M-634

Formerly Utilized Sites Remedial Action Program (FUSRAP)

ADMINISTRATIVE RECORD

for the Maywood Site, New Jersey

US Army Corps of Engineers®

M-634

ORNL/RASA-86/64
(MJ18V)

HEALTH AND SAFETY RESEARCH DIVISION

Nuclear and Chemical Waste Programs
(Activity No. AH 10 05 00 0; ONLWC01)

RESULTS OF THE INDEPENDENT RADIOLOGICAL VERIFICATION SURVEY AT THE BALLOD ASSOCIATES PROPERTY, ROCHELLE PARK, NEW JERSEY (MJ18V)

M. G. Yalcintas
C. A. Johnson*

*Biology Division

Date of Issue — November 1986

Investigation Team

B. A. Berven – RASA Program Manager
W. D. Cottrell – FUSRAP Project Director
M. G. Yalcintas – Field Survey Supervisor

Work performed as part of the
RADIOLOGICAL SURVEY ACTIVITIES PROGRAM

Prepared by the
OAK RIDGE NATIONAL LABORATORY
Oak Ridge, Tennessee 37831
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under Contract No. DE-AC05-84OR21400

CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

Research for this project was sponsored by the Division of Facility and Site Decommissioning Projects, U.S. Department of Energy. The authors wish to acknowledge the support of J. E. Baublitz, Deputy Director, Office of Remedial Action and Waste Technology, E. G. DeLaney, Director, Division of Facility and Site Decommissioning Projects, and members of their staff. The authors recognize the valuable contributions of C. Leichtweis of Bechtel National, Inc. (BNI), for providing the data collected by BNI during the remedial action; B. S. Ellis, C. A. Muhr, and D. W. Greene of the RASA group for data collection; and T. R. Stewart, RASA, for the preparation of graphics. In addition, the authors appreciate the manuscript preparation by S. E. Huckaba, RASA; J. M. Wyrick, Biology Division; and S. W. Hawthorne, F. C. Littleton, and B. C. Littleton, Information Resources Organization.

RESULTS OF THE INDEPENDENT RADIOLOGICAL VERIFICATION SURVEY AT THE BALLOD ASSOCIATES PROPERTY, ROCHELLE PARK, NEW JERSEY (MJ18V)*

INTRODUCTION

Processing of thorium ores was performed in Maywood, New Jersey, between 1916 and 1956 by the Maywood Chemical Works.[1] During the course of thorium processing the wastes from the operations were pumped to diked areas west of the plant. Additional material was placed in two piles surrounded by earthen dikes. In 1932, Route 17 was built through this disposal area. The Maywood Chemical Works ceased thorium processing in 1956 and subsequently was sold to Stepan Chemical Company in 1959. After 1963, on several occasions wastes were removed from the west side of New Jersey Route 17. This area is now owned by Ballod and Associates. In 1984, the U.S. Department of Energy (DOE) was assigned the responsibility by Congress for the decontamination project involving the site and vicinity properties in Maywood and Rochelle Park under the Formerly Utilized Sites Remedial Action Program (FUSRAP).

This site, referred to as the Maywood site, had surface and subsurface radionuclide concentrations in excess of the DOE criteria listed in Table 1. It has been identified through radiological assessment procedures by Oak Ridge Associated Universities and Nuclear Safety Associates, Inc.,[1,2] for the purpose of decontamination based on DOE's remedial action objectives. The Maywood site and vicinity properties, which include the Ballod property and the residential properties on Park Way and Grove Street in Rochelle Park, were assigned by DOE to FUSRAP although the contamination at the Maywood site did not result from the Atomic Energy Program.

From June to December, 1984, Bechtel National, Inc. (BNI), the project management contractor designated by DOE, performed remedial action on this property. This remedial action is on one of ten designated properties in the Rochelle Park area. A diagram of the Ballod property and surrounding area is shown in Fig. 1. Based on drawings showing the extent of contamination, the property was excavated and the contaminated material transported to the Maywood Interim Storage Site (MISS), adjacent to the Stepan Company plant.[3] After removal of all contaminated soil, the property was restored to its original condition. By using a combination of procedures, the contamination was controlled and prevented from spreading to other areas. A post-remedial radiological survey was conducted by BNI to ensure compliance with DOE remedial action guidelines.[4]

The DOE adopted a policy to assign an independent verification contractor to ensure the effectiveness of remedial actions performed within FUSRAP. The Radiological Survey Activities Group of Oak Ridge National Laboratory (ORNL) has been assigned the responsibility for this task at the Maywood site. This report describes the methods and results of that verification.

---

*The survey was performed by members of the Radiological Survey Activities Group of the Health and Safety Research Division at Oak Ridge National Laboratory under DOE contract DE-AC05-84OR21400 with Martin Marietta Energy Systems, Inc.

From January to June, 1986, ORNL conducted the verification activity for the Rochelle Park properties, including the Ballod Associates property. A diagram of the Ballod property showing the approximate property boundaries and grid network established for measurements outside the buildings is shown in Fig. 2. This location is one in a series of properties that were suspected of being radioactively contaminated, and that have been surveyed by BNI[3] to identify horizontal and vertical boundaries of radionuclide concentrations exceeding remedial action criteria. (Verification of these properties will be completed in 1986.) A contaminated area of >30,000 m^2 that exceeded the guidelines was located on the grounds of the property and was excavated. A diagram of the Ballod property with excavation depths is shown in Fig. 3.

PROCEDURES

Objectives

The objective of the verification activities was to confirm (1) that available documentation adequately and accurately describes the post–remedial action radiological conditions of the entire property that is to be certified and (2) that the remedial action reduced contamination levels to within authorized limits.

Document Reviews

Review of the designation/characterization report[3] prepared by BNI indicates that the contaminated areas on the vicinity properties were shallow deposits most likely created by runoff from the Ballod property; thus, it was appropriate to designate these properties as well as the Ballod property for remedial action.

The post–remedial action report[4] indicates that the area excavated on the Ballod property was as identified in the designation report. The post–remedial action survey was performed on this property as described for a generic site in Ref. 5. This survey consists of ground-level beta-gamma measurements, surface gamma measurements, and systematic and biased soil sampling. From the review of the post–remedial action report, it can be concluded that the BNI survey procedure used for this property is satisfactory. All reported ^{238}U, ^{226}Ra, and ^{232}Th soil sample concentrations are below the average guideline limits set by DOE (Table 1).

VERIFICATION SURVEY AND ANALYSIS

Typical background radiation levels for the Rochelle Park, New Jersey, area are presented in Table 2. The data are provided for purposes of comparison with the survey results presented in this section.

All 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 samples.

Gamma Measurements

Eighty-two gamma exposure rate measurements were made by ORNL at the ground surface and at 1 m above the surface. The results and the locations of these readings are presented in Table 3. Gamma exposure rates at 1 m and at the surface ranged from 8 to 15 μR/h (microroentgens* per hour) and averaged 10 μR/h.

Soil Sampling

Before backfilling, >700 soil samples were taken by BNI in the excavated area. The procedures used for soil sample analysis have been described in Ref. 3. Results of the soil sample analysis and the locations of the samples are given by BNI in the post-remedial confirmatory report.

Forty-four of these systematic soil samples taken by BNI from different locations at various depths were selected for independent verification by ORNL (see Table 4). The 44 surface samples have been analyzed for ^{238}U, ^{226}Ra, and ^{232}Th according to the procedure described in Ref. 6.

Concentrations of ^{238}U in the soil samples ranged from 0.02 to 2.0 pCi/g (picocuries† per gram) and averaged 0.82 pCi/g. Concentrations of ^{226}Ra in the soil samples ranged from 0.24 to 1.2 pCi/g and averaged 0.60 pCi/g. Concentrations of ^{232}Th in the soil samples ranged from 0.35 to 4.7 pCi/g and averaged 1.2 pCi/g. Locations of the soil samples are shown in Fig. 4. Results of ORNL analyses for the aforementioned 44 soil samples are given in Table 4, with results by BNI in parentheses for comparison. The significance of difference between average ORNL values and average BNI values was tested by a single sample *t*-test assuming ratios of paired values are log normally distributed. For 88 degrees of freedom and a 0.05 level of significance, the values in the critical range for a *t*-test of the null hypothesis are greater than 2.0. The observed *t* value for ^{232}Th is 1.2, which is not significant. The associated *P* value is 0.25. Hence there is no evidence in these data to indicate that the average log ratio is different from zero. Because BNI's results for ^{238}U were not absolute (see Table 4), no statistical test was performed for this radionuclide.

Confirmatory Soil Analyses

Systematic and biased soil samples from various locations and depths were taken by ORNL for independent verification. (Samples collected from selected locations that showed elevated gamma radiation levels are designated as biased samples.) These samples were analyzed for ^{238}U, ^{226}Ra, and ^{232}Th according to the procedures described in Ref. 6.

---

*The roentgen (R) is a unit which was defined for radiation protection purposes for people exposed to penetrating X rays or gamma radiation. A microroentgen (μR) is one millionth of a roentgen. A milliroentgen (mR) is one thousandth of a roentgen or one thousand microroentgens.

†The curie is a unit used to define the radioactivity in a substance and equals that quantity of any radioactive isotope undergoing 2.2×10^{12} disintegrations per minute. The picocurie is one million-millionth of a curie or that amount yielding 2.2 disintegrations per minute.

Systematic soil samples

Forty-one systematic soil samples were taken by ORNL and analyzed for ^{238}U, ^{226}Ra, and ^{232}Th according to the procedures.[6] Locations of the soil samples are shown in Fig. 5.

Concentrations of ^{238}U in the surface soil ranged from 0.3 to 4.5 pCi/g and averaged 1.2 pCi/g. Concentrations of ^{226}Ra ranged from 0.24 to 2.0 and averaged 0.74 pCi/g. Concentrations of ^{232}Th ranged from 0.34 to 4.4 pCi/g, averaging 1.7 pCi/g. Concentrations in the subsurface samples were 3.3, 1.0, and 12 pCi/g for ^{238}U, ^{226}Ra, and ^{232}Th, respectively. Results and locations of the soil samples are shown in Table 5.

Biased soil samples

Twenty-two biased soil samples were taken by ORNL and analyzed for ^{238}U, ^{226}Ra, and ^{232}Th according to the procedures.[6] Locations of the soil samples are shown in Fig. 6.

Concentrations of ^{238}U in the surface soil ranged from 0.63 to 2.8 pCi/g and averaged 1.6 pCi/g. Concentrations of ^{226}Ra ranged from 0.41 to 1.5 and averaged 0.70 pCi/g. Concentrations of ^{232}Th ranged from 0.89 to 3.8 pCi/g, averaging 2.7 pCi/g. Subsurface concentrations ranged from 0.8 to 5.7 pCi/g for ^{238}U, averaging 2.1 pCi/g. Subsurface ^{226}Ra concentrations ranged from 0.57 to 1.3 pCi/g, averaging 0.76 pCi/g. For ^{232}Th, the concentrations ranged from 1.4 to 12 pCi/g and averaged 4.6 pCi/g. (DOE guidelines for ^{226}Ra and ^{232}Th in surface and subsurface soil are 5 and 15 pCi/g, respectively.) Results and locations of the soil samples are shown in Table 6.

CONCLUSION

Measurements of the gamma exposure levels taken from the excavated area before backfilling determined that the exposure rate at 1 m above the ground surface ranged from 8 to 14 μR/h and averaged 10 μR/h. For comparison, the background for the state of New Jersey[7–9] averages ~8 μR/h and ranges from 6 to 11 μR/h based on 1968 measurements. The results of soil radionuclide analyses for ^{238}U, ^{226}Ra, and ^{232}Th show that all soil concentration measurements are within the limits prescribed by DOE radiological guidelines.[10]

Based upon the results of the post–remedial action data which were confirmed by the verification survey data, soil concentration measurements fall well below the limits prescribed by DOE radiological guidelines established for this site. It is concluded that the site successfully meets the DOE remedial action objectives.

REFERENCES

1. L. W. Cole, J. Berger, P. Cotten, R. Gosslee, L. Sowell, and C. Weaver, *Radiological Assessment of Ballod Associates Property (Stepan Chemical Company), Maywood, New Jersey,* Oak Ridge Associated Universities, Oak Ridge, Tenn., July 30, 1981.

2. H. W. Morton, *Natural Thorium in Maywood, New Jersey,* Nuclear Safety Associates, Inc., Potomac, Md., September 29, 1982.

3. *Radiological Survey Report for Maywood Vicinity Properties on Grove Avenue and Park Way, Maywood, New Jersey,* Bechtel National, Inc., Advanced Technology Division, Oak Ridge, Tenn., DOE/OR/20722-11, June 1984.

4. *Post-Remedial Action Report for the Ballod Associates Property, Rochelle Park, New Jersey,* Bechtel National, Inc., Advanced Technology Division, Oak Ridge, Tenn., DOE/OR/20722-82, October 1985.

5. *Remedial Action Work Plan for the Maywood Site.* U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, Tenn., ORO-850, Rev. 1, April 1985.

6. T. E. Myrick, B. A. Berven, W. D. Cottrell, W. A. Goldsmith, and F. F. Haywood, *Procedures Manual for the Remedial Action Survey and Certification Activities (RASCA) Program,* Oak Ridge National Laboratory, ORNL/TM-8600, September 1982.

7. U.S. Department of Energy, *Radiological Survey of the Middlesex Municipal Landfill, Middlesex, New Jersey,* DOE/EV-0005/20, April 1980.

8. S. G. Levin, R. K. Stoms, E. Kuerze, and W. Huskisson, "Summary of Natural Environmental Gamma Radiation Using a Calibrated Portable Scintillation Counter," *Radiological Health Data Report* **9**:679–695 (1968).

9. C. L. Lindekin, K. R. Peterson, D. E. Jones, and R. E. McMillen, "Geographical Variations in Environmental Radiation Background in the United States." *Proceedings of the Second International Symposium on the Natural Radiation Environment,* CONF-720805-P-1, pp. 317–331 (1972).

10. U.S. Department of Energy, *Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites,* Rev. 1, July 1985.

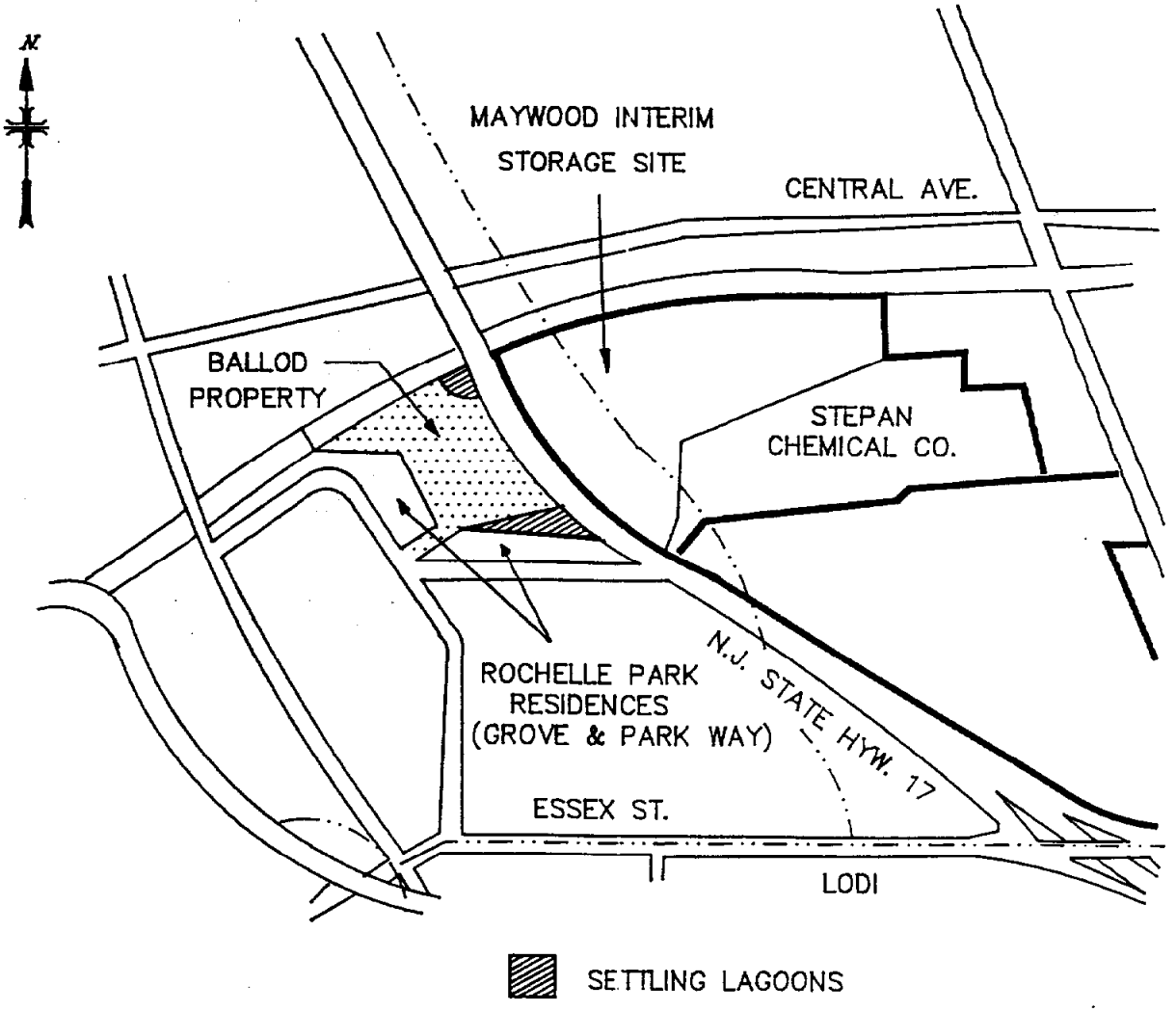

Fig. 1. Ballod Associates property and surrounding area, Rochelle Park, New Jersey.

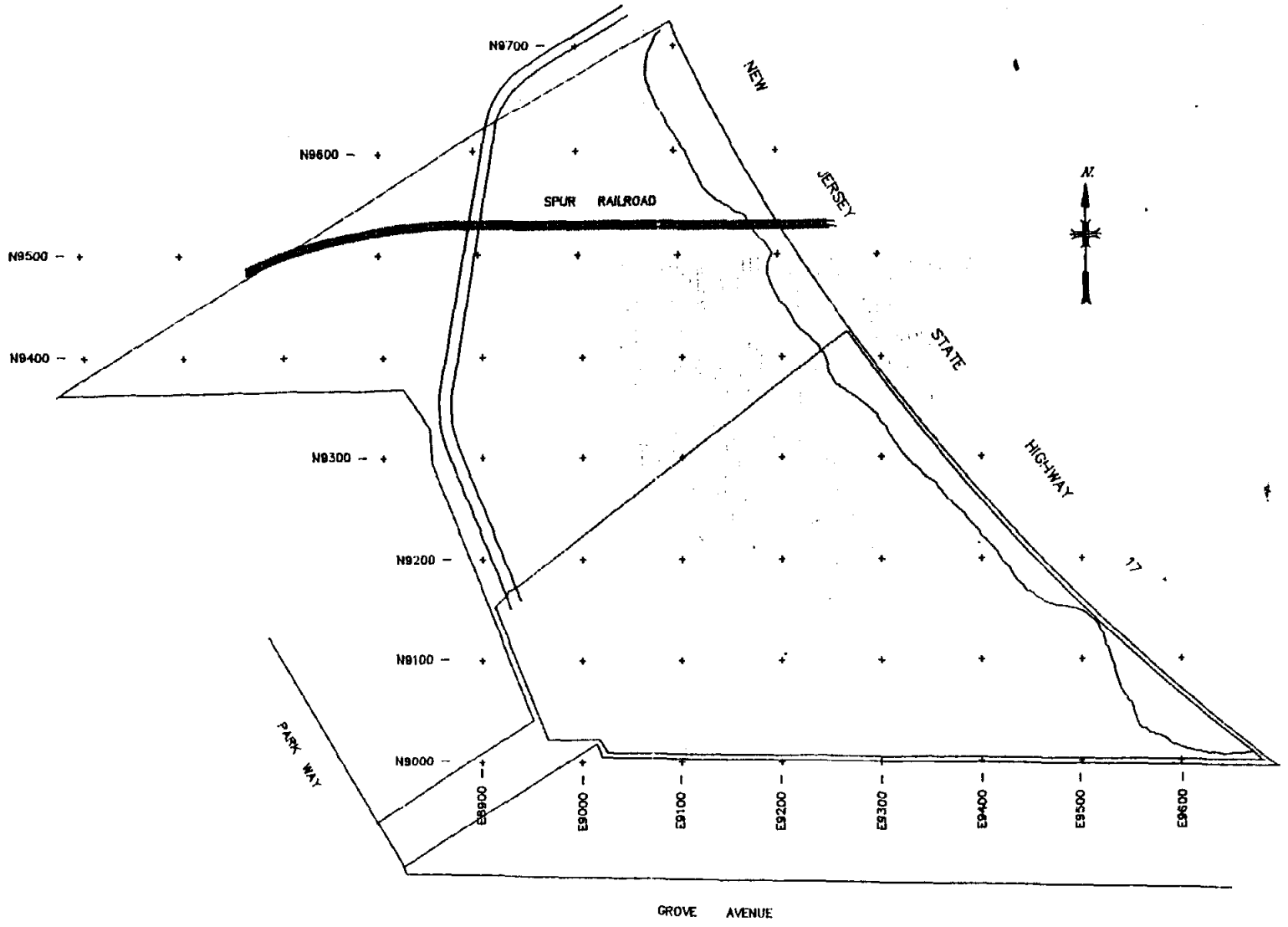

Fig. 2. Diagram showing grid point and grid block locations outdoors on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V).

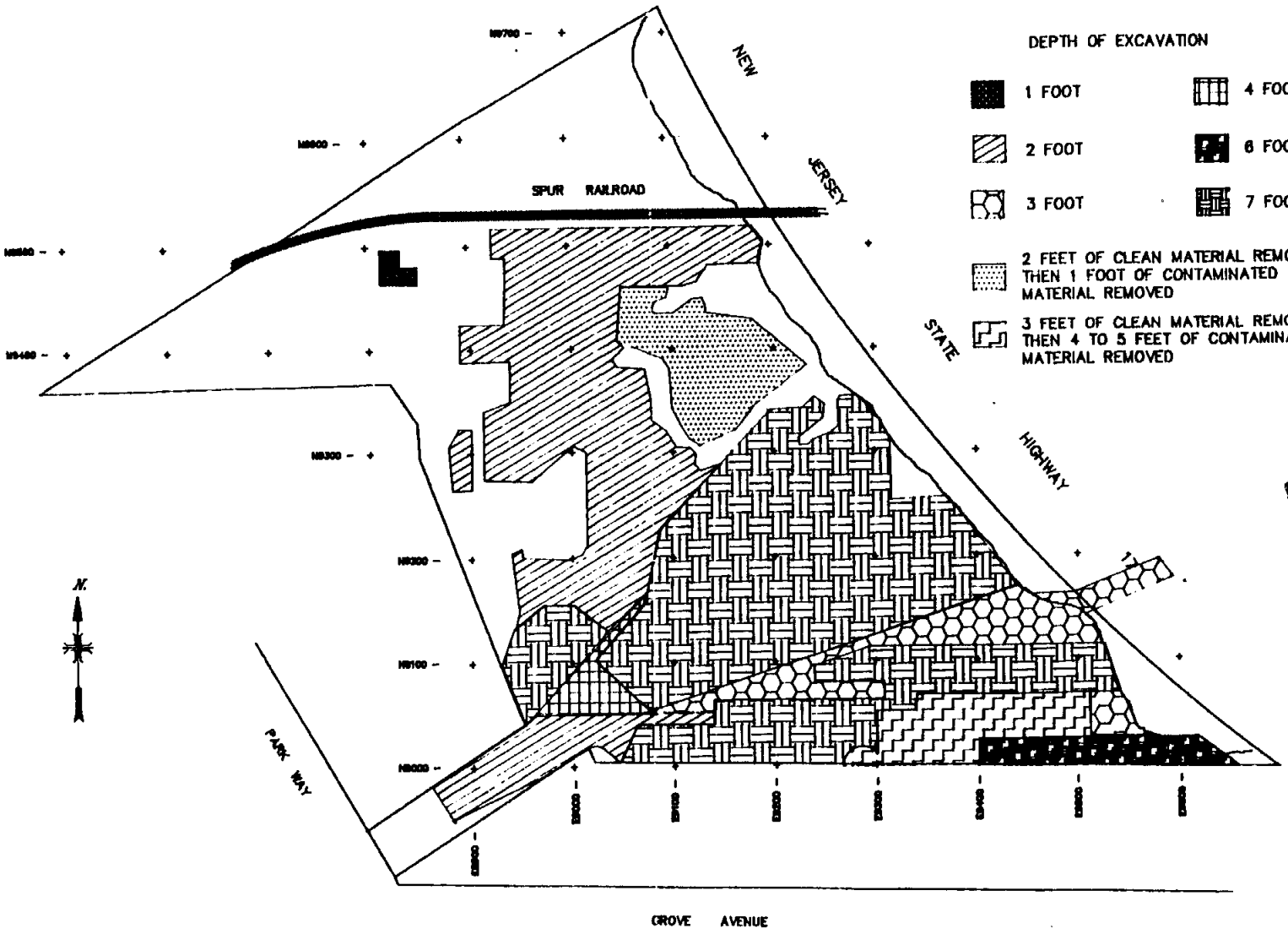

Fig. 3. Diagram showing excavation depths on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V).

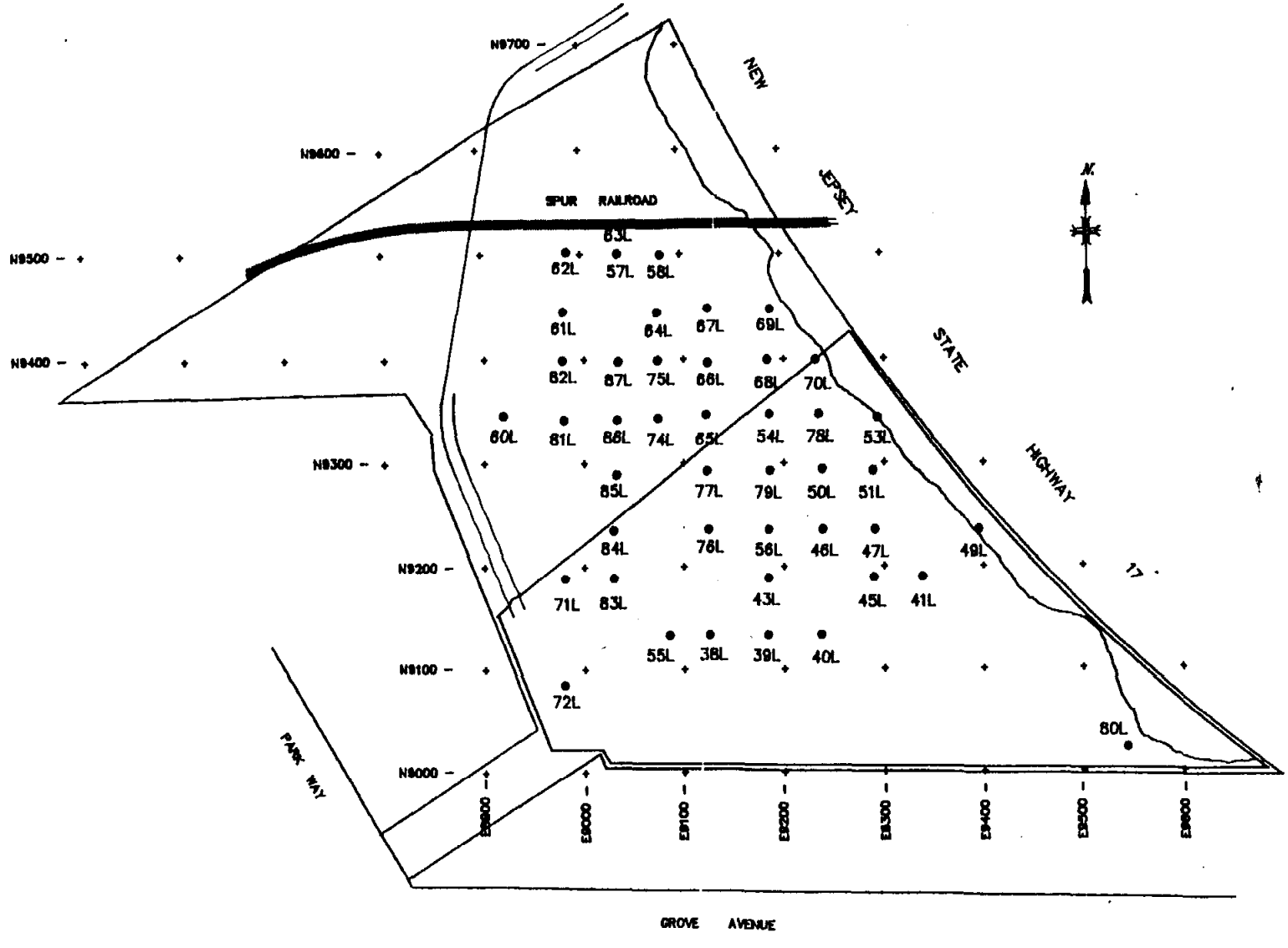

Fig. 4. Locations of systematic soil samples on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V).

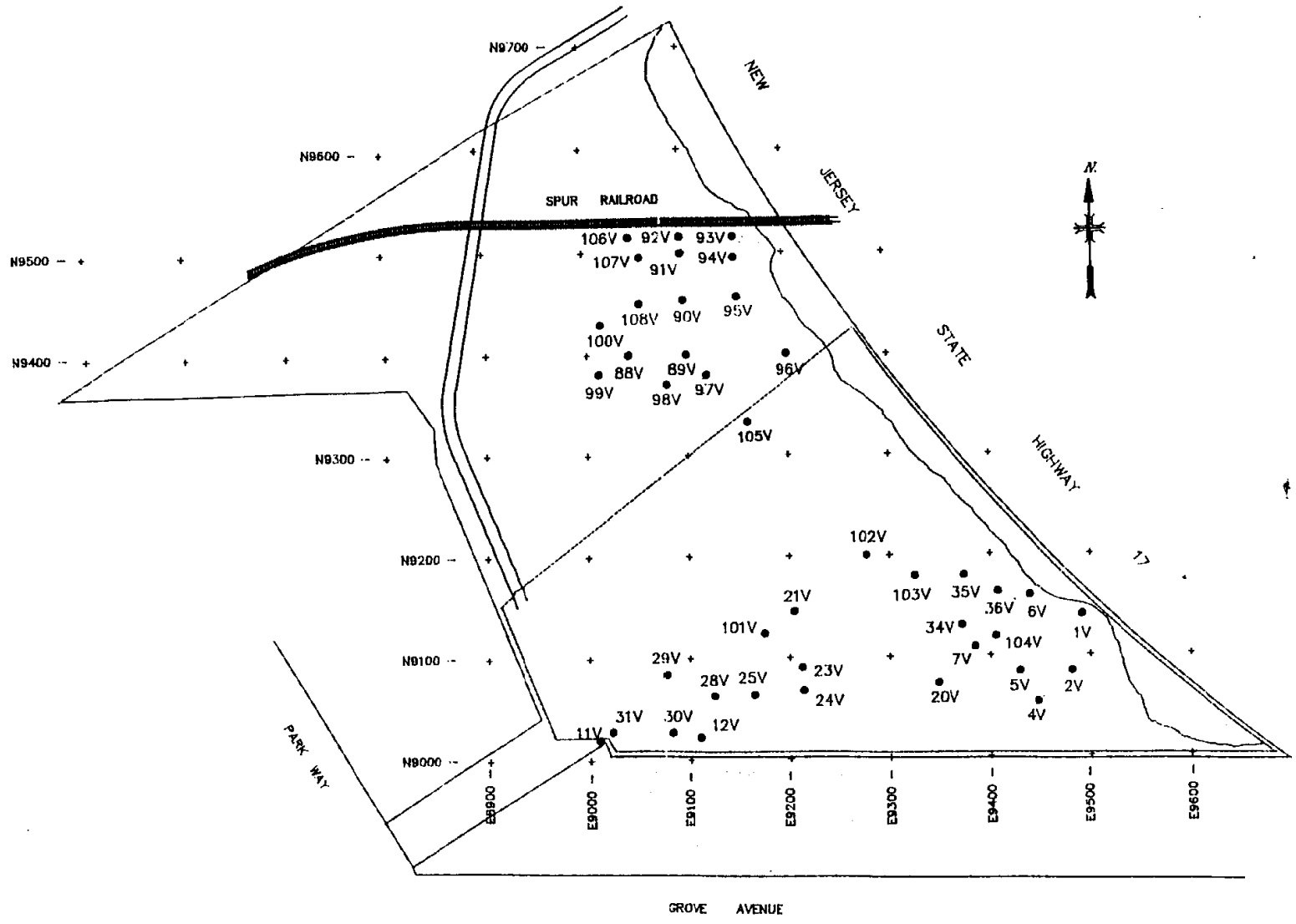

Fig. 5. Locations of verification soil samples (systematic) on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V).

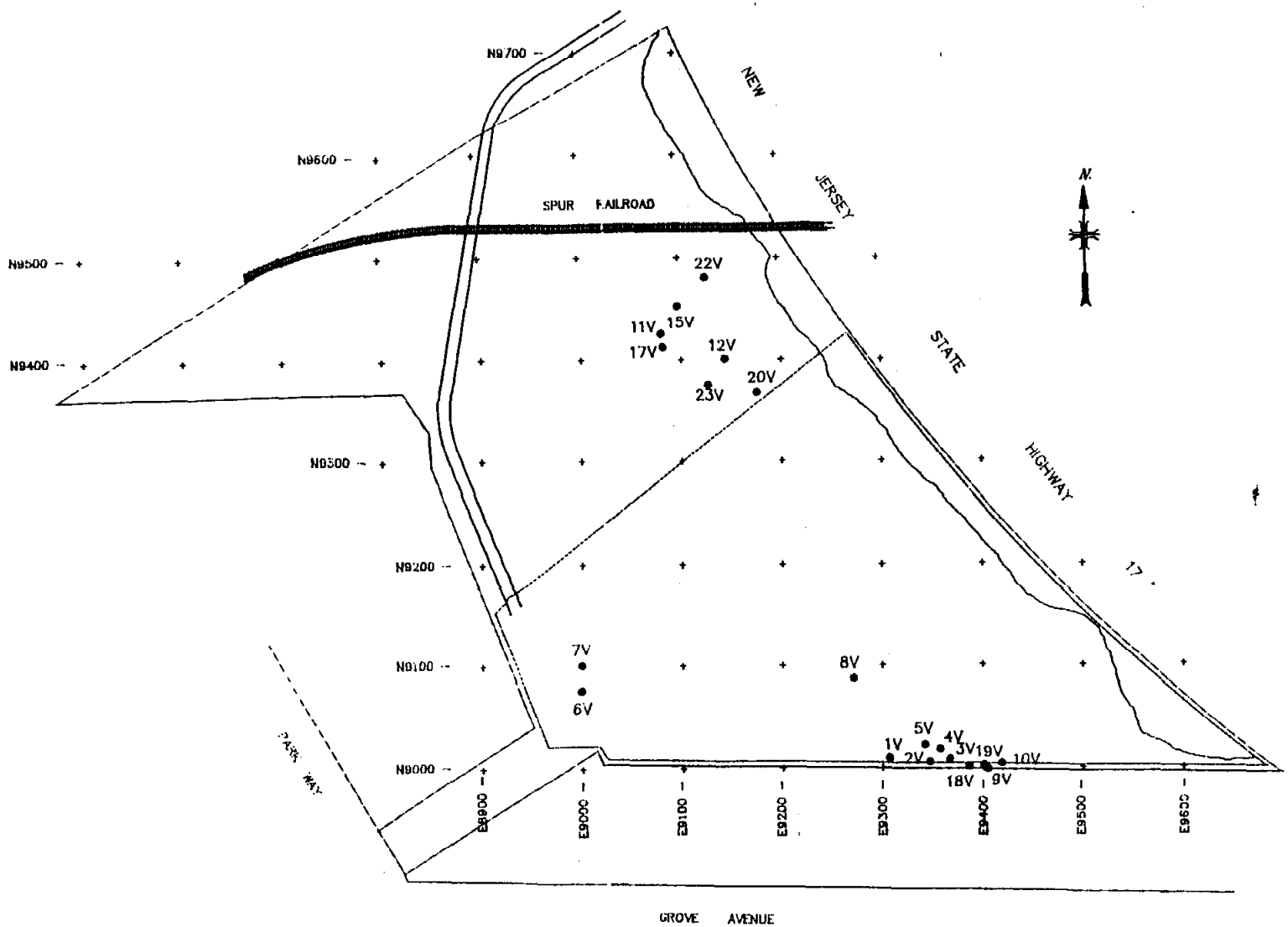

Fig. 6. Locations of verification soil samples (biased) on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V).

Table 1. Summary of residual contamination guidelines for the Rochelle Park, New Jersey, site

Soil (Land) Guidelines (Maximum Limits for Unrestricted Use)

Radionuclide	Soil concentration (pCi/g) above background[a,b]
^{226}Ra ^{228}Ra ^{230}Th ^{232}Th	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use

Structure Guidelines (Maximum Limits for Unrestricted Use)

Indoor Radon Decay Products

For ^{222}Ra and ^{220}Rn concentrations in buildings, the average annual radon decay product concentration (including background) due to uranium or thorium by-products should not exceed 0.02 WL after remedial action. When remedial action has been performed and it would be unreasonably difficult and costly to reduce the level below 0.03 WL, the remedial action may be terminated, and the reasons for termination should be documented. Remedial action shall be undertaken for any building that exceeds an annual average radon decay product concentration (including background) of 0.03 WL.

Indoor Gamma Radiation

The indoor gamma radiation after decontamination shall not exceed 20 microroentgen per hour (20 μR/h) above background in any occupied or habitable building.

Indoor/Outdoor Structure Surface Contamination

Radionuclide[d]	Allowable Surface Residual Contamination[c] (dpm/100 cm^2)		
	Average[e,f]	Maximum[e]	Removable[e]
Transuranics, ^{226}Ra, ^{228}Ru, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac, ^{125}I, ^{129}I	100	300	20
Natural Th, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, ^{133}I	1,000	3,000	200
Natural U, ^{235}U, ^{238}U, and associated decay products	5,000	15,000	1,000

Table 1 (continued)

Indoor/Outdoor Structure Surface Contamination

Radionuclide[d]	Allowable Surface Residual Contamination[c] (dpm/100 cm^2)		
	Average[e,f]	Maximum[e]	Removable[e]
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above	5,000	15,000	1,000

[a]In the event of occurrence of mixtures of radionuclides, the fraction contributed by each radionuclide to its limit shall be determined, and the sum of these fractions shall not exceed 1.

[b]These guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100-m^2 surface area.

[c]As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[d]Where surface contamination by both alpha- and beta-gamma–emitting radionuclides exists, the limits established for alpha- and beta-gamma–emitting radionuclides shall apply independently.

[e]Measurements of average contaminant should not be averaged over more than 1 m^2. For objects of less surface area, the average shall be derived for each such object.

[f]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 mg/cm^2 of total absorber.

Table 2. Background radiation levels in the Rochelle Park, New Jersey, and surrounding area

Type of radiation measurement or sample	Radiation level or radionuclide concentration	
	Range	Average
Gamma exposure rate at 1 m above floor or ground surface (μR/h)[a]	8–11	9
Concentration of radionuclides in soil (pCi/g)[b]		
^{238}U	0.13–1.4	0.86
^{226}Ra	0.24–1.4	0.87
^{232}Th	0.31–1.5	0.9

[a]Values obtained from 35 locations in the Rochelle Park area.[8]

[b]Soil samples obtained from locations around the Maywood area.[6]

Table 3. Results and locations of the gamma exposure rate measurements on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V)

Coordinates[a]		Gamma exposure rate at 1 m (μR/h)	Gamma exposure rate at the ground surface (μR/h)
East	North		
8850	9500	12	12
8850	9450	11	11
8850	9400	11	11
8850	9350	11	9
8850	9300	9	9
8850	9250	9	9
8850	9200	9	9
8900	9500	13	13
8900	9450	12	11
8900	9400	12	13
8900	9350	10	10
8900	9300	10	10
8900	9250	10	11
8900	9200	9	9
8950	9450	13	13
8950	9400	12	12
9000	9450	13	15
9000	9400	13	12
9000	9350	11	11
9000	9300	9	9
9000	9250	9	10
9000	9200	9	9
9000	9150	9	9
9000	9100	9	9
9000	9050	9	8
9000	9000	8	8
9050	9400	13	13
9050	9350	12	12
9050	9300	11	11
9050	9250	11	11
9050	9200	10	10
9050	9150	10	10
9050	9100	9	9
9050	9050	9	9
9046	9081	9	8
9100	9400	12	10
9100	9350	11	12
9100	9300	10	10
9100	9250	10	10
9100	9200	9	10
9100	9150	9	9

Table 3 (continued)

Coordinates[a]		Gamma exposure rate at 1 m (μR/h)	Gamma exposure rate at the ground surface (μR/h)
East	North		
9100	9100	8	9
9100	9050	8	8
9100	9000	8	8
9150	9450	14	14
9150	9350	12	12
9150	9300	11	11
9150	9250	10	10
9150	9150	9	9
9150	9100	9	9
9150	9050	9	9
9150	9000	8	8
9200	9150	9	10
9200	9100	9	9
9200	9050	9	9
9200	9000	8	8
9250	9250	10	10
9250	9200	10	10
9250	9150	10	9
9250	9100	9	10
9250	9050	9	9
9250	9000	9	9
9300	9250	10	11
9300	9200	10	10
9300	9150	10	9
9300	9100	10	10
9300	9050	10	9
9300	9000	9	9
9350	9200	10	10
9350	9150	10	10
9350	9100	11	10
9350	9050	10	10
9350	9000	10	9
9400	9150	11	11
9400	9100	10	10
9400	9050	10	10
9400	9000	12	15
9450	9100	11	11
9450	9050	11	10
9450	9000	10	10
9500	9000	10	10
9550	9000	10	10

[a]Grid block locations are shown in Fig. 2.

Table 4. Results of soil sample analyses by ORNL on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V)

BNI results are shown in parentheses

Sample	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g)		
	East	North		^{226}Ra[b]	^{232}Th[b]	^{238}U[c]
				Systematic Samples[d]		
38L	9125	9125	0–15	0.71 ± 0.1 (0.5)	1.5 ± 0.1 (1.1)	0.9 (<1.6)
39L	9175	9125	0–15	0.84 ± 0.2 (0.7)	2.6 ± 0.2 (3.7)	2.0 (<1.5)
40L	9225	9125	0–13	0.73 ± 0.07 (0.5)	1.5 ± 0.1 (1.0)	0.02 (1.1)
41L	9325	9175	0–13	0.33 ± 0.09 (0.3)	0.41 ± 0.05 (0.3)	0.5 (<1.7)
43L	9175	9175	0–15	0.29 ± 0.03 (0.2)	0.35 ± 0.02 (0.3)	0.3 (<1.8)
45L	9275	9175	0–13	0.32 ± 0.1 (0.2)	0.45 ± 0.06 (0.6)	0.6 (<2.1)
46L	9225	9225	0–15	0.40 ± 0.1 (0.3)	1.9 ± 0.1 (1.8)	0.8 (0.6)
47L	9275	9225	0–15	0.24 ± 0.04 (0.2)	0.4 ± 0.02 (0.4)	0.3 (<0.6)
49L	9375	9225	0–15	1.2 ± 0.2 (0.2)	4.7 ± 0.2 (0.4)	2.0 (<0.7)
50L	9225	9275	0–15	0.28 ± 0.09 (0.2)	0.39 ± 0.06 (0.4)	0.7 (<1.0)
51L	9275	9275	0–15	0.46 ± 0.05 (0.5)	0.68 ± 0.03 (2.1)	0.86 ±.59 (2.2)
53L	9275	9325	0–15	0.61 ± 0.05 (0.7)	1.6 ± 0.1 (1.6)	0.8 (<2.1)
54L	9575	9175	0–15	0.83 ± 0.2 (1.1)	1.7 ± 0.1 (2.9)	0.9 (1.3)
55L	9075	9125	0–13	0.64 ± 0.1 (0.6)	0.93 ± 0.08 (1.1)	0.9 (<2.5)
56L	9175	9225	0–15	0.48 ± 0.1 (0.4)	0.46 ± 0.06 (0.4)	0.8 (<1.3)
57L	9025	9475	0–15	0.64 ± 0.1 (0.7)	2.3 ± 0.1 (2.0)	1.0 (<2.4)
58L	9075	9475	0–15	0.60 ± 0.1 (0.6)	0.89 ± 0.09 (0.8)	0.7 (<1.0)
60L	8925	9325	0–15	0.48 ± 0.1 (0.3)	0.56 ± 0.05 (0.6)	0.8 (<1.4)
61L	8975	9425	0–15	0.74 ± 0.1 (0.4)	1.5 ± 0.1 (1.2)	0.8 (<1.1)
62L	8975	9475	0–15	0.68 ± 0.1 (0.6)	1.2 ± 0.1 (1.8)	0.7 (<1.4)
63L	9025	9475	0–15	0.69 ± 0.1 (0.7)	1.5 ± 0.1 (2.0)	0.9 (<2.4)
64L	9075	9425	0–15	0.71 ± 0.1 (0.5)	1.0 ± 0.1 (0.9)	0.9 (<1.4)
65L	9125	9325	0–15	0.61 ± 0.1 (0.6)	1.1 ± 0.1 (1.1)	0.7 (<2.5)
66L	9125	9375	0–15	0.62 ± 0.05 (0.5)	1.4 ± 0.1 (1.4)	1.0 (<2.8)
67L	9125	9425	0–15	0.55 ± 0.2 (0.3)	0.68 ± 0.06 (1.0)	0.8 (<2.8)
68L	9175	9375	0–15	0.56 ± 0.1 (0.5)	0.74 ± 0.07 (0.7)	0.7 (1.4)
69L	9175	9425	0–15	0.86 ± 0.2 (0.6)	2.3 ± 0.1 (1.7)	1.0 (<3.1)
70L	9225	9375	0–15	0.76 ± 0.2 (0.6)	1.9 ± 0.1 (1.4)	1.0 (<1.0)
71L	8975	9175	0–15	0.78 ± 0.1 (0.4)	0.83 ± 0.08 (0.8)	0.8 (<2.6)
72L	8975	9075	0–15	0.33 ± 0.1 (0.2)	0.71 ± 0.07 (0.6)	0.6 (<1.9)
74L	9075	9325	0–15	0.61 ± 0.1 (0.5)	0.93 ± 0.08 (1.0)	0.8 (<2.0)
75L	9075	9375	0–15	0.62 ± 0.1 (0.5)	1.5 ± 0.1 (0.9)	0.9 (<13.3)
76L	9125	9225	0–15	0.55 ± 0.09 (0.3)	0.72 ± 0.06 (0.8)	0.7 (<2.1)
77L	9125	9275	0–15	0.54 ± 0.1 (0.4)	0.64 ± 0.07 (0.6)	0.7 (<2.0)
78L	9225	9325	0–15	0.79 ± 0.2 (0.6)	2.6 ± 0.1 (2.3)	0.9 (<1.4)
79L	9175	9275	0–15	0.63 ± 0.1 (0.6)	1.4 ± 0.1 (1.8)	0.7 (<1.9)
80L	9525	9025	0–15	0.56 ± 0.1 (0.5)	0.85 ± 0.07 (0.6)	0.7 (<2.2)
81L	8975	9325	0–15	0.61 ± 0.1 (0.6)	0.77 ± 0.07 (<0.7)	0.9 (<2.3)

Table 4 (continued)

Sample	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g)		
	East	North		^{226}Ra[b]	^{232}Th[b]	^{238}U[c]
				Systematic Samples[d]		
82L	8975	9375	0–15	0.80 ± 0.1 (0.5)	1.1 ± 0.1 (1.3)	0.7 (<2.9)
83L	9025	9175	0–15	0.58 ± 0.1 (0.4)	0.88 ± 0.08 (0.8)	0.9 (<1.0)
84L	9025	9225	0–15	0.62 ± 0.1 (0.4)	0.83 ± 0.07 (0.8)	0.8 (<1.4)
85L	9025	9275	0–15	0.55 ± 0.1 (0.5)	0.68 ± 0.08 (0.7)	0.8 (<1.4)
86L	9025	9325	0–15	0.56 ± 0.1 (0.5)	0.70 ± 0.06 (0.9)	0.8 (<0.8)
87L	9025	9375	0–15	0.65 ± 0.1 (0.4)	0.88 ± 0.09 (0.7)	0.8 (0.8)

[a]Locations of soil samples are shown on Fig. 4.
[b]Indicated counting error is at the 95% confidence level ($\pm 2\sigma$).
[c]Analytical error of measurement results is less than ± 5% (95% confidence level).
[d]Systematic samples are taken at grid locations irrespective of gamma exposure.

Table 5. Results of verification analyses of systematic soil samples taken by ORNL on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V)

Sample	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g)		
	East	North		^{226}Ra[b]	^{232}Th[b]	^{238}U[c]
Systematic Samples[d]						
01V	9485	9126	0–5	1.1 ± 0.09	1.4 ± 0.4	1.5
02V	9475	9075	0–5	0.50 ± 0.08	0.73 ± 0.2	0.57
04V	9442	9042	0–5	0.66 ± 0.04	0.93 ± 0.2	0.67
05V	9425	9075	0–5	0.24 ± 0.06	0.34 ± 0.2	0.3
06V	9434	9140	0–5	2.0 ± 0.2	2.9 ± 0.6	1.7
07V	9390	9105	0–5	0.44 ± 0.06	0.51 ± 0.2	0.43
11V	9025	9013	0–5	1.2 ± 0.2	1.4 ± 0.6	2.2
12V	9115	9115	0–5	0.85 ± 0.01	3.9 ± 0.9	0.93
20V	9351	9070	0–5	0.96 ± 0.05	2.9 ± 0.7	1.2
21V	9206	9140	0–5	0.72 ± 0.04	4.4 ± 0.9	1.5
23V	9225	9075	0–5	0.49 ± 0.05	0.67 ± 0.2	0.57
24V	9210	9040	0–5	1.1 ± 0.05	3.7 ± 0.9	1.3
25V	9160	9045	0–5	0.47 ± 0.08	0.66 ± 0.2	0.53
28V	9125	9060	0–5	1.2 ± 0.1	1.3 ± 0.4	4.2
29V	9075	9075	0–5	1.3 ± 0.2	0.9 ± 0.3	4.5
30V	9075	9025	0–5	0.81 ± 0.2	0.95 ± 0.2	1.1
31V	9025	9025	0–5	0.68 ± 0.03	0.64 ± 0.2	1.3
34V	9375	9125	0–5	0.52 ± 0.04	0.56 ± 0.04	0.77
35V	9375	9175	0–5	0.34 ± 0.05	0.98 ± 0.3	0.5
36V	9405	9155	0–5	1.9 ± 0.1	3.5 ± 0.8	2.0
88V	9050	9400	0–15	0.58 ± 0.1	1.5 ± 0.2	0.8
89V	9100	9400	0–15	0.46 ± 0.06	0.96 ± 0.1	0.6
90V	9100	9450	0–15	0.92 ± 0.06	4.3 ± 0.2	1.9
91V	9100	9500	0–15	0.64 ± 0.2	2.9 ± 0.4	1.0
92V	9100	9521	0–15	0.73 ± 0.05	3.3 ± 0.5	1.0
93V	9150	9518	0–15	0.72 ± 0.07	4.2 ± 0.6	1.6
94V	9150	9500	0–15	0.56 ± 0.2	2.1 ± 0.04	1.0
95V	9150	9450	0–15	0.60 ± 0.05	2.4 ± 0.2	1.1
96V	9200	9400	0–15	0.84 ± 0.07	1.3 ± 0.1	1.1
97V	9125	9375	15–30	1.0 ± 0.7	12 ± 1	3.3
98V	9075	9375	0–15	0.60 ± 0.07	1.5 ± 0.1	0.8
99V	9024	9375	0–15	0.57 ± 0.03	1.1 ± 0.1	0.8

Table 5 (continued)

Sample	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g)		
	East	North		^{226}Ra[b]	^{232}Th[b]	^{238}U[c]
			Systematic Samples[d]			
100V	9025	9425	0–15	0.55 ± 0.08	1.0 ± 0.2	0.77
101V	9175	9125	0–15	0.45 ± 0.06	0.73 ± 0.2	0.53
102V	9225	9200	0–15	0.57 ± 0.05	0.81 ± 0.2	0.8
103V	9325	9175	0–15	0.41 ± 0.03	0.58 ± 0.09	0.5
104V	9400	9125	0–15	0.52 ± 0.06	1.1 ± 0.2	0.77
105V	9150	9350	0–15	0.51 ± 0.05	0.76 ± 0.09	0.63
106V	9050	9521	0–15	0.55 ± 0.1	1.3 ± 0.2	0.73
107V	9050	9500	0–15	0.58 ± 0.1	2.1 ± 0.2	0.83
108V	9050	9450	0–15	0.56 ± 0.04	1.4 ± 0.2	0.73

[a]Locations of soil samples are shown on Fig. 5.

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

[c]Analytical error of measurement results is less than ±5% (95% confidence level).

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

Table 6. Results of verification analyses of biased soil samples taken by ORNL on the Ballod Associates property, Rochelle Park, New Jersey (MJ18V)

Sample	Location[a]		Depth (cm)	Radionuclide concentration (pCi/g)		
	East	North		^{226}Ra[b]	^{232}Th[b]	^{238}U[c]
Biased Samples[d]						
01V	9301	9014	15–30	0.64 ± 0.07	3.0 ± 0.4	1.5
02V	9342	9008	15–30	0.74 ± 0.08	3.7 ± 0.2	1.9
03V	9363	9008	15–30	0.64 ± 0.06	2.3 ± 0.3	1.6
04AV	9351	9018	0–15	0.72 ± 0.1	3.6 ± 0.4	1.4
04BV	9351	9018	15–30	0.61 ± 0.05	1.4 ± 0.2	0.8
05V	9334	9017	15–30	0.83 ± 0.2	3.8 ± 0.3	1.3
06V	9000	9085	0–15	0.41 ± 0.01	1.1 ± 0.1	0.63
07V	9000	9100	0–15	0.52 ± 0.03	0.89 ± 0.1	0.67
08V	9260	9080	0–15	0.41 ± 0.06	2.1 ± 0.3	0.97
09V	9400	9002	15–30	0.57 ± 0.03	2.5 ± 0.2	1.0
10V	9407	8998	15–30	0.91 ± 0.1	6.0 ± 0.4	3.0
11V	9088	9425	15–30	0.80 ± 0.2	12 ± 1	5.7
12V	9150	9400	15–30	1.3 ± 0.2	2.0 ± 1	2.1
15V	9105	9442	15–30	0.98 ± 0.2	7.7 ± 0.6	2.8
17V	9087	9425	0–15	0.50 ± 0.07	3.6 ± 0.5	2.8
18AV	9388	9000	0–15	0.89 ± 0.09	3.7 ± 0.4	2.4
18BV	9388	9000	15–30	0.62 ± 0.09	1.6 ± 0.2	1.5
19V	9400	9000	15–30	0.58 ± 0.05	2.4 ± 0.2	1.0
20V	9165	9365	15–30	0.62 ± 0.1	5.2 ± 0.3	1.8
22AV	9123	9475	0–15	1.5 ± 0.1	2.6 ± 0.2	2.2
22BV	9123	9475	15–30	0.86 ± 0.1	11 ± 0.5	3.7
23V	9140	9370	0–60	0.61 ± 0.04	3.8 ± 0.4	1.7

[a]Locations of soil samples are shown on Fig. 6.

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

[c]Analytical error of measurement results is less than ±5% (95% confidence level).

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

ORNL/RASA-86/64
(MJ18V)

INTERNAL DISTRIBUTION

1. B. A. Berven
2. R. O. Chester
3. W. D. Cottrell
4. C. A. Johnson
5. S. V. Kaye
6. J. L. Marley
7. P. T. Owen
8. T. H. Row
9–13. M. G. Yalcintas
14. IR&A Publications Office
15. Laboratory Records – RC

EXTERNAL DISTRIBUTION

16–20. S. W. Ahrends, U.S. Department of Energy, Technical Services Division, Oak Ridge Operations Office, Oak Ridge, TN 37831

21. J. D. Berger, Oak Ridge Associated Universities, P.O. Box 117, Oak Ridge, TN 37831

22–24. E. G. DeLaney, U.S. Department of Energy, Director, Division of Facilities and Site Decommissioning Projects, Office of Nuclear Energy, 19901 Germantown Road, Germantown, MD 20874

25–27. C. E. Miller, U.S. Department of Energy, Director, Surplus Facilities Management, Richland Operations Office, P.O. Box 550, Richland, WA 99352

28–29. J. F. Nemec, Bechtel National, Inc., 800 Oak Ridge Turnpike, Oak Ridge, TN 37831

30. J. W. Wagoner II, U.S. Department of Energy, Division of Facilities and Site Decommissioning Projects, Office of Nuclear Energy, 19901 Germantown Road, Germantown, MD 20874

31. A. Wallo, Aerospace Corporation, Environmental and Conservation Directorate, 955 L'Enfant Plaza, SW, Suite 4000, Washington, DC 20024

32. Office of Assistant Manager, Energy Research and Development, Oak Ridge Operations Office, Oak Ridge, TN 37831

33–34. Office of Scientific and Technical Information, U.S. Department of Energy, Oak Ridge, TN 37831