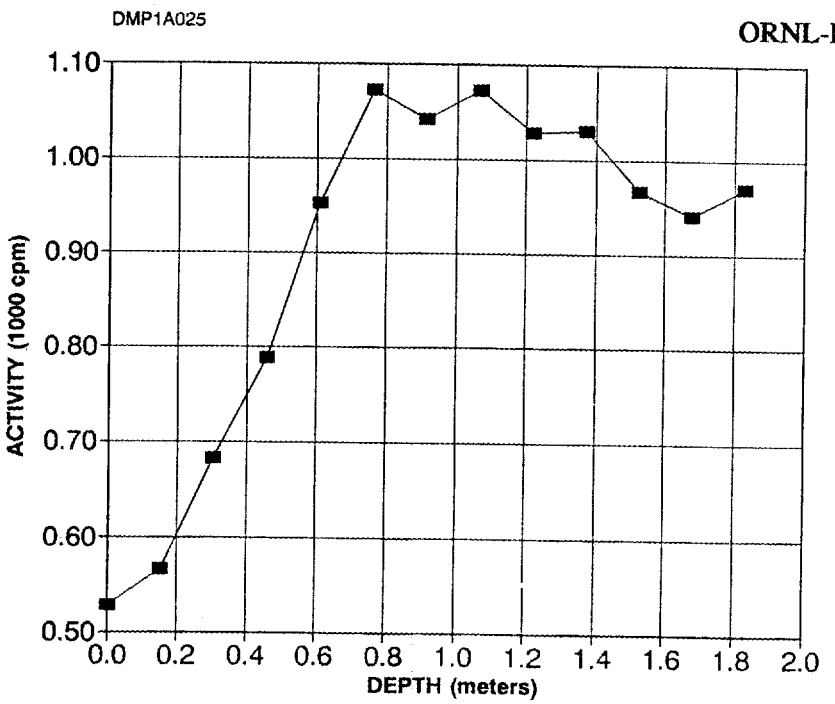

Fig. A.23. Gamma profile of auger hole A25.

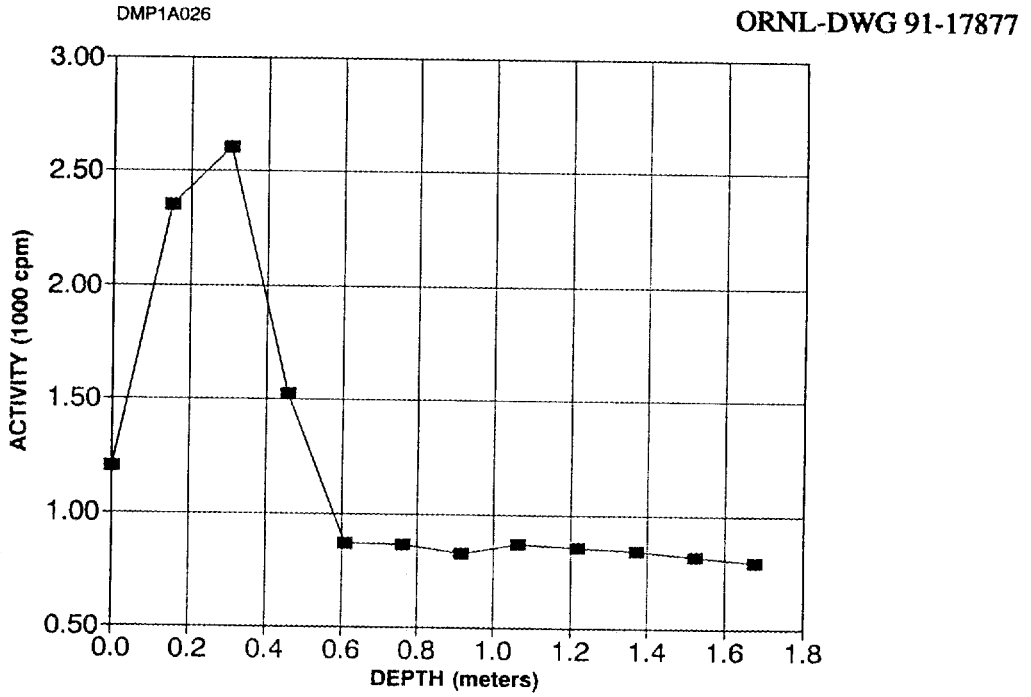

Fig. A.24. Gamma profile of auger hole A26.

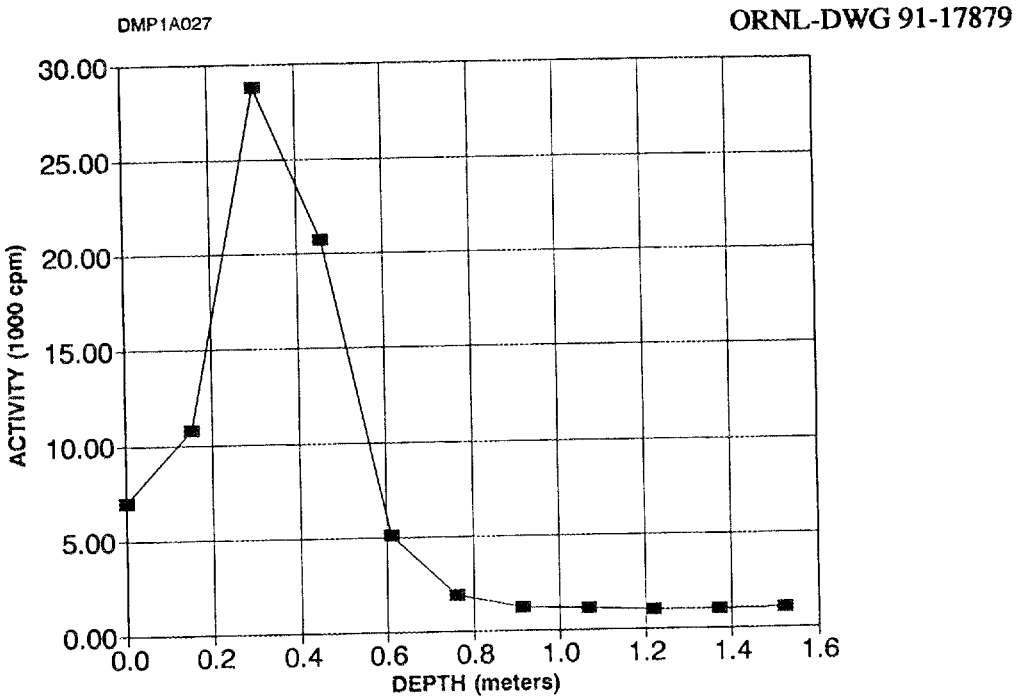

Fig. A.25. Gamma profile of auger hole A27.

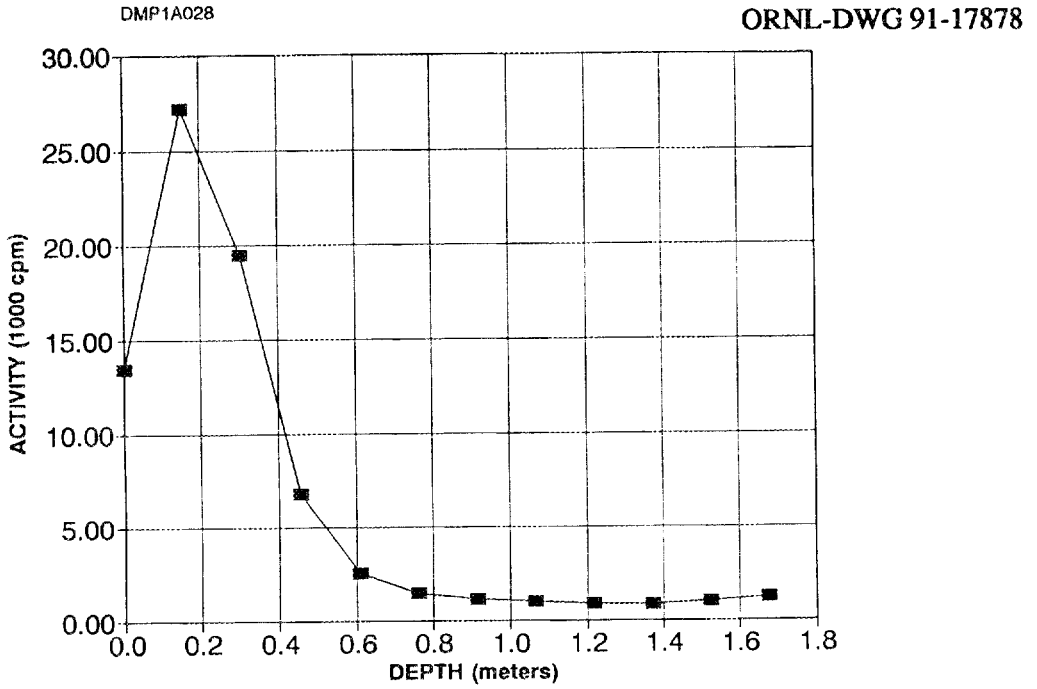

Fig. A.26. Gamma profile of auger hole A28.

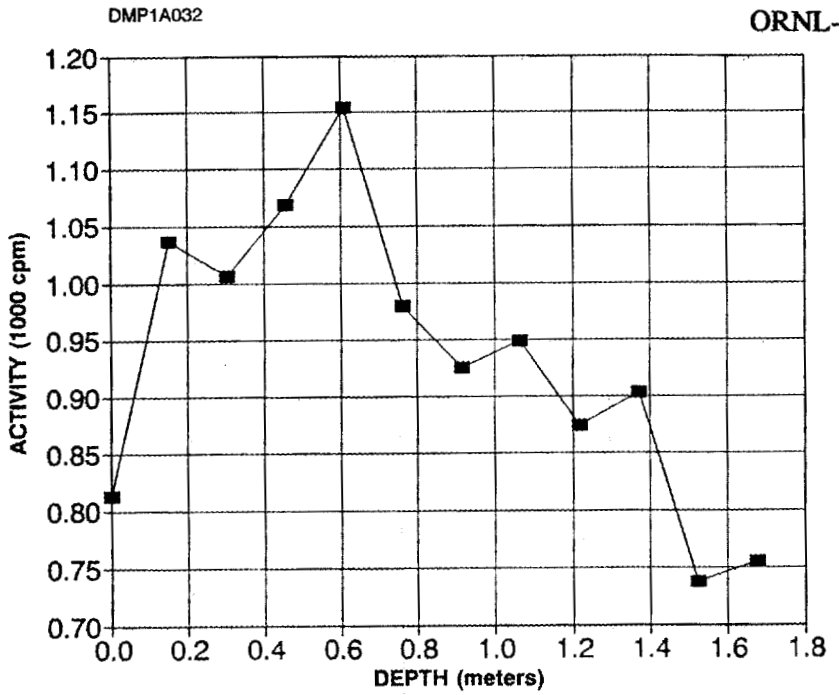

Fig. A.27. Gamma profile of auger hole A32.

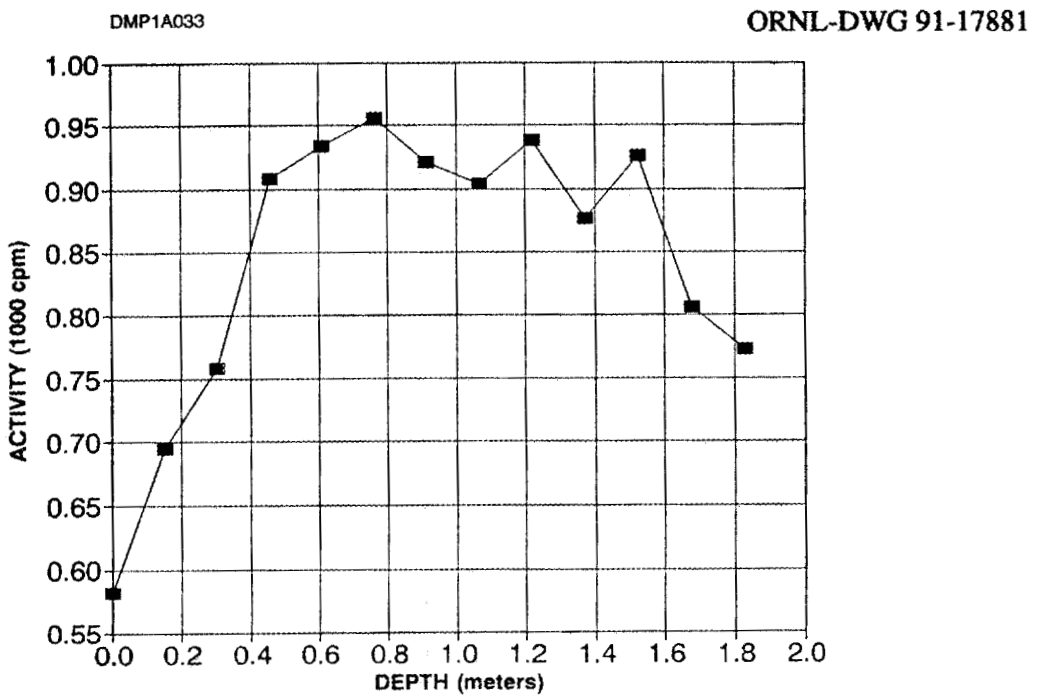

Fig. A.28. Gamma profile of auger hole A33.

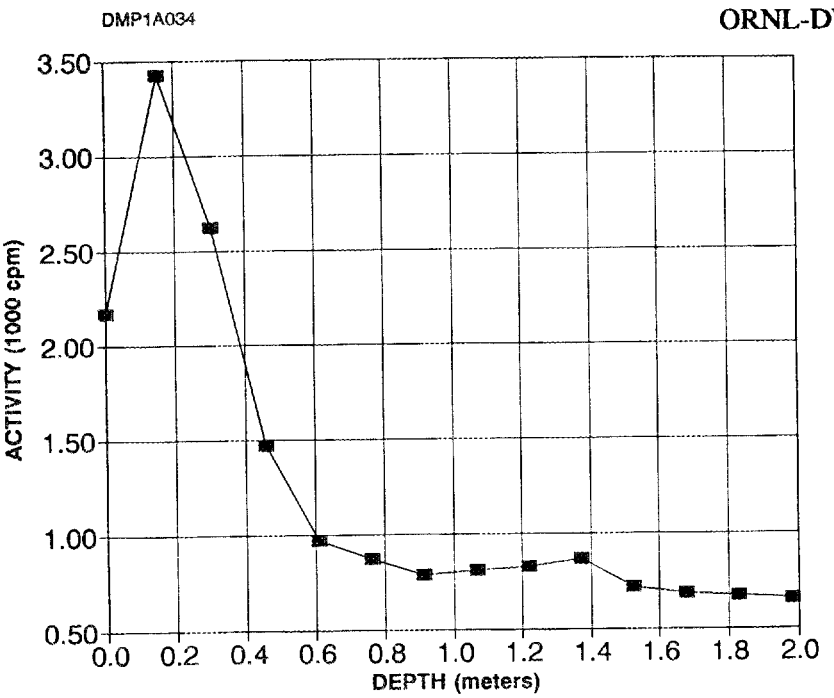

Fig. A.29. Gamma profile of auger hole A34.

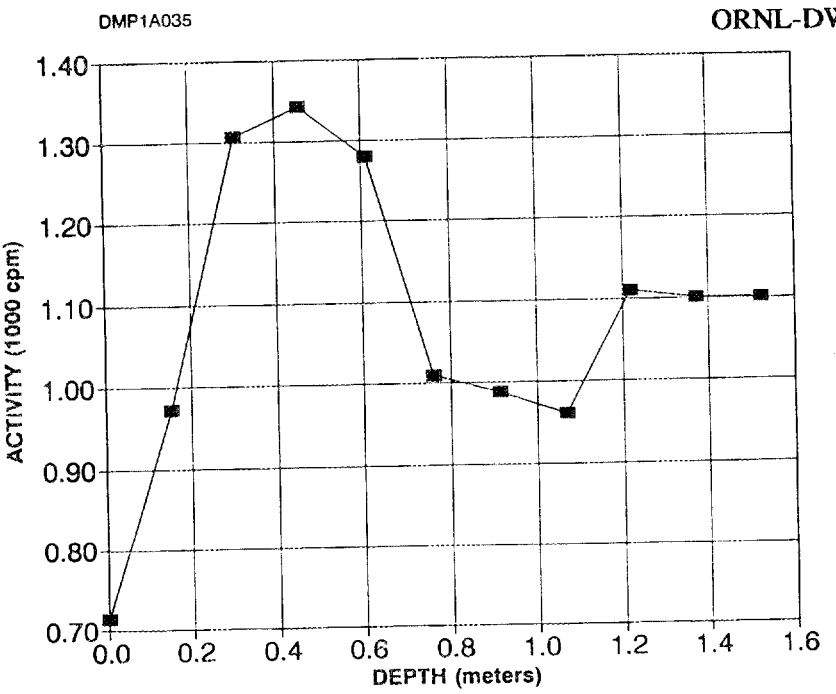

Fig. A.30. Gamma profile of auger hole A35.

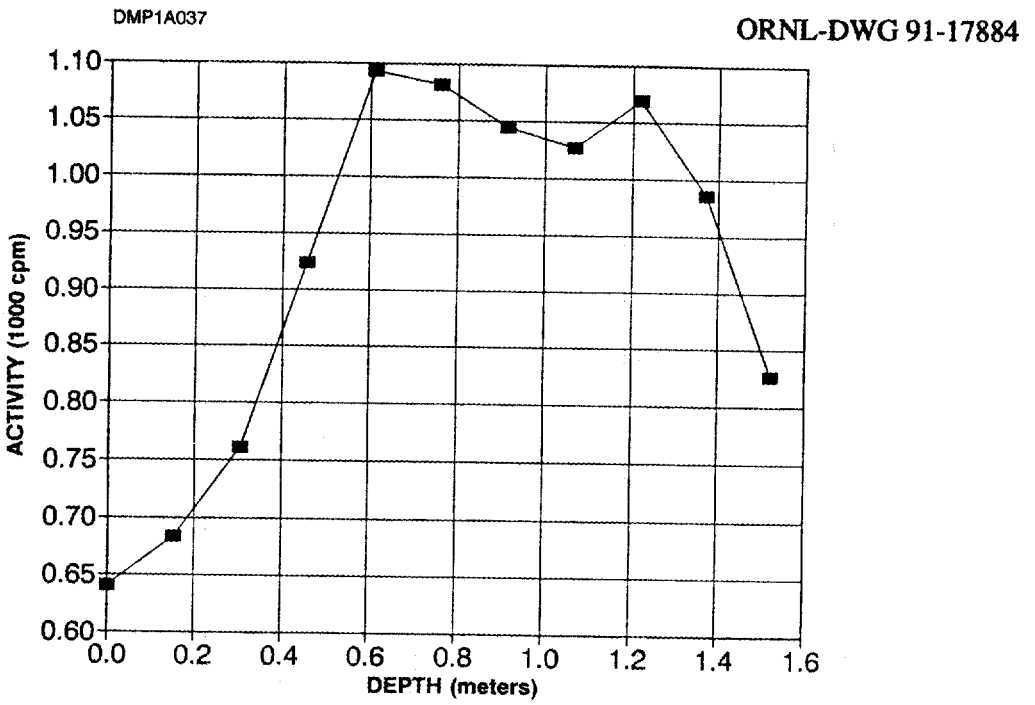

Fig. A.31. Gamma profile of auger hole A37.

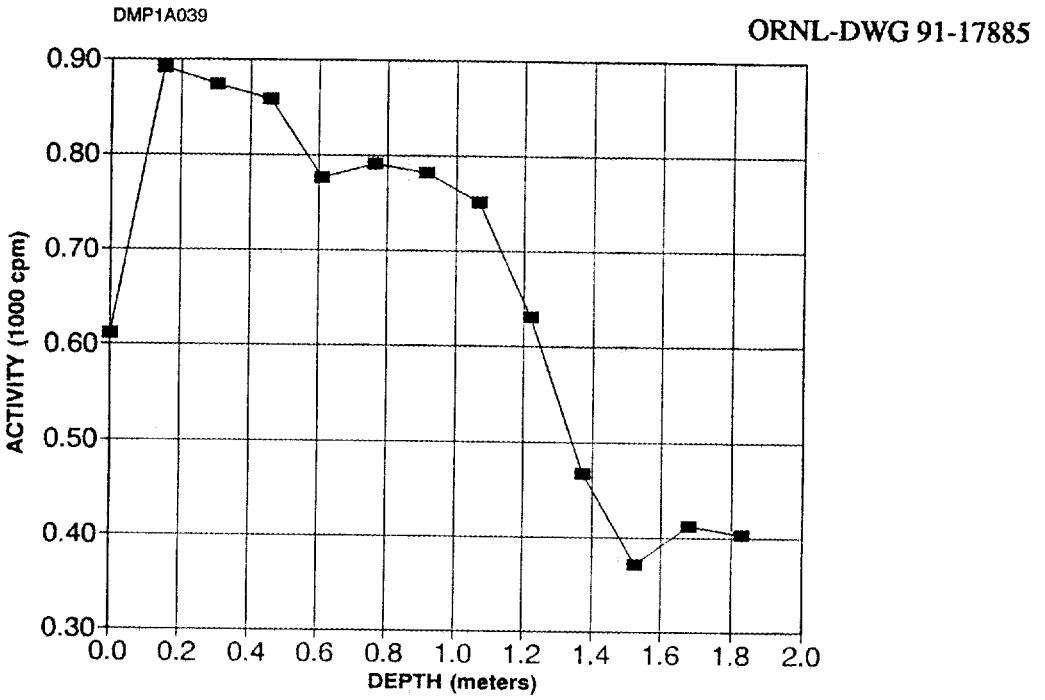

Fig. A.32. Gamma profile of auger hole A39.

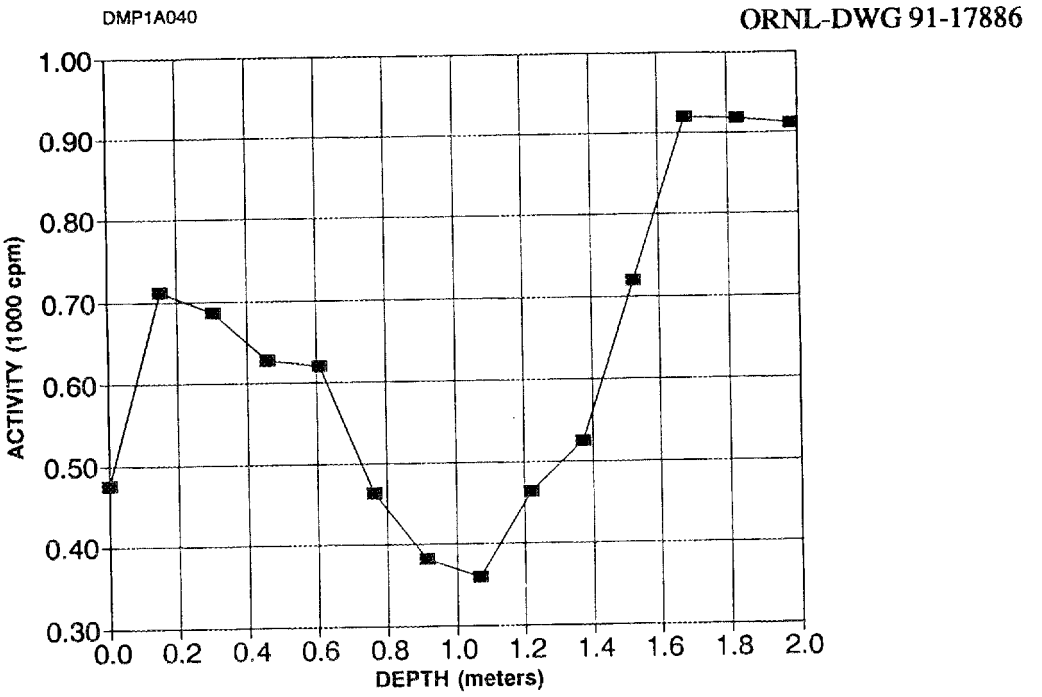

Fig. A.33. Gamma profile of auger hole A40.

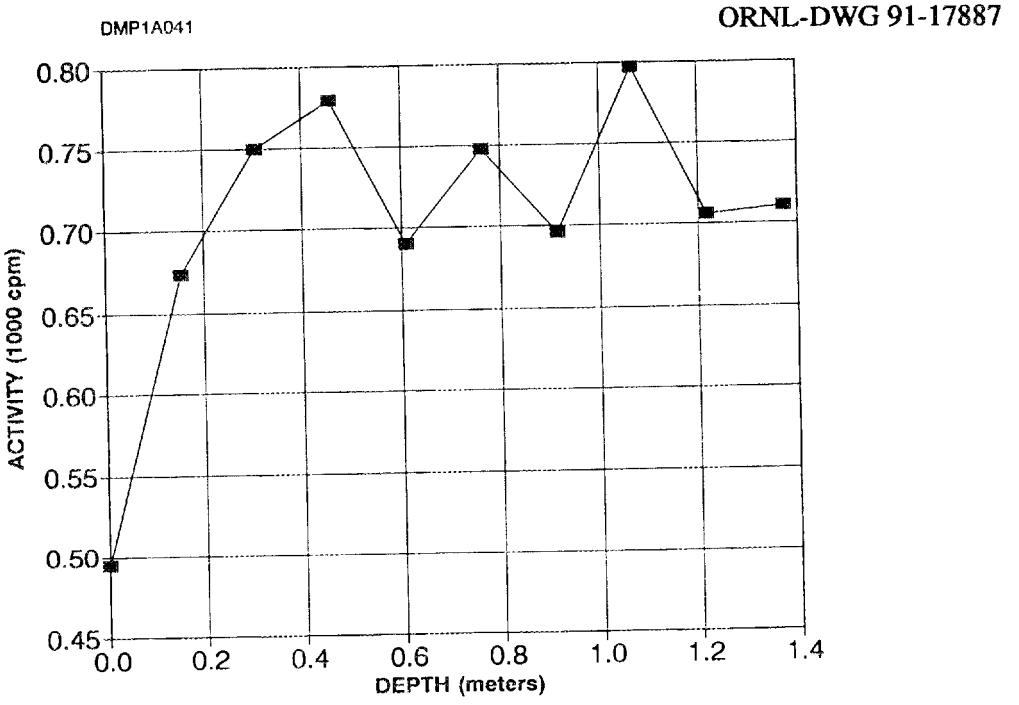

Fig. A.34. Gamma profile of auger hole A41.

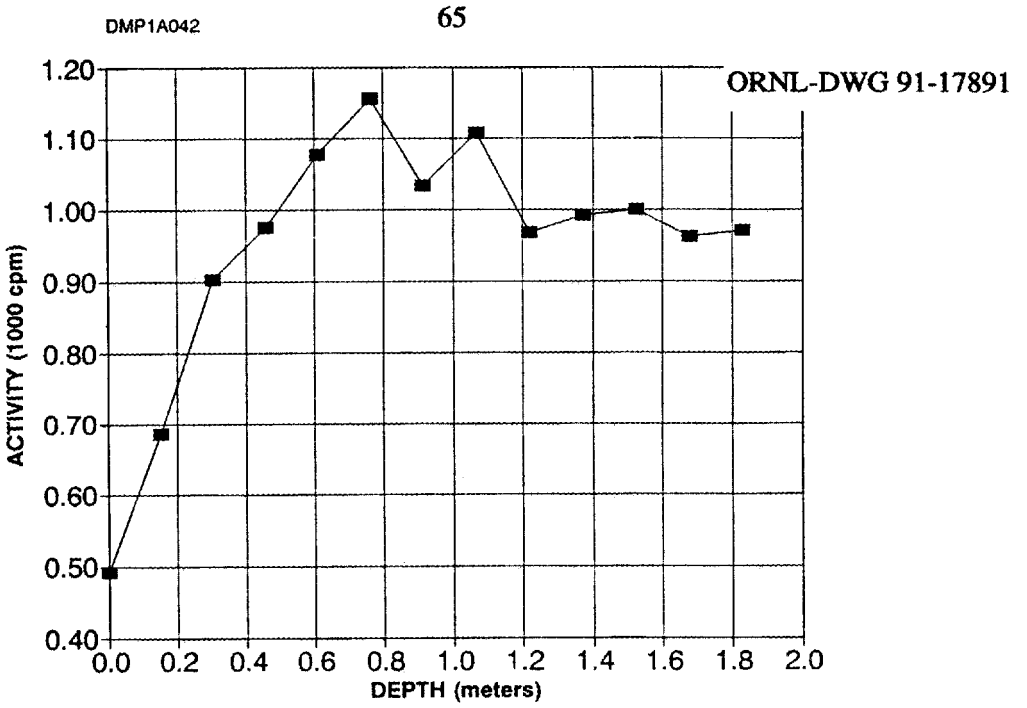

Fig. A.35. Gamma profile of auger hole A42.

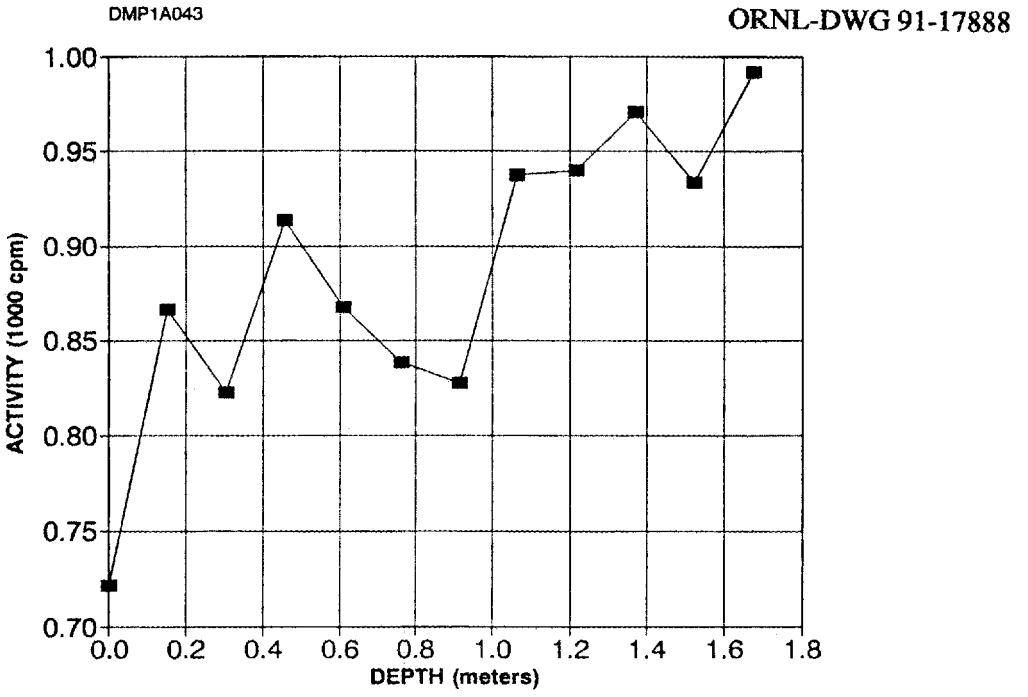

Fig. A.36. Gamma profile of auger hole A43.

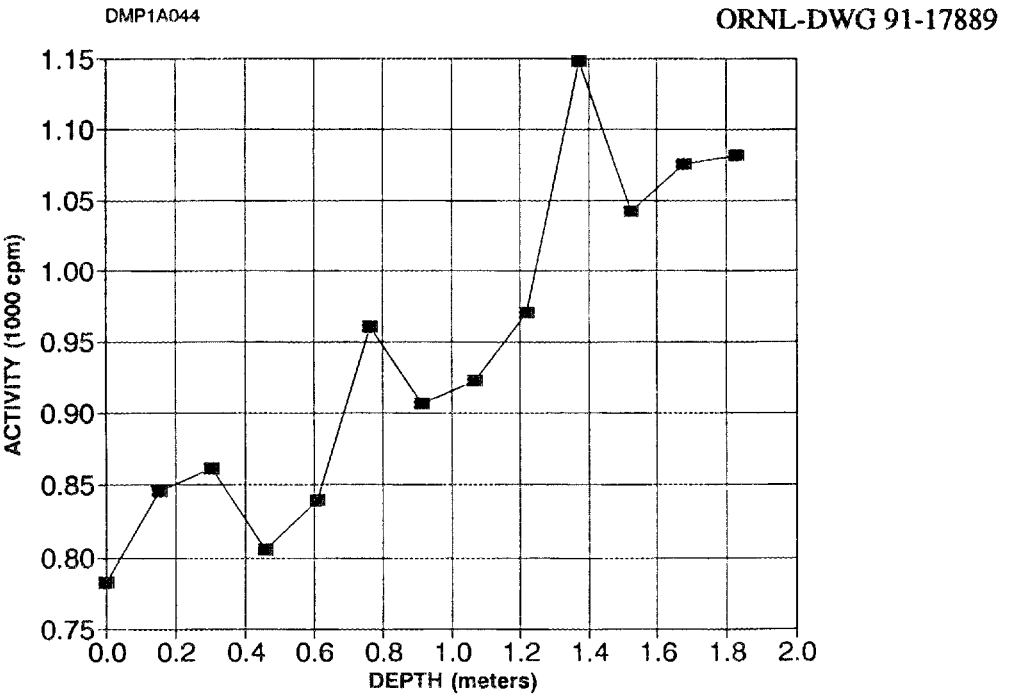

Fig. A.37. Gamma profile of auger hole A44.

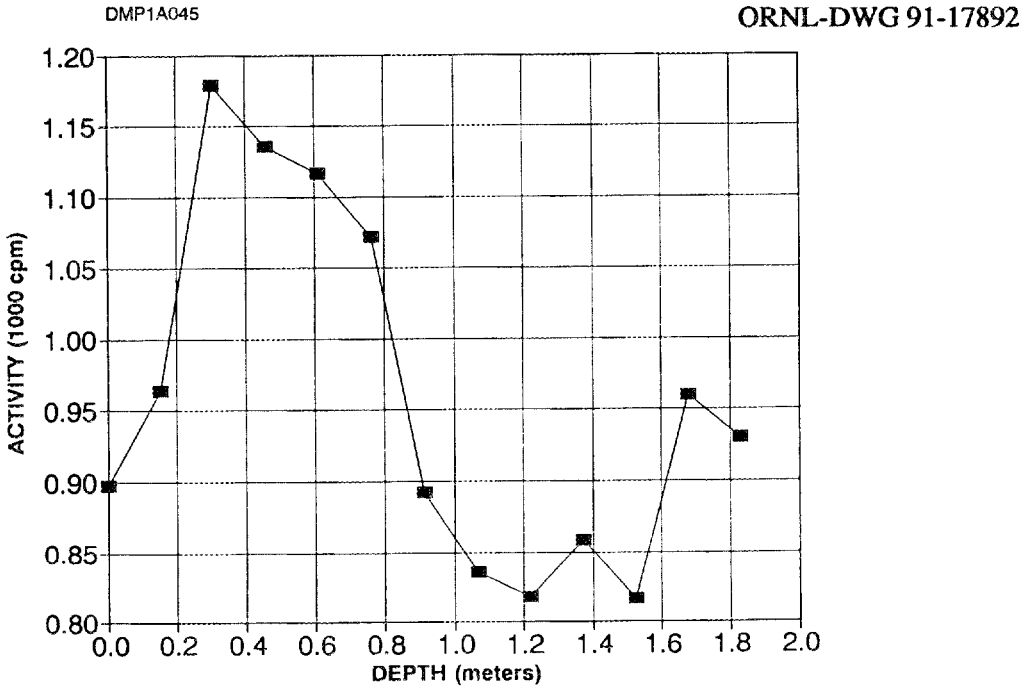

Fig. A.38. Gamma profile of auger hole A45.

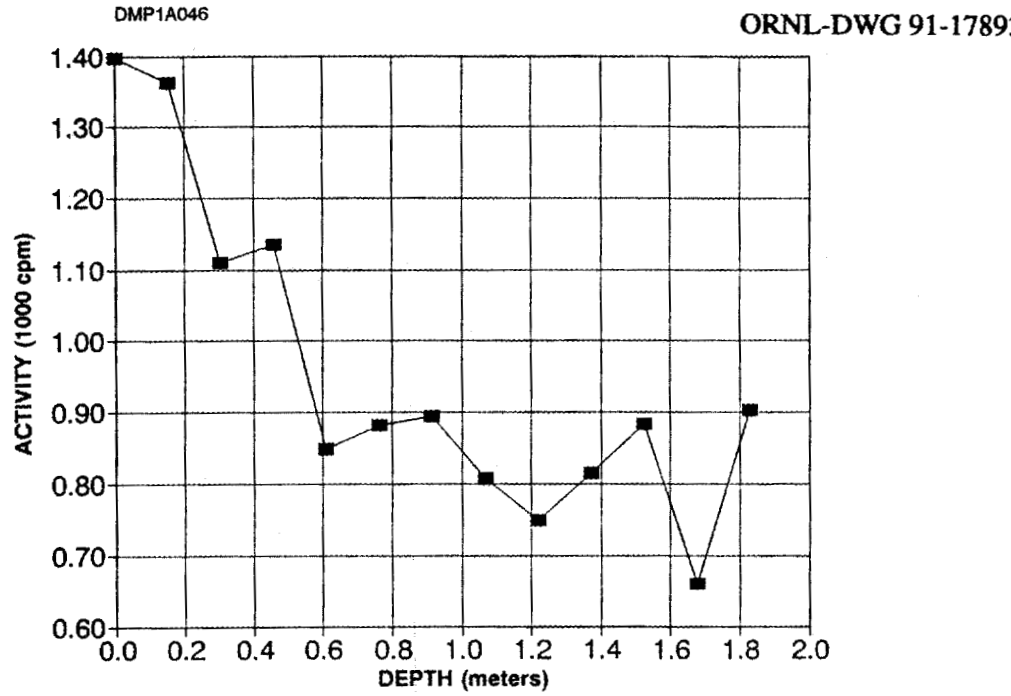

Fig. A.39. Gamma profile of auger hole A46.

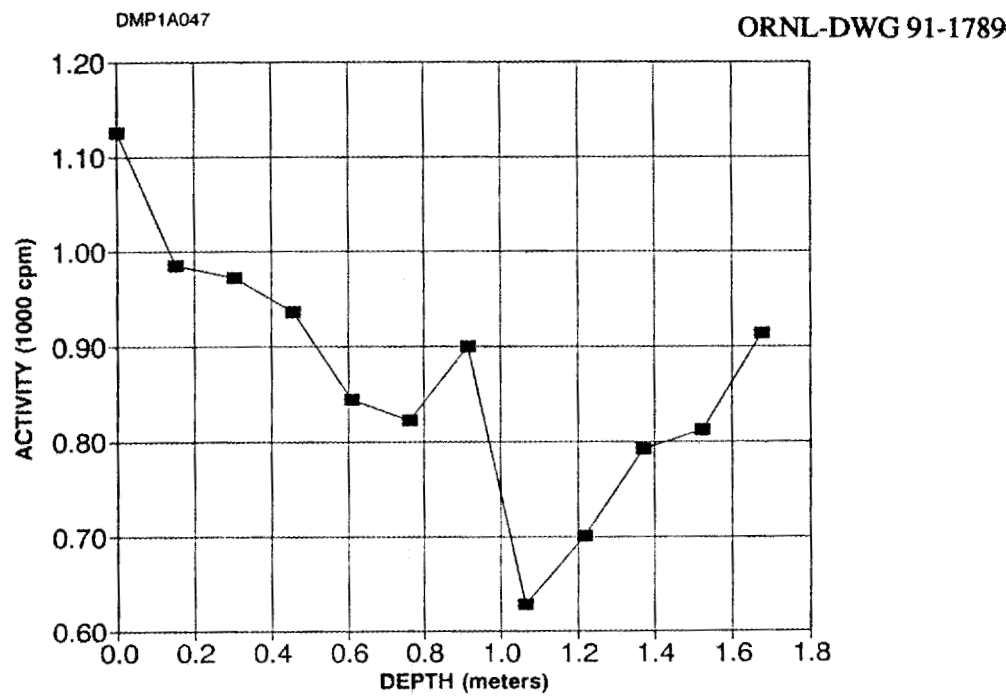

Fig. A.40. Gamma profile of auger hole A47.

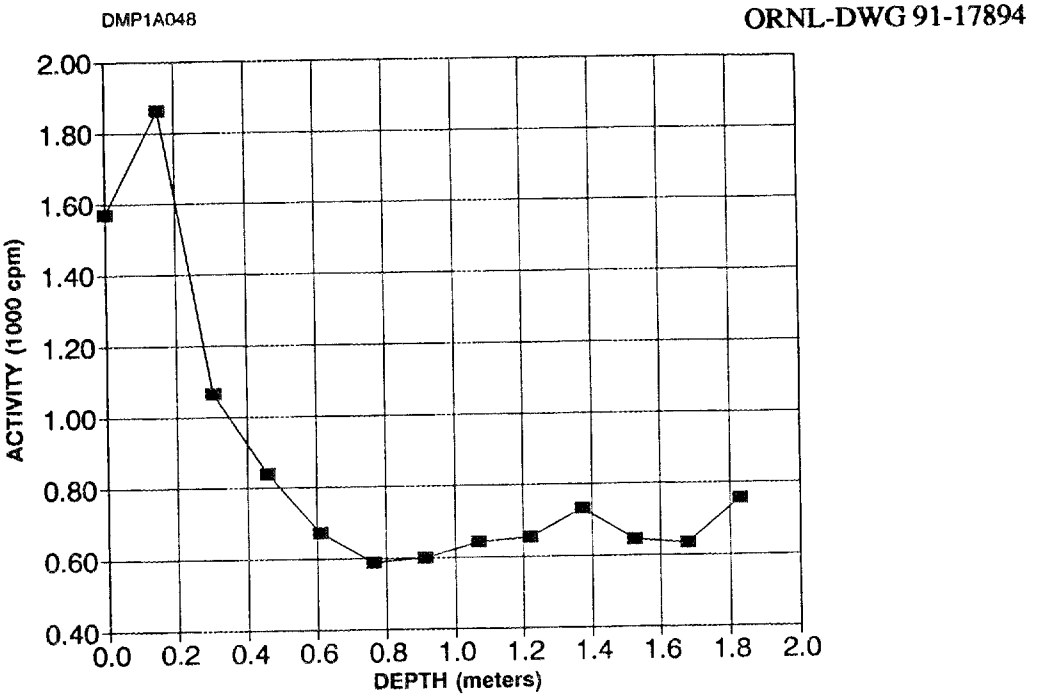

Fig. A.41. Gamma profile of auger hole A48.

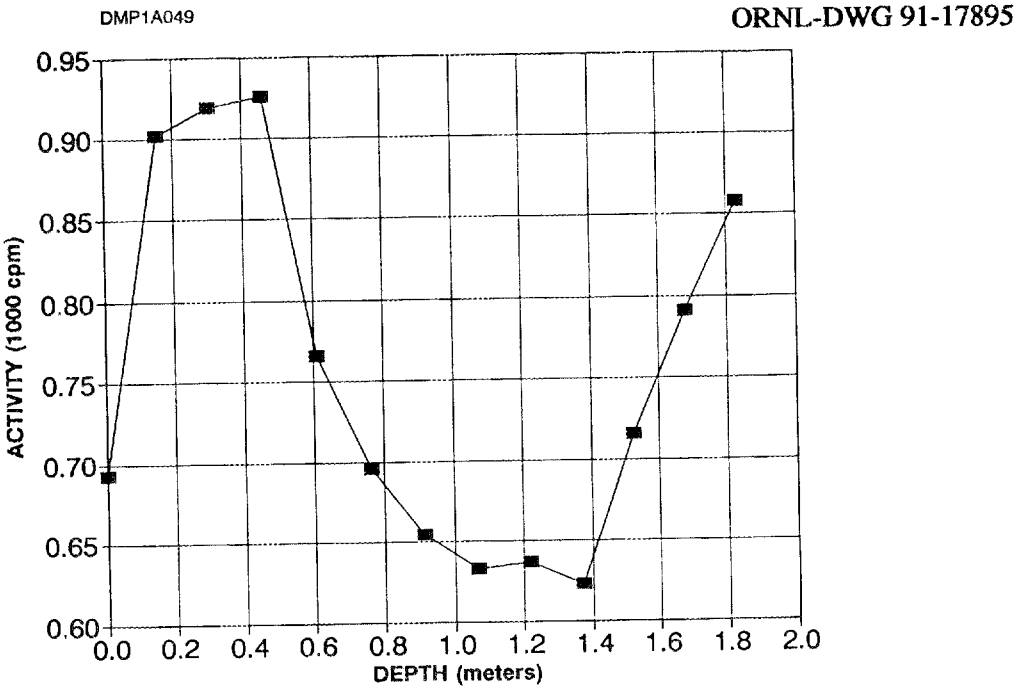

Fig. A.42. Gamma profile of auger hole A49.

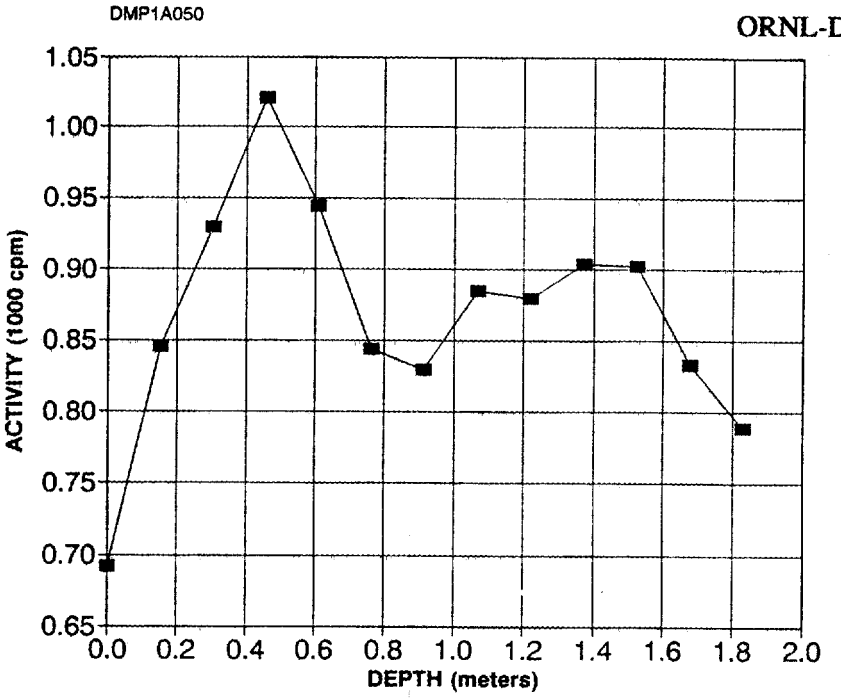

Fig. A.43. Gamma profile of auger hole A50.

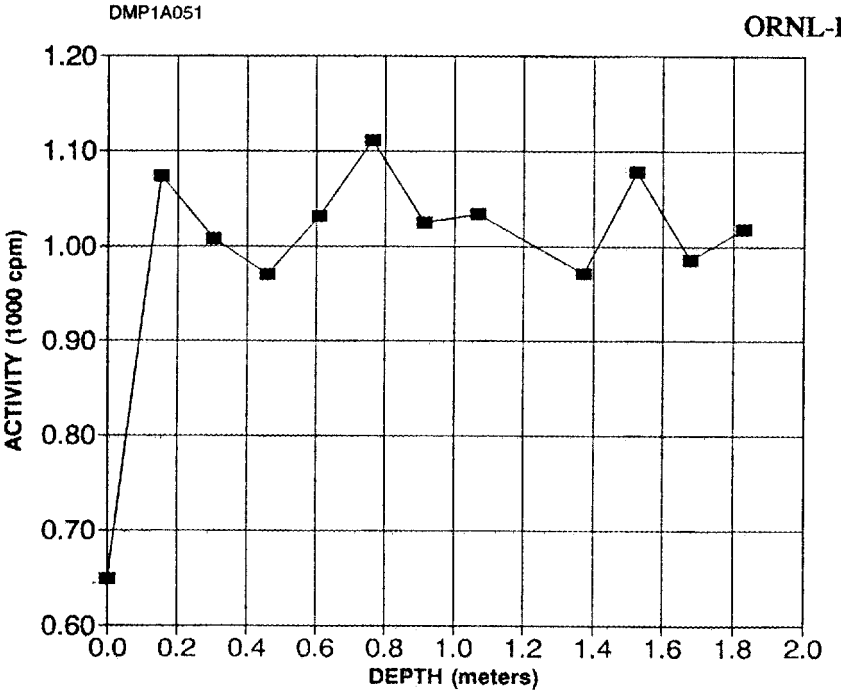

Fig. A.44. Gamma profile of auger hole A51.

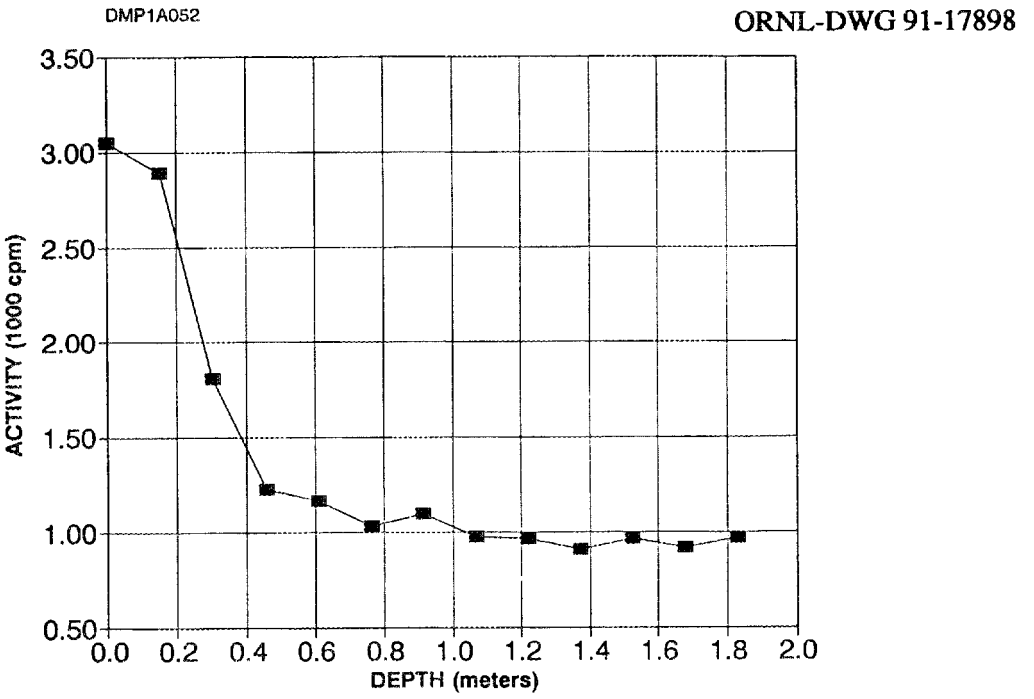

Fig. A.45. Gamma profile of auger hole A52.

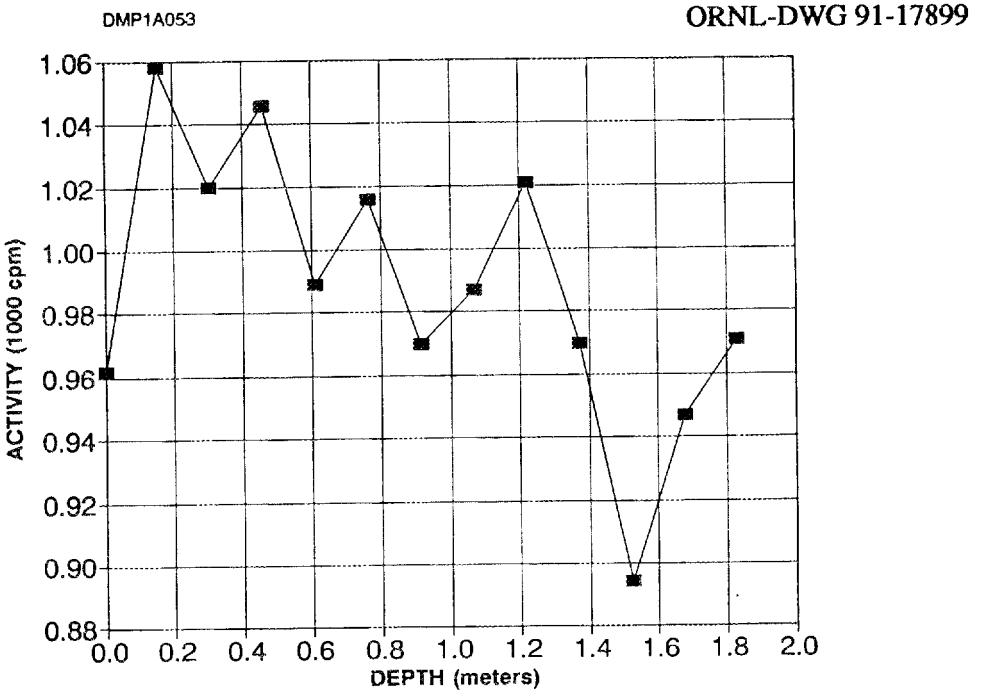

Fig. A.46. Gamma profile of auger hole A53.

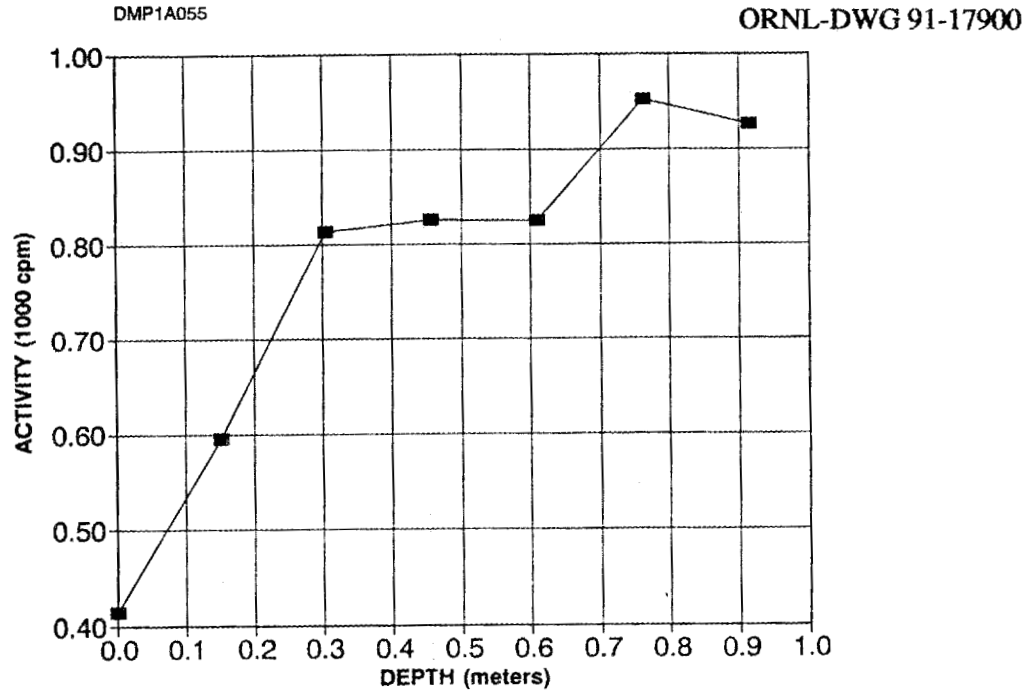

Fig. A.47. Gamma profile of auger hole A55.

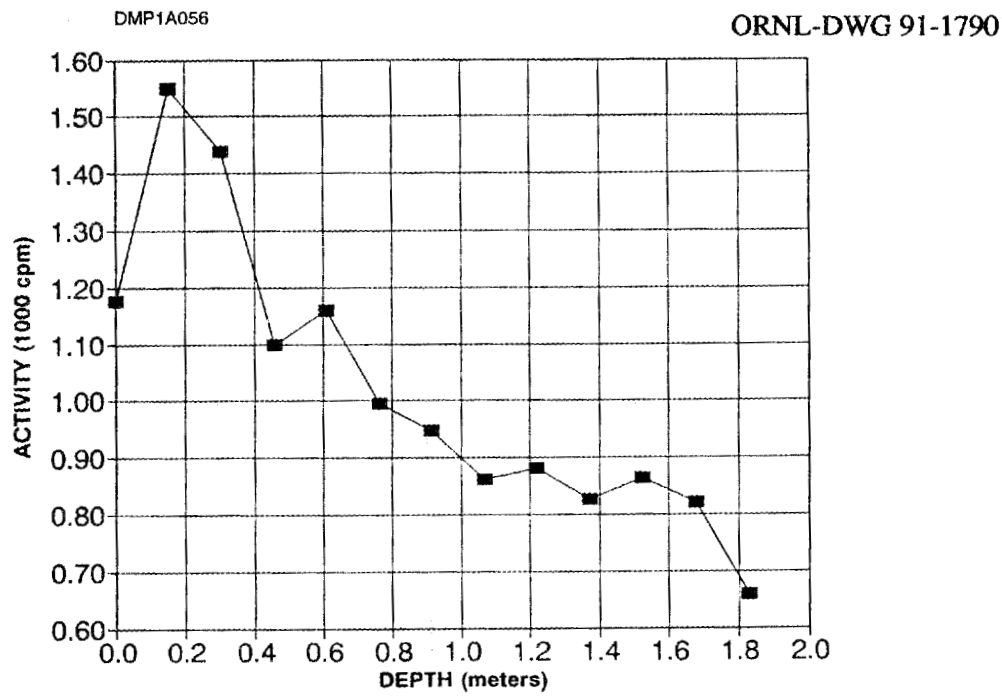

Fig. A.48. Gamma profile of auger hole A56.

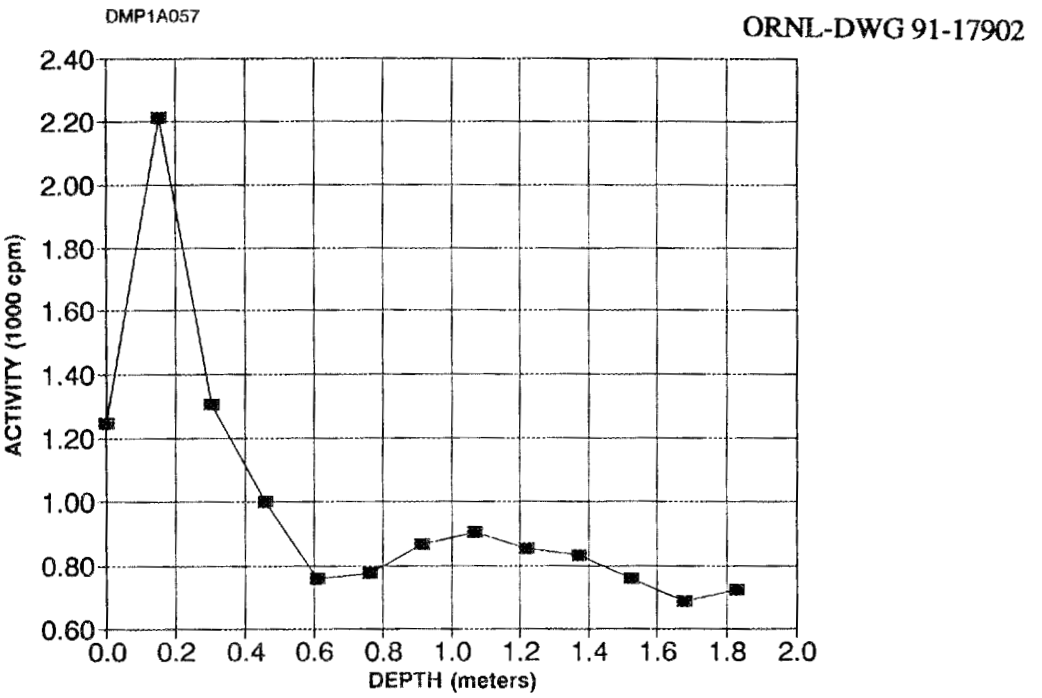

Fig. A.49. Gamma profile of auger hole A57.

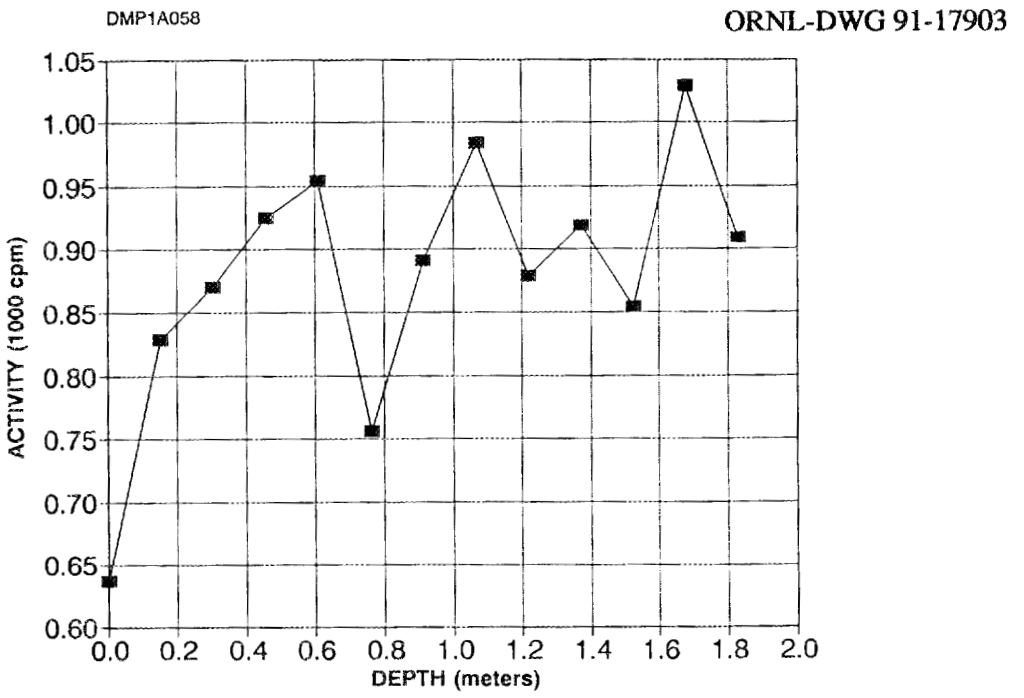

Fig. A.50. Gamma profile of auger hole A58.

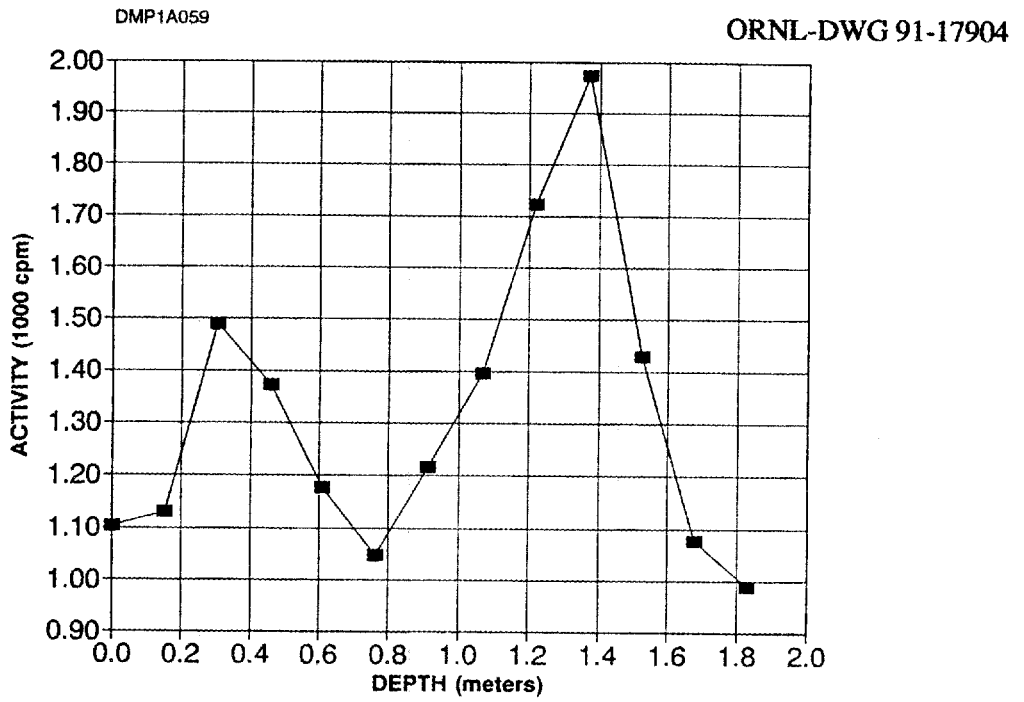

Fig. A.51. Gamma profile of auger hole A59.

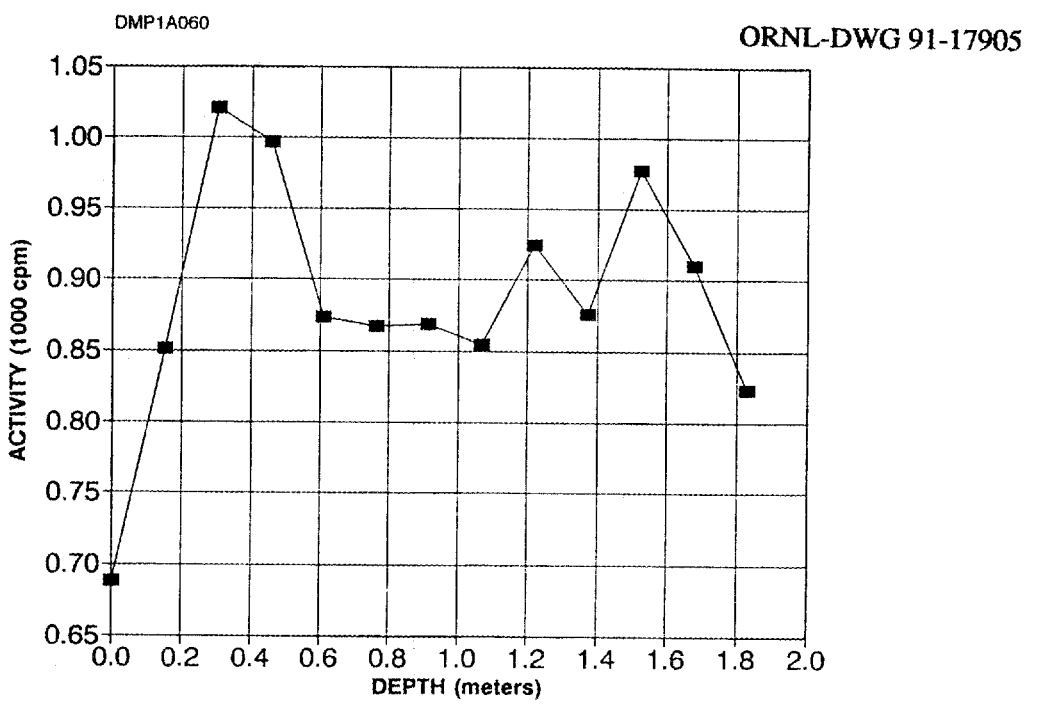

Fig. A.52. Gamma profile of auger hole A60.

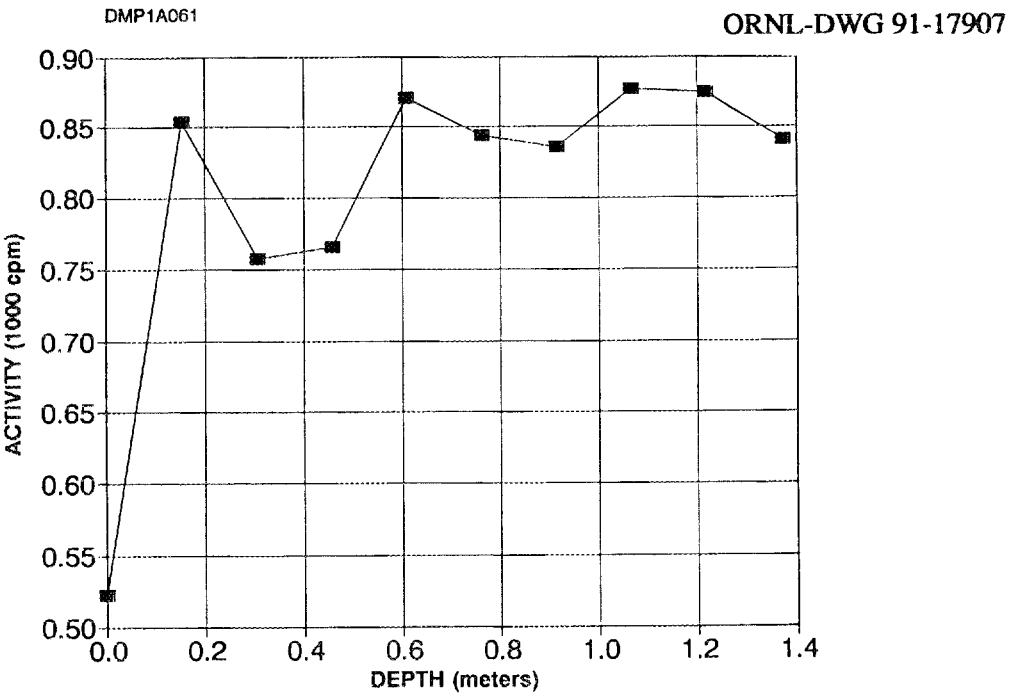

Fig. A.53. Gamma profile of auger hole A61.

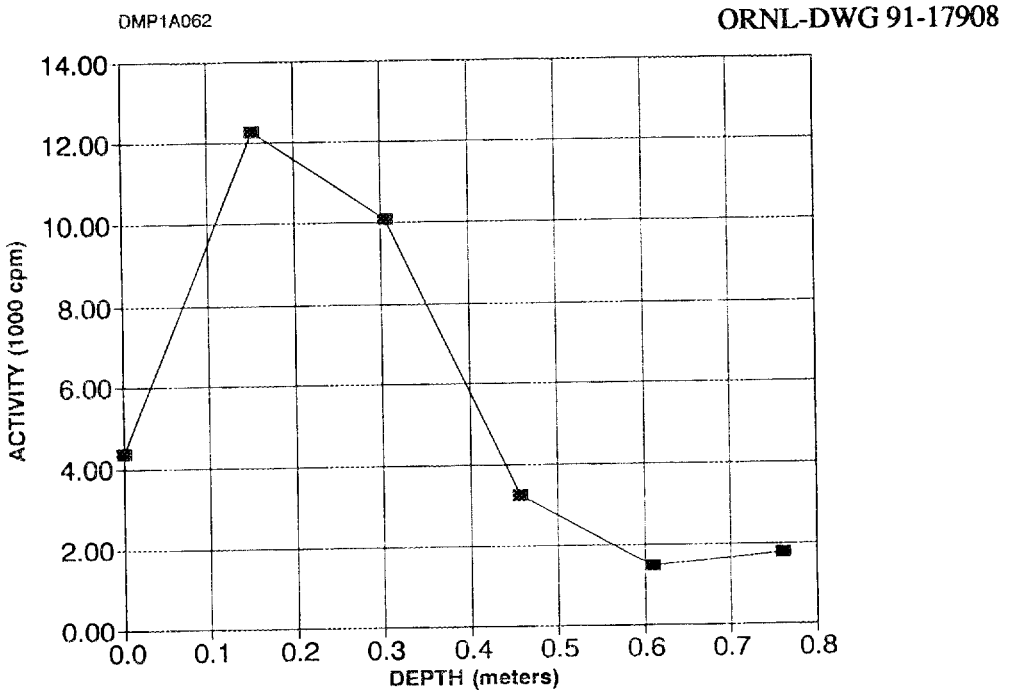

Fig. A.54. Gamma profile of auger hole A62.

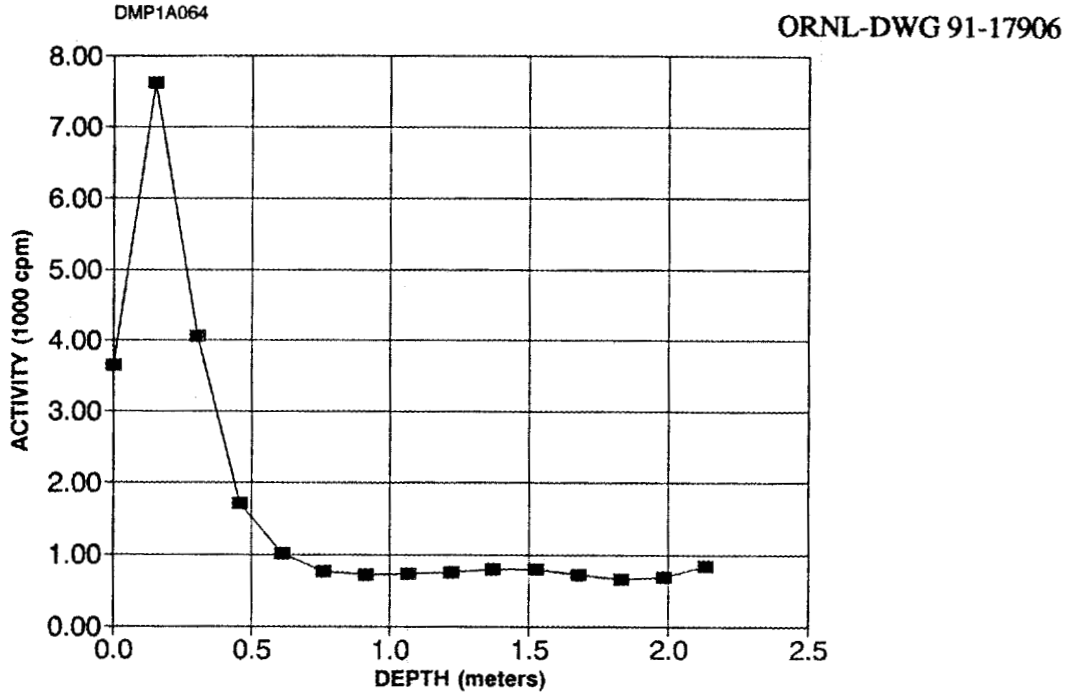

Fig. A.55. Gamma profile of auger hole A64.

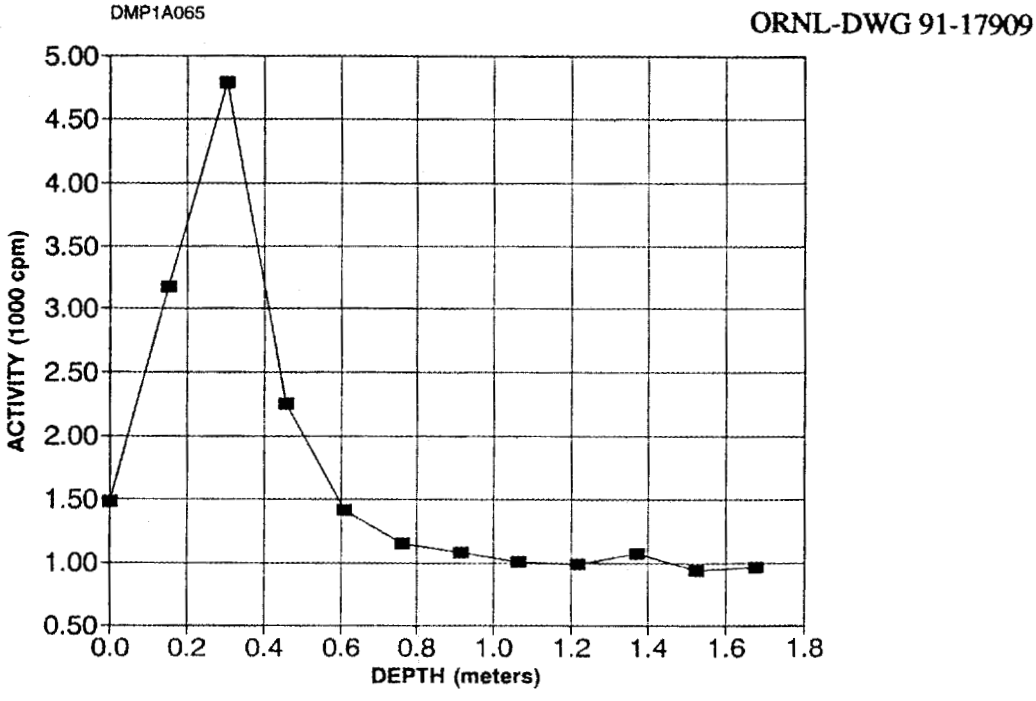

Fig. A.56. Gamma profile of auger hole A65.

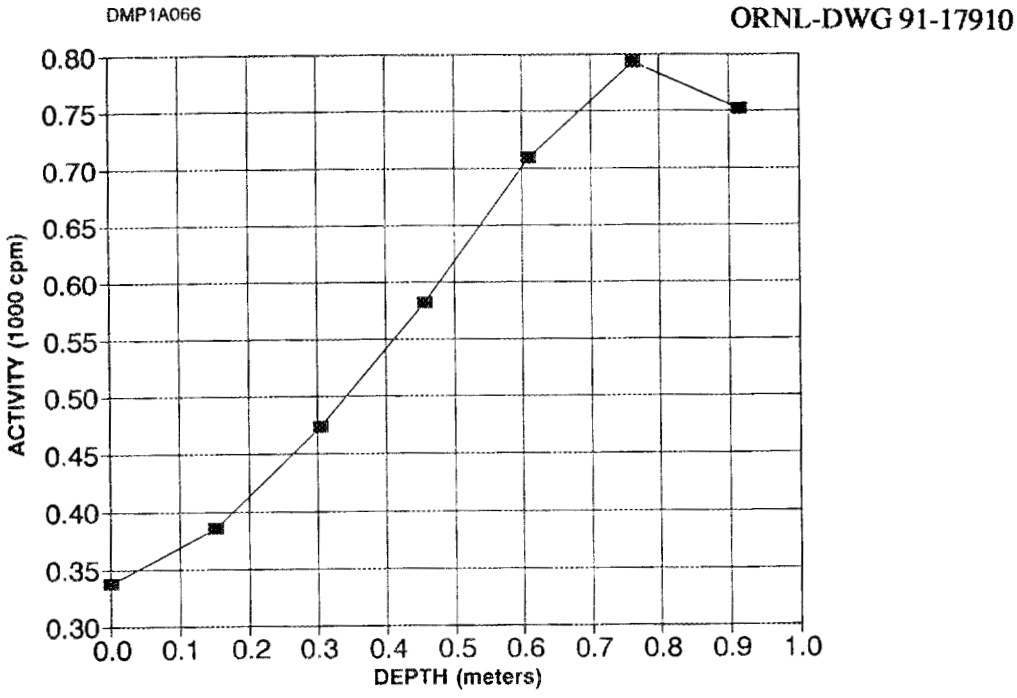

Fig. A.57. Gamma profile of auger hole A66.

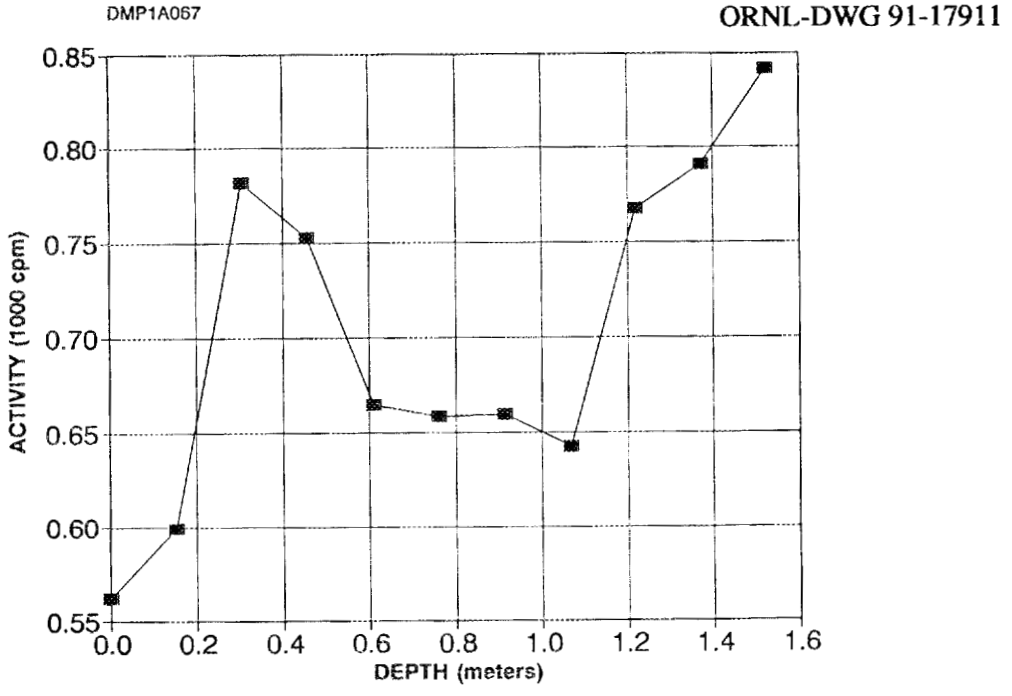

Fig. A.58. Gamma profile of auger hole A67.

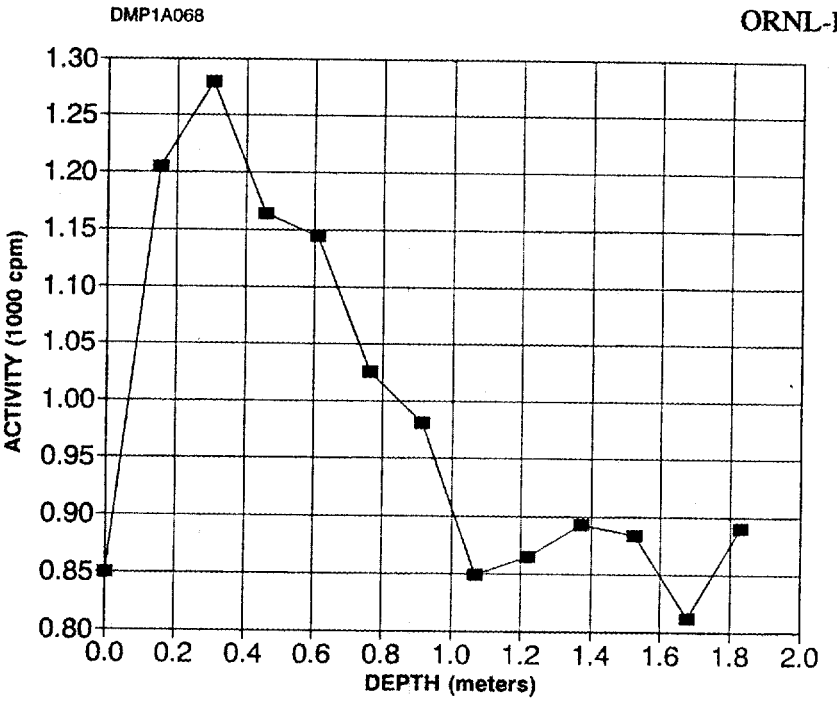

Fig. A.59. Gamma profile of auger hole A68.

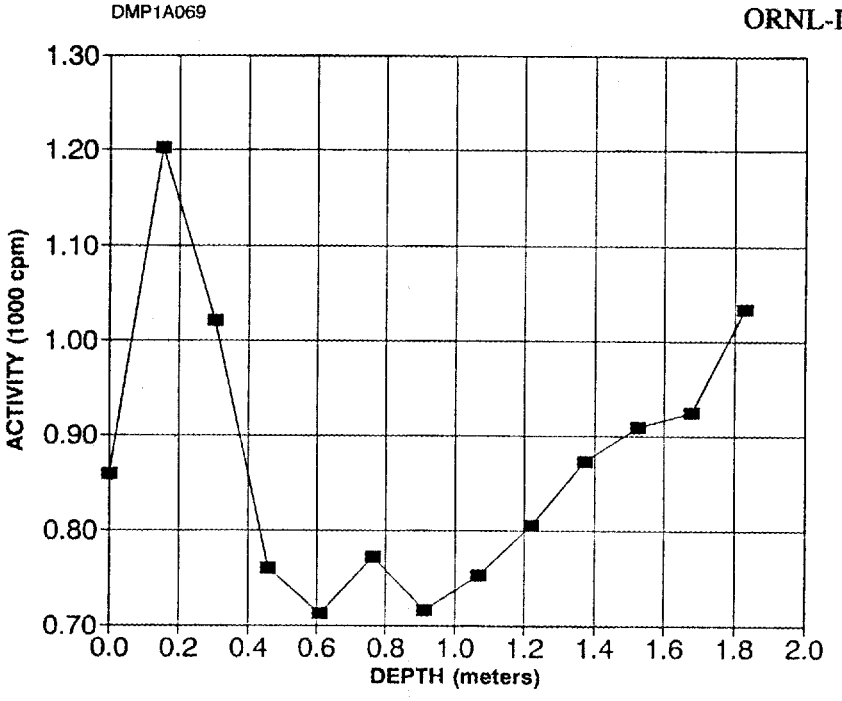

Fig. A.60. Gamma profile of auger hole A69.

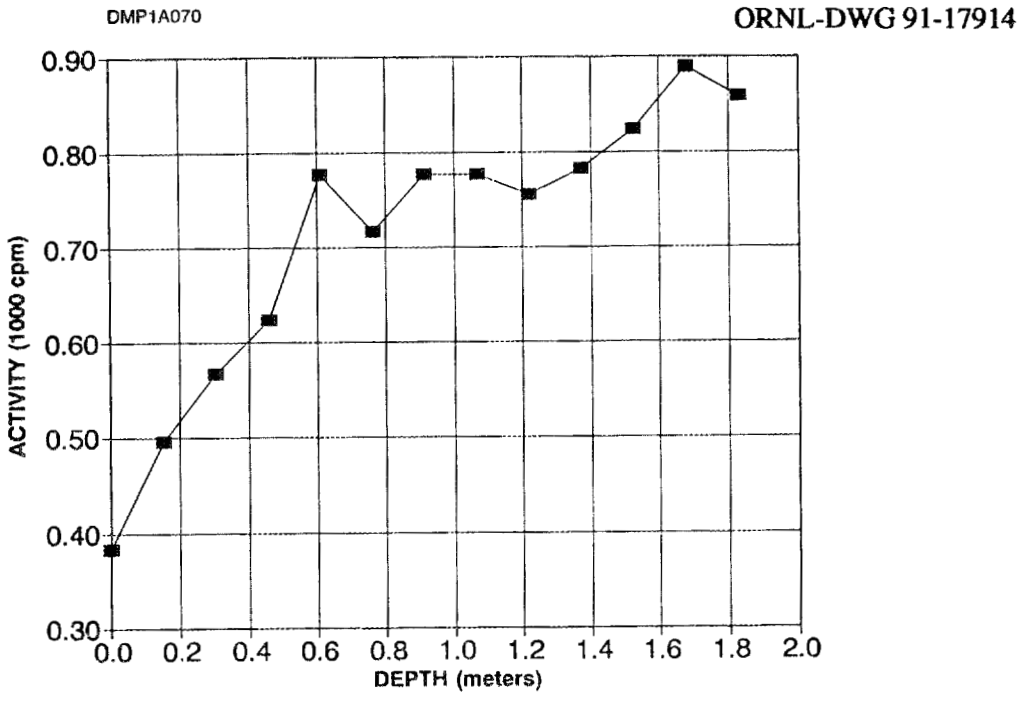

Fig. A.61. Gamma profile of auger hole A70.

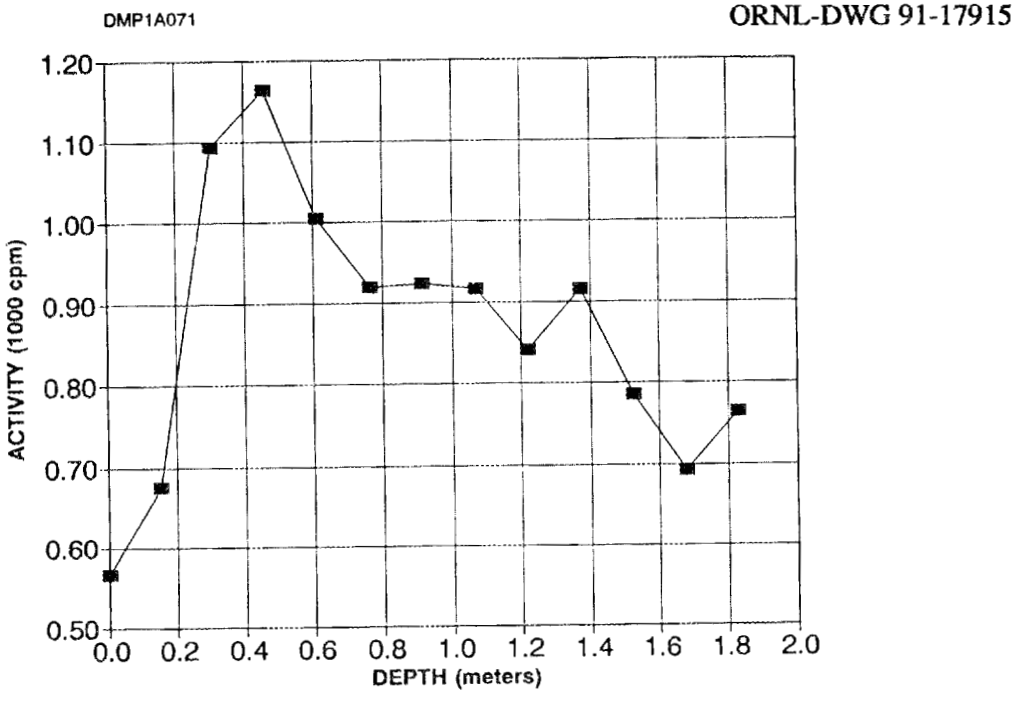

Fig. A.62. Gamma profile of auger hole A71.

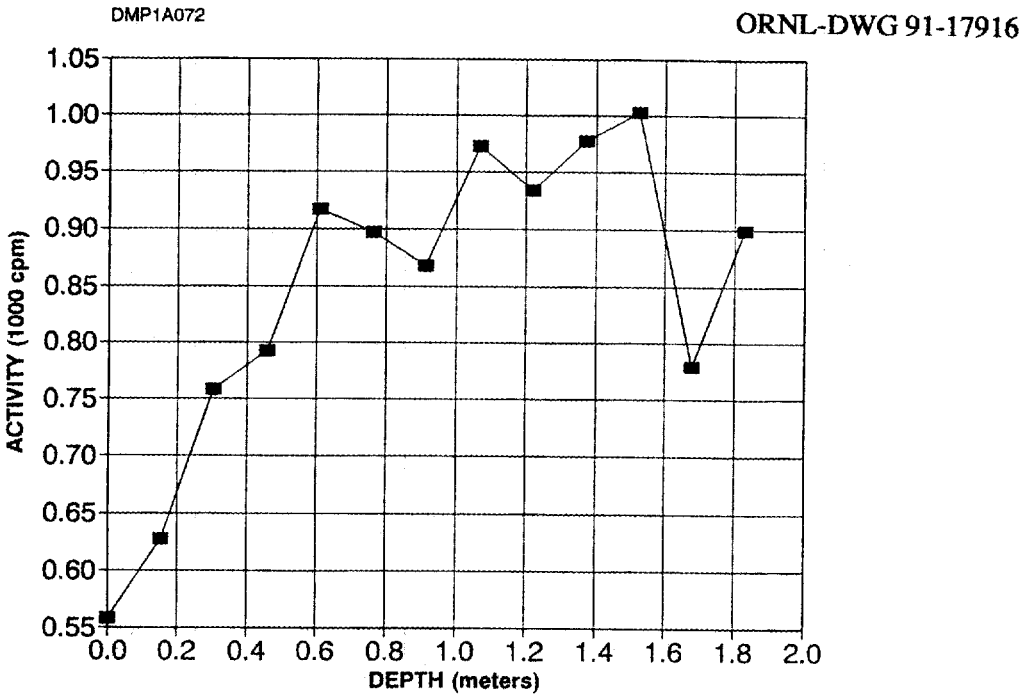

Fig. A.63. Gamma profile of auger hole A72.

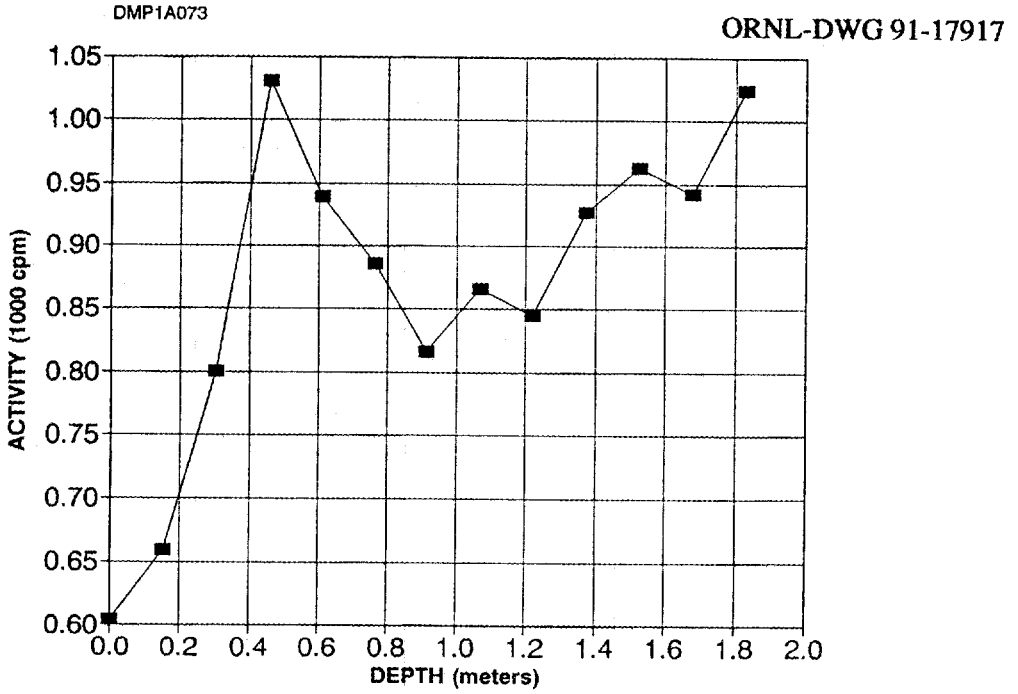

Fig. A.64. Gamma profile of auger hole A73.

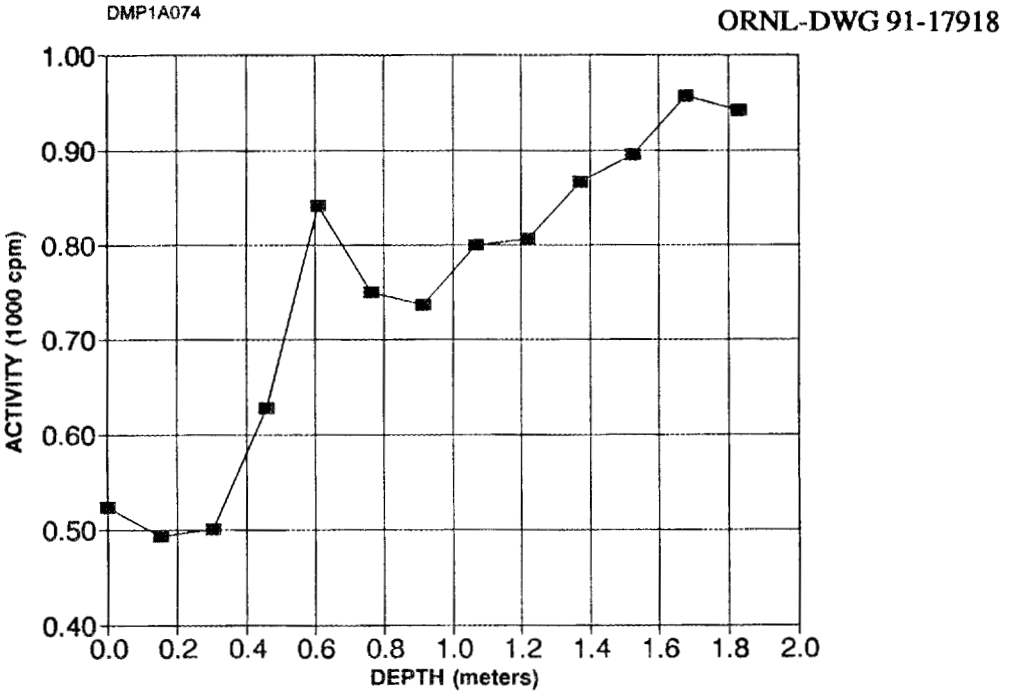

Fig. A.65. Gamma profile of auger hole A74.

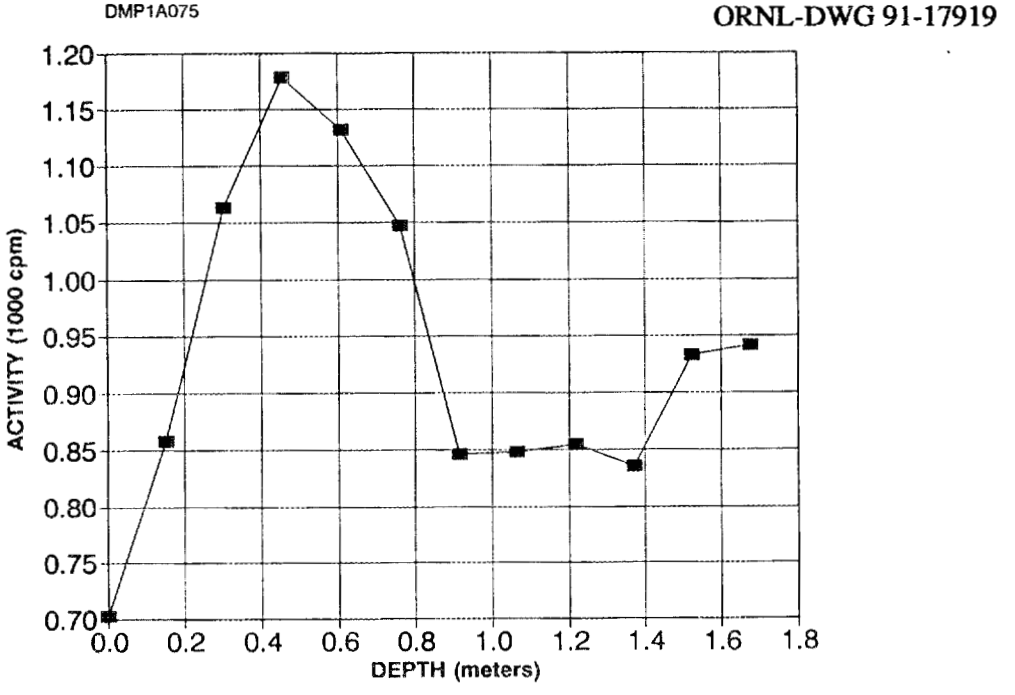

Fig. A.66. Gamma profile of auger hole A75.

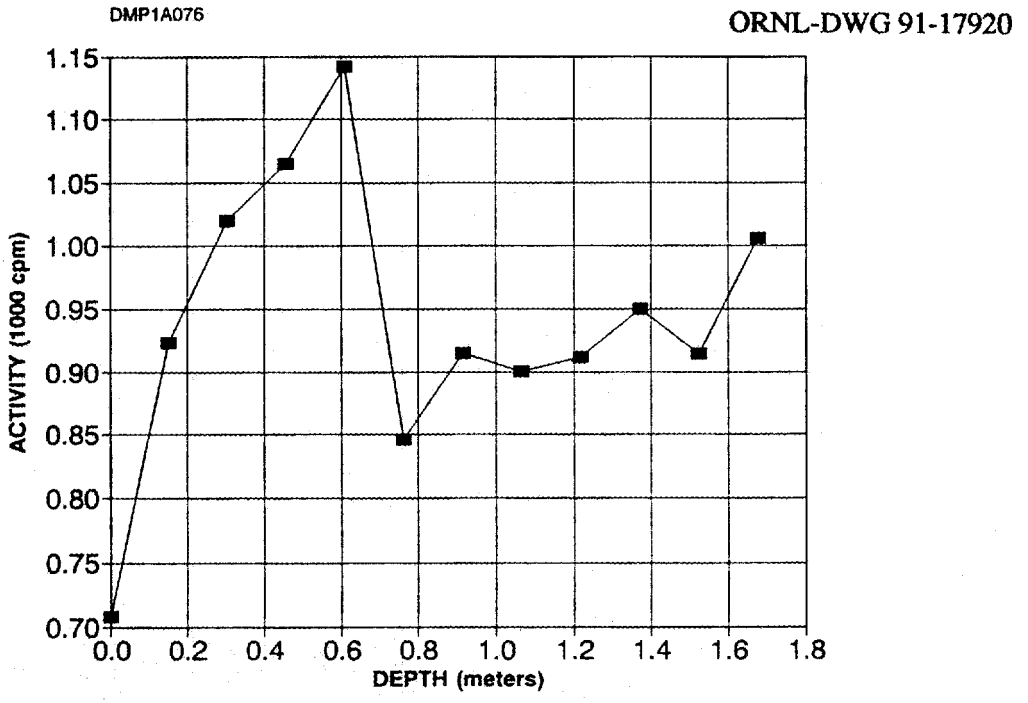

Fig. A.67. Gamma profile of auger hole A76.

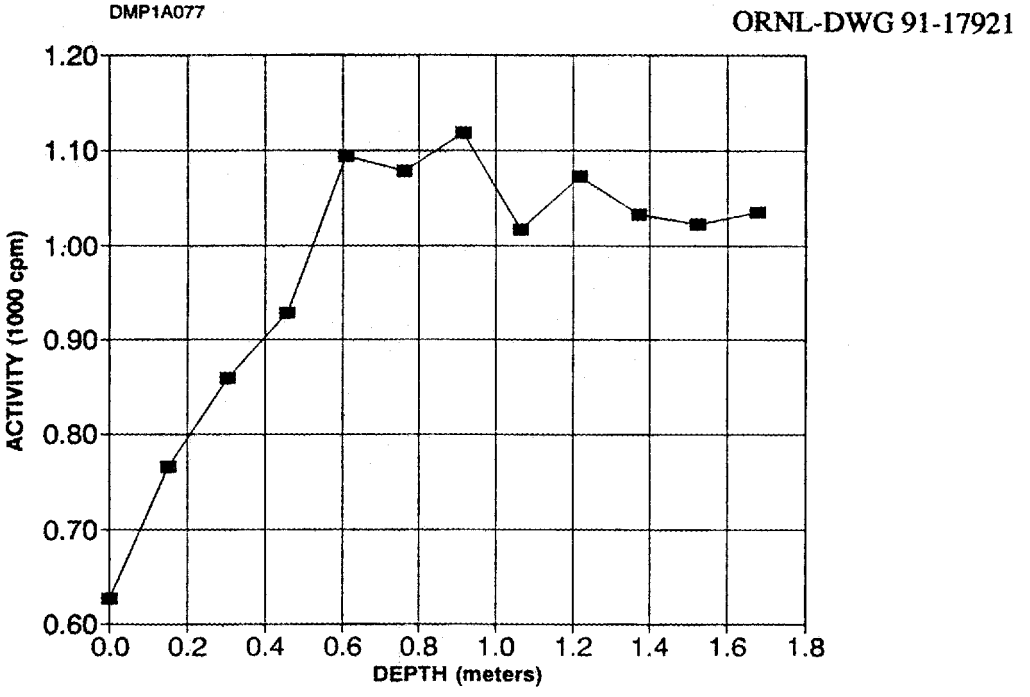

Fig. A.68. Gamma profile of auger hole A77.

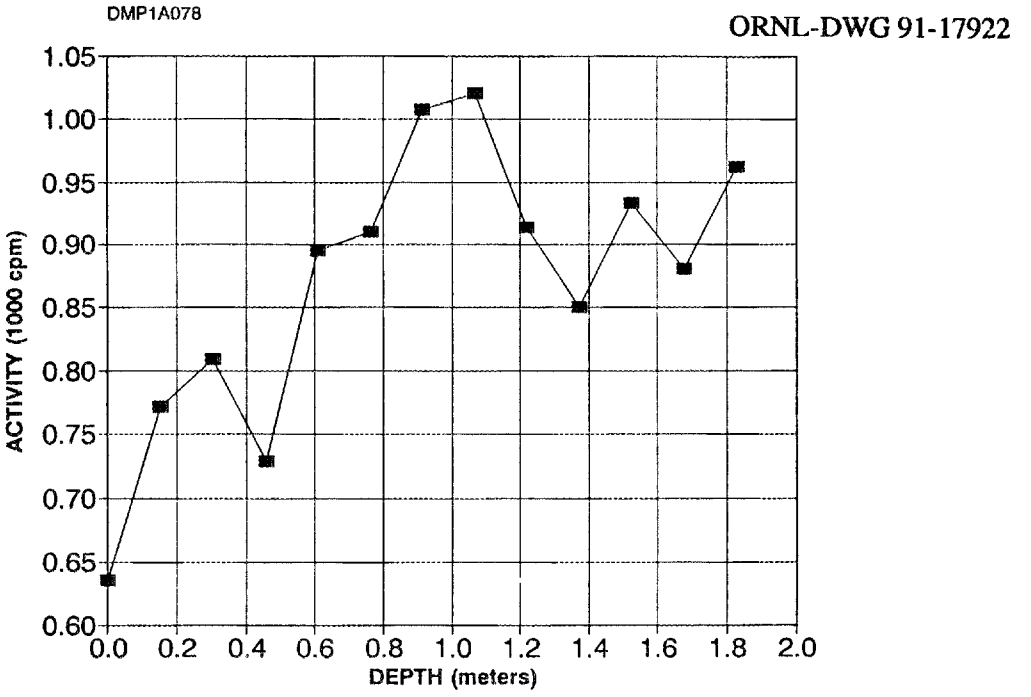

Fig. A.69. Gamma profile of auger hole A78.

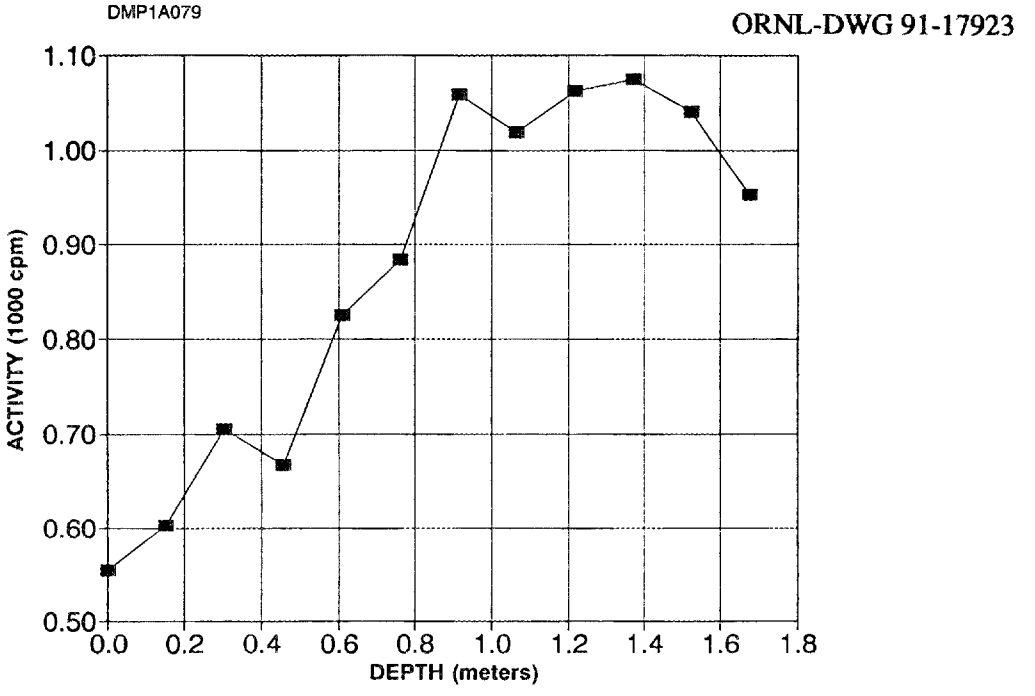

Fig. A.70. Gamma profile of auger hole A79.

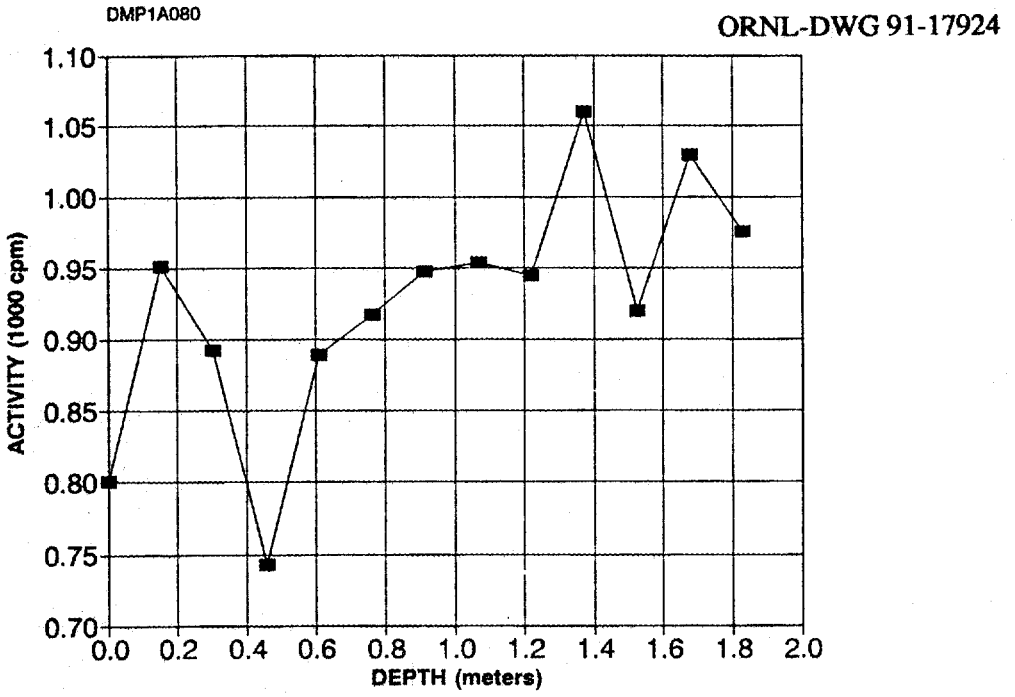

Fig. A.71. Gamma profile of auger hole A80.

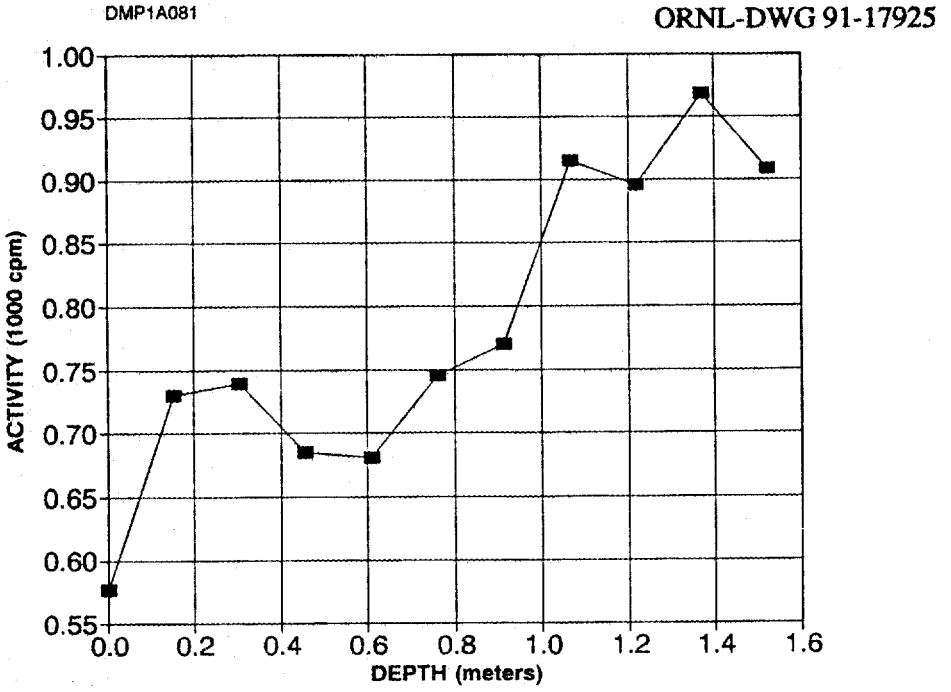

Fig. A.72. Gamma profile of auger hole A81.

INTERNAL DISTRIBUTION

1. B. A. Berven
2–6. R. F. Carrier
7–12. W. D. Cottrell
13. L. M. Floyd
14–19. R. D. Foley
20. C. A. Johnson
21. S. V. Kaye
22. A. P. Malinauskas
23. M. E. Murray
24. P. T. Owen
25. D. A. Roberts
26. R. E. Rodriguez
27. P. S. Rohwer
28–30. R. E. Swaja
31. M. S. Uziel
32. J. K. Williams
33–35. Laboratory Records – RC
36. ORNL Patent Section
37. Central Research Library
38. ORNLTechnical Library, Y-12
39–44. MAD Records Center

EXTERNAL DISTRIBUTION

45. J. D. Berger, Oak Ridge Associated Universities, E/SH Division, Environmental Survey and Site Assessment Program, P.O. Box 117, Oak Ridge, TN 37831-0117

46. R. W. Doane, TMA/Eberline, 795A Oak Ridge Turnpike, Oak Ridge, TN 37830

47. J. J. Fiore, U.S. Department of Energy, Office of Eastern Area Programs, Office of Environmental Restoration (EM-423), Washington, DC 20545

48–50. G. K. Hovey, Bechtel National, Inc., FUSRAP Department, Oak Ridge Corporate Center, 151 Lafayette Drive, P.O. Box 350, Oak Ridge, TN 37831-0350

51. L. K. Price, U.S. Department of Energy, Former Sites Restoration Division, DOE Field Office, OR, P. O. Box 2001, Oak Ridge, TN 37831-8723

52. C. D. Young, Roy F. Weston, Inc., 12800 Middlebrook Road, Suite 207, Germantown, MD 20874

53. J. W. Wagoner, U.S. Department of Energy, Office of Environmental Restoration & Waste Management, Decontamination and Decommissioning Division (EM-423), Washington DC 20545

54-77. W. Alexander Williams, U.S. Department of Energy, Office of Environmental Restoration and Waste Management, Decontamination and Decommissioning Division (EM-423), Washington DC 20545

78. Office of Assistant Manager, Energy Research and Development, DOE Field Office, OR, P.O. Box 2001, Oak Ridge, TN 37831 8600

79–90. Office of Scientific and Technical Information, DOE, P.O. Box 62, Oak Ridge, TN 37831