CONFIRMATORY SURVEY
OF THE OYSTER CREEK FORKED RIVER PROPERTY
LACEY TOWNSHIP, OCEAN COUNTY, NEW JERSEY
(DOCKET NO. 50-219, RFTA NO. 99-040)

Prepared by

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Division of Waste Management

FINAL REPORT

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ABBREVIATIONS AND ACRONYMS

ALARA	as low as reasonably achievable
ASME	American Society of Mechanical Engineers
BKG	background
cm	centimeter
cm^2	square centimeter
CT	Combustion Turbine
cpm	counts per minute
DCGL	derived concentration guideline level
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute/100 square centimeters
EML	Environmental Measurements Laboratory
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
GPU	General Public Utilities
HSA	historical site assessment
kg	kilogram
m	meter
m^2	square meter
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
mm	millimeter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MeV	million electron volts
mrem	millirem
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NMSS	Office of Nuclear Material Safety and Safeguards
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram

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INTRODUCTION AND SITE HISTORY

The Oyster Creek Nuclear Generating Station is a single unit, boiling water reactor located in Lacey Township, Ocean County, near Barnegat Bay. The plant is owned by Jersey Central Power and Light Company and is operated by General Public Utilities (GPU) Nuclear. Recently, GPU Nuclear informed the U.S. Nuclear Regulatory Commission (NRC) that they plan to sell land adjacent to the Oyster Creek nuclear power plant in Lacey Township, NJ. GPU Nuclear, the plant's current owner, intends to sell 657 acres of the approximately 800-acre site (referred to here as the Forked River Property). The sale will reduce the current site boundary around the plant to enclose only about 150 acres of land. The NRC staff has been evaluating the proposed sale to determine if there are any issues that have the potential to adversely affect public health and safety, impact the environment or compromise the continued safe operation of the Oyster Creek Nuclear Generating Station.

The original intended use of the 657-acre property was for the construction of the now canceled Forked River Nuclear Station Unit 1. Since then, the property has been used for activities related to the Oyster Creek license, including general employee training, specialty craft training, non-radiological fabrication and construction activities, vehicle repair, plant control room simulator, and other administrative activities (GPU 1999). GPU Nuclear performed a historical site assessment (HSA) in 1998 for the property to be sold and identified locations where radioactive material is currently or had been previously located. The locations included Buildings 1, 5, 8, 12, and 14, the Firing Range, Spectrum Building (now demolished), and Switchyard Building. Exempt and/or sealed sources were identified in several of the buildings. On occasion, licensee vehicles containing tools with residual contamination were parked at the Motor Pool Area (Building 5).

GPU Nuclear has provided its basis for concluding the property is suitable to be released in accordance with NRC regulations, as well as the results of radiological surveys and assessments used to support this determination. GPU Nuclear has evaluated the potential effects on this land area from

the operation of the plant and the results of its radiological reviews. NRC staff members have discussed the process for evaluating GPU's proposed land transfer, and have identified inspection plans to ensure that regulatory requirements are met and to verify that the property meets the criteria for unrestricted release.

The major radiological contaminants of concern for the site are Co-60 and Cs-137, and to a lesser degree various other fission and activation products. GPU Nuclear documented that they conducted a Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) scoping survey in the land area and selected buildings. GPU Nuclear concluded that based on the result that no measurable licensed material was identified on the property, compliance with unrestricted release criteria was demonstrated (GPU 1999 and NRC 1997b). Specifically, the release criteria selected were 25 mrem/y and ALARA (as low as reasonably achievable) (NRC 1997a).

The NRC's Division of Waste Management requested that the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) perform confirmatory survey activities on the land areas and buildings included in the sale.

SITE DESCRIPTION

The Oyster Creek site is traversed by U.S. Highway Route 9. Geographically, the site is situated in the Outer Coastal Plain near the Pinelands National Reserve. Barnegat Bay Inlet and the Atlantic Ocean are within 10 miles of the plant (Figure 1).

The 657 acre site being proposed for sale consists of an electrical substation, Combustion Turbine (CT) facility, shipping and receiving warehouse, Firing Range, training facilities, administrative offices and general storage buildings (Figure 2). GPU Nuclear plans to lease the buildings after the sale.

OBJECTIVES

The objectives of the confirmatory survey were to provide independent contractor field data reviews and radiological data for use by the NRC in evaluating the adequacy and accuracy of the licensee's procedures and final status survey results, relative to the established release criteria.

DOCUMENT REVIEW

ESSAP has reviewed GPU Nuclear's radiological survey results and supporting documentation concerning the property to be sold (GPU 1999). The documents were reviewed for general thoroughness, accuracy, and consistency. Survey procedures and data were evaluated to assure that the licensee's surface scans, surface activity measurements and soil sampling were performed in accordance with stated procedures and that the results were adequately documented.

PROCEDURES

A survey team from ESSAP visited the Oyster Creek Forked River Property during the period November 15 to 18, 1999 and performed visual inspections, and independent measurements and sampling of various interior and exterior portions of the site that are to be sold. Survey activities were conducted in accordance with a site-specific survey plan and the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 1999a, 1998a and b). Appendices A and B provide additional information on survey equipment and procedures that were used during the survey activities.

INTERIOR SURVEY PROCEDURES

GPU Nuclear's historical site assessment was used as a guide in the selection of measurement and sampling locations within the buildings reported to have radioactive material present at some time in their history. Locations within Building 1 (Laboratory Training Areas), Building 5 (Motor Pool Area), Building 6 (components sandblasted), Building 7, Building 8 (fixed activity tools), Building 14 (whole body counter; sealed calibration sources), and Building 20 were surveyed.

Reference Grid

Measurement and sampling locations were referenced to prominent building features.

Surface Scans

Surface scans for beta and gamma radiation were performed over 50 to 100% of accessible floor, lower wall, equipment and other interior surfaces using gas proportional and NaI scintillation detectors. All detectors were coupled to ratemeter-scalers with audible indicators. Particular attention was given to cracks and joints in the floors and walls, ledges, ducts, and other locations where material may have accumulated. Locations of elevated direct radiation were marked for further investigation.

Surface Activity Measurements

Construction material-specific backgrounds, performed in areas of similar construction but without a history of radioactive material use, were used to correct gross surface activity measurements. Direct measurements for total beta activity were performed using gas proportional detectors. A total of 124 measurements were performed within the buildings. A smear sample, to determine removable gross alpha and gross beta activity levels over a 100 cm^2 surface area, was collected at each direct measurement location. Figures 3 through 9 show direct measurement locations.

EXTERIOR SURVEY PROCEDURES

GPU Nuclear's historical site assessment was used as a guide in the selection of measurement and sampling locations in exterior areas. Exterior surveys were performed at the Firing Range (parking lot and adjacent area), the former construction site, the Building 17 materials laydown and depression areas, an area south of the Switchyard, and the Spectrum Building site.

Reference Grid

Measurement and sampling locations were referenced to prominent site features or existing landmarks.

Surface Scans

Gamma surface scans within the Firing Range and adjacent parking lot, transportation routes, former Spectrum Building land area, and other general land areas—e.g., land areas adjacent to the discharge canal and depressions near Building 17—were conducted using NaI scintillation detectors and ratemeters with audible indicators.

Soil Sampling

Surface (0 to 15 cm) soil samples were collected from the impacted area adjacent to the Firing Range and from the surrounding area and transportation route to the Firing Range. Surface soil samples were also collected from the former Spectrum Building land area and other general land areas (depressions and equipment laydown area near Building 17, vicinity of intake canal, and former Forked River construction site).

Subsurface soil samples to a depth of one meter were collected from three locations in the former Forked River construction site. Locations selected for subsurface sampling were from areas that previously had been backfilled. Two of the surface soil sampling locations in the raised gradient adjacent to the Firing Range parking lot were selected for subsurface sampling. This area corresponded to where contaminated soil at one time had been placed and then later removed.

A total of 41 surface and subsurface samples were collected from 31 sampling locations. Figures 10 through 12 show sampling locations.

Miscellaneous Sampling

Three sediment samples were collected from each of the two settling basins located on the property (Figure 13). Groundwater samples were collected by GPU Nuclear personnel from four of the existing monitoring wells and provided to ESSAP for analysis (Figure 14).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to ORISE's ESSAP laboratory in Oak Ridge, Tennessee for analysis and interpretation. Sample analyses were performed in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 1999b). Soil and sediment samples were analyzed by solid state gamma spectrometry for Co-60 and Cs-137. Spectra were also reviewed for any other identifiable photopeaks. Miscellaneous sample results were reported in units of picocuries per gram (pCi/g). Groundwater samples were analyzed for gross alpha and gross beta activity, tritium and strontium-90 concentrations. Groundwater samples were also screened by gamma spectrometry for Co-60 and Cs-137, and any other identifiable photopeaks. Sample results were reported in units of picocuries per liter (pCi/L). Smears were analyzed for gross alpha and gross beta activity using a low-background proportional counter. Direct measurement data and smear data were converted to units of disintegrations per minute per one hundred square centimeters (dpm/100 cm^2).

FINDINGS AND RESULTS

SURVEY RESULTS: INTERIOR

The results of the survey for the building interiors are provided below.

Surface Scans

Surface scans for beta and gamma radiation did not identify any elevated activity, with the exception of known sealed sources in the whole body count room and "slag sand" in the sand blast room of Building 6.

Surface Activity Measurements

Surface activity ranges for individual buildings are shown on Table 1. Total beta activity for all direct measurements ranged from -360 to 810 dpm/100 cm^2. Removable activity ranged from 0 to 5 dpm/100 cm^2 and -5 to 18 dpm/100 cm^2 for gross alpha and gross beta, respectively.

SURVEY RESULTS: EXTERIOR

Surface Scans

Surface scans for gamma radiation did not identify any areas of elevated activity.

Radionuclide Concentrations in Soil

Radionuclide concentrations in surface and subsurface soil samples are shown in Table 2. Radionuclide concentration ranges in surface samples were less than 0.02 to 0.53 pCi/g for Cs-137 and less than 0.07 pCi/g for Co-60. The concentrations in all subsurface samples were less than 0.04 pCi/g for both Cs-137 and Co-60

Miscellaneous Sampling

Radionuclide concentrations ranges in settling pond sediments for Cs-137 and Co-60 were less than 0.02 to 0.66 pCi/g and less than 0.11 pCi/g, respectively. Radionuclide concentrations for sediment samples are shown in Table 3.

Tritium concentrations in the water samples collected from four monitoring wells were all less than the MDC of the procedure (365 pCi/L), while gross alpha activity ranged from 3.7 to 17.1 pCi/L and gross beta activity ranged from 5.9 to 15.2 pCi/L. Triplicate analyses were performed on the sample yielding the highest gross alpha and gross beta results. These additional results indicate that the initial aliquot may have exhibited a higher activity due to (1) the inhomogeneous nature of the water sample, since the water samples were not filtered, and (2) the radioactive decay of Ra-224 (3-day

half-life) in the sample assuming that its parent, Th-232, is not soluble and is not present in the water sample. Radionuclide concentrations for individual water samples (including the additional analyses) are shown in Table 4.

COMPARISON OF RESULTS WITH GUIDELINES

The primary contaminants of concern at this site are fission and activation products, primarily Co-60 and Cs-137. The site release criteria for unrestricted use adopted by GPU Nuclear is 25 mrem/y and ALARA. The applicable derived concentration guideline levels (DCGLs) for surface activity, based on 25 mrem/y, are 7,050 dpm/100 cm^2 for Co-60 and 28,000 dpm/100 cm^2 for Cs-137 (GPU 1999). The applicable derived concentration guideline levels for soil are 3.79 pCi/g for Co-60 and 11.0 pCi/g for Cs-137 (GPU 1999).

All surface activity results were significantly below the most restrictive DCGL of 7050 dpm/100 cm^2. The maximum value measured was 810 dpm/100 cm^2. The only surface activity distinguishable from background that was identified was associated with the "slag sand" in Building 6 and the sealed sources contained in the other buildings. No removable activity was identified. Similarly, soil samples did not contain any residual radionuclide concentrations distinguishable from background[1] and therefore satisfied the DCGL. The maximum concentration of Cs-137 measured in soil was 0.53 pCi/g. All Co-60 concentrations were less than the respective minimum detectable concentration (MDC).

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[1]Background samples to determine the contribution of Cs-137 from weapons testing fallout deposited in the vicinity of the Forked River Property were not collected during this survey. However, previously reported Cs-137 results indicate a range of Cs-137 in New Jersey coastal plain soils from 0.02 to 1.5 pCi/g. This range is consistent with the United States average of about 0.75 pCi/g, as reported in NCRP Report No. 50, Environmental Radiation Measurements, 1976. Results were decay corrected, if necessary.

References:

PSEG 1998 Annual Radiological Environmental Monitoring Report, April 1999.

1998 NRC Sampling Results from location in Cumberland County, New Jersey.

Oyster Creek REMP data from 1987 to 1994.

NCRP Report No. 50, 1976.

Criteria for water and sediments have not been established. Any activity detected in these samples was comparable to background.

SUMMARY

During the period of November 15 to 18, 1999, the Environmental Survey and Site Assessment Program (ESSAP) performed confirmatory survey activities of various interior and exterior portions of the Oyster Creek Forked River Property in Lacey Township, New Jersey. Confirmatory survey activities included document reviews, surface scans, surface activity measurements, smear sampling, and soil and miscellaneous sampling.

ESSAP's confirmatory surveys of the interior and exterior portions of the Forked River Property did not identify any locations of elevated activity (other than the aforementioned known sealed sources and slag sand.) Radionuclide concentrations in soil and sediment samples were all within the release criteria established for the project, and all were consistent with background concentration levels.

FIGURES

759–001 (1)

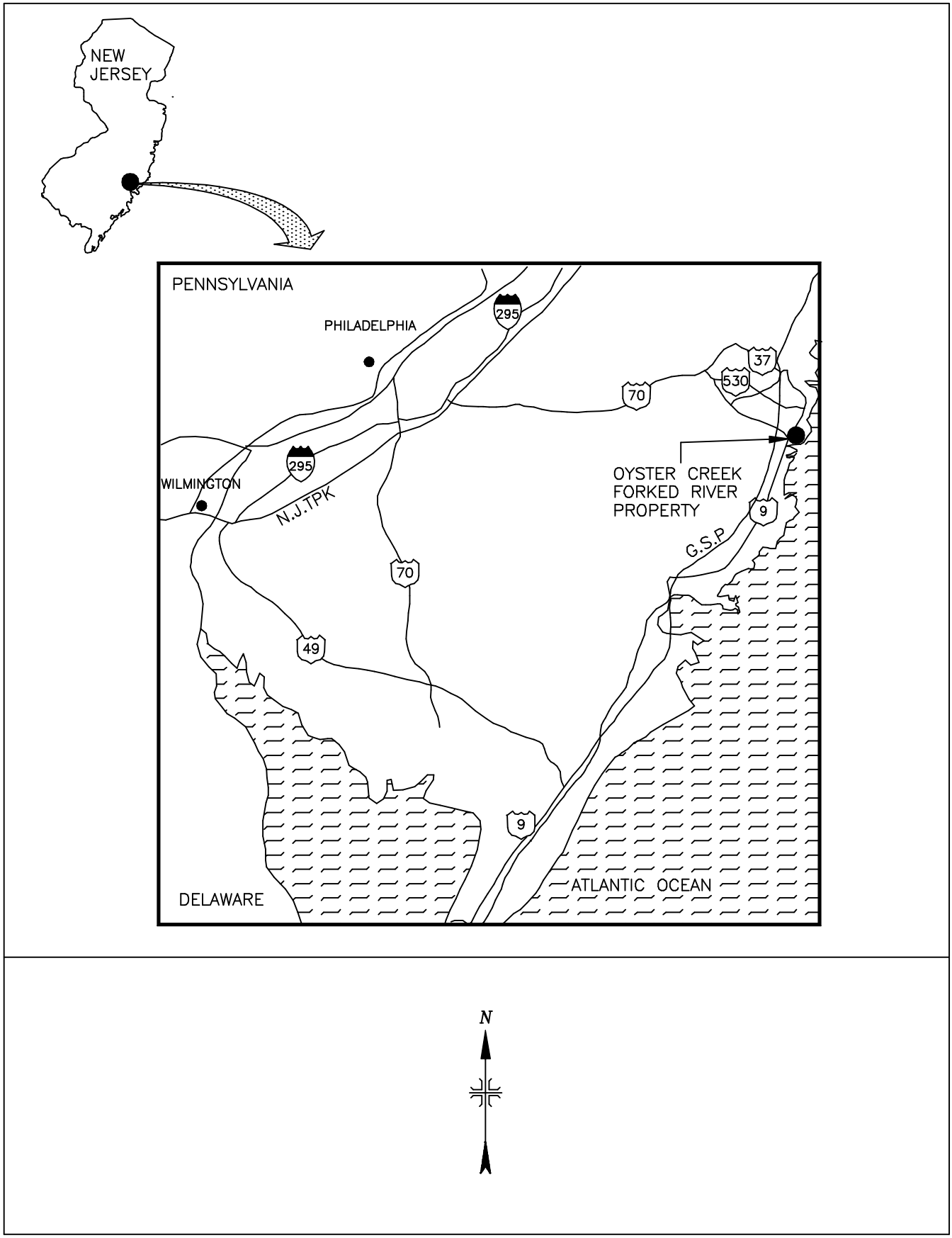


FIGURE 1: Location of the Oyster Creek Forked River Property, Lacey Township, New Jersey

759–015 (1)

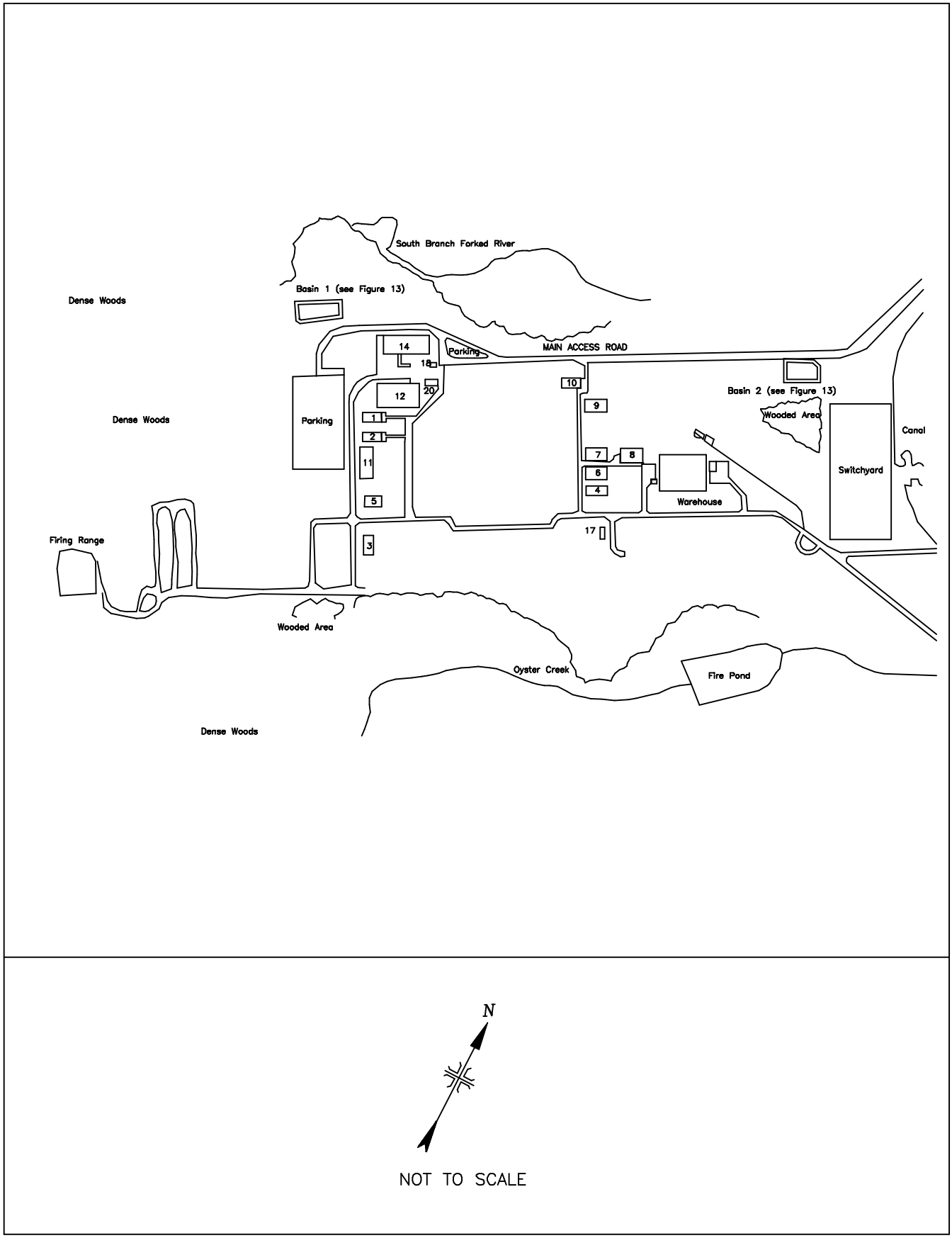
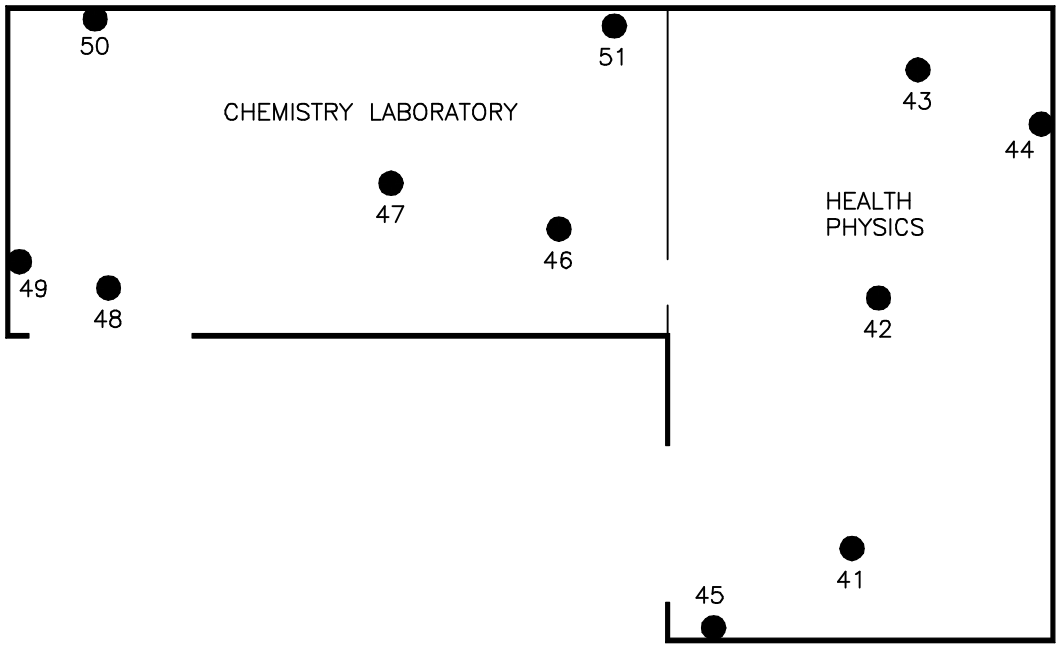


FIGURE 2: Oyster Creek Forked River Property – Plot Plan

759–003 (x)



MEASUREMENT/SAMPLING LOCATIONS

● # SINGLE–POINT LOWER WALLS AND FLOOR

N

NOT TO SCALE

FIGURE 3: Building 1, H.P. and Chemistry Laboratories – Measurement and Sampling Locations

759–004 (1)

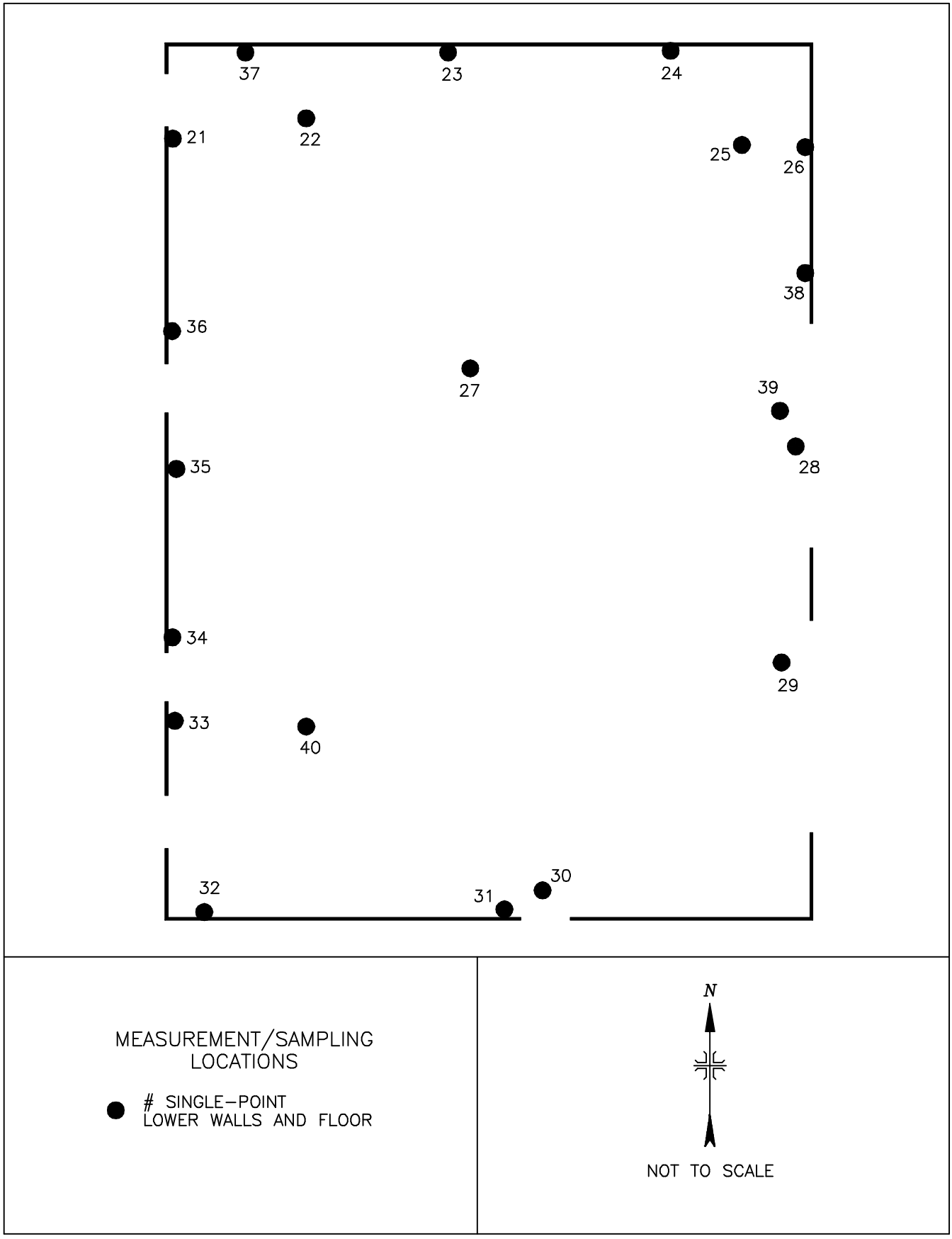


FIGURE 4: Building 5, Motor Pool Area – Measurement and Sampling Locations

759–005 (x)

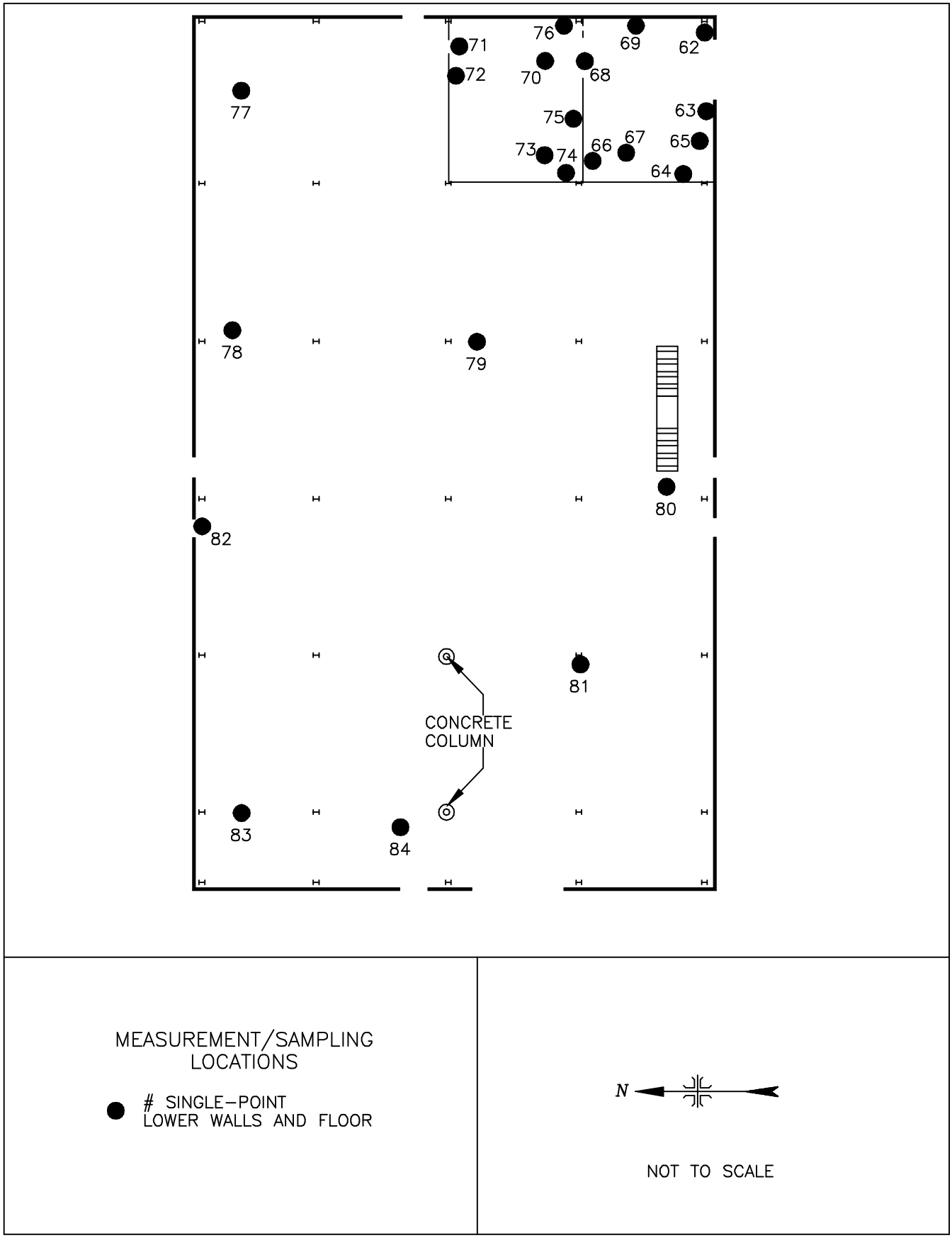


FIGURE 5: Building 6 – Measurement and Sampling Locations

759–006 (1)

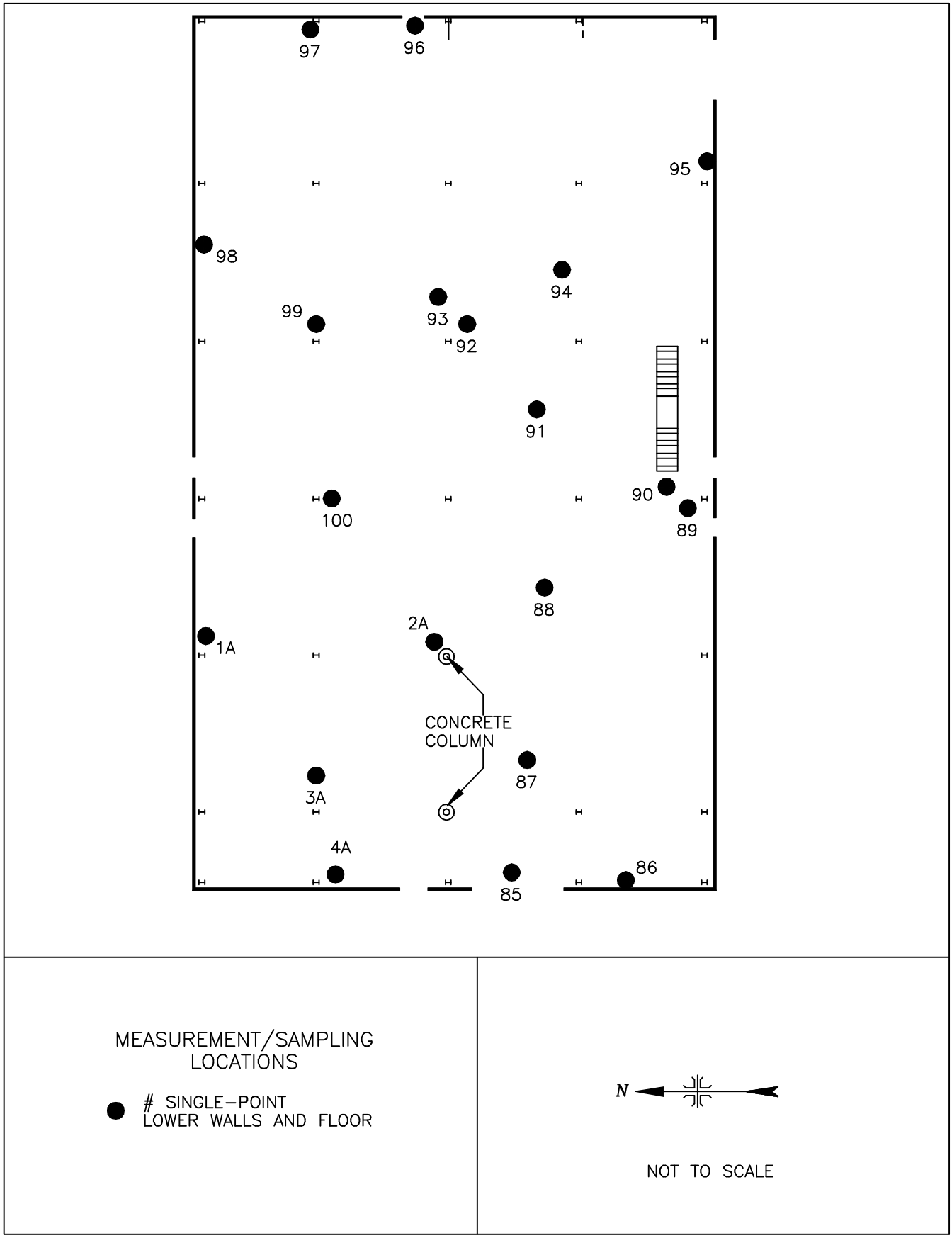


FIGURE 6: Building 7 – Measurement and Sampling Locations

759–007 (x)

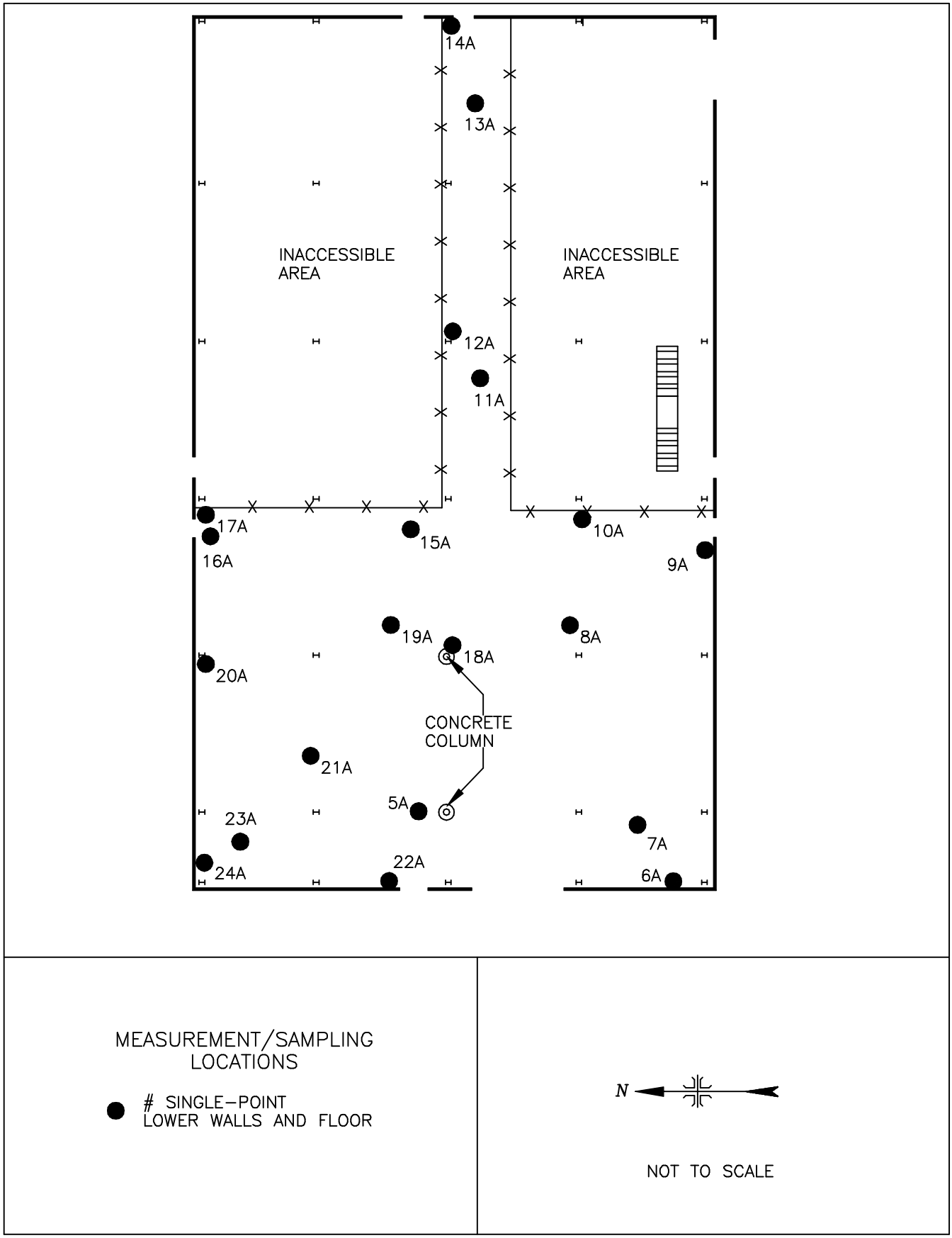


FIGURE 7: Building 8 – Measurement and Sampling Locations

759–008 (1)

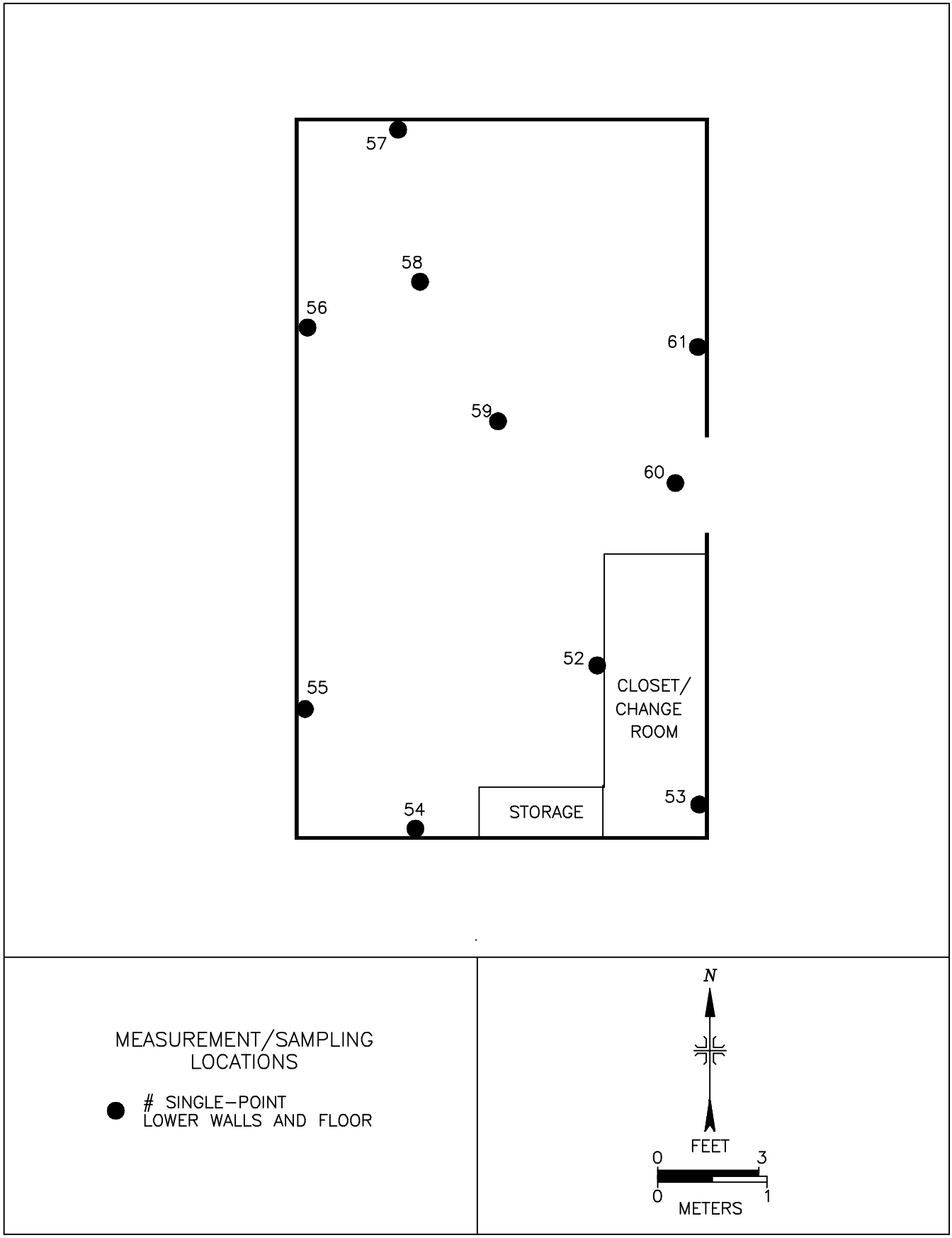
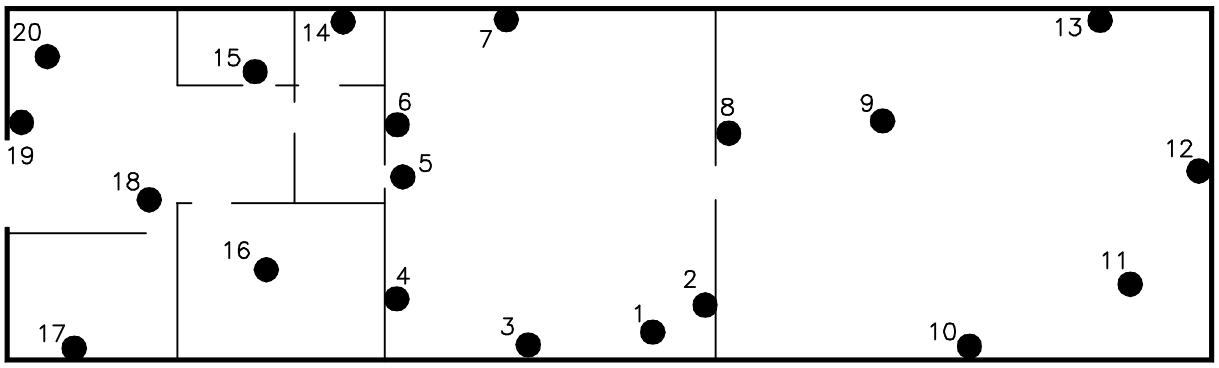


FIGURE 8: Building 14, Whole Body Count Room – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

● # SINGLE–POINT LOWER WALLS AND FLOOR

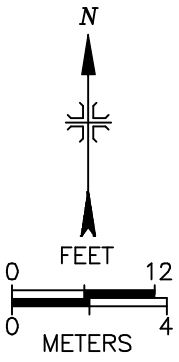


FIGURE 9: Building 20 – Measurement and Sampling Locations

759–010 (1)

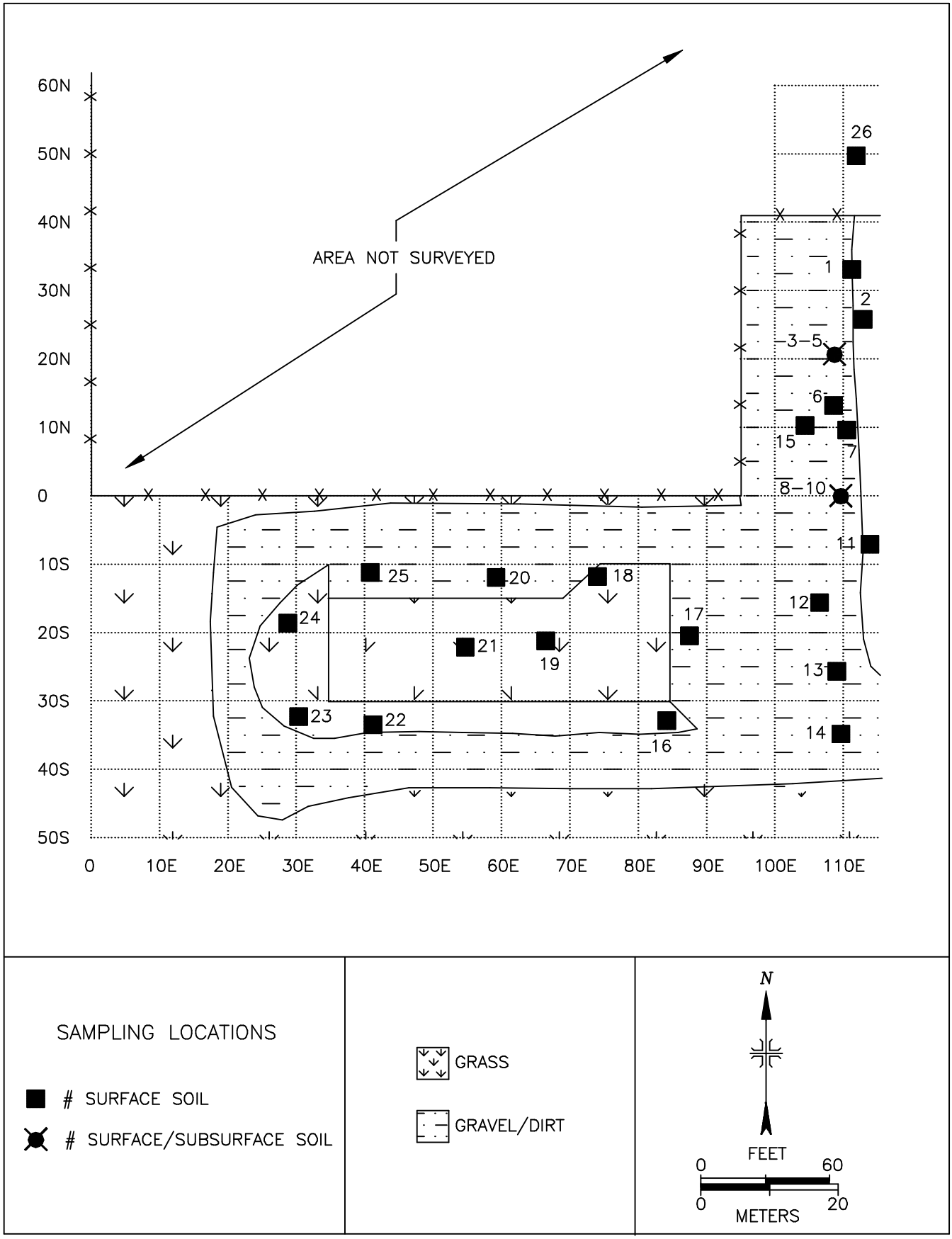


FIGURE 10: Firing Range Parking Lot – Sampling Locations

759–011 (1)

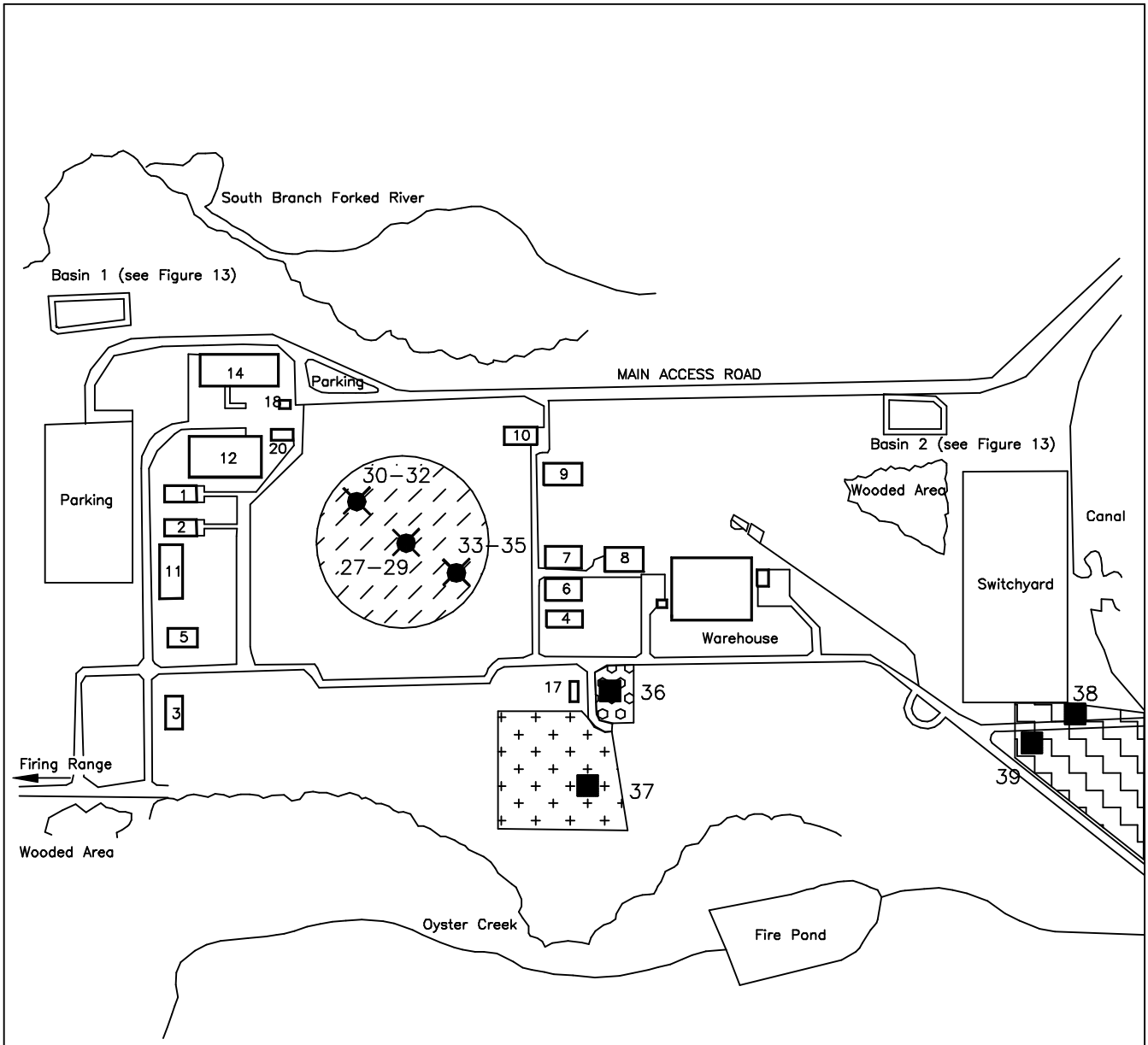


FIGURE 11: Excavated, Adjacent Switch Yard, Laydown, and Depression Areas – Sampling Locations

759–012 (x)

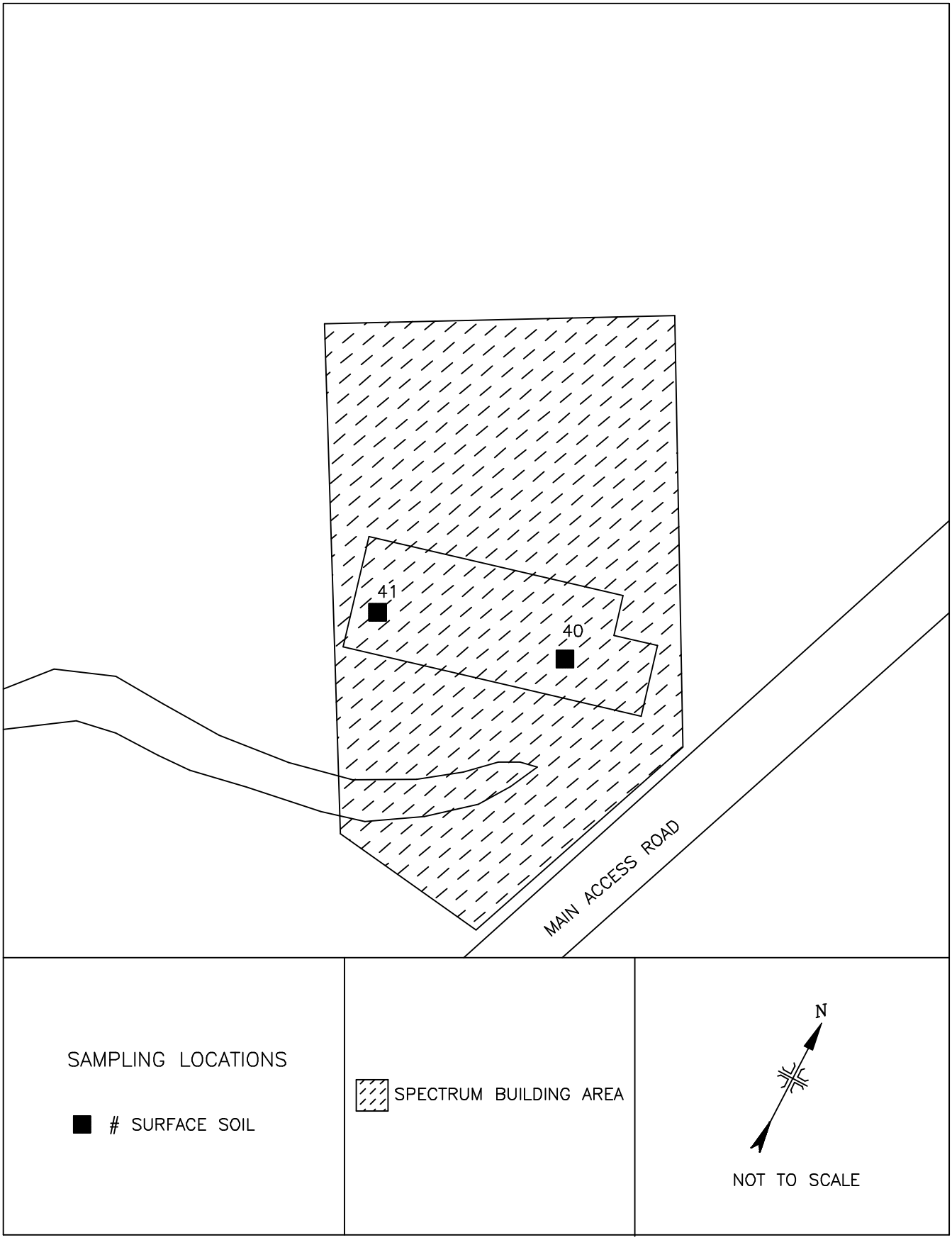


FIGURE 12: Spectrum Building Site – Sampling Locations

759–013 (1)

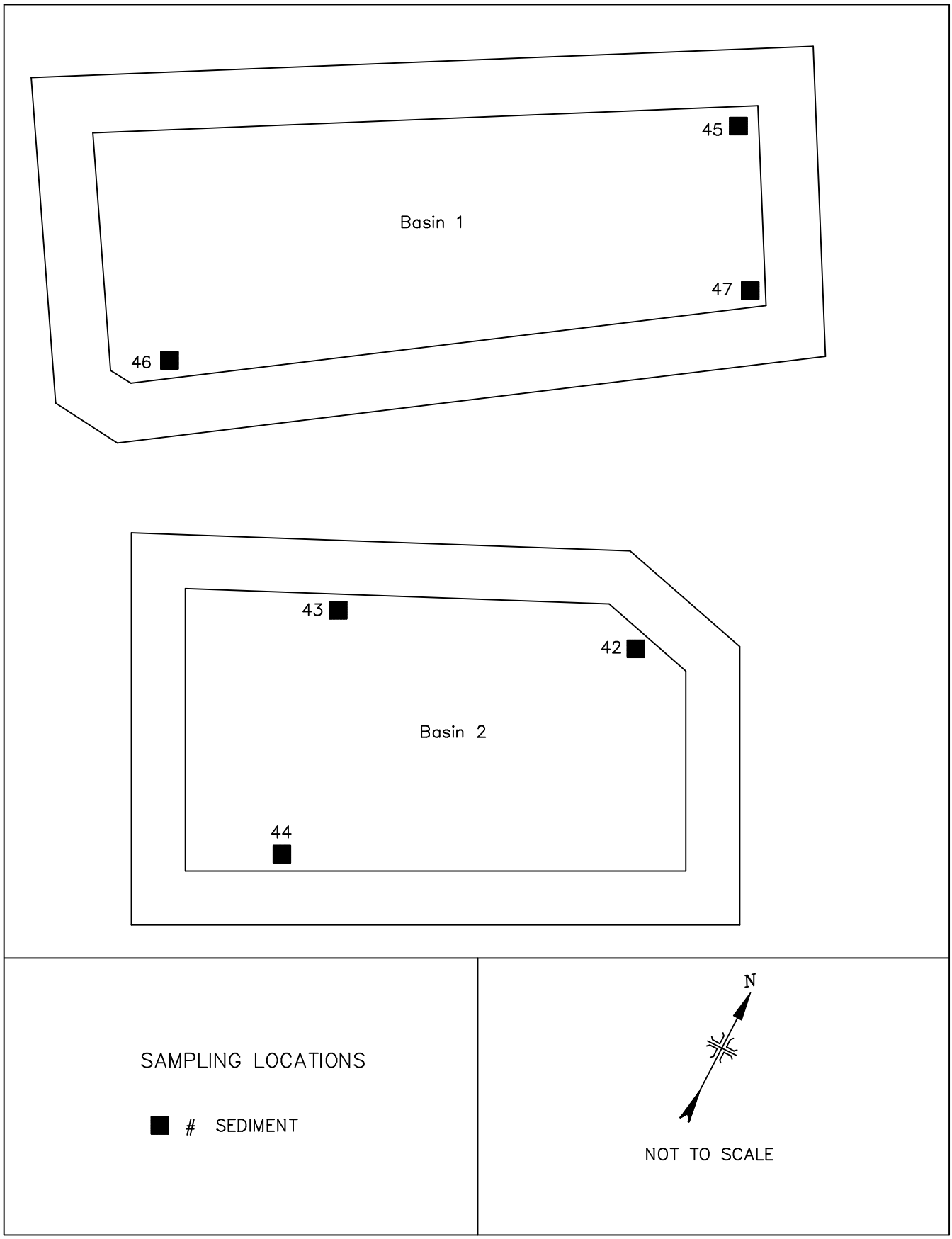


FIGURE 13: Settling Basins – Sampling Locations

759–014 (2)

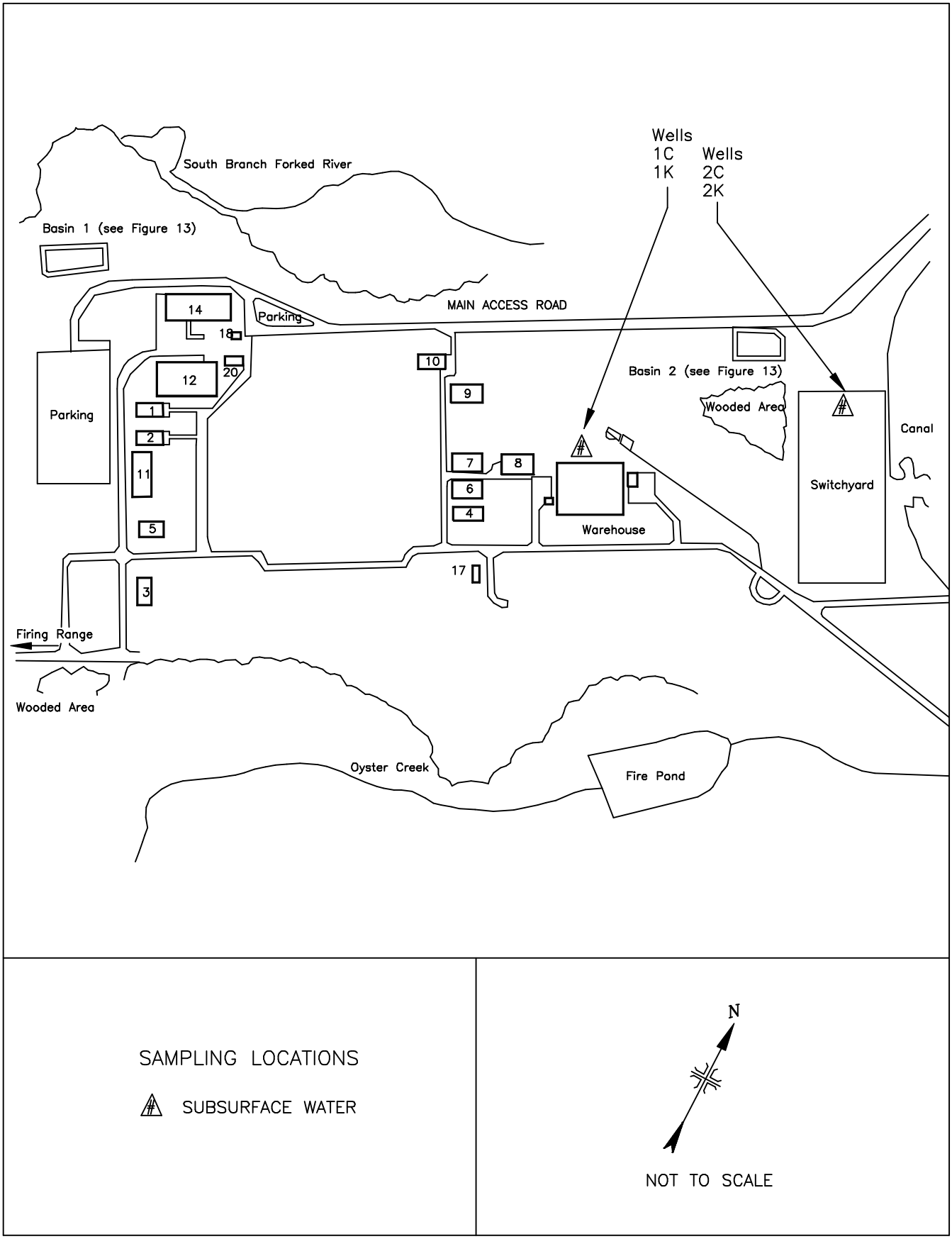


FIGURE 14: Groundwater Monitoring Well Sampling Locations

TABLES

TABLE 1

SUMMARY OF SURFACE ACTIVITY LEVELS
OYSTER CREEK FORKED RIVER PROPERTY
BUILDING INTERIORS
LACEY TOWNSHIP, NEW JERSEY

Building[a]	Number of Direct Measurements	Total Activity (dpm/100 cm^2)[b]	Removable Activity (dpm/100 cm^2)	
			Alpha	Beta
Building 1 H.P. and Chemistry Laboratories	11	-200 to 810	0 to 3	-4 to 9
Building 5 Motor Pool Area	20	-250 to 700	0 to 3	-4 to 5
Building 6	23	-340 to 570	0 to 5	-5 to 18
Building 7	20	-360 to 410	0 to 1	-4 to 5
Building 8	20	-320 to 740	0 to 1	-4 to 6
Building 14 Whole Body Count Room	10	-290 to 600	0 to 3	-1 to 16
Building 20	20	-340 to 350	0 to 1	-4 to 3

[a]Refer to Figures 3 through 9.
[b]The minimum detectable concentrations (MDCs) for direct measurements of surface activity ranged from 460 to 580 dpm/100 cm^2, depending on the surface material.

TABLE 2

RADIONUCLIDE CONCENTRATIONS IN SURFACE AND SUBSURFACE SOIL SAMPLES OYSTER CREEK FORKED RIVER PROPERTY LACEY TOWNSHIP, NEW JERSEY

Sample Number[a]	Sample Depth (cm)	Radionuclide Concentrations (pCi/g)	
		Cs-137	Co-60
Firing Range			
S001	0-15	< 0.04	< 0.03
S002	0-15	< 0.02	< 0.02
S003	0-15	0.04 ± 0.02[b]	< 0.05
S004	45-60	0.03 ± 0.02	< 0.02
S005	85-100	< 0.02	< 0.02
S006	0-15	< 0.03	< 0.04
S007	0-15	0.02 ± 0.02	< 0.02
S008	0-15	< 0.04	< 0.05
S009	45-60	< 0.04	< 0.04
S010	85-100	< 0.04	< 0.04
S011	0-15	< 0.02	< 0.02
S012	0-15	< 0.02	< 0.03
S013	0-15	0.03 ± 0.03	< 0.04
S014	0-15	< 0.02	< 0.02
S015	0-15	0.04 ± 0.02	< 0.02
S016	0-15	0.02 ± 0.01	< 0.02
S017	0-15	< 0.03	< 0.03
S018	0-15	0.04 ± 0.02	< 0.02
S019	0-15	0.14 ± 0.04	< 0.03

TABLE 2 (Continued)

RADIONUCLIDE CONCENTRATIONS
IN SURFACE AND SUBSURFACE SOIL SAMPLES
OYSTER CREEK FORKED RIVER PROPERTY
LACEY TOWNSHIP, NEW JERSEY

Sample Number	Sample Depth (cm)	Radionuclide Concentrations (pCi/g)	
		Cs-137	Co-60
Firing Range (continued)			
S020	0-15	0.04 ± 0.02	< 0.02
S021	0-15	0.03 ± 0.02	< 0.02
S022	0-15	0.05 ± 0.02	< 0.04
S023	0-15	0.12 ± 0.02	< 0.02
S024	0-15	0.53 ± 0.06	< 0.03
S025	0-15	0.03 ± 0.01	< 0.02
S026	0-15	< 0.03	< 0.03
Former Construction Site			
S027	0-15	< 0.03	< 0.03
S028	45-60	< 0.03	< 0.03
S029	85-100	0.02 ± 0.01	< 0.02
S030	0-15	< 0.03	< 0.04
S031	45-60	< 0.03	< 0.02
S032	85-100	< 0.02	< 0.02
S033	0-15	< 0.03	< 0.03
S034	45-60	< 0.02	< 0.02
S035	85-100	< 0.03	< 0.04
Building 17 Laydown and Depression Areas			
S036	0-15	< 0.02	< 0.02
S037	0-15	< 0.02	< 0.03

TABLE 2 (Continued)

RADIONUCLIDE CONCENTRATIONS
IN SURFACE AND SUBSURFACE SOIL SAMPLES
OYSTER CREEK FORKED RIVER PROPERTY
LACEY TOWNSHIP, NEW JERSEY

Sample Number	Sample Depth (cm)	Radionuclide Concentrations (pCi/g)	
		Cs-137	Co-60
Area South of Switchyard			
S038	0-15	0.11 ± 0.03	< 0.02
S039	0-15	0.29 ± 0.06	< 0.07
Spectrum Building Site			
S040	0-15	0.24 ± 0.04	< 0.03
S041	0-15	0.23 ± 0.03	< 0.02

[a]Refer to Figures 10 through 12.
[b]Uncertainties represent the 95% confidence level, based on total propagated uncertainty.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN SEDIMENT SAMPLES OYSTER CREEK FORKED RIVER PROPERTY LACEY TOWNSHIP, NEW JERSEY

Sample Number[a]	Radionuclide Concentrations (pCi/g)	
	Cs-137	Co-60
Pond 1		
S045	0.43 ± 0.08[b]	< 0.09
S046	< 0.02	< 0.02
S047	0.66 ± 0.12	< 0.10
Pond 2		
S042	0.21 ± 0.07	< 0.11
S043	0.23 ± 0.07	< 0.08
S044	0.03 ± 0.02	< 0.03

[a]Refer to Figure 13.
[b]Uncertainties represent the 95% confidence level, based on total propagated uncertainty.

TABLE 4

RADIONUCLIDE CONCENTRATIONS IN WATER SAMPLES OYSTER CREEK FORKED RIVER PROPERTY LACEY TOWNSHIP, NEW JERSEY

Sample Location (Number)[a]	Radionuclide Concentrations (pCi/L)			
	Gross Alpha	Gross Beta	Tritium	Sr-90
Well #1k (W001)	6.8 ± 1.5[b]	10.6 ± 1.8	-10 ± 210	-1.3 ± 1.7
Well #2k (W002)	3.7 ± 1.2	5.9 ± 1.5	-160 ± 210	-0.9 ± 1.7
Well #1c (W003)	17.1 ± 2.8[c]	15.2 ± 2.2[c]	-90 ± 210	0.2 ± 1.7[d]
Well #2c (W004)	8.1 ± 1.6	9.4 ± 1.7	-80 ± 210	-0.2 ± 1.7

[a]Refer to Figure 14.
[b]Uncertainties represent the 95% confidence level, based on total propagated uncertainty.
[c]Additional analyses were performed on aliquots from sample W003 and the results were as follows:

Gross Alpha	Gross Beta
7.5 ± 1.4	7.9 ± 1.2
6.5 ± 1.3	7.8 ± 1.2
7.0 ± 1.4	8.0 ± 1.2

[d]Additional analysis was performed on an aliquot from sample W003. The Sr-90 result was 1.0 ± 1.8 pCi/L.

Sample Location (Number)[a]	Radionuclide Concentrations (pCi/L)						
	Mn-54	Co-60	Zn-65	Ag-110m	Cs-137	Eu-152	Am-241
Well #1k (W001)	< 3.9[b]	< 4.7	< 8.1	< 3.6	< 4.7	< 9.9	< 5.6
Well #2k (W002)	< 2.9	< 3.8	< 6.3	< 2.6	< 2.9	< 7.8	< 4.6
Well #1c (W003)	< 5.1	< 6.2	< 11	< 4.9	< 5.4	< 14	< 7.6
Well #2c (W004)	< 4.0	< 4.8	< 7.5	< 3.7	< 4.7	< 10	< 5.7

[a]Refer to Figure 14.
[b]Values reported as "< #" refer to analytical results that are below the minimum detectable concentration (MDC) - i.e., the radionuclide was not detected in the sample.

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U.S. Nuclear Regulatory Commission. Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM). Washington, DC; NUREG-1575; December 1997b.

APPENDIX A
MAJOR INSTRUMENTATION

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The display of a specific product is not to be construed as an endorsement of the product or its manufacturer by the author or his employer.

DIRECT RADIATION MEASUREMENT

Instruments

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

Ludlum Floor Monitor
Model 230-1
(Ludlum Measurements, Inc.,
Sweetwater, TX)

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

Detectors

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

Ludlum Gas Proportional Detector
Model 43-68
Effective Area, 126 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

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
DEC Alpha
(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
Alpha Vax Workstation
(Canberra, Meriden, CT)

High Purity Extended Range Intrinsic Detector
Model No. GMX-45200-5
(ORTEC)
used in conjunction with:
Lead Shield Model SPG-16-K8
(Nuclear Data)
Multichannel Analyzer
DEC Alpha
(Canberra, Meriden, CT)

Low-Background Gas Proportional Counter
Model LB-5100-W
(Oxford, Oak Ridge, TN)

APPENDIX B
SURVEY AND ANALYTICAL PROCEDURES

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SURVEY AND ANALYTICAL PROCEDURES

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the detectors slowly over the surface; the distance between the detector 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 floors of the surveyed areas. Other surfaces were scanned using small area (126 cm^2) hand-held detectors. 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:

Beta - gas proportional detector with ratemeter-scaler

Gamma - NaI scintillation detector with ratemeter

Scan MDCs were estimated using the calculational approach described in NUREG-1507.[2] The scan MDC is a function of many variables, including the background level. Background levels for the floor monitor typically range from 800 to 1400 cpm, and can range from 250 to 450 cpm for the hand-held gas proportional detector. Additional parameters selected for the calculation of scan MDCs include a 1-second observation interval, a specified level of performance at the first scanning stage of 95% true positive rate and 25% false positive rate, which yields a d' value of 2.32 (NUREG-1507, Table 6.1), and a surveyor efficiency of 0.5. The instrument efficiencies for the floor monitor and hand-held gas proportional detector

[2]NUREG-1507. Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. US Nuclear Regulatory Commission. Washington, DC; June 1998.

calibrated to Tc-99 were 0.24 and 0.3, respectively. To illustrate an example for the floor monitor, the minimum detectable count rate (MDCR) and scan MDC can be calculated as follows:

b_i = (800 cpm)(1 s)(1 min/60 s) = 13 counts,
MDCR = $(2.32)(13)^{½}$ [(60 s/min)/(1 s)] = 508 cpm,
$MDCR_{surveyor}$ = $508/(0.5)^{½}$ = 720 cpm

The scan MDC is calculated assuming a source efficiency of 0.25 (for Tc-99):

$$Scan\ MDC = \frac{720}{(0.25)\ (0.24)} = 12{,}000\ dpm/100\ cm^2$$

For the given background range, the estimated scan MDC range for the floor monitor is 12,000 to 15,800 dpm/100 cm^2; and 5,400 to 7,200 dpm/100 cm^2 for the hand-held gas proportional detector.

The scan MDC for the NaI scintillation detector for Co-60 and Cs-137 were obtained directly from NUREG-1507. The scan MDCs were 5.8 and 10.4 pCi/g, respectively, for Co-60 and Cs-137.

Surface Activity Measurements

Measurements of total beta activity levels were performed using gas proportional detectors with portable ratemeter-scalers.

Because different building materials (poured concrete, brick, wood, steel, etc.) may have different background levels, average background count rates were determined for each material encountered in the surveyed area at a location of similar construction and having no known radiological history. The background count rates for the gas proportional detectors averaged 227 cpm for concrete floors, 182 cpm for concrete block, 188 cpm for wood and 140 cpm for metal.

Count rates (cpm), which were integrated over one minute in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net rate by the total efficiency ($\epsilon_i \times \epsilon_s$) and correcting for the active area of the detector. The 2π instrument efficiencies were 0.39 and 0.40 for the gas proportional detectors calibrated to Tc-99. The source efficiency factor (ϵ_s) was 0.25. Therefore, the total efficiency factor for

the detectors was 0.10. The beta activity MDCs ranged from 460 to 580 dpm/100 cm^2, depending on the surface material. The physical probe area for the gas proportional detectors was 126 cm^2.

Removable Activity Measurements

Removable gross alpha and gross beta activity levels were determined using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

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.

Water Sampling

Approximately 3.8 liters of water was collected from each sample location. The samples were transferred to a plastic container, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Gross Alpha/Beta

Smears were counted on a low-background gas proportional system for gross alpha and gross beta activity. The gross alpha and gross beta MDCs were 9 and 15 dpm/100 cm^2, respectively.

Gamma Spectroscopy

Samples of soil were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in a 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry. 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. All photopeaks associated with the radionuclides of concern were reviewed for consistency of activity. Energy peaks used for determining the activities of radionuclides of concern were:

Cs-137	0.662 MeV
Co-60	1.173 MeV (or 1.332 MeV)

Spectra were also reviewed for other identifiable photopeaks.

Nominal MDCs for Cs-137 and Co-60 based on a count time of 60 minutes and 800-gram sample quantity were 0.07 and 0.08 pCi/g, respectively.

Gross Alpha and Beta in Water

A known volume of water was acidified with dilute nitric acid, concentrated and dried in a planchet. Samples were counted in a low-background proportional counter.

H-3 in Water

Liquid sample analysis for H-3 was performed by placing a representative portion of the samples into a scintillation cocktail and counting on a liquid scintillation counter. Samples were then spiked with a known amount of tritium, carbon-14, and strontium-90 standards and recounted on the liquid scintillation counter. Data from both counts were calculated using an in-house program to determine activity.

Sr-90 in Water

The water samples were evaporated directly and the residue was treated as a soil sample. Strontium concentrations within the samples were then determined in a low-background gas proportional counter, and the count rate was corrected for yttrium ingrowth. The chemical yield was determined gravimetrically.

UNCERTAINTIES AND DETECTION LIMITS

The uncertainties associated with the analytical data presented in the tables of this report represent total propagated uncertainty at the 95% confidence level. Total propagated uncertainties refer to the propagation of all random uncertainties, including counting error and uncertainties associated with each analytical procedure.

Detection limits, referred to as minimum detectable concentration (MDC), were based on 3 plus 4.65 times the standard deviation of the background count [$3 + (4.65\sqrt{BKG})$]. 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.

CALIBRATION AND QUALITY ASSURANCE

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

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, (January 1998)
- Laboratory Procedures Manual, (October 1999)
- Quality Assurance Manual, (May 1998)

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.

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 laboratory Quality Assurance Programs.
- Training and certification of all individuals performing procedures.
- Periodic internal and external audits.