Prepared by
Oak Ridge Associated Universities

Prepared for
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RADIOLOGICAL SURVEY
RADIATION TECHNOLOGY INCORPORATED
(UNRESTRICTED AREA)
ROCKAWAY, NEW JERSEY

R. J. HYSONG

Radiological Site Assessment Program
Manpower Education, Research, and Training Division

DRAFT REPORT
JUNE 1987

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DRAFT REPORT

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RADIOLOGICAL SURVEY
RADIATION TECHNOLOGY INCORPORATED
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INTRODUCTION

Radiation Technology Incorporated is licensed by the Nuclear Regulatory Commission (license number 29-13613-02) to perform service irradiations of medical products and certain food, using sealed Co-60 gamma sources. Previous leakage from sources has resulted in low-level Co-60 contamination of the irradiator pool and other areas of the facility. In addition to the Co-60 contamination, some Cs-137 contamination has occurred, due to external contamination on sources, when received at the site. Radiation Technology Incorporated also is licensed to perform decontamination of reactor components. Although no decontamination operations have been conducted in recent years, such work would be a source of potential Co-60 and Cs-137 contamination on the site.

Licensed activities are performed on a 6 ha restricted access site. Radiation Technology Incorporated (RTI) also owns approximately 100 ha of property, directly across the road from the licensed site. This other property is an unrestricted area and has been leased by several different organizations in recent years. RTI has performed limited surveys of buildings and open land in the unrestricted area, to determine whether contaminated or radioactive materials may have been transferred inadvertently from the licensed site. The Nuclear Regulatory Commission's (NRC) Region I Office, requested that the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU) conduct a radiological survey of the unrestricted areas of the RTI property to determine if the licensee's contamination control procedures have been effective. The survey was performed during April 13-17, 1987. Procedures and results of that survey are presented in this report.

SITE DESCRIPTION

The RTI facilities are located on Lake Denmark Road, approximately 10 km north of Rockaway, New Jersey (Figure 1). The restricted (licensed) site is on the north side of the road; the unrestricted area is south of Denmark Road. Both areas are enclosed by chainlink fencing. Portions of the unrestricted area

are covered with dense woods or heavy undergrowth; there are small ravines and streams throughout the property. The site is partially developed with paved and unpaved roads and contains numerous buildings (Figure 2). Most of these buildings are badly deteriorated and contain refuse and discarded equipment.

SURVEY PROCEDURES

Objective

The objective of the ORAU survey was to determine the radiological condition of the unrestricted area of the RTI site. Radiological information to be obtained included:

1. Direct radiation levels throughout the site;
2. Surface contamination levels on building floors and miscellaneous objects; and,
3. Concentrations of radionuclides in soil.

Procedures

A. Building Surveys

Surface Scans

Accessible floor surfaces, stored equipment, drums, and miscellaneous items were scanned using NaI(Tl) scintillation detectors and ratemeters with audible indicators. Random floor scans were also conducted with thin-window "pancake" GM detectors. Locations of elevated contact radiation levels were noted.

Measurement of Surface Contamination Levels

A total of 177 direct beta-gamma contamination measurements were randomly made on the floors of buildings (Table 3). Smears for removable contamination were also obtained at the location of each direct measurement. The total number of measurements varied within each of the buildings, based on building size, and findings as the survey progressed. No surface contamination measurements were performed within several building structures (i.e. R-2, S-11, S-37, R-3),

which were badly deteriorated; however, the floors and debris in such structures were gamma scanned during the survey.

Exposure Rate Measurements

Gamma exposure rates were determined at the floor surface and 1 m above the floor at the location of the maximum radiation level in each building, using NaI(Tl) scintillation detectors, cross calibrated against a pressurized ionization chamber (PIC). The maximum exposure rate associated with contaminated objects, identified by indoor gamma scans, was also determined.

Miscellaneous Sampling/Measurements

A sample of residue was removed from a drum, identified in Building R-34 as having a slightly elevated gamma level.

A portable multichannel analyzer and NaI(Tl) detector were used to identify the radioactive contaminant on a rectangular, metal frame stored inside the second storage shed near Building R-47. Total and removable beta-gamma contamination on the frame, as well as, contact exposure rates were determined.

B. Outdoor Surveys

Surface Scans

Walkover surface scans were conducted up to 5 meters beyond either side of all access roads up to 10 meters from the sides of each building, and in areas of discarded refuse/equipment identified during the survey. Walkover scans were also conducted on the outside perimeters of the restricted and unrestricted area fences. The walkover scans, were performed using portable NaI(Tl) scintillation detectors and ratemeters with audible indicators. Locations of elevated contact radiation were identified for later characterization.

Exposure Rate Measurements

Gamma exposure rates were determined at 49 random locations and at 4 locations of elevated radiation levels, identified by the walkover survey

(Figures 3 to 6). Exposure rates were measured at the soil surface and at 1 m above the surface, using a NaI(Tl) scintillation detector, cross calibrated against a PIC.

Soil Sampling

Surface soil samples were obtained at the location of each random gamma exposure rate measurement, and from areas of elevated surface radiation levels identified by walkover scans. One 45 cm deep composite soil sample was obtained from an elevated area outside the restricted area fence (Figures 3 to 6).

Miscellaneous Sampling/Measurements

A water sample was collected from the drum with elevated gamma levels, identified during walkover scans in the dump east of Building R-47 (location 50, Figure 5). A portable multichannel analyzer and NaI(Tl) detector were used to identify the radioactive contamination in the barrel. A rock sample, representative of several subsurface rocks having associated elevated gamma levels, was obtained for analysis.

Background and Baseline Determinations

Soil samples and exposure rate measurements were obtained at six locations within a range of 0.5 to 10 km from the site, to provide baseline concentrations of radionuclides and gamma exposure rate levels for comparison purposes. Locations of background measurements and baseline samples are shown in Figure 7.

Sample Analysis and Interpretation of Results

Samples and direct measurement data were returned to Oak Ridge, Tennessee for analysis and data reduction. One water sample and 53 soil samples were analyzed by solid state gamma spectrometry. Radionuclides of primary interest were Co-60 and Cs-137; however, spectra were reviewed for other identifiable radionuclides. Smears and the water sample were analyzed for gross beta levels using a low-background proportional counter.

RESULTS

Background Levels and Baseline Concentrations

Background exposure rates and baseline soil concentrations of Co-60 and Cs-137 from the vicinity of RTI are presented in Tables 1 and 2. Exposure rates ranged from 10 to 12 μR/h at the soil surface and from 10 to 11 μR/h at 1 m above the surface. Concentrations of Cs-137 in soil ranged from <0.05 to 0.69 pCi/g, and Co-60 concentrations ranged from <0.04 to <0.08 pCi/g. These background levels and baseline concentrations are typical of the New Jersey area.

Building Surveys

Surface Scans

Gamma and beta-gamma scans did not identify any areas of elevated radiation from building floors; however, two objects having elevated gamma levels were noted. A gamma exposure rate of 28 μR/h was measured inside a barrel, located in the former welding shop of Building R-34 (Figure 5). Gamma spectrometry identified the contaminant in the residue as Co-60.

A gamma exposure rate of 600 μR/h (contact) was measured on a rectangular, metal frame, stored in a metal drum, inside a storage shed near Building R-47 (Figure 5). Gamma spectrometry identified the contaminant as Co-60. Total beta-gamma and removable surface contamination levels from the frame were 1.2×10^6 and 830 dpm/100 cm^2, respectively.

Surface Contamination Levels

Results of surface contamination measurements on building floors, are presented in Table 3. The total beta-gamma contamination levels ranged from <420 to 3000 dpm/100 cm^2 and removable contamination levels ranged from <5 to 14 dpm/100 cm^2.

Exposure Rate Measurements

Exposure rate measurements inside buildings are presented in Table 4. Exposure rates ranged from 7 to 18 μR/h at floor surfaces and at one meter from the surface.

Outdoor Survey

Surface Scans

Walkover surface scans conducted outside buildings and along roadways within the unrestricted area identified two small areas (<1 m^2) of elevated contact radiation. Investigations at locations 17 and 52 (Figures 3 and 5) uncovered large rocks just below the soil surface with contact exposure rates of 170 and 90 μR/h respectively (Table 5). Gamma spectrometry performed on one of the rocks indicated that it contains elevated concentrations of naturally occurring radionuclides i.e. Th-232, U-238, K-40, Ra-226. Soil samples from both locations contain typical background radionuclide concentrations (Table 6).

Gamma scans of discarded barrels, equipment, and miscellaneous objects within the unrestricted area identified a drum, containing water, in the dump east of Building R-47 (location 50, Figure 5). The highest exposure rate obtained on the outer surface of the drum (160 μR/h) was below water level, but the drum did not appear to contain any sludge material. In situ gamma spectrometry identified the primary contaminant as Co-60; a water sample from the drum contained 70 ± 3 pCi/l gross beta-gamma activity. A soil sample from beneath the drum contained 0.76 pCi/g Co-60 (refer to Table 6).

Walkover gamma scans outside the restricted area perimeter fence identified one elevated area (approximately 5 m^2) along a small drainage creek north of Building R-60 (location 53, Figure 6). Gamma levels in this area ranged from 24 to 28 μR/h at the surface and 18 μR/h at 1 m above the location of maximum contact radiation. A composite soil sample, collected to a depth of 45 cm, contained a Co-60 concentration of 17.1 pCi/g (Table 6).

With the exception of these 4 areas, outdoor surface scans generally indicated radiation levels from 9 to 16 μR/h. Elevations up to 24 μR/h were encountered near asphalt fill material and many large boulders.

Exposure Rate Measurements

Results of exposure rate measurements at each soil sampling location are presented in Table 7. Exposure rates at the surface ranged from 9 to 24 μR/h; at 1 m above the surface the exposure rates ranged from 9 to 16 μR/h. Both ranges are slightly elevated due to the presence of rock outcroppings near location 28. On the average, random exposure rate measurements are comparable to the average baseline gamma level of 11 μR/h.

Radionuclide Concentrations in Soil

Concentrations of cobalt-60 and cesium-137 from random sampling locations are presented in Table 8. Cobalt-60 concentrations ranged from <0.03 to <0.09 pCi/g. Cesium-137 concentrations ranged from <0.04 to 1.67 pCi/g. On the average, Co-60 and Cs-137 concentrations in random soil samples are comparable to the average baseline concentrations of <0.06 pCi/g of Co-60 and 0.36 pCi/g of Cs-137.

Soil concentrations of Co-60 and Cs-137 from areas identified by surface scans are presented in Table 6. The Cs-137 concentrations from all 4 locations are comparable to the average baseline concentration; however, the Co-60 concentration at two of the locations is significantly greater than the average Co-60 baseline concentration. The Co-60 concentrations in the soil samples from beneath the drum in the waste dump and outside the restricted area fence are higher than the average baseline concentration by factors of 13 and 300, respectively.

The exposure rate at one meter above the surface of both elevated areas does not exceed the NRC guideline limit of 10 μR/h above background levels; however, the concentration of Co-60 in soil outside of the restricted area fence does exceed concentrations of Co-60 (6-10 pCi/g) typically accepted by the NRC for release of sites for unrestricted use.

SUMMARY

At the request of the Nuclear Regulatory Commission, Oak Ridge Associated Universities performed a survey at the Radiation Technology Incorporated

facility in Rockaway, New Jersey during the period April 13-17, 1987. Radiological information collected included contamination levels on building surfaces, direct radiation levels, and concentrations of Co-60 and Cs-137 in soil.

The survey identified four items or areas with Co-60 contamination levels in excess of the NRC guidelines, typically accepted for unrestricted areas. These were a metal frame in a storage shed near Building R-47; a barrel containing fixed residue in Building R-34; a drum in the waste dump east of Building R-47; and a small soil area in a drainage ditch outside the restricted area fence. Contamination levels and the area or volume of contaminated material are such that, in ORAU's opinion, there is not a potential for significant personnel exposures or contamination from these locations. However, the presence of contamination in unrestricted areas suggests a deficiency in contamination control procedures. Contamination in the drainage stream near the restricted area also indicates a pathway for migration of Co-60 from the site to the offsite environment.

RTI5

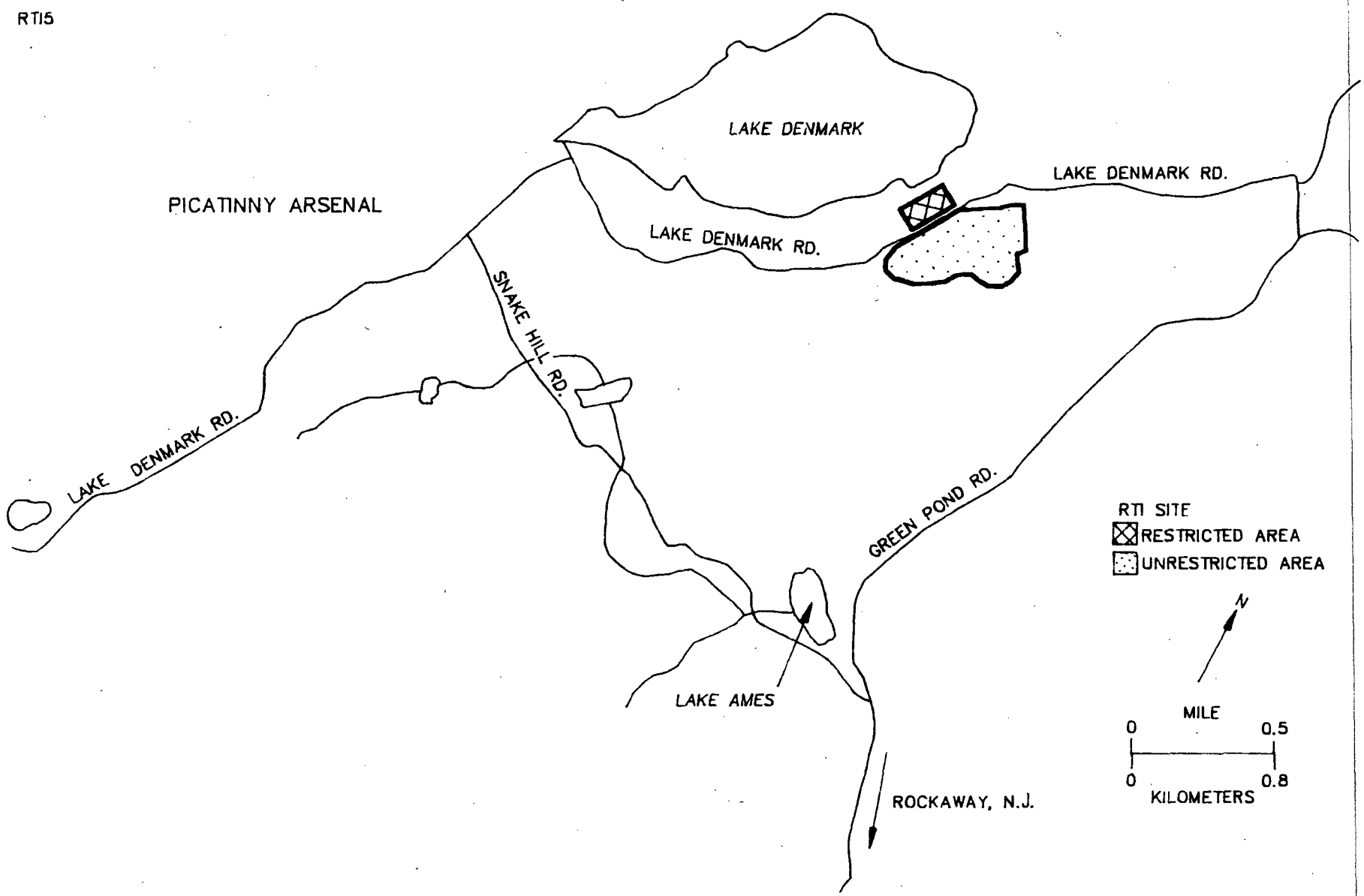

FIGURE 1: Map of North Rockaway, New Jersey Area Indicating Location of the Radiation Technology, Inc. Plant Site

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RTI6

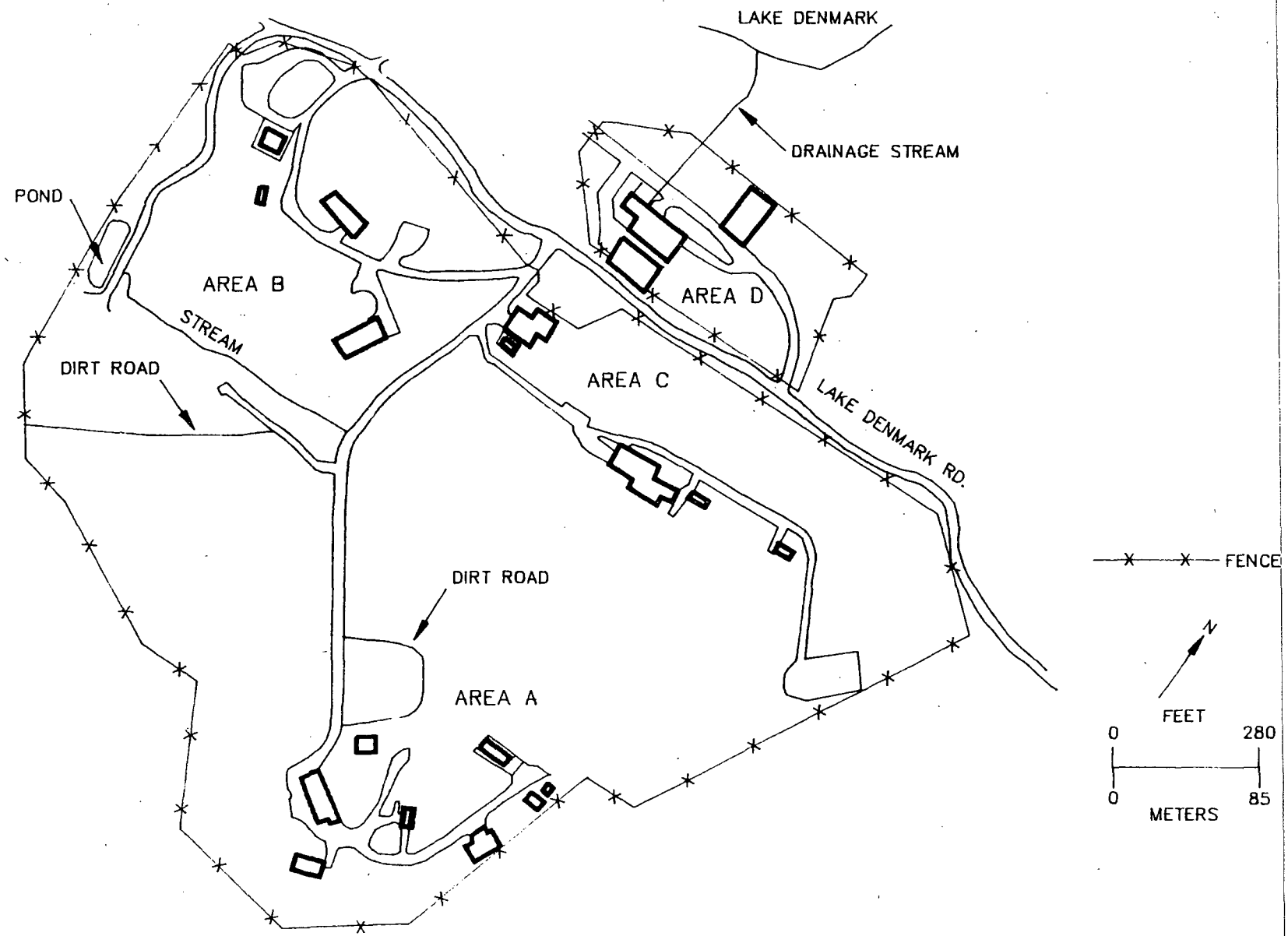

FIGURE 2: Radiation Technology, Inc. Property Layout Indicating Prominent Surface Features

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RTI4

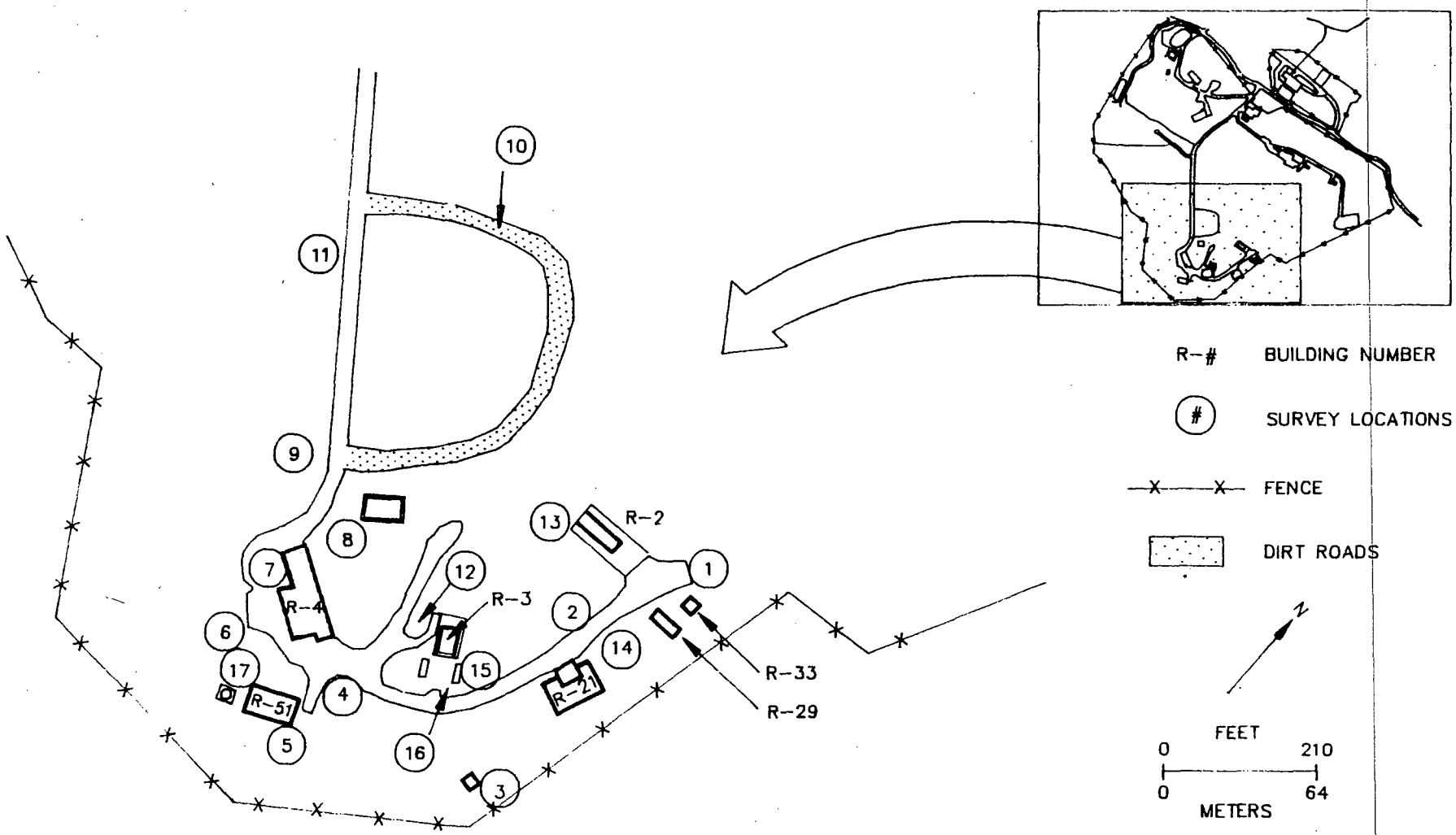

FIGURE 3: Map of Area A Indicating Survey Locations 1 through 17

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RT11

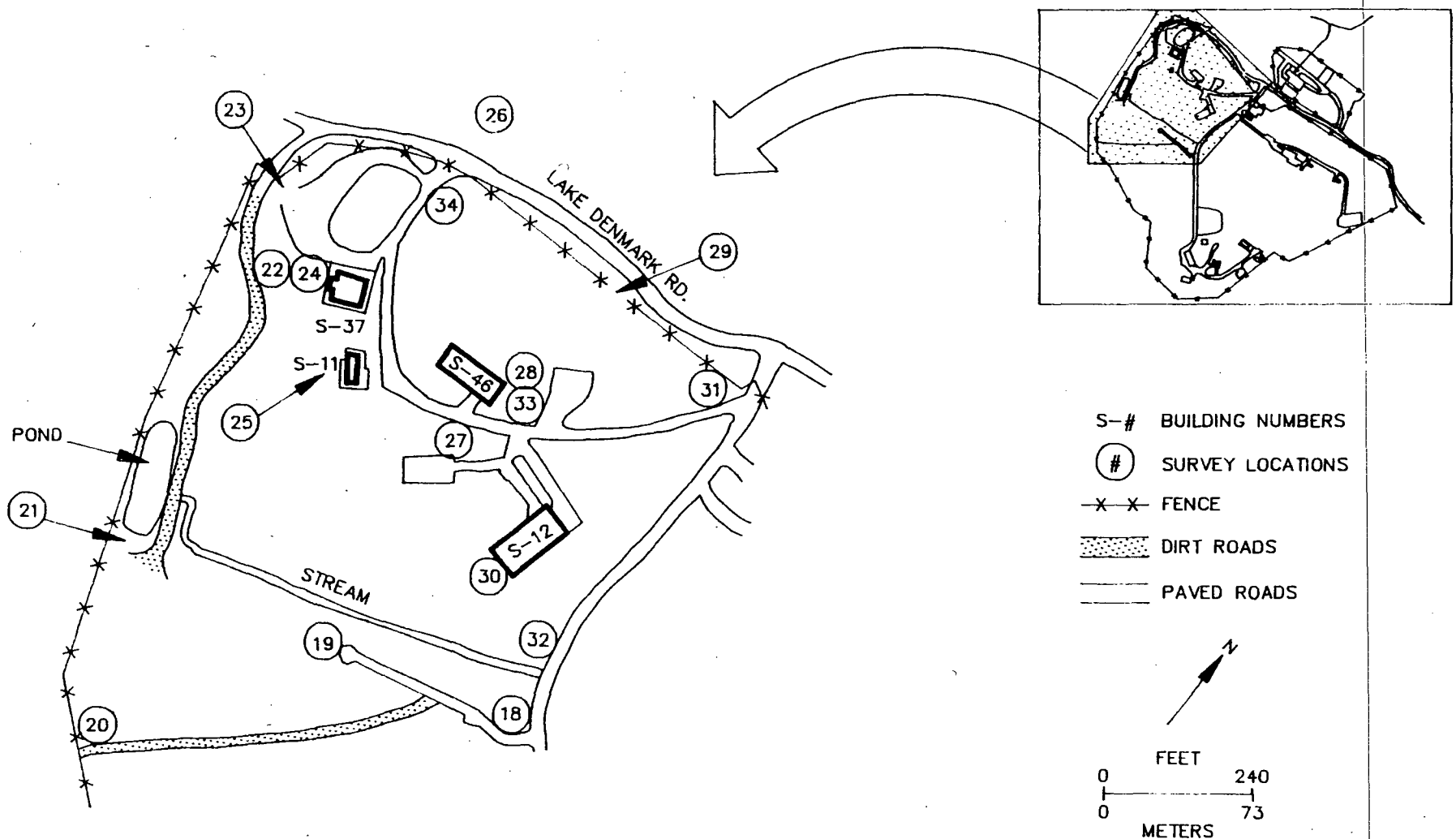

FIGURE 4: Map of Area B Indicating Survey Locations 18 through 34

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RT12

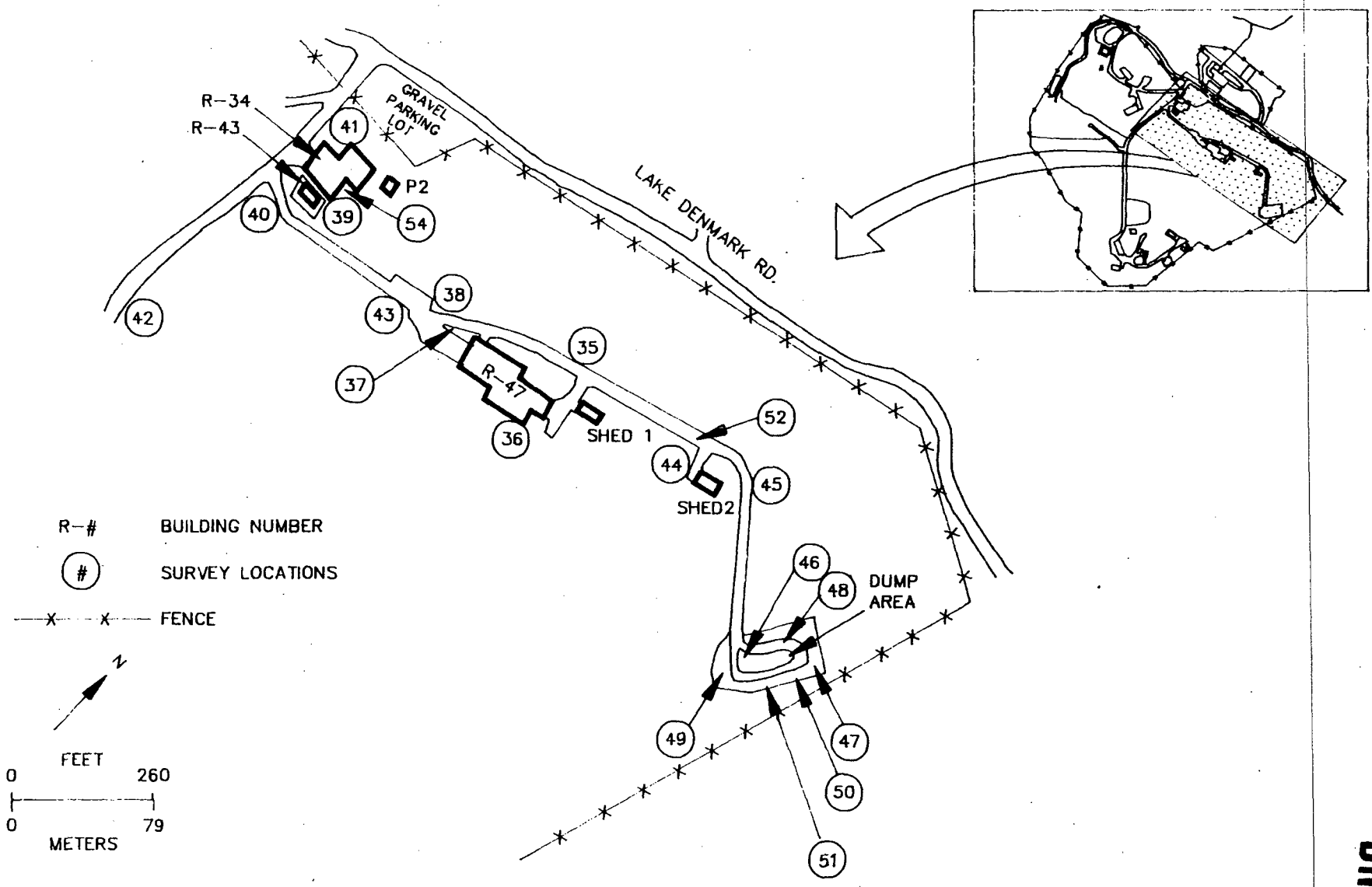

FIGURE 5: Map of Area C Indicating Survey Locations 35 through 52

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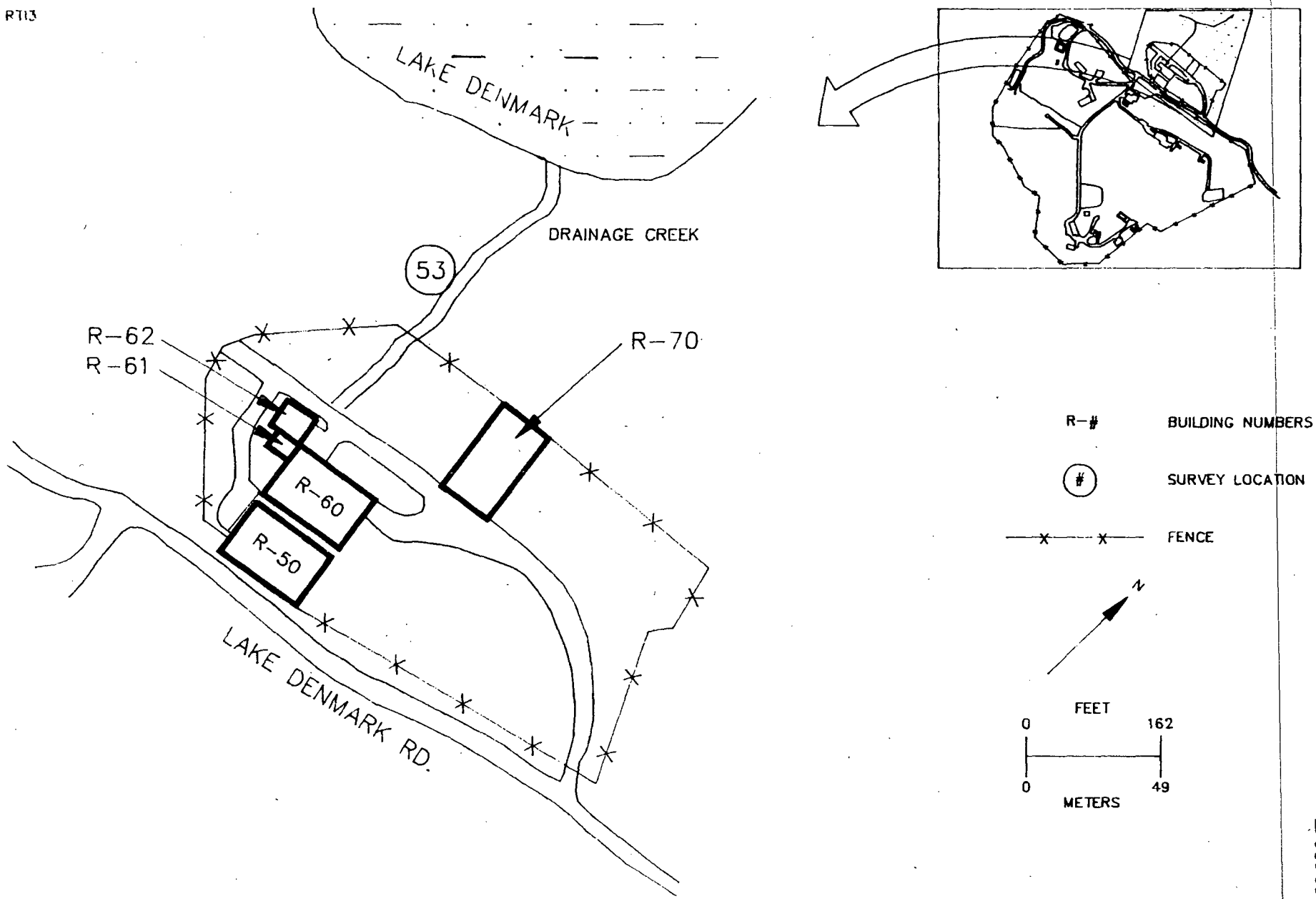

FIGURE 6: Map of Area D Indicating Survey Location 53

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RTI5a

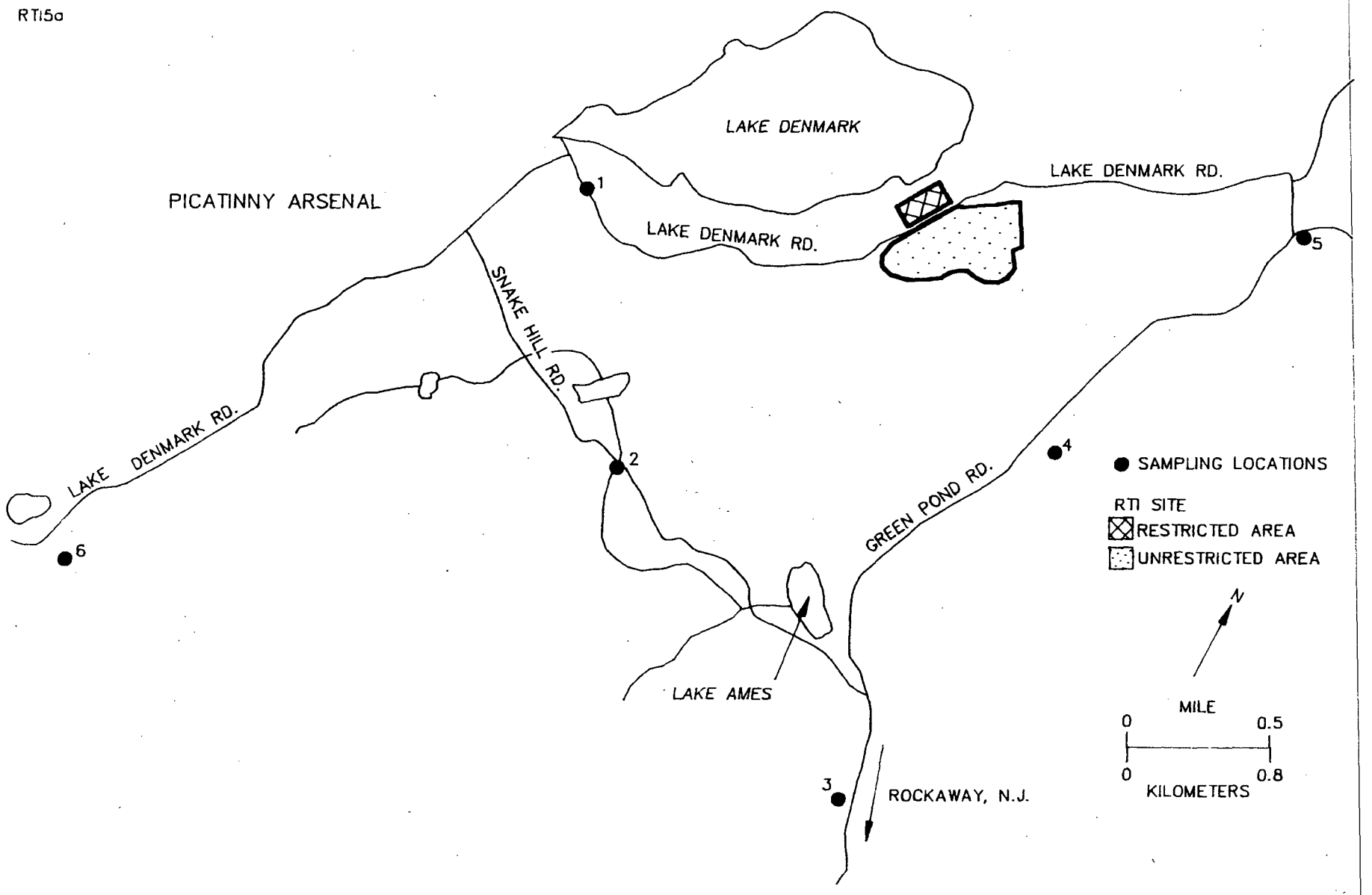

FIGURE 7: Locations of Background Measurements and Baseline Samples in the Vicinity of the RTI Site

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TABLE 1

EXPOSURE RATES MEASURED
AT BASELINE SAMPLE LOCATIONS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Sample Location[a]	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Gamma Exposure Rates at the Surface (μR/h)
1	10	10
2	10	10
3	11	11
4	11	12
5	10	10
6	11	10

[a]Refer to Figure 7.

TABLE 2

COBALT-60 AND CESIUM-137 CONCENTRATIONS
MEASURED IN BASELINE SAMPLES
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Sample Location[a]	Radionuclide Concentrations (pCi/g)	
	Co-60	Cs-137
1	<0.06	0.38 ± 0.10[b]
2	<0.06	<0.05
3	<0.06	0.69 ± 0.13
4	<0.08	<0.06
5	<0.08	0.53 ± 0.13
6	<0.04	0.45 ± 0.08

[a]Refer to Figure 7.
[b]Uncertainties are 2σ based only on counting statistics; additional system uncertainties of ± 6 to 10% have not been included in this data.

TABLE 3

SUMMARY OF FLOOR SURFACE CONTAMINATION MEASUREMENTS IN BUILDINGS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Building[a]	Number of Measurements	RANGE OF SURFACE CONTAMINATION Total Beta-Gamma (dpm/100 cm^2)	Removable Beta-Gamma (dpm/100 cm^2)
R-34	30	<430-1500	<5-9
R-43	5	<430-3000	<5
R-47	32	<430-1600	<5-7
R-33	2	600-630	<5
R-29	8	<430	<5-14
R-21	10	<430-1100	<5-7
R-51	20	<420-920	<5-7
R-4	30	<420-920	<5-10
S-12	10	<420-1100	<5-12
S-46	30	<430-1600	<5-8

[a]Refer to Figures 3, 4, and 5.

TABLE 4

EXPOSURE RATES MEASURED INSIDE BUILDINGS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Building[a]	Gamma Exposure Rate at 1 m Above the Surface (μR/h)	Gamma Exposure Rate at the Surface (μR/h)
R-34	7-15	11-16
R-43	11	11-13
R-47	9-13	10-16
R-33	7-12	7-12
R-29	9-10	10-12
R-21	10-12	7-14
R-51	9-10	9-10
R-4	9-16	11-16
S-12	12-14	12-15
S-46	12-18	12-18

[a]Refer to Figures 3, 4, and 5.

TABLE 5

EXPOSURE RATES MEASURED AT LOCATIONS OF ELEVATED RADIATION LEVELS IDENTIFIED BY WALKOVER SCANS RADIATION TECHNOLOGY INCORPORATED ROCKAWAY, NEW JERSEY

Location	Gamma Exposure Rate at 1 m Above the Surface (μR/h)	Gamma Exposure Rate at the Surface (μR/h)
17[a]	11	170
50[b]	13	18
52[b]	16	90
53[c]	18	28

[a]Refer to Figure 3.
[b]Refer to Figure 5.
[c]Refer to Figure 6.

TABLE 6

COBALT-60 AND CESIUM-137 SOIL CONCENTRATIONS IN SAMPLES FROM LOCATIONS OF ELEVATED RADIATION LEVELS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Sample Location	Radionuclide Concentrations (pCi/g)	
	Co-60	Cs-137
17[a]	<0.05	0.23 ± 0.12[d]
50[b]	0.76 ± 0.17	0.10 ± 0.09
52[b]	<0.10	0.90 ± 0.19
53[c]	17.1 ± 0.7	0.78 ± 0.33

[a]Refer to Figure 3.
[b]Refer to Figure 5.
[c]Refer to Figure 6.
[d]Uncertainties are 2σ based only on counting statistics;, additional system uncertainties of ± 6 to 10% have not been included in this data.

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TABLE 7

EXPOSURE RATES MEASURED OUTSIDE
AT RANDOM SURVEY LOCATIONS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Location[a]	Gamma Exposure Rate at 1 m Above the Surface (μR/h)	Gamma Exposure Rate at the Surface (μR/h)
AREA A[a]		
1	10	10
2	11	11
3	10	10
4	10	10
5	9	9
6	11	11
7	10	10
8	10	10
9	11	11
10	11	12
11	10	10
12	10	10
13	11	11
14	10	10
15	10	11
16	10	10
17	e	e
AREA B[b]		
18	10	10
19	10	10
20	10	10
21	12	12
22	12	11
23	12	14
24	11	12
25	11	11
26	11	12
27	10	10
28	14	24
29	10	10
30	11	11
31	11	11
32	10	10
33	12	12
34	11	11
AREA C[c]		
35	12	12
36	11	11
37	13	16

TABLE 7 (Continued)

EXPOSURE RATES MEASURED OUTSIDE
AT RANDOM SURVEY LOCATIONS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Location	Gamma Exposure Rate at 1 m Above the Surface (μR/h)	Gamma Exposure Rate at the Surface (μR/h)
38	16	18
39	10	11
40	11	11
41	11	11
42	10	10
43	14	18
44	16	18
45	12	12
46	12	12
47	12	12
48	11	12
49	12	12
50	e	e
51	10	11
52	e	e
AREA D[d]		
53	e	e

[a]Refer to Figure 3.
[b]Refer to Figure 4.
[c]Refer to Figure 5.
[d]Refer to Figure 6.
[e]Refer to Table 5.

TABLE 8

COBALT-60 AND CESIUM-137 CONCENTRATIONS IN SOIL
FROM RANDOM SURVEY LOCATIONS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Sample Location[a]	Radionuclide Concentrations (pCi/g) Co-60	Cs-137
AREA A[a]		
1	<0.05	0.37 ± 0.12[f]
2	<0.05	0.27 ± 0.11
3	<0.03	0.24 ± 0.09
4	<0.03	0.41 ± 0.09
5	<0.04	<0.05
6	<0.04	<0.05
7	<0.05	0.15 ± 0.12
8	<0.04	<0.04
9	<0.04	<0.06
10	<0.05	0.35 ± 0.10
11	<0.04	0.20 ± 0.96
12	<0.04	<0.04
13	<0.05	0.76 ± 0.13
14	<0.04	<0.05
15	<0.06	1.17 ± 0.21
16	<0.05	0.90 ± 0.15
17	e	e
AREA B[b]		
18	<0.05	0.36 ± 0.09
19	<0.08	0.30 ± 0.17
20	<0.08	0.75 ± 0.16
21	<0.07	0.76 ± 0.15
22	<0.06	0.43 ± 0.17
23	<0.04	0.33 ± 0.12
24	<0.07	0.48 ± 0.12
25	<0.04	<0.05
26	<0.08	0.63 ± 0.15
27	<0.03	0.25 ± 0.08
28	<0.09	1.67 ± 0.22
29	<0.05	0.74 ± 0.14
30	<0.06	<0.06
31	<0.08	0.33 ± 0.12
32	<0.08	<0.08
33	<0.06	0.92 ± 0.19
34	<0.03	0.67 ± 0.13
AREA C[c]		
35	<0.06	0.17 ± 0.09
36	<0.05	<0.06
37	<0.05	0.43 ± 0.14
38	<0.07	0.83 ± 0.24
39	<0.05	0.67 ± 0.11

TABLE 8 (Continued)

COBALT-60 AND CESIUM-137 CONCENTRATIONS IN SOIL
FROM RANDOM SURVEY LOCATIONS
RADIATION TECHNOLOGY INCORPORATED
ROCKAWAY, NEW JERSEY

Sample Location	Radionuclide Concentrations (pCi/g)	
	Co-60	Cs-137
40	<0.06	0.52 ± 0.12
41	<0.05	0.34 ± 0.13
42	<0.07	1.37 ± 0.18
43	<0.06	0.83 ± 0.15
44	<0.08	<0.10
45	<0.09	0.60 ± 0.15
46	<0.07	<0.09
47	<0.07	<0.11
48	<0.04	<0.07
49	<0.08	<0.10
50	e	e
51	<0.06	0.62 ± 0.23
52	e	e
AREA D[d]		
53	e	e

[a]Refer to Figure 3.
[b]Refer to Figure 4.
[c]Refer to Figure 5.
[d]Refer to Figure 6.
[e]Refer to Table 6.
[f]Uncertainties are 2σ based only on counting statistics; additional system uncertainties of ± 6 to 10% have not been included in this data.

APPENDIX A

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

APPENDIX A

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

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

A. Direct Radiation Measurements

Eberline RASCAL
Portable Scaler/Ratemeter
Model PRS-1
(Eberline, Sante Fe, NM)

Eberline PRM-6
Portable Ratemeter
(Eberline, Sante Fe, NM)

Victoreen Gamma Scintillator (NaI) Probe
Model 489-55
(Victoreen, Inc., Cleveland, OH)

Reuter-Stokes Pressurized Ionization Chamber
Model RSS-111
(Reuter-Stokes, Cleveland, OH)

Eberline GM Pancake Probe
Model HP-260
(Eberline, Sante Fe, NM)

Victoreen Beta-Gamma "Pancake" Probe
Model 489-110
(Victoreen, Inc., Cleveland, OH)

Canberra Multichannel Analyzer
Series 30
(Canberra Industries Inc., Meriden, CT)

Harshaw (NaI) Detector
(Harshaw Chemical Co., Solon, OH)

B. Laboratory Analyses

High-Purity Germanium Detector
Model GMX-23195-S, 23% efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield, G-16
(Gamma Products Inc., Palos Hills, IL)

Intrinsic Germanium Detector
Model MIGC2525SD/8
(Princeton-Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead Shield, SPG-16-K8
(Gamma Products, Inc., Palos Hills, IL)

Pulse Height Analyzer
ND-66/ND-680 System
(Nuclear Data, Inc., Schaumburg, IL)

Low Background Alpha-Beta Counter
Model LB5100-2080
(Tennelec, Inc., Oak Ridge, TN)

APPENDIX B

MEASUREMENT AND ANALYTICAL PROCEDURES

Appendix B

MEASUREMENT AND ANALYTICAL PROCEDURES

Gamma Surface Scans

Walkover surfaces scans were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation detectors containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Areas exceeding the ambient background count-rate range were marked for further measurements and sampling.

Gamma Exposure Rate Measurement

Measurements of gamma exposure rates were performed primarily using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation detectors containing 3.2 cm x 3.8 cm NaI(Tl) scintillation crystals. Count rates were converted to exposure rates (μR/h) using factors determined by comparing the response of the scintillation detector with that of a Reuter Stokes model RSS-111 pressurized ionization chamber at locations on the Radiation Technology Incorporated site.

Beta-Gamma Measurements

Beta-gamma surface scans were performed using Eberline Model PRS-1 portable scaler/ratemeters with Victoreen Model 489-110 beta-gamma pancake probes. Areas where count rates exceeded several times the ambient background were marked for further investigation.

Measurements of direct beta-gamma radiation levels were performed using Eberline Model PRS-1 portable scaler/ratemeters with Model HP-260 thin-window pancake G-M probes. Count rates (cpm) were converted to disintegration rates (dpm/100 cm^2) by dividing the net rate by the 4π efficiency and normalizing to the active area of the detector (15.5 cm^2). The average background count rate was 40 cpm for the G-M probes, and the average counting efficiency was 20%.

Water Sample Analysis

The water sample was rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by subsequent filtration through 0.45 μm membrane filters. The filtrate was acidified by addition of 10 ml of concentrated nitric acid, and a known volume of the sample was evaporated to dryness. The filter papers and filtrate were counted for gross beta using a Tennelec Model LB-5100 low-background proportional counter. The sample was also examined by gamma spectroscopy to identify primary gamma emitters.

Removable Contamination Measurements

Smears were performed using numbered filter paper disks, 47 mm in diameter. Smears were sealed in labeled envelopes with the location and other pertinent information recorded and returned to Oak Ridge, where they were counted using a low-background alpha-beta proportional system.

Soil Sample Analysis

Soil samples were dried, mixed, and a portion placed in a 0.5 liter Marinelli beaker. The quantity placed in each beaker was chosen to reproduce the calibrated counting geometry and ranged from 411 to 883 grams of soil. Net soil weights were determined and the samples counted using solid state detectors and a Nuclear Data Model ND-680 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.

Uncertainties and Detection Limits

The uncertainties associated with analytical data presented in the tables of this report, represent the 95% (2σ) confidence levels, based only on counting statistics. 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 the 2σ statistical deviation of the background count, the sample concentration was reported as less than the

minimum detectable concentration (<MDC). Because of variation in background levels and the effects of the Compton continuum caused by other constituents in the samples, the MDC's for specific radionuclide differ from sample to sample. Additional uncertainties of ± 6 to 10%, associated with sampling and laboratory procedures, have not been propagated into the data presented in this report.

Calibration and Quality Assurance

Laboratory and field survey procedures are documented in the following manuals, developed specifically for Oak Ridge Associated Universities' Radiological Site Assessment Program: "Survey Procedures Manual", Revision 2, March 1986; "Laboratory Procedures Manual", Revision 2, May 1986; and "Quality Assurance Manual", Revision 0, July 1986.

With the exception of the portable gamma scintillation survey meters, field and laboratory instruments are calibrated with NBS-traceable standards. The calibration procedures for the portable gamma instruments are performed by comparison with an NBS-traceable pressurized ionization chamber.

Quality control procedures on all instruments included daily background and check-source measurements to confirm equipment operation within acceptable statistical fluctuations. The ORAU laboratory participates in the EPA Cross Check and EML Quality Assurance Programs.