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RADIOLOGICAL SURVEY OF 990 JERSEY AVENUE NEW BRUNSWICK, NEW JERSEY

T. J. VITKUS

Prepared for the
Office of Environmental Restoration
U.S. Department of Energy

ORISE

OAK RIDGE INSTITUTE FOR SCIENCE AND EDUCATION

Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

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FINAL REPORT

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Newbrunswick - November 17, 1993

RADIOLOGICAL SURVEY OF
990 JERSEY AVENUE
NEW BRUNSWICK, NEW JERSEY

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ABBREVIATIONS AND ACRONYMS

ac	acre
AEC	Atomic Energy Commission
ASME	American Society of Mechanical Engineers
BNI	Bechtel National, Inc.
cm	centimeter
cpm	counts per minute
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EML	Environmental Measurement Laboratories
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
ft^3	cubic foot
FUSRAP	Formerly Utilized Sites Remedial Action Program
GM	Geiger-Müeller
ha	hectare
kg	kilogram
km	kilometer
MeV	megaelectron volt
mi	mile
NaI	sodium iodide
NBL	New Brunswick Laboratory
NIST	National Institute of Standards and Technology
ORISE	Oak Ridge Institute for Science and Education
PMC	Project Management Contractor
ZnS	zinc sulfide

on the site. Bechtel National, Inc. (BNI), the FUSRAP project management contractor (PMC) performed a limited radiological survey of the NBL. This survey identified several areas with elevated direct gamma radiation and elevated soil concentration levels of Ra-226, Th-232, and U-238.[1] One of these contaminated locations was adjacent to the southwestern property boundary, which borders a privately owned parcel of land.

The DOE's Office of Environmental Restoration and Waste Management recommended that the current radiological condition of this vicinity property be determined and requested that the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) conduct a radiological survey of the property. This report summarizes the procedures and results of that survey.

SITE DESCRIPTION

The vicinity property is located at 990 Jersey Avenue, approximately 3.2 km (2 mi) southwest of downtown New Brunswick, New Jersey (Figure 1). The 1 ha (2.5 ac) site is in a light industrial area and contains one building, from which two separate businesses operate. The property is bounded to the northeast by NBL, to the southeast by the Pennsylvania Railroad, to the southwest by a light industrial facility, and to the northwest by Jersey Avenue (Figure 2). Surfaces are predominantly asphalt parking and driveways with smaller areas of grass and soil.

OBJECTIVE

The objective of the survey was to determine the radiological status of the site, relative to the DOE Order 5400.5 Chapter IV guidelines. The results will be used by DOE/EM to determine whether there is need for further actions under FUSRAP.

PROCEDURES

A preliminary visit was made to the site on April 20, 1993. Then on June 5 and 6, and July 8, 1993 a survey team from ESSAP performed radiological measurements and sampling at the site.

Survey activities were conducted in accordance with a May 27, 1993 site specific survey plan submitted to and approved by DOE/HQ.[2]

REFERENCE SYSTEM

ESSAP utilized prominent site features to reference measurement and sampling locations.

SURFACE SCANS

Surface scans for alpha, beta, and gamma activity were performed over 100 percent of the property grounds, using gas proportional and NaI detectors. Detectors were coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation, identified by scans, were marked for further investigation.

SOIL SAMPLING

Surface soil samples were collected from 13 locations on the property, 5 of which were locations beneath the asphalt drive that forms the northern property boundary (Figure 3). Additional subsurface samples, to depths of up to 75 cm, were collected from 4 of the 13 sampling locations.

SURFACE ACTIVITY MEASUREMENTS

Direct measurements for total alpha and total beta activity levels were made at 24 locations (Figure 4).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ESSAP's Oak Ridge, Tennessee, facility for analysis and interpretation. Soil samples were analyzed by gamma spectrometry for Ra-226, U-238, U-235, Th-232, and Th-228. Spectra were also reviewed for any other identifiable photopeaks. Alpha

spectrometry was used to analyze two composite samples for isotopic plutonium and one individual sample for isotopic uranium. Results of soil analyses were reported in units of pCi/g. Direct measurement data were converted to units of dpm/100 cm^2.

Survey results were compared with the DOE guidelines for residual contamination which are found in DOE order 5400.5 and summarized in Appendix C.

FINDINGS AND RESULTS

SURFACE SCANS

Surface scans identified one location of elevated direct gamma radiation, five times background level, on the north property boundary (Figure 5). Investigative scans determined that the elevated gamma radiation was confined to an area of approximately 1 m^2.

RADIONUCLIDE CONCENTRATIONS IN SOIL

Radionuclide concentrations in soil samples are summarized in Table 1. The concentration ranges in surface samples (0 to 15 cm) were 0.6 to 3.8 pCi/g for Ra-226, 0.4 to 2.1 pCi/g for U-238, 0.1 to 0.7 pCi/g for U-235, 0.7 to 1.5 pCi/g for Th-232, and 0.8 to 1.2 pCi/g for Th-228. Concentration ranges in subsurface samples (greater than 15 cm in depth) were 0.5 to 22.0 pCi/g for Ra-226, 0.7 to 9.5 pCi/g for U-238, 0.1 to 3.4 pCi/g for U-235, 0.8 to 2.1 pCi/g for Th-232, and 1.0 to 1.7 pCi/g for Th-228. The plutonium concentration levels in the two composite samples were less than the minimum detectable activities of the procedures which were less than 0.08 pCi/g for Pu-238 and less than 0.07 pCi/g for Pu-239/240. The U-238 to U-234 ratio provided by the isotopic uranium analysis of the sample from the 30 to 45 cm depth of location #1 indicated that the uranium present was in naturally occurring isotopic abundances.

SURFACE ACTIVITY LEVELS

All surface activity levels were less than 66 dpm/100 cm^2 for alpha and less than 590 dpm/100 cm^2 for beta.

COMPARISON OF RESULTS WITH GUIDELINES

The radionuclide soil concentrations and the surface activity levels were compared with the DOE guidelines summarized in Appendix C.

The generic DOE guidelines for residual above background concentrations of radionuclides in soil, assuming secular equilibrium, are as follows:

Ra-226, Ra-228, Th-230, and Th-232	— 5 pCi/g averaged over the first 15 cm of soil below the surface — 15 pCi/g averaged over 15 cm thick layers of soil more than 15 cm below the surface

The 30 to 45 cm depth interval sample from location #1 contained 22.0 pCi/g of Ra-226, which exceeds the 15 pCi/g above background guideline. However, the guidelines permit averaging the soil concentration levels over an area of up to 100 m^2. The mean Ra-226 concentration for the contiguous area, developed from the Table 1 results for location #'s 1, 3 (18 m from location #1), 4 (23 m from location #1), and 13 (4 m from location #1) at the 30 to 45 cm depth interval, was 6.2 pCi/g.

The most restrictive total surface contamination guidelines found in Appendix C were used for alpha and beta activity level comparisons. Total alpha activity levels were therefore compared to Ra-226 guidelines, of 100 dpm/100 cm^2, average in a 1 m^2 area, and 300 dpm/100 cm^2, maximum in a 100 cm^2 area.[3] Total beta activity levels were compared to the Th-232 guidelines

of 1000 dpm/100 cm^2, average in a 1 m^2 area and 3000 dpm/100 cm^2, maximum in a 100 cm^2 area. All measured activity levels were well within these guidelines.

SUMMARY

The Environmental Survey and Site assessment Program performed a limited radiological survey of a vicinity property of the New Brunswick Laboratory on June 5 and 6, and July 8, 1993. Survey activities included surface scans, direct measurements, and soil sampling.

The survey identified one localized subsurface area of soil, adjacent to contamination previously identified on the New Brunswick Laboratory site, with approximately 22.0 pCi/g of Ra-226. The subsurface zone containing elevated concentrations of Ra-226 ranged from 15 cm to 60 cm in depth, with the highest concentration at the 30 to 45 cm depth. However, the average Ra-226 concentration over the contiguous 100 m^2 area satisfies the guideline. Radionuclide concentration levels in all other soil samples were below guideline levels; most were within the range of typical background levels. All surface activity levels were well below guideline levels.

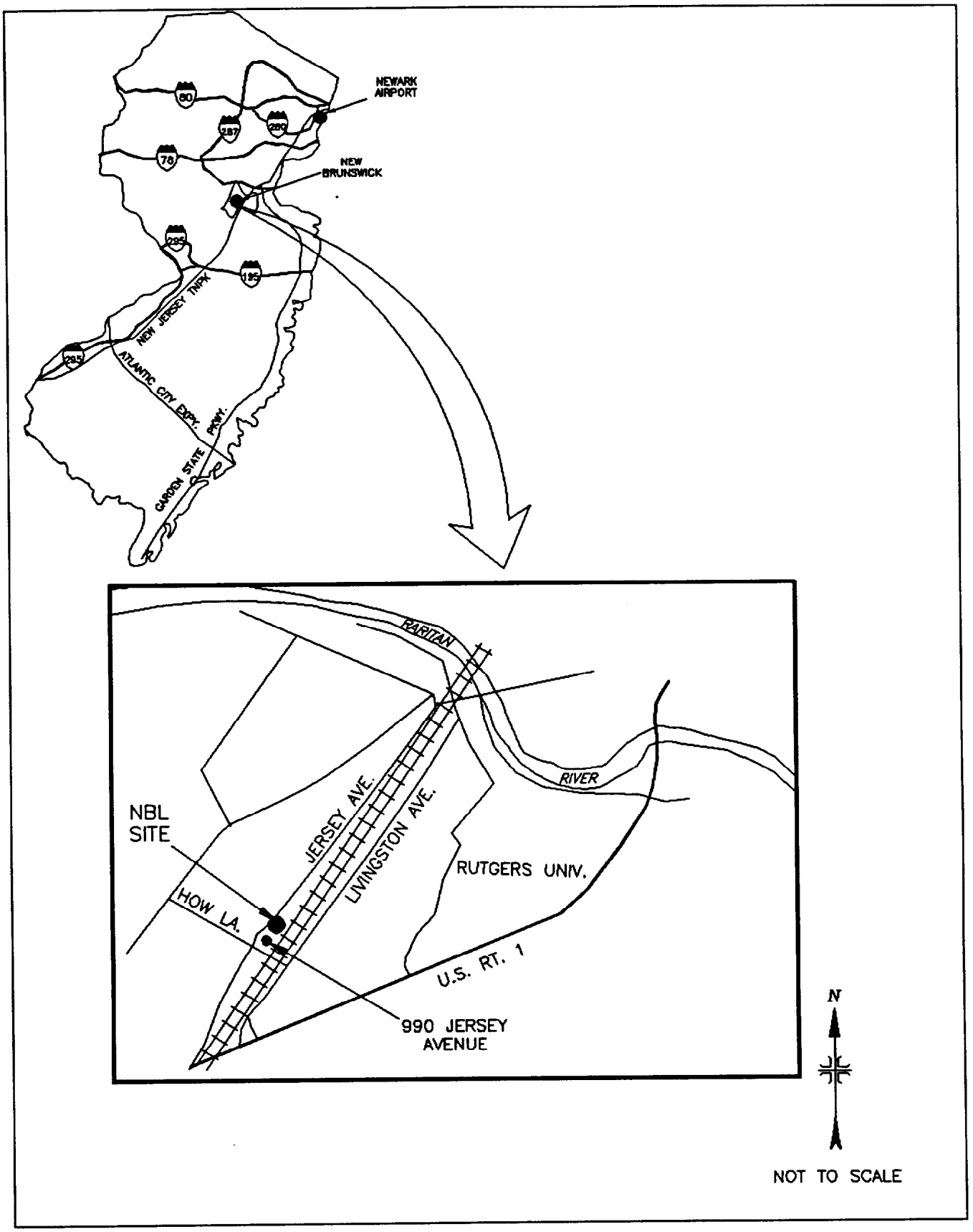

FIGURE 1: Location of the New Brunswick Laboratory Site, New Brunswick, New Jersey

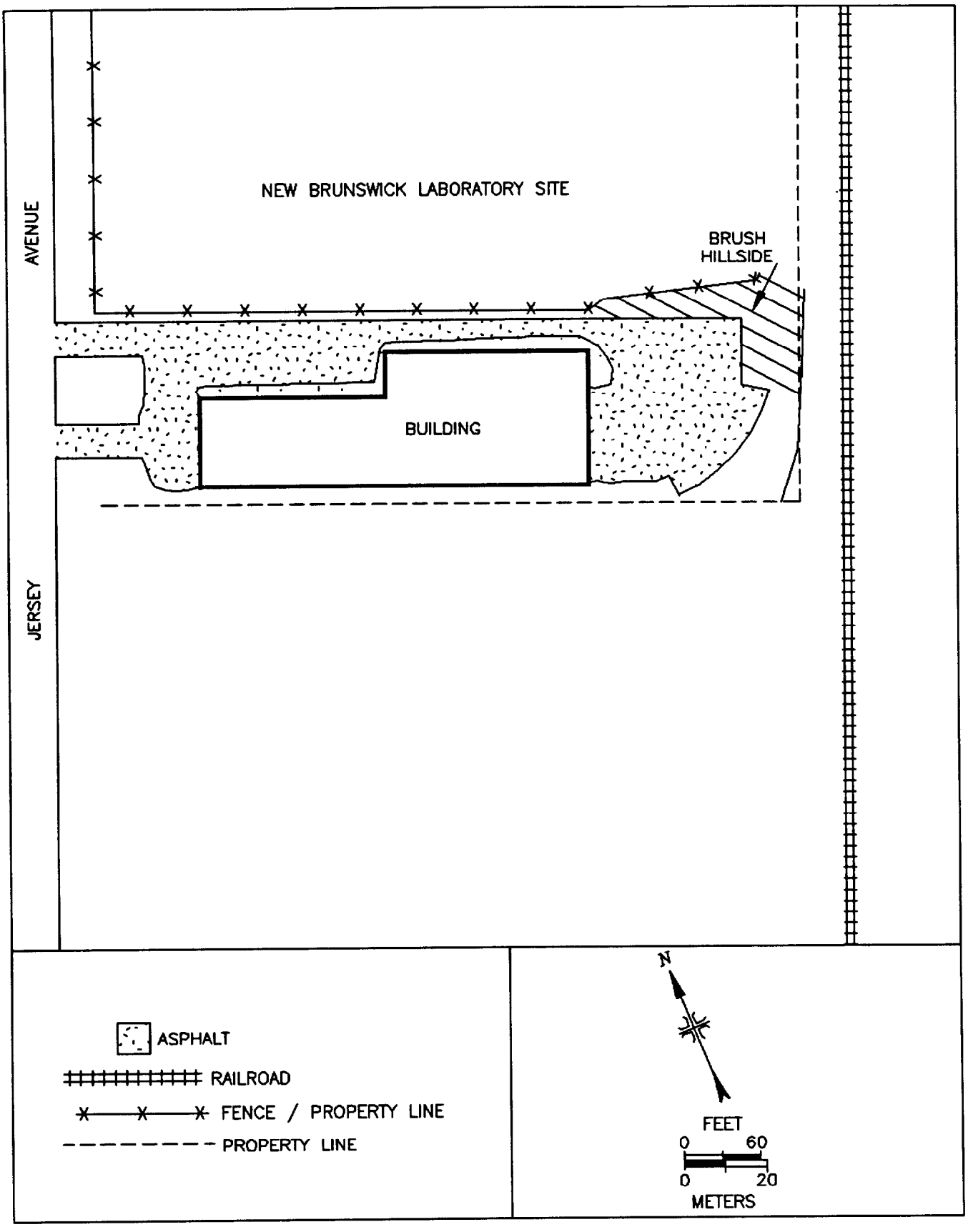

FIGURE 2: Plot Plan of the 990 Jersey Avenue Property

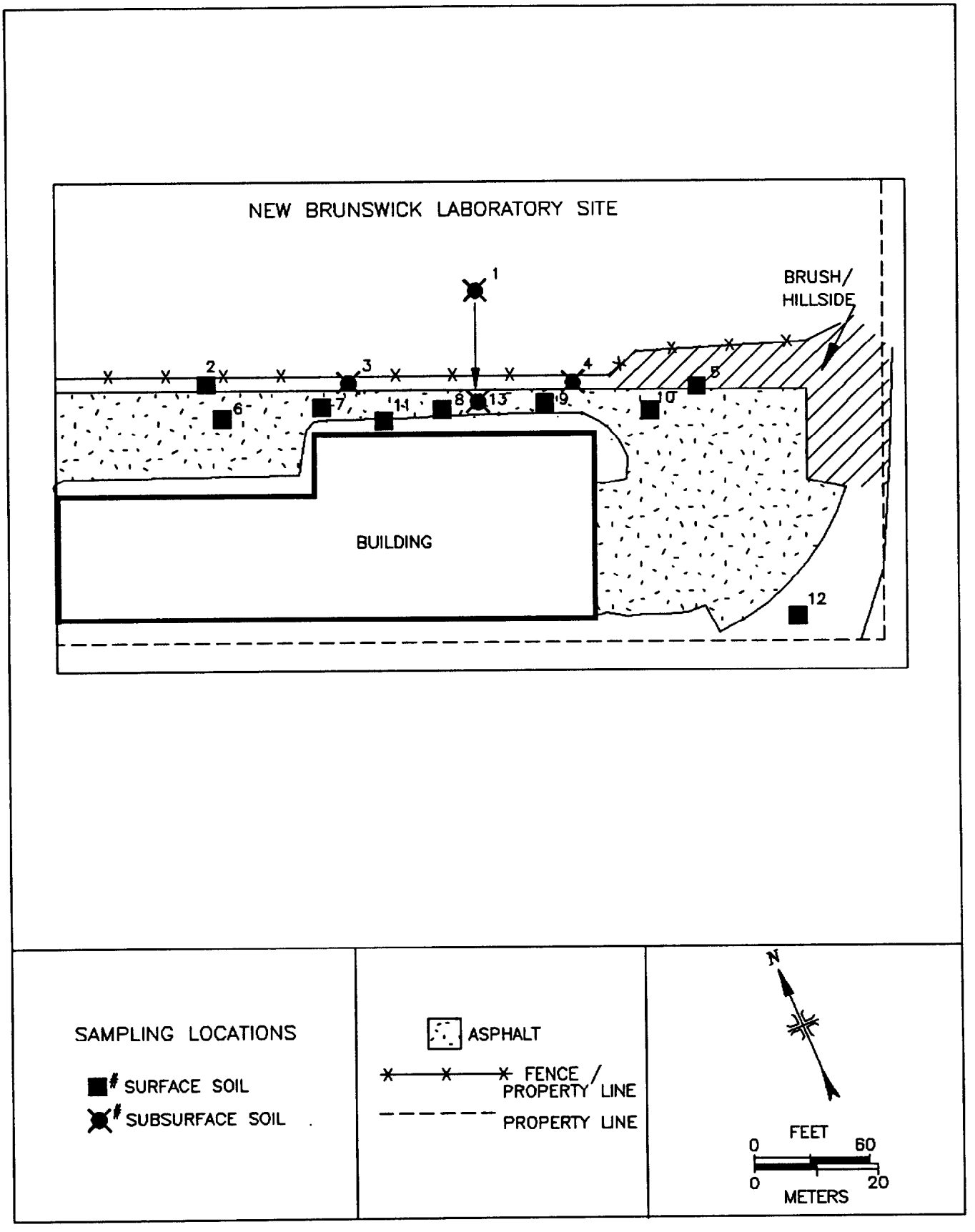

FIGURE 3: 990 Jersey Avenue – Sampling Locations

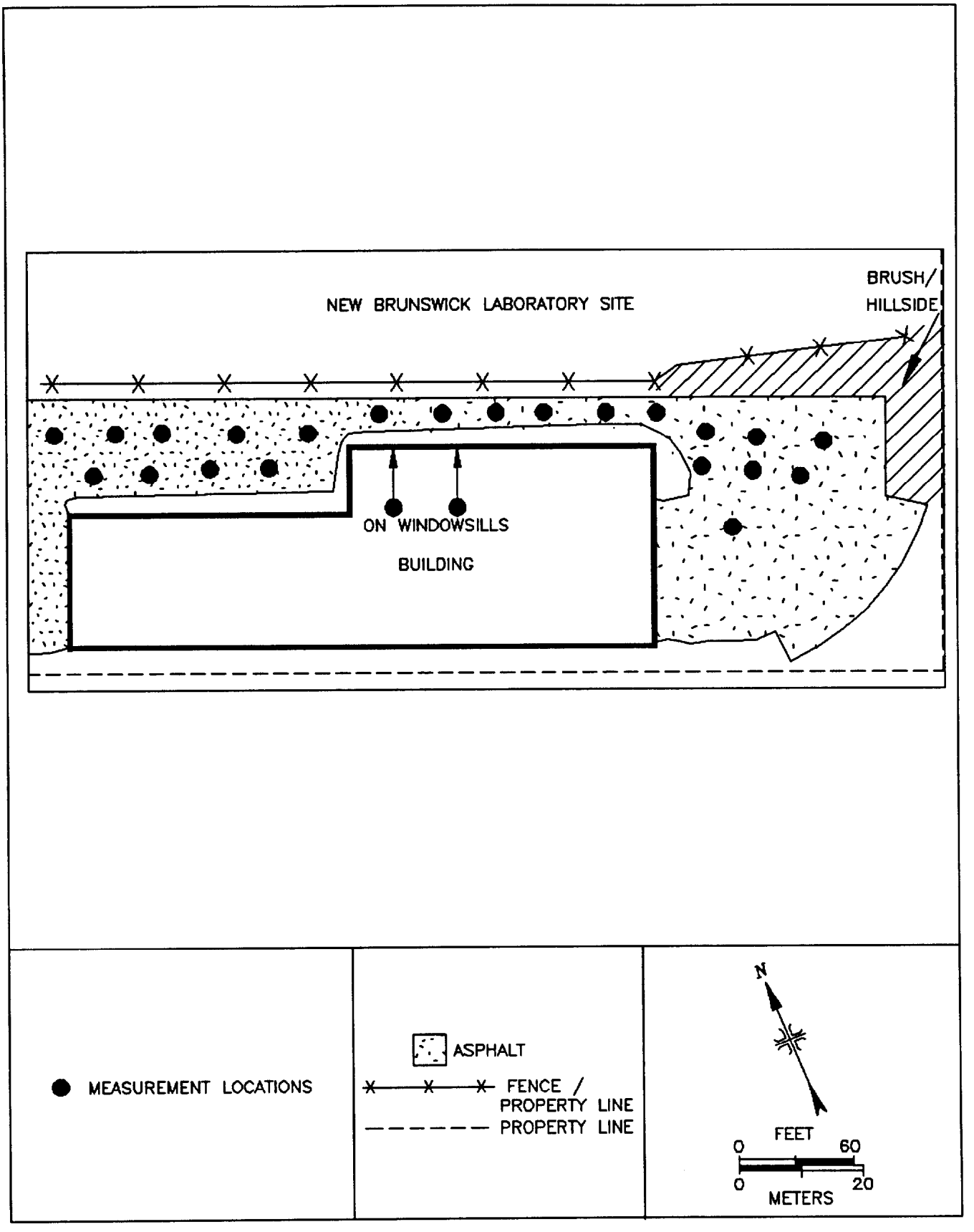

FIGURE 4: 990 Jersey Avenue – Measurement Locations

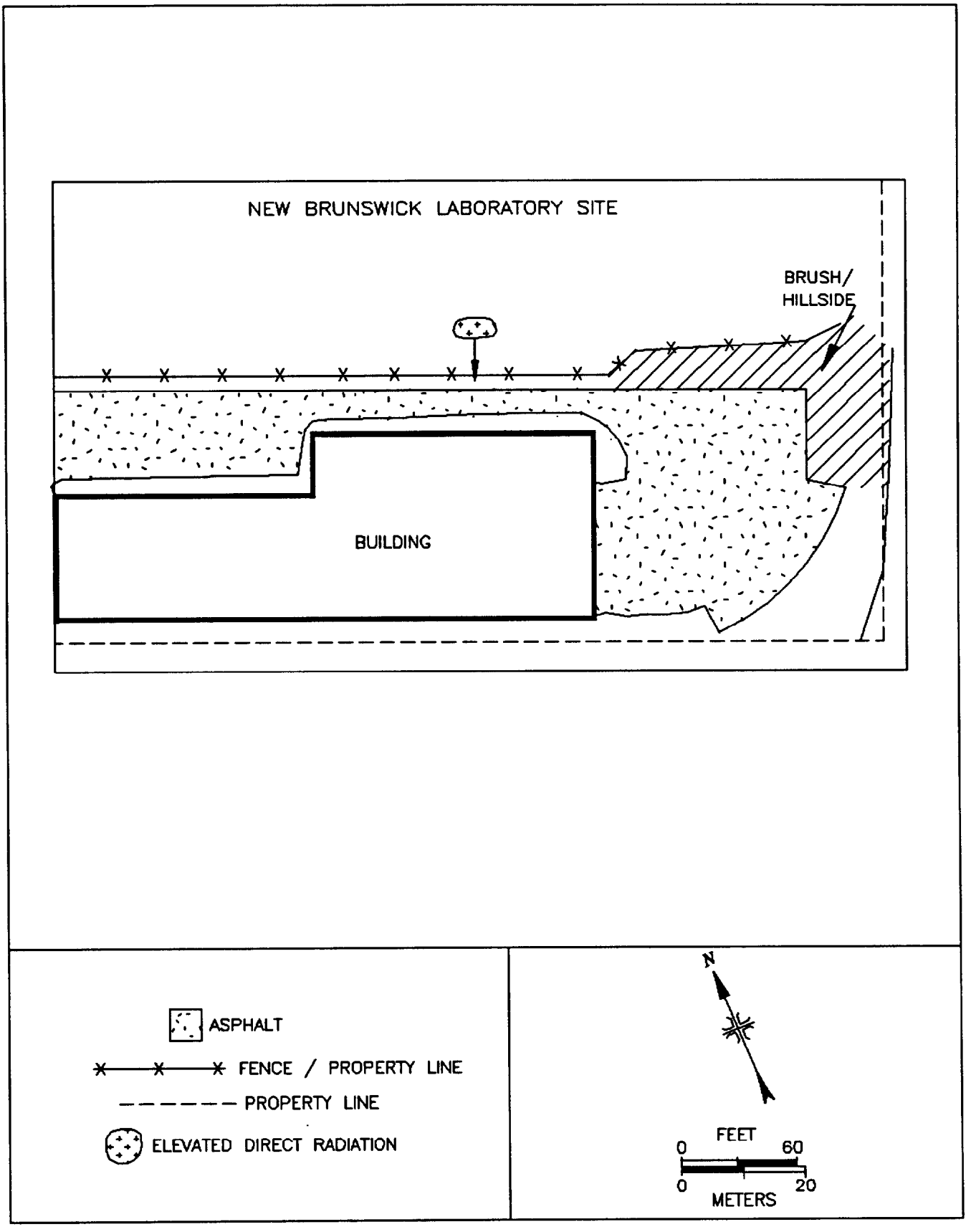

FIGURE 5: 990 Jersey Avenue — Location of Elevated Direct Radiation

TABLE 1

RADIONUCLIDE CONCENTRATIONS IN SOIL
990 JERSEY AVENUE
NEW BRUNSWICK, NEW JERSEY

Location[a] and Depth		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-238	U-235	Th-232	Th-228
1	0-15 cm	3.8 ± 0.5[b]	1.4 ± 0.4	0.7 ± 0.1	1.2 ± 0.6	1.2 ± 0.2
	15-30 cm	11.3 ± 0.8	3.6 ± 2.8	2.2 ± 0.3	2.1 ± 0.6	1.6 ± 0.2
	30-45 cm	22.0 ± 1.0	9.5 ± 3.8	3.4 ± 0.3	1.2 ± 0.6	1.5 ± 0.3
	45-60 cm	9.2 ± 1.7	2.2 ± 0.4	1.5 ± 0.1	1.2 ± 0.3	1.4 ± 0.2
	60-75 cm	3.1 ± 0.4	1.4 ± 1.4	0.4 ± 0.1	1.3 ± 0.4	1.1 ± 0.2
2	0-15 cm	0.7 ± 0.2	0.6 ± 0.9	0.1 ± 0.1	0.7 ± 0.3	0.8 ± 0.1
3	0-15 cm	0.8 ± 0.2	1.0 ± 0.4	0.1 ± 0.1	1.1 ± 0.3	1.0 ± 0.1
	15-30 cm	0.5 ± 0.2	0.7 ± 0.9	0.1 ± 0.1	0.9 ± 0.4	1.1 ± 0.1
	30-45 cm	1.0 ± 0.2	2.6 ± 1.5	0.2 ± 0.1	1.3 ± 0.3	1.2 ± 0.1
	45-60 cm	1.0 ± 0.3	1.7 ± 1.4	0.1 ± 0.1	0.8 ± 0.4	1.3 ± 0.2
	60-75 cm	0.8 ± 0.2	1.7 ± 1.2	0.1 ± 0.1	1.6 ± 0.4	1.3 ± 0.1
4	0-15 cm	0.7 ± 0.2	2.1 ± 1.7	0.1 ± 0.1	0.7 ± 0.3	0.8 ± 0.1
	15-30 cm	0.9 ± 0.2	0.9 ± 1.3	0.1 ± 0.1	1.1 ± 0.4	1.4 ± 0.1
	30-45 cm	0.9 ± 0.3	1.4 ± 1.5	0.2 ± 0.1	1.5 ± 0.6	1.7 ± 0.2
	45-60 cm	0.8 ± 0.2	1.2 ± 1.2	0.1 ± 0.1	1.2 ± 0.4	1.4 ± 0.1

TABLE 1 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL
990 JERSEY AVENUE
NEW BRUNSWICK, NEW JERSEY

Location[a] and Depth		Radionuclide Concentrations (pCi/g)				
		Ra-226	U-238	U-235	Th-232	Th-228
5	0-15 cm	0.8 ± 0.2	1.0 ± 1.3	0.1 ± 0.1	0.8 ± 0.3	1.1 ± 0.1
6	0-15 cm	0.7 ± 0.2	0.5 ± 0.8	0.1 ± 0.1	0.8 ± 0.3	0.9 ± 0.1
7	0-15 cm	0.9 ± 0.2	0.7 ± 0.3	0.1 ± 0.1	1.4 ± 0.4	1.2 ± 0.1
8	0-15 cm	0.7 ± 0.2	1.2 ± 1.0	0.1 ± 0.1	1.0 ± 0.4	1.2 ± 0.1
9	0-15 cm	0.7 ± 0.2	0.4 ± 1.0	0.1 ± 0.1	1.3 ± 0.3	1.2 ± 0.1
10	0-15 cm	0.6 ± 0.2	1.0 ± 1.0	0.1 ± 0.1	0.9 ± 0.3	0.9 ± 0.1
11	0-15 cm	0.6 ± 1.5	0.9 ± 1.2	0.1 ± 0.1	0.9 ± 0.3	1.1 ± 0.1
12	0-15 cm	2.0 ± 0.3	1.2 ± 1.5	0.3 ± 0.1	1.5 ± 0.6	1.1 ± 0.2
13	0-15 cm	0.7 ± 0.2	1.6 ± 1.1	0.1 ± 0.1	1.3 ± 0.4	0.9 ± 0.2
	15-30 cm	0.7 ± 0.3	0.8 ± 1.4	0.2 ± 0.1	1.6 ± 0.5	1.4 ± 0.2
	30-45 cm	0.8 ± 0.2	1.0 ± 1.1	0.2 ± 0.1	1.4 ± 0.4	1.3 ± 0.2
	45-60 cm	0.7 ± 0.3	1.2 ± 0.4	0.1 ± 0.1	1.1 ± 0.4	1.0 ± 0.1

[a]Refer to Figure 3.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics.

REFERENCES

1. U.S. Department of Energy, Memorandum from S. M. Cange to W. A. Williams, "Limited-Characterization Data for the New Brunswick Site," November 19, 1992.

2. Letter, T. J. Vitkus, ORISE, to W. A. Williams, Designation and Certification Manager, U.S. Department of Energy, "Proposed Radiological Survey Plan for 990 Jersey Avenue, New Brunswick Laboratory Vicinity Property, New Brunswick, New Jersey", May 27, 1993.

3. U.S. Nuclear Regulatory Commission, Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," June 1974.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A

MAJOR INSTRUMENTATION

The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the authors or their employers.

DIRECT RADIATION MEASUREMENT

Instruments

Eberline Pulse Ratemeter
Model PRM-6
(Eberline, Santa Fe, NM)

Ludlum Floor Monitor
Model 239-1
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Ludlum Ratemeter-Scaler
Model 2221
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Detectors

Eberline GM Detector
Model HP-260
Effective Area, 15.5 cm^2
(Eberline, Santa Fe, NM)

Eberline ZnS Scintillation Detector
Model AC-3-7
Effective Area, 59 cm^2
(Eberline, Santa Fe, NM)

Ludlum Gas Proportional Detector
Model 43-37
Effective Area, 550 cm^2
(Ludlum Measurements, Inc.,
Sweetwater, TX)

Victoreen NaI Scintillation Detector
Model 489-55
3.2 cm x 3.8 cm Crystal
(Victoreen, Cleveland, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

Alpha Spectrometry System
Canberra, Meriden, CT)
Used in conjunction with:
Multichannel Analyzer
3100 Vax Workstations
(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detectors
Model No: ERVDS30-25195
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-11
(Nuclear Lead, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

High-Purity Germanium Detector
Model GMX-23195-S, 23% Eff.
(EG&G ORTEC, Oak Ridge, TN)
Used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL) and
Multichannel Analyzer
3100 Vax Workstation
(Canberra, Meriden, CT)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the probes slowly over the surface; the distance between the probe and the surface was maintained at a minimum - nominally about 1 cm. A large surface area, gas proportional floor monitor was used to scan the paved portions of the surveyed areas. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

Alpha	—	gas proportional detector with ratemeter-scaler
Beta	—	gas proportional detector with ratemeter-scaler
Gamma	—	NaI scintillation detector with ratemeter

Surface Activity Measurements

Measurements of total alpha and total beta activity levels were performed using ZnS scintillation and GM detectors with ratemeters-scalers. Count rates (cpm), which were integrated over 1 minute for alpha measurements and 5 minutes for beta measurements in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net rate by the 4 π efficiency and correcting for sample count time and the active area of the detector. The alpha activity background countrate for the ZnS scintillation detector was 1 cpm. The alpha efficiency factor was 0.19 for the ZnS scintillation detector. The beta activity background count rate for the GM detector averaged 56 cpm. The beta efficiency factor was 0.17 for the GM detector. The

effective windows for the ZnS scintillation and GM detectors were 59 cm^2, and 15.5 cm^2, respectively.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Gamma Spectrometry

Soil Samples

Soil samples were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry and ranged from 500 to 800 g of material. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

Ra-226	0.609 MeV from Bi-214*
Th-228	0.239 MeV from Pb-212
Th-232	0.911 MeV from Ac-228*
U-235	0.186 MeV
U-238	0.063 and 0.093 MeV from Th-234* (or 1.001 MeV from Pa-234 m)*

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

Alpha Spectrometry

Soil Samples

Soil was crushed, homogenized and analyzed for isotopic plutonium and uranium. Samples were dissolved by potassium fluoride and pyrosulfate fusion and the elements of interest were precipitated with barium sulfate. Barium sulfate precipitate was redissolved and the specific elements of interest were individually separated by liquid-liquid extraction and re-precipitated with a cerium fluoride carrier. The precipitate was then counted using surface barrier and ion implanted detectors (Canberra), alpha spectrometers (Tennelec and Canberra), and a multichannel analyzer (Nuclear Data).

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent the 95% confidence level for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. When the net sample count was less than 2.71 + 4.66 times the statistical deviation of the background count, the sample concentration was reported as less than the detection limit of the measurement procedures. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

CALIBRATION AND QUALITY ASSURANCE

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual Revision 7 (May 1992)
- Laboratory Procedures Manual Revision 7 (April 1992)
- Quality Assurance Manual Revision 5 (May 1992)

The procedures contained in these manuals were developed to meet the requirements of DOE Order 5700.6C and ASME NQA-1 for Quality Assurance and contain measures to assess processes during their performance.

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations,
- Participation in EPA and EML Quality Assurance Programs,
- Training and certification of all individuals performing procedures, and
- Periodic internal and external audits.

APPENDIX C

SUMMARY OF DEPARTMENT OF ENERGY RESIDUAL RADIOACTIVE MATERIAL GUIDELINES

APPENDIX C

SUMMARY OF DEPARTMENT OF ENERGY RESIDUAL RADIOACTIVE MATERIAL GUIDELINES[1]

BASIC DOSE LIMITS

The basic dose limit for the annual radiation dose (excluding radon) received by an individual member of the general public is 100 mrem/yr.[2] In implementing this limit, DOE applies as low as reasonably achievable principles to set site-specific guidelines.

EXTERNAL GAMMA RADIATION

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restriction on its use shall not exceed the background level by more than 20 μR/h and will comply with the basic dose limits when an appropriate-use scenario is considered.

SURFACE CONTAMINATION GUIDELINES

	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[a]		
Radionuclides[b]	Average[c,d]	Maximum[d,e]	Removable[d,f]
Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000β-γ	15,000β-γ	1,000β-γ

[a] 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 measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

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

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

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at a depth of 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 cm^2.

[f] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping an area of that size with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

SOIL GUIDELINES

Radionuclides	Soil Concentration (pCi/g) Above Background[a,b,c]
Radium-226, Radium-228, Thorium-230, Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface.
Other Radionuclides	Soil guidelines are calculated on a site-specific basis, using the DOE manual developed for this use.

[a] These guidelines take into account ingrowth of radium-226 from thorium-230 or thorium-232 and radium-228 and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that (1) the dose for the mixtures will not exceed the basic

dose limit, or (2) the sum of ratios of the soil concentration of each radionuclide to the allowable limit for that radionuclide will not exceed 1 ("unity").

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

[c] If the average concentration in any surface or below-surface area, less than or equal to 25 m^2, exceeds the authorized limit of guideline by a factor of $(100/A)^{1/2}$, where A is the area or the elevated region in square meters, limits for "hot spots" shall also be applicable. Procedures for calculating these hot spot limits, which depend on the extent of the elevated local concentrations, are given in the DOE Manual for Implementing Residual Radioactive Materials Guidelines.[3] In addition, every reasonable effort shall be made to remove any source of radionuclide that exceeds 30 times the appropriate limit for soil, irrespective of the average concentration in the soil.

REFERENCES

1. "Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," U.S. Department of Energy, Revision 2, March 1987.

2. "Radiation Protection of the Public and the Environment," DOE Order 5400.5, U.S. Department of Energy, February 8, 1990.

3. Argonne National Laboratory "A Manual for Implementing Residual Radioactive Material Guidelines," DOE/CH8901, June 1989.