DESIGNATION SURVEY
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Prepared by

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
cm	centimeter
CE	Combustion Engineering
cm^2	square centimeter
cpm	counts per minute
DOE	U.S. Department of Energy
DOE-EM	Office of Environmental Restoration and Waste Management
DOE-ORO	DOE Oak Ridge Operations
dpm/100 cm^2	disintegrations per minute/100 square centimeters
EML	Environmental Measurement Laboratory
EPA	Environmental Protection Agency
ESSAP	Environmental Survey and Site Assessment Program
FSRD	Former Sites Restoration Division
ft^2	square feet
FUSRAP	Formerly Utilized Sites Remedial Action Program
GM	Geiger-Mueller
h	hour
HEU	highly enriched uranium
kg	kilogram
km	kilometer
m	meter
m^2	square meter
MDA	minimum detectable activity
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
ORAU	Oak Ridge Associated Universities
ORISE	Oak Ridge Institute for Science and Education
ORNL	Oak Ridge National Laboratory
pCi/g	picocuries per gram
ZnS	zinc sulfide

DESIGNATION SURVEY
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

INTRODUCTION AND SITE HISTORY

Combustion Engineering (CE) has operated a facility on the site near Windsor, Connecticut as part of its efforts as a contractor for the Atomic Energy Commission (AEC), predecessor agency of the Department of Energy (DOE), on nuclear reactor and fuel projects. Beginning in 1955 and continuing for over a decade, CE served as a direct contractor to the AEC and as a subcontractor to other firms for a number of projects involving the use of highly enriched uranium (HEU) provided by the AEC. The uranium furnished for use at the CE facility varied from approximately 5% to over 90% enrichment of U-235.[1]

Portions of the Windsor site, formerly utilized for AEC activities, includes Buildings 3, 5 and 6, the related drainpipes and sewer lines, the waste storage pad area, the drum burial site, and the site brook. Radiological surveys conducted in the early 1980's, identified areas of thorium and uranium (enrichments ranged from 1 to 80%) contamination in the burn and drum storage area (referred to as the septic field in this report). This area was remediated by CE in 1986 and a confirmatory survey conducted by Oak Ridge Associated Universities (ORAU) in 1989 concluded that the area was within Nuclear Regulatory Commission (NRC) guidelines for thorium and uranium in soil.[2] CE also currently operates a nuclear fuel manufacturing facility licensed by the NRC, number SNM-1067, on the Windsor site.

The Department of Energy's Office of Environmental Restoration and Waste Management (EM) recommended that the current status of HEU (for purposes of this survey, defined to be uranium enriched to not less than 20% in the isotope U-235) on the CE site be determined; the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute of Science and Education (ORISE) was requested to perform a survey of the site.

SITE DESCRIPTION

The CE site, which consists of approximately 1100 acres, is located on Prospect Hill Road in a mixed industrial and residential area, approximately 5 kilometers southwest of Bradley International Airport (Figure 1). Interstate 91 runs to the east of the site and the site brook runs east to west on the north end of the site and joins the Farmington River northwest of the site. The site is comprised of more than a dozen buildings with several smaller support facilities (Figure 2). The site is also characterized by various wooded areas and three ponds.

The waste storage pad area is an approximately 110 m x 220 m plot of land, lightly wooded with a mildly sloping terrain, located at the interior of the site. The drum burial pit, approximately five times smaller in area than the waste storage pad area, is characterized by level terrain situated between two steep embankments.

Uranium fuel fabrication was historically performed in Building 3, while Building 5 was similarly used for AEC contract work. Buildings 3 and 5 are currently used to support research and development projects. Building 6 served as a waste dilution and pumping facility for the liquid streams from Buildings 3 and 5. Two sewer lines discharged material from Building 6, one to the sewage treatment facility and the other to the site brook.

The industrial and sanitary drain lines at the CE Site have undergone significant re-routing throughout their history. The sanitary lines from Buildings 3 and 5 originally ran to the septic field, later to the on-site sewage treatment facility, and currently to the municipal treatment plant. Radioactive waste lines from Buildings 3 and 5 initially ran to Building 6 for monitoring/treatment, and from Building 6 to the sewage treatment facility. Presently, there is no radioactive waste system in use; industrial lines run directly to the sewage treatment facility and into the site brook without monitoring/treatment. Non-radioactive, clean industrial liquids drain to the sewage treatment plant, but receive no treatment or holdup unless a problem is suspected. In summary, three separate drain lines (i.e., old sanitary, old industrial, and new industrial) run north from the Building 3, 5, and 6 complex to the sewage treatment facility and

site brook. Numerous other lines have been removed from service, but remain in their original underground locations.

PROJECT ORGANIZATION AND RESPONSIBILITY

DOE Headquarters provides overview and coordination for all FUSRAP activities. The DOE Oak Ridge Operations (DOE-ORO) is responsible for implementation of FUSRAP and the Former Sites Restoration Division (FSRD) of DOE-ORO, manages the daily activities.

Under the standard FUSRAP protocol, an initial investigation/survey of a potential site is performed by ORISE or Oak Ridge National Laboratory (ORNL), under contract to DOE Headquarters. If appropriate, DOE Headquarters designates the site into FUSRAP, based upon the results provided by the initial investigation. The Combustion Engineering Site was selected for such an initial investigation/survey.

OBJECTIVE

The objective of the survey was to provide sufficient information to determine the radiological status (limited to uranium with an enrichment of not less than 20% in the U-235 isotope)[1] of the site, relative to the FUSRAP guidelines and DOE Order 5400.5, Chapter IV. The results will be used by DOE/EM to determine whether further actions under FUSRAP will be taken.

DOCUMENT REVIEW

ESSAP reviewed the site background information provided by the DOE.[1] Additionally, information provided by CE during a preliminary site visit by ESSAP was reviewed and used as a guide in the selection of measurement and sampling locations.

PROCEDURES

During the period from November 15 through 18, 1993, ESSAP performed a designation survey of the Combustion Engineering Site. The survey was in accordance with a survey plan, dated November 12, 1993, submitted to and approved by the DOE.[3,4] This report summarizes the procedures and results of the survey.

INTERIOR

ESSAP used the following procedures for the interior portions of the survey.

Refererce Grid

The existing 10-foot (3.1 m) reference grid system established by CE on the walls in Building 3, was used by ESSAP for survey reference. Additionally, measurements and samples from the floors, drains, and equipment in Buildings 3, 5, and 6 were referenced to prominent building features.

Surface Scans

Surface scans for alpha, beta and gamma activity were performed on floors, upper and lower walls, drains, and equipment, using ZnS scintillation, GM, and NaI scintillation detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Locations of elevated direct radiation, identified by surface scans, were marked for further investigation.

Surface Activity Measurements

Measurements to determine total alpha and beta surface activity levels were performed on randomly selected surfaces within the suspect areas (i.e., locations previously surveyed by CE and suspected of being contaminated with HEU). Twenty-five surface activity measurements were performed on these indoor areas; including the drains, walls, and floors in Buildings 3, 5,

and 6. Smear samples for determining removable activity were obtained from direct measurement locations where miscellaneous samples were not collected. Measurement and sampling locations for total and removable activity are illustrated on Figures 3 through 9. Figures were not provided for two surface activity measurements located on the Building 3 south wall and Building 6 first floor.

Miscellaneous Sampling

Sixteen residue, paint, fiberglass and sediment samples were collected from floors, drains, and walls in Buildings 3 and 6. No material was available to sample from suspect areas in Building 5. Miscellaneous sampling locations are shown in Figures 3 through 7 and 9.

EXTERIOR

ESSAP used the following procedures for outdoor portions of the survey.

Reference Grid

The 30-foot (9.1 m) grid system, established by CE in the waste storage pad area and drum burial site, was used for referencing measurement and sampling locations. Ungridded areas (e.g., site brook, septic field, sewage treatment facility, roof surfaces and vents, etc.) were referenced to prominent site features or existing landmarks and recorded on appropriate drawings.

Surface Scans

Surface scans of outdoor locations, including the waste storage pad area (twelve of the 30-foot grid blocks were randomly selected for survey activities), drum burial site, site brook and banks, septic field, grounds north of Building 3 and sewage treatment facility, were conducted using NaI scintillation detectors and ratemeters with audible indicators. Locations of elevated radiation, suggesting the presence of surface or near surface contamination, were marked for

further investigation. Numerous locations of elevated radiation were identified in many of these areas, therefore, surface scans were terminated once a sufficient number of sampling locations had been selected from each area.

Scans of exterior building surfaces (e.g., roof surfaces and vents) and access locations (manholes) to industrial and sewer lines were conducted using NaI scintillation detectors and ZnS scintillation detectors. Locations of elevated radiation were marked for further investigation.

Soil Sampling

Background soil samples were collected from five off-site locations within 0.5 to 10 km of the site, during a previous ESSAP survey at the CE site.[2]

Surface and subsurface soil samples were collected from 12 locations of elevated direct radiation within the waste storage pad area (Figure 10) and from 6 locations within the drum burial pit (Figure 11). Soil samples were also collected from the grounds north of Buildings 3, septic field, sewer treatment facility and site brook banks. These soil sampling locations are shown on Figures 12 through 15.

Miscellaneous Sampling

Sediment samples were collected from 16 manhole access locations to sewer and industrial drain lines (Figure 16) and at 10 locations within the site brook (Figure 17). A sediment sample was also collected from the site outfall to the Small Pond (Figure 12).

Two residue samples were collected from roof vents atop Building 3. A buried piece of plastic, identified by elevated direct radiation levels during surface scanning, was collected from the drum burial pit (Figure 11).

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and survey data were returned to the ESSAP Oak Ridge laboratory for analyses and interpretation. All 96 soil and miscellaneous samples were analyzed by gamma spectrometry; 26 of the samples were also analyzed by alpha spectrometry. Spectra were reviewed for U-235 and U-238, and any other identifiable photopeaks. Gamma spectrometry results were used to provide only qualitative information on the percentage U-235 enrichment (e.g., comparison of the U-235 enrichment in samples to the 20% U-235 enrichment action level), while actual U-235 enrichments were reported for samples analyzed by alpha spectrometry. The percentage of U-235 enrichment was calculated by dividing the U-234, U-235, and U-238 activity concentrations by their respective specific activities, and determining the ratio of the U-235 isotopic weight to the total uranium weight. Soil and miscellaneous sample results were reported in units of picocuries per gram (pCi/g). Smears were analyzed for gross alpha and gross beta activity. Direct measurement data and smear data were converted to units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2). Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices A and B.

FINDINGS AND RESULTS

INTERIOR

Surface Scans

Surface scans of Buildings 3, 5, and 6 identified elevated direct radiation at the following locations: floor drains, I-beams and insulated piping within the Drop Tube Furnace Testing area, and Vault Room walls within Building 3; and basement floor and miscellaneous equipment within Building 6. Surface scans in Building 5 did not identify any areas of elevated direct radiation. Additional surface activity measurements and sampling were performed at these locations.

Surface Activity Levels

Results of total and removable activity are summarized in Table 1. The twenty-five surface activity measurements on interior surfaces ranged from <66 to 5,100 dpm/100 cm^2 and $<1,300$ to 23,000 dpm/100 cm^2 for alpha and beta, respectively (Figures 3 through 9). Removable activity ranged from <12 to 17 dpm/100 cm^2 for alpha and was less than the minimum detectable activity (MDA) of the procedure, which is <16 dpm/100 cm^2 for beta.

Uranium Concentrations in Miscellaneous Samples

Uranium concentrations in miscellaneous samples (i.e., residue, fiberglass insulation, paint, etc.) collected from drains, sumps, walls and floors are presented in Tables 2 and 6. The U-235 activity in one fiberglass sample from the Building 3 walls was <35 pCi (Table 2), with a corresponding U-235 enrichment less than 20%. The U-235 concentration in one sample of pipe insulation wrap was 97.8 pCi/g, with a corresponding U-235 enrichment of approximately 20% (Table 2). Alpha spectrometry analysis, performed on 6 fiberglass samples from Building 3 walls, resulted in total uranium concentrations ranging from 1.60 to 601.33 pCi/g, and corresponding U-235 enrichments ranging from 0.59% to 38% (Table 6).

The U-235 concentrations in three Building 3 drain residue samples were less than 1.3 pCi/g, with corresponding U-235 enrichments less than 20% (Table 2). Alpha spectrometry analysis of drain residue sample #1 resulted in a total uranium concentration of 13,190 pCi/g and a U-235 enrichment of 44% (Table 6).

Alpha spectrometry analysis on 2 paint samples from the Building 3 north wall resulted in total uranium concentrations of 43.8 and 864 pCi/g, and corresponding U-235 enrichments of 46% and 32%, respectively (Table 6).

The U-235 concentration in 2 floor and equipment residue samples in the basement of Building 6 were 228.7 and 385.5 pCi/g, with corresponding U-235 enrichments both less than 20% (Table 2).

Alpha spectrometry analysis of the sediment sample from the sump resulted in a total uranium concentration of 13,850 pCi/g, with a U-235 enrichment of 13% (Table 6).

EXTERIOR

Surface Scans

Surface scans of outdoor locations, including the waste storage pad area, drum burial site, and site brook and banks identified numerous areas of elevated direct radiation. In the waste storage pad area, 10 of the 12 randomly selected grid blocks exhibited elevated direct radiation. Locations of elevated direct radiation in the drum burial pit were limited to the actual areas within excavations (that exposed the buried drums) and near a tree in grid block E2 (Figure 11). Locations of elevated direct radiation in the site brook were identified along the site brook bank (Figure 15) and from sample locations #5 to #9 (Figure 17).

Surface scans of the grounds north of Building 3, septic field and sewage treatment plant were generally within the range of ambient background levels. Two locations on the grounds north of Building 3 exhibited direct radiation levels approximately three to six times ambient background levels (sample locations #1 and #3 in Figure 12).

Surface scans of the manhole access locations to sewer and industrial lines identified elevated direct radiation in the following manholes: old and new industrial lines at manhole locations #6 and #7 on Figure 16, radiological line southeast of Building 6A (#12), industrial line exiting east of Building 6 (#14), and industrial line northeast of Building 3 (#13).

Surface scans for alpha and beta activity on the roof surfaces and vents did not identify any areas of elevated direct radiation.

Uranium Concentrations in Soils

Radionuclide concentrations in background samples were < 0.2 pCi/g for U-235 and ranged from < 0.7 to 1.8 pCi/g for U-238.[2]

Uranium concentrations in soil samples, collected both randomly and from locations of elevated direct radiation, are summarized in Tables 3 and 6. The U-235 concentrations in the waste storage pad area ranged from <0.1 to 2169 pCi/g (Table 3). Alpha spectrometry analysis, performed on 7 samples from the waste storage pad area, resulted in total uranium concentrations ranging from 21.02 to 1,173 pCi/g, and corresponding U-235 enrichments ranging from 23% to 48% (Table 6).

The U-235 concentrations in the drum burial pit ranged from < 0.1 to 620.1 pCi/g (Table 3). Alpha spectrometry analysis, performed on 2 samples from the drum burial pit, resulted in total uranium concentrations of 25.5 and 917 pCi/g, and corresponding U-235 enrichments of 33% and 58% (Table 6).

The U-235 concentrations in grounds north of Building 3 ranged from < 0.1 to 148.0 pCi/g (Table 3). Alpha spectrometry analysis, performed on 2 samples from the grounds north of Building 3, resulted in total uranium concentrations of 39.1 and 768 pCi/g, and corresponding U-235 enrichments of 3.7% and 36% (Table 6).

The U-235 concentrations on the site brook banks ranged from 12.1 to 77.2 pCi/g (Table 3). Alpha spectrometry analysis of the sediment sample from the site brook bank resulted in a total uranium concentration of 24,090 pCi/g and a U-235 enrichment of 17% (Table 6). Much of the uranium contamination on the site brook bank appeared to be associated with partially buried clam shells. Additional laboratory analysis was performed to evaluate the quantity of uranium activity separately for both the clam shell fraction and the soil fraction. The quantity of U-235 in the soil component ranged from 63% to 93%, and from 7% to 37% in the clam shell component.

The U-235 concentrations in the septic field and sewage treatment facility grounds ranged from < 0.1 to 1.2 pCi/g, with corresponding U-235 enrichments less than 20% (Table 3). However, total thorium activity from borehole samples in the septic field ranged from 7.7 to 32.6 pCi/g.

Uranium Concentrations in Miscellaneous Samples

Uranium concentrations in sediment samples collected from manhole access locations to sewer and industrial lines are summarized in Tables 4 and 6. The U-235 concentrations in these samples ranged from < 0.1 to 3868 pCi/g (Table 4). Alpha spectrometry analysis, performed on 3 samples from the manhole access locations, resulted in total uranium concentrations ranging from 334 to 4,900 pCi/g, and corresponding U-235 enrichments ranging from 13% to 55% (Table 6).

Uranium concentrations in sediment samples collected from the site brook and outfall to the Small Pond are summarized in Tables 5 and 6. The U-235 concentrations in these samples ranged from <0.1 to 16.7 pCi/g (Table 5). Alpha spectrometry analysis of sediment sample from the site brook at location #8 resulted in a total uranium concentration of 16,740 pCi/g and a U-235 enrichment of 58% (Table 6).

The U-235 concentrations in residue samples collected from the Building 3 roof vents were <2.3 pCi/g (Table 2), with corresponding U-235 enrichments less than 20%.

The U-235 activity on the buried piece of plastic near the drum burial pit was 307,400 pCi (Table 2), with a corresponding U-235 enrichment greater than 20%.

COMPARISON OF RESULTS WITH GUIDELINES

The radioactive contaminant of concern at the CE site is highly enriched uranium (i.e., greater than 20% enrichment in the U-235 isotope). The surface contamination guidelines for uranium are presented in Appendix C, and are as follows:[5]

Total Activity

5,000 α (alpha) dpm/100 cm^2, averaged over 1 m^2

15,000 α dpm/100 cm^2, maximum in 100 cm^2

Removable Activity

1,000 α dpm/100 cm^2

The site-specific soil guideline for enriched uranium will be determined pursuant to DOE Order 5400.5 if portions of the CE site are designated into FUSRAP.[6]

Surface activity measurements for total and removable activity in areas surveyed in Building 3 were within the surface contamination guidelines. However, laboratory analysis on the paint samples from the north wall of Building 3 indicates the presence of HEU in the paint. One surface activity measurement on the basement floor of Building 6 exceeded the 15,000 dpm/100 cm^2 criterion (Table 1).

Analyses of miscellaneous samples collected from interior areas identified the following locations within Building 3 as contaminated with HEU: drain location #1 (Figure 3), east wall locations #1 and #2 (Figure 5), pipe insulation wrap in the Drop Tube Furnace Testing area (Figure 6), and the north wall and Vault Room wall (Figure 7). The sediment sample collected from the Building 6 sump, while containing significant quantities of uranium contamination, did not exceed the 20% U-235 enrichment action level.

Analyses of soil and sediment samples collected from outdoor areas identified the following locations as contaminated with HEU: waste storage pad area (Figure 10), drum burial pit

(Figure 11), grounds north of Building 3 (Figure 12), site brook bank (Figure 15), sewer and industrial lines at manhole access locations (Figure 16), and the site brook (Figure 17).

Designation survey activities did not identify HEU contamination at any location within Building 5, on the grounds of the septic field or sewage treatment facility, on any roof surfaces or vents, or the outfall to the Small Pond.

SUMMARY

At the request of the U.S. Department of Energy, the Oak Ridge Institute for Science and Education's Environmental Survey and Site Assessment Program conducted a designation survey at the Combustion Engineering Site in Windsor, Connecticut. The interior survey activities consisted of surface scans for alpha, beta, and gamma activity on the floors, walls, drains and equipment, measurements of total and removable activity, and miscellaneous sampling. The exterior survey activities consisted of scans for gamma activity in the outdoor areas, and soil and miscellaneous sampling.

The designation survey identified several interior and exterior locations as containing highly enriched uranium (greater than 20% enrichment in the U-235 isotope). The interior areas include drain location #1, east wall locations #1 and #2, pipe insulation wrap in the Drop Tube Furnace Testing area, and the north wall and Vault Room wall within Building 3. The exterior areas include the waste storage pad area, drum burial pit, grounds north of Building 3, site brook bank, sanitary sewer and industrial drain lines, and the site brook.

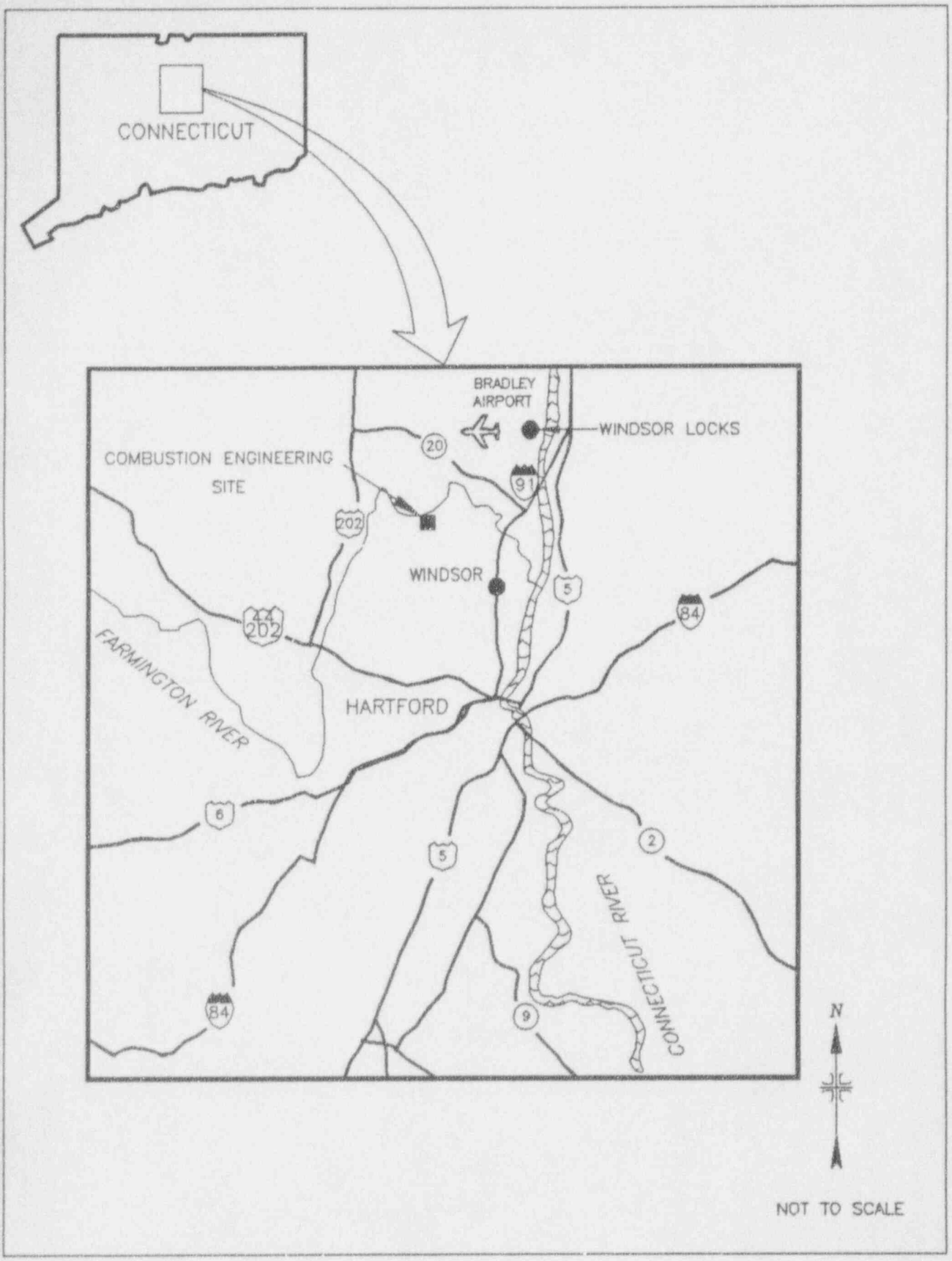


FIGURE 1: Location of the Combustion Engineering Site – Windsor, Connecticut

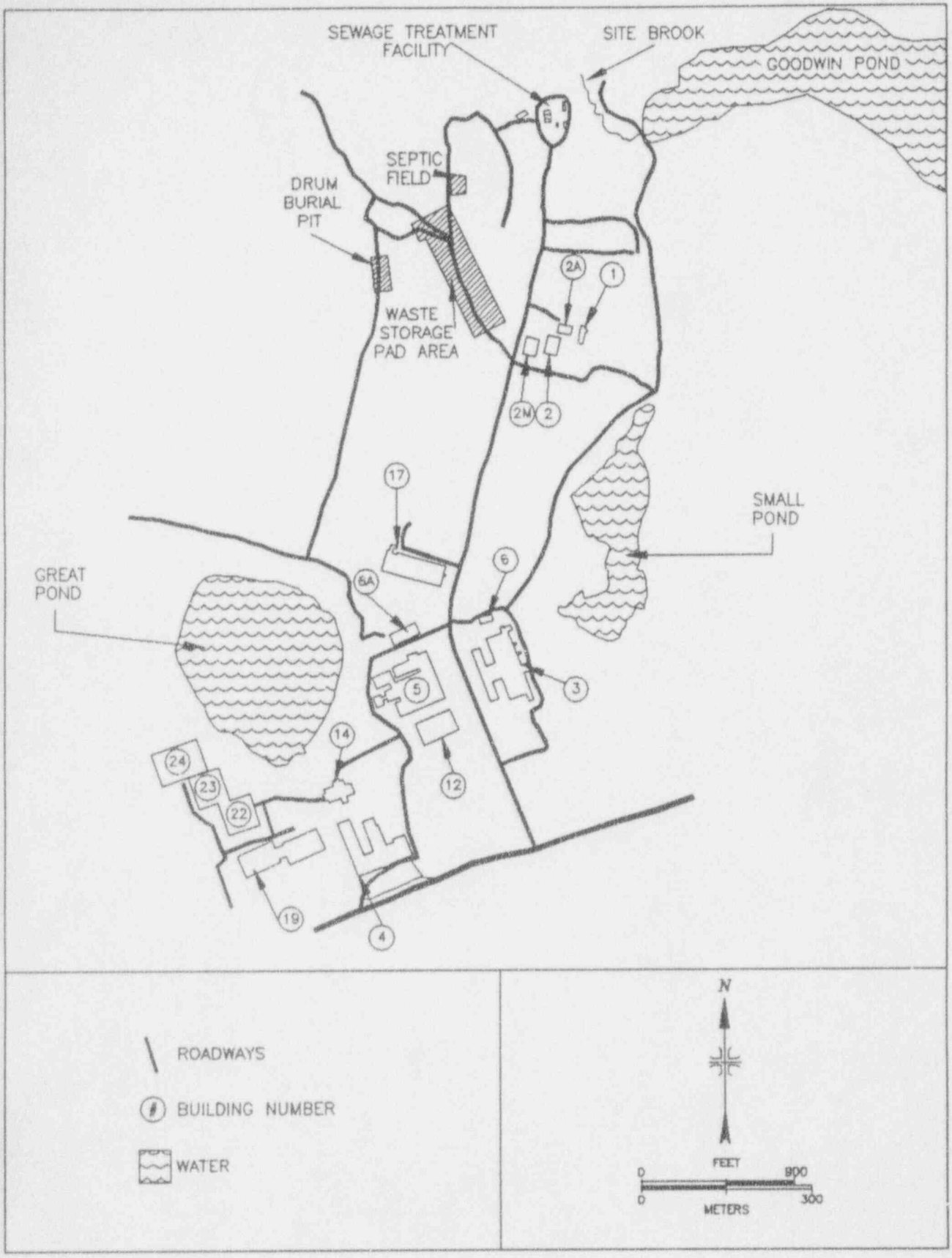


FIGURE 2: Plot Plan of the Combustion Engineering Site – Windsor, Connecticut

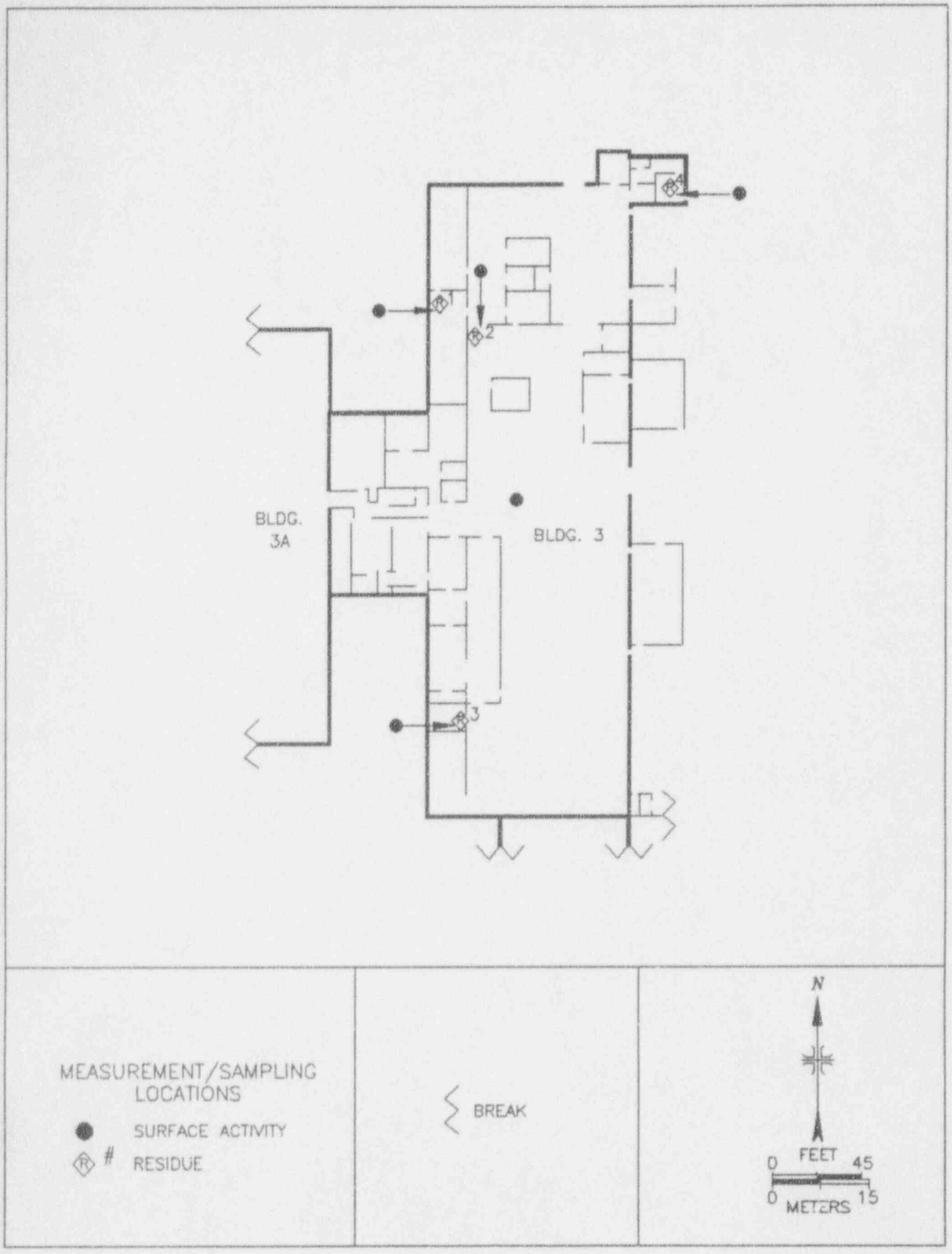


FIGURE 3: Building 3, Drains – Measurement and Sampling Locations

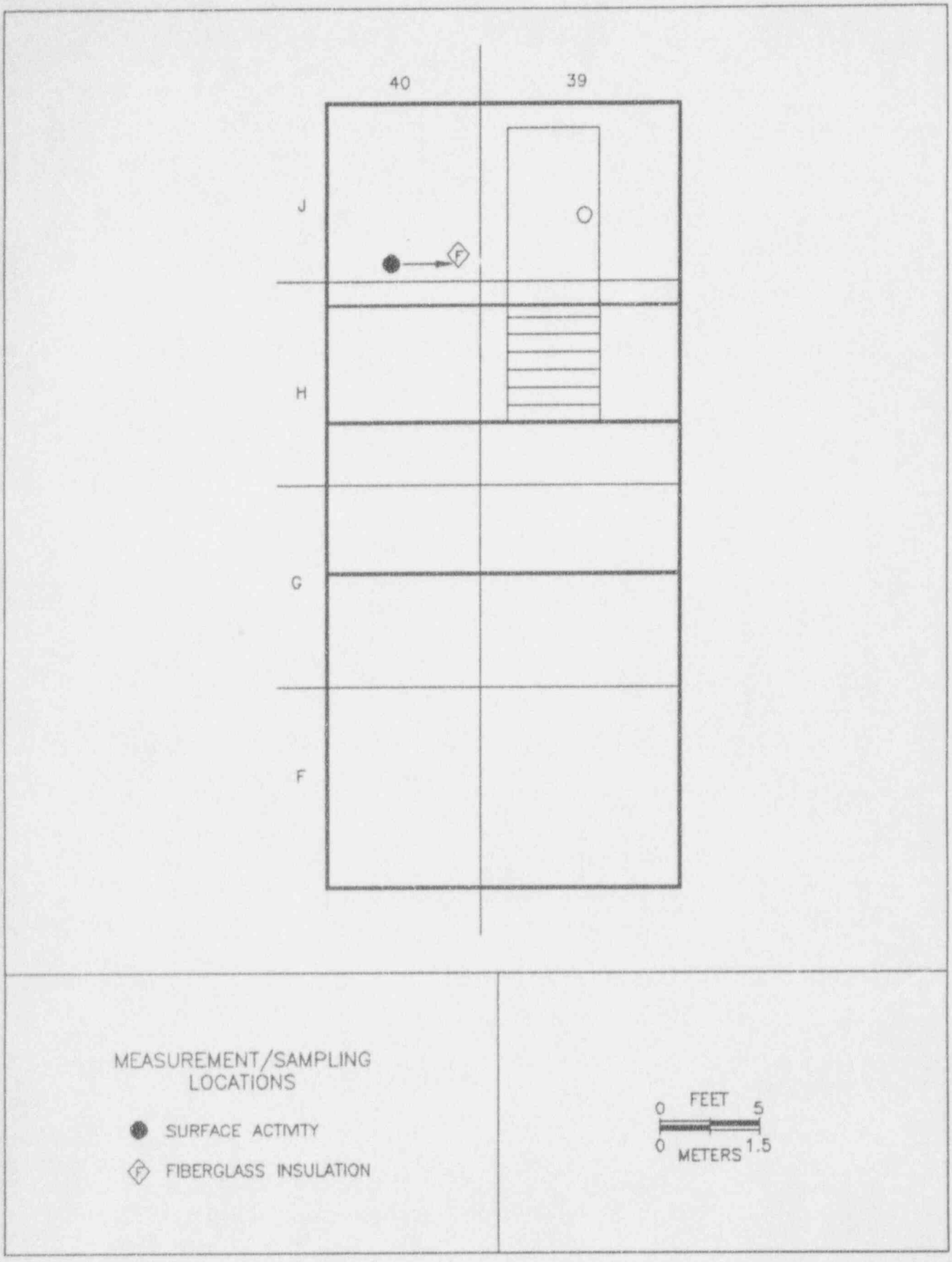
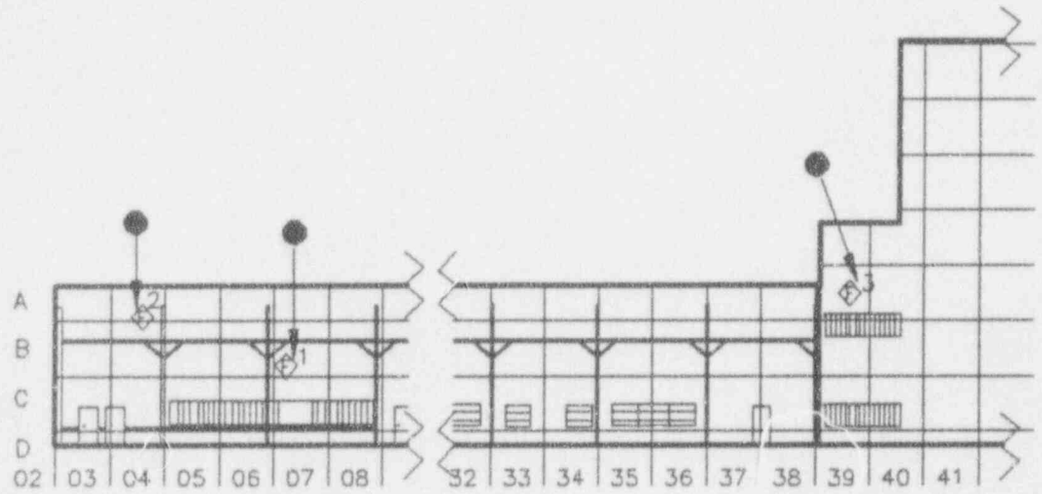


FIGURE 4: Building 3, High Bay, West Wall – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

SURFACE ACTIVITY

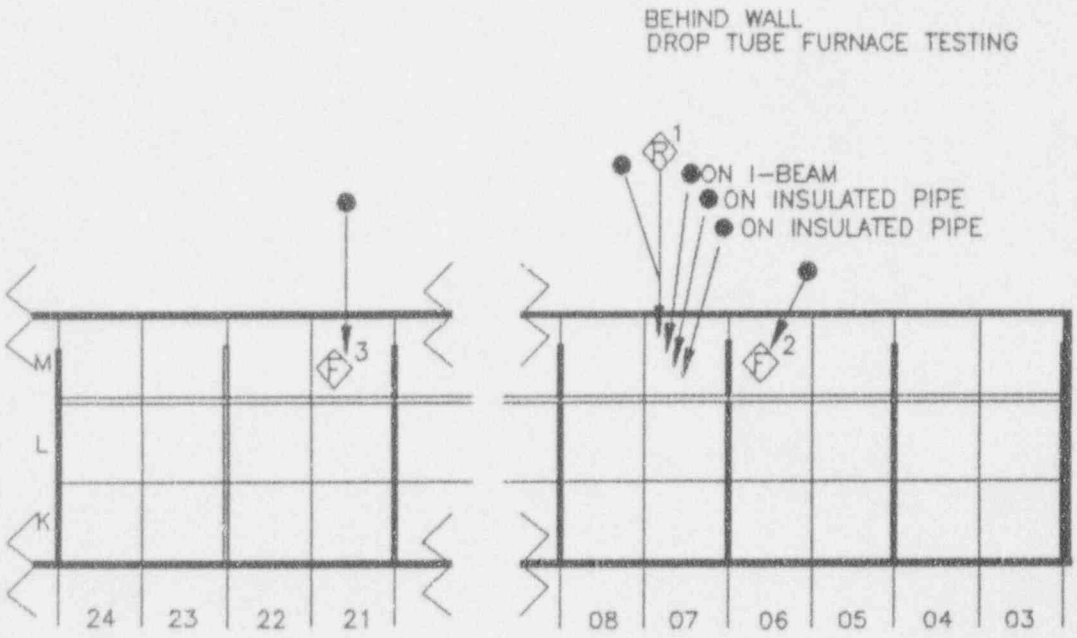
F# FIBERGLASS INSULATION

BREAK

FEET 0 30

METERS 0 10

FIGURE 5: Building 3, East Wall – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

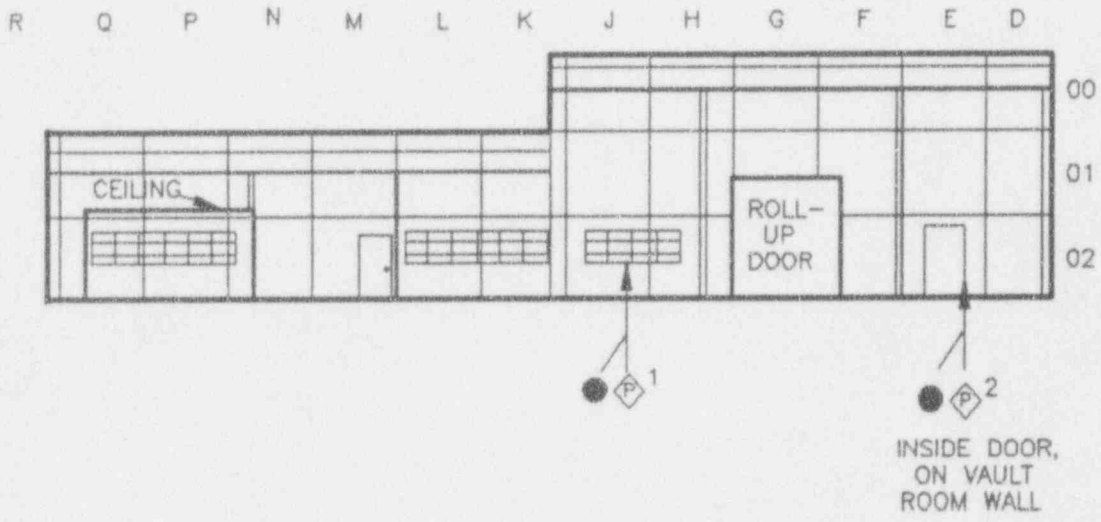
- SURFACE ACTIVITY
- F# FIBERGLASS INSULATION
- R# RESIDUE, PIPE INSULATION WRAP

BREAK

FEET 0 30

METERS 0 10

FIGURE 6: Building 3, West Wall Above Crane Rail – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

● SURFACE ACTIVITY

P # PAINT

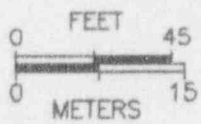
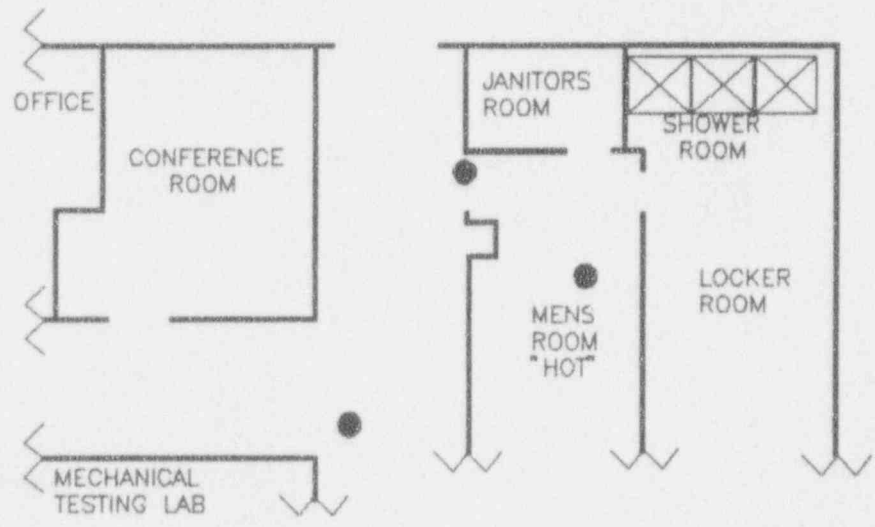


FIGURE 7: Building 3, North Wall – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS
DRAINS

SURFACE ACTIVITY

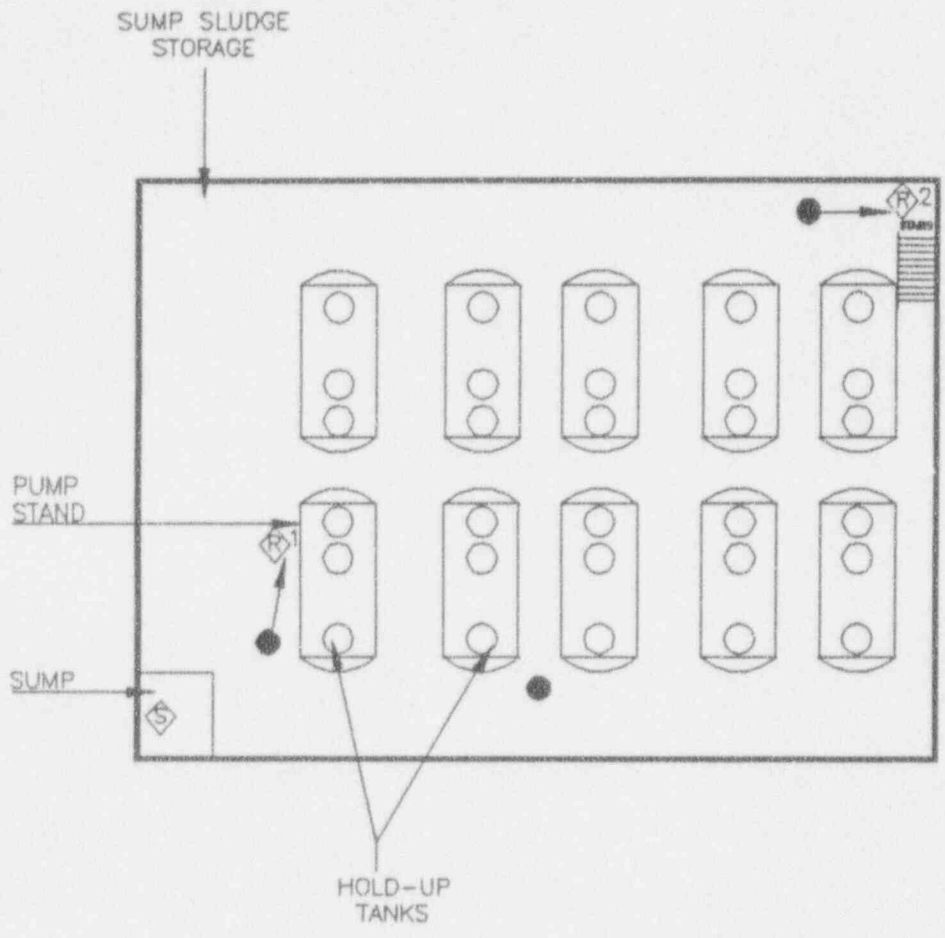
BREAK

N

FEET 0 9

METERS 0 3

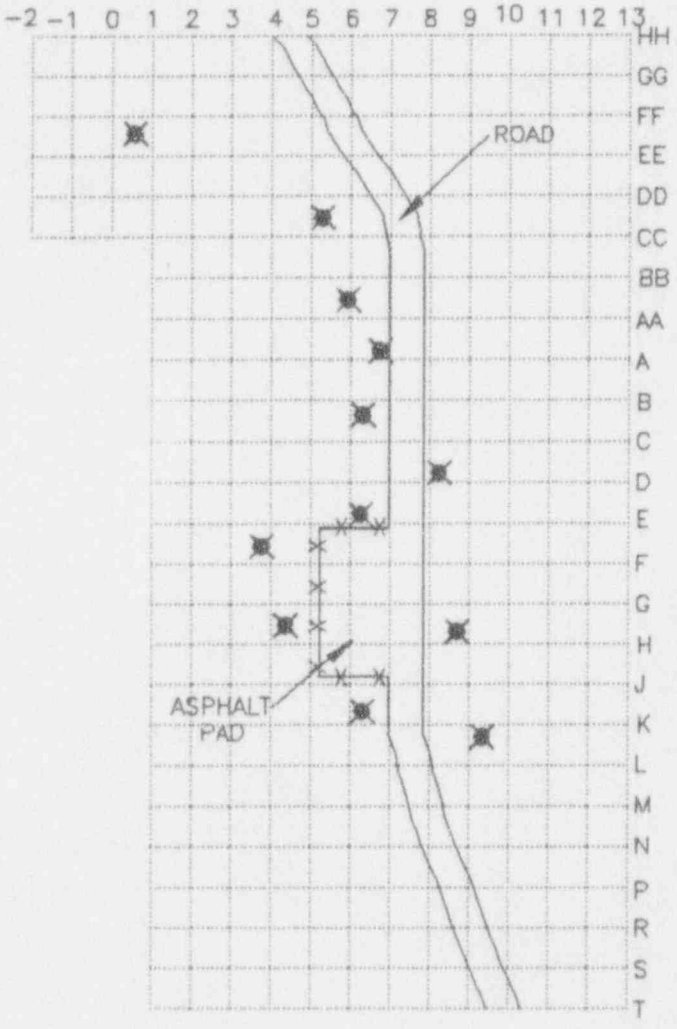
FIGURE 8: Building 5, Northeast Corner Drains – Measurement and Sampling Locations



MEASUREMENT/SAMPLING
LOCATIONS

- SURFACE ACTIVITY
- S SEDIMENT
- R # RESIDUE

FIGURE 9: Building 6, Basement – Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

SOIL

FENCE

N

0 FEET 90

0 METERS 30

FIGURE 10: Waste Storage Pad Area – Measurement and Sampling Locations

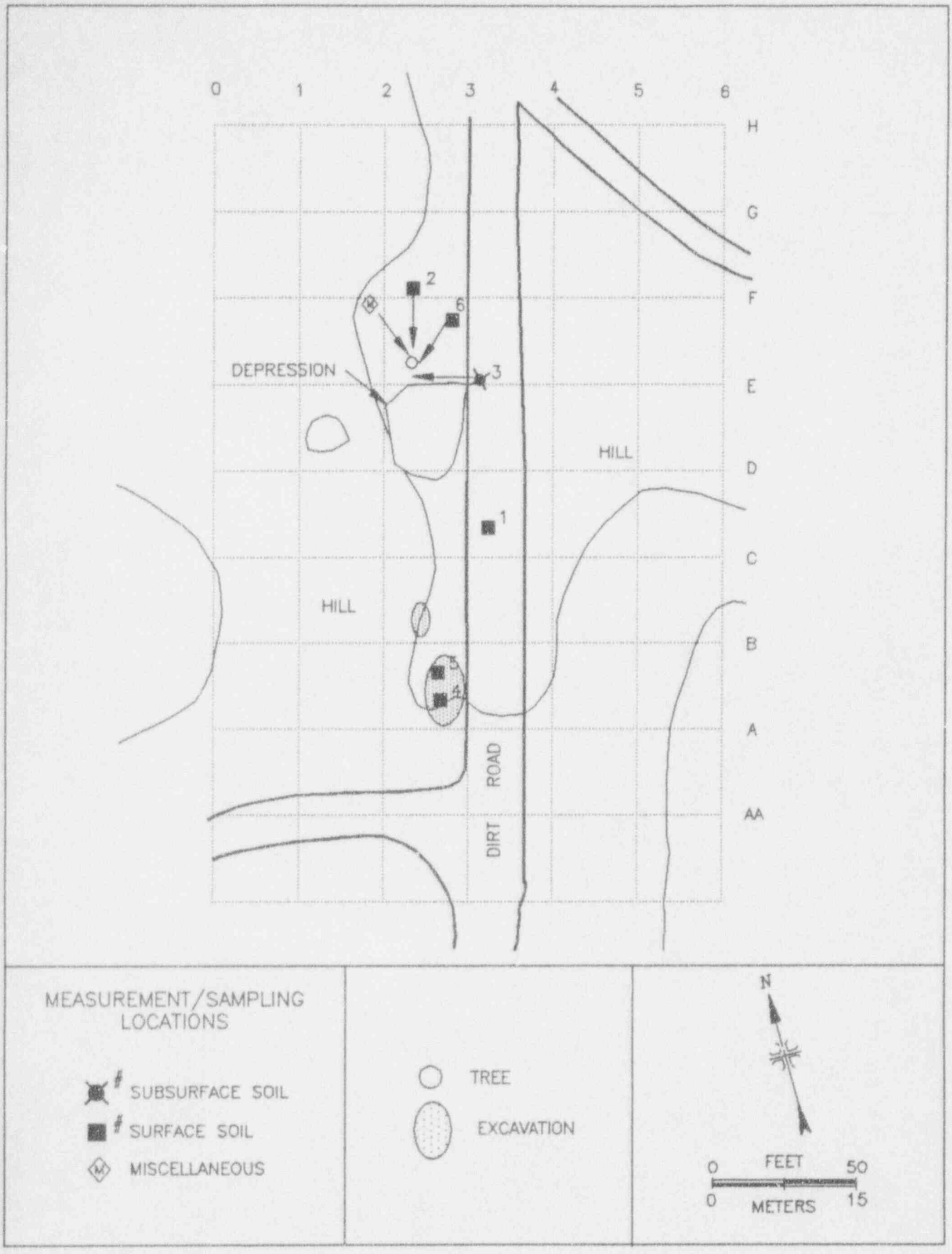


FIGURE 11: Drum Burial Pit – Measurement and Sampling Locations

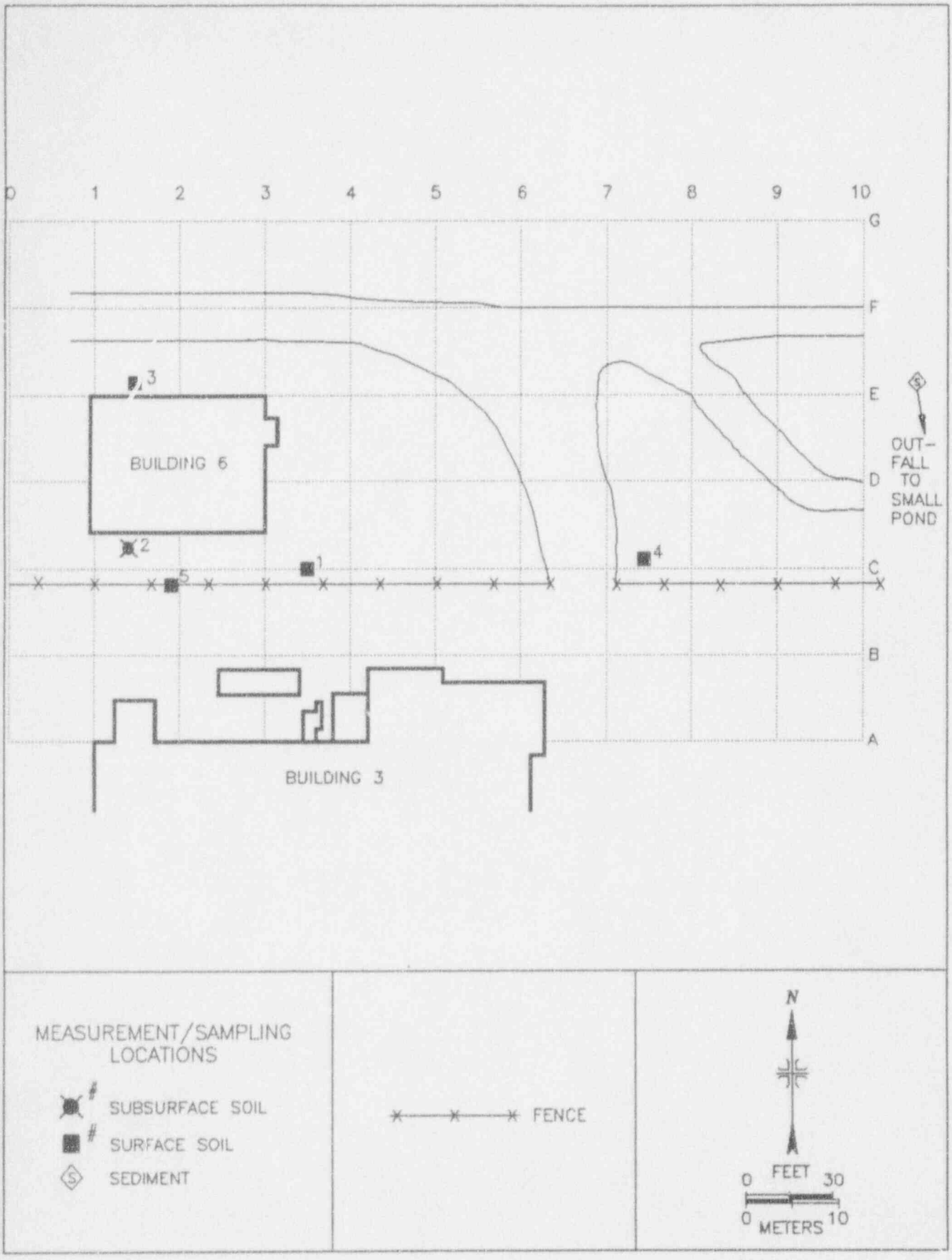
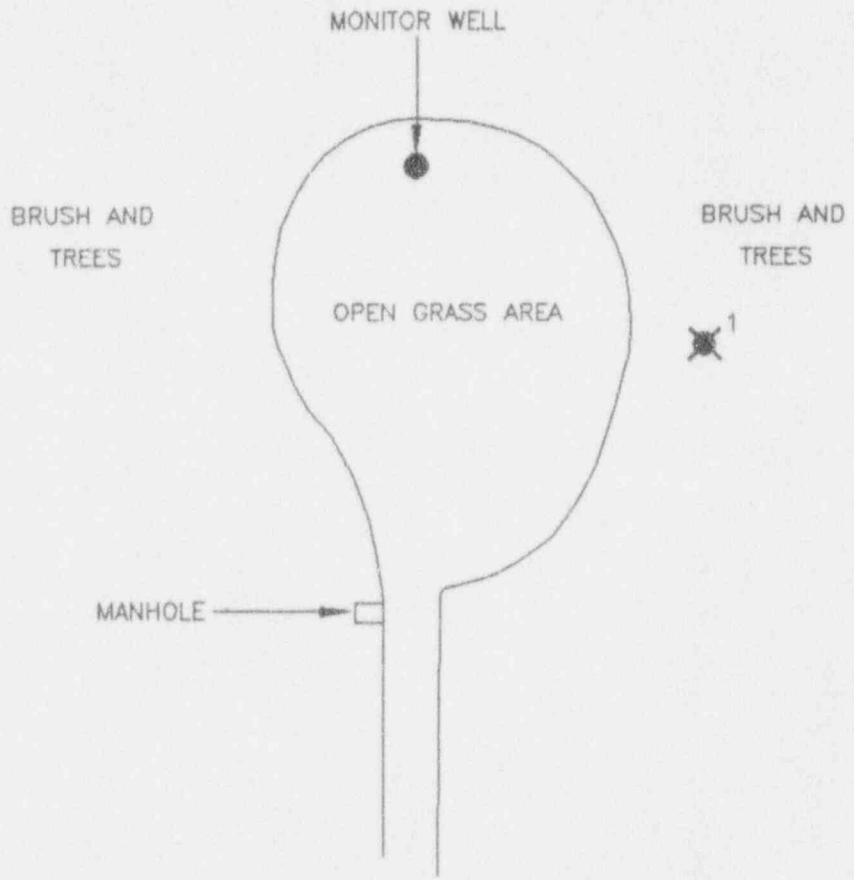


FIGURE 12: Grounds North of Building 3 -- Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

1 SOIL

NOT TO SCALE

FIGURE 13: Septic Field – Measurement and Sampling Locations

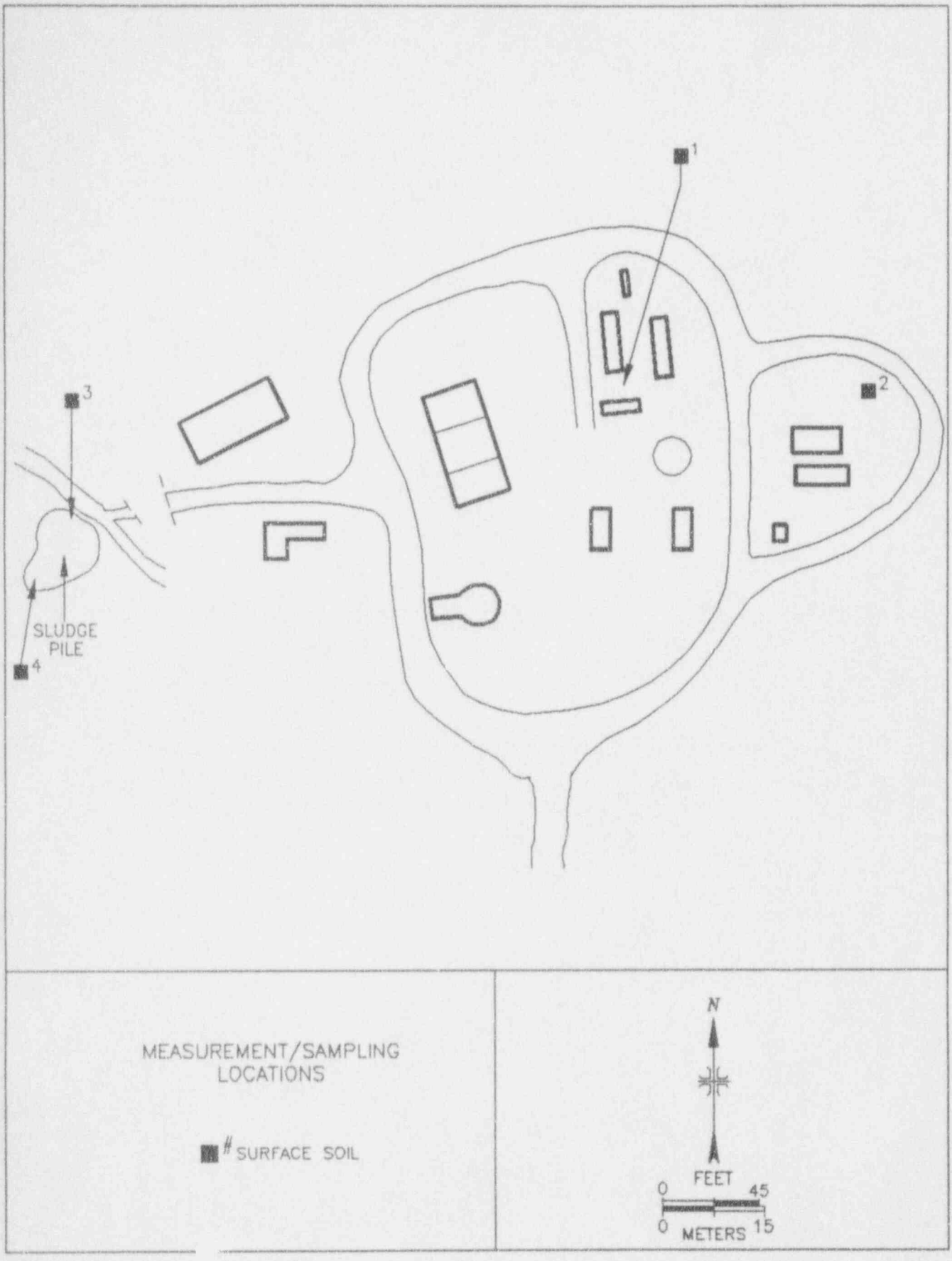
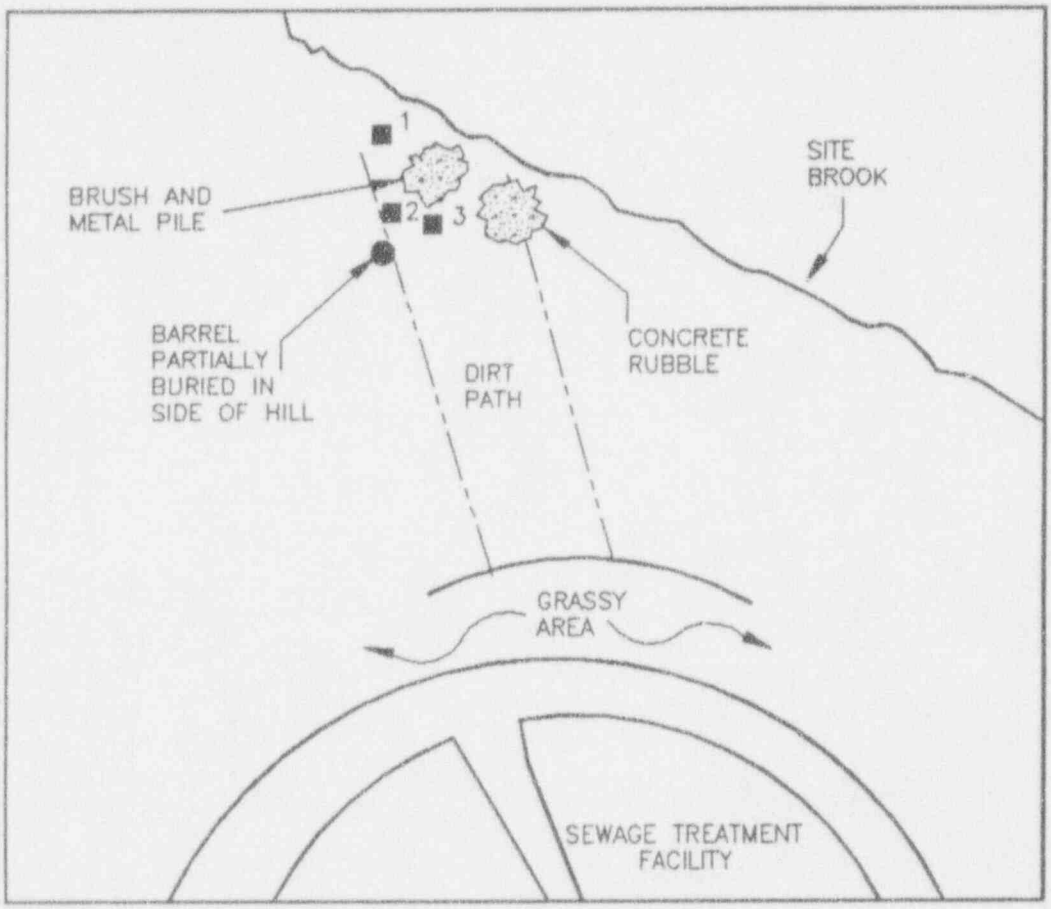


FIGURE 14: Sewage Treatment Facility – Measurement and Sampling Locations



MEASUREMENT/SAMPLING
LOCATIONS

■ SURFACE SOIL

N

NOT TO SCALE

FIGURE 15: Trash Piles on Site Brook Bank – Measurement and Sampling Locations

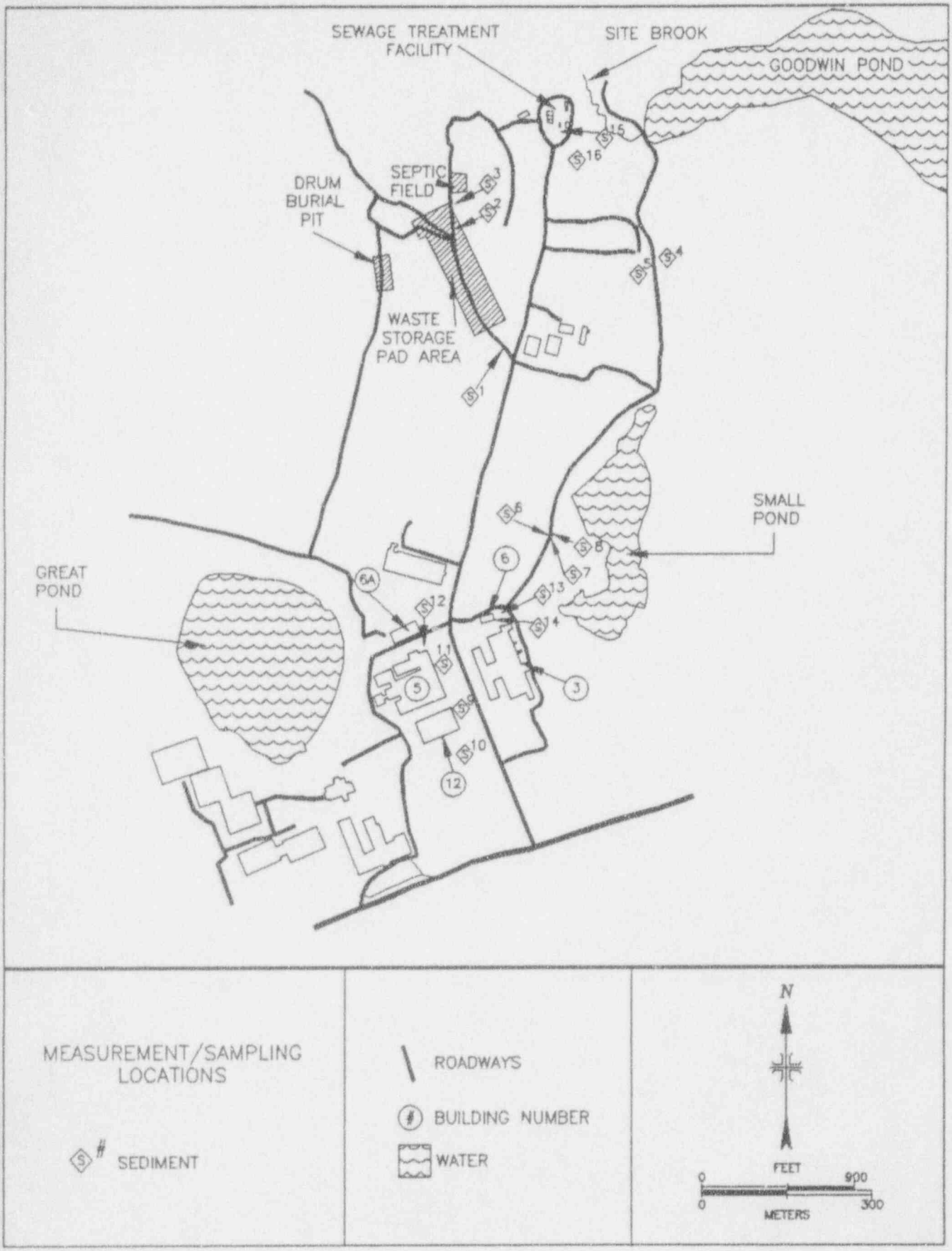


FIGURE 16: Sewer Line Manholes – Measurement and Sampling Locations

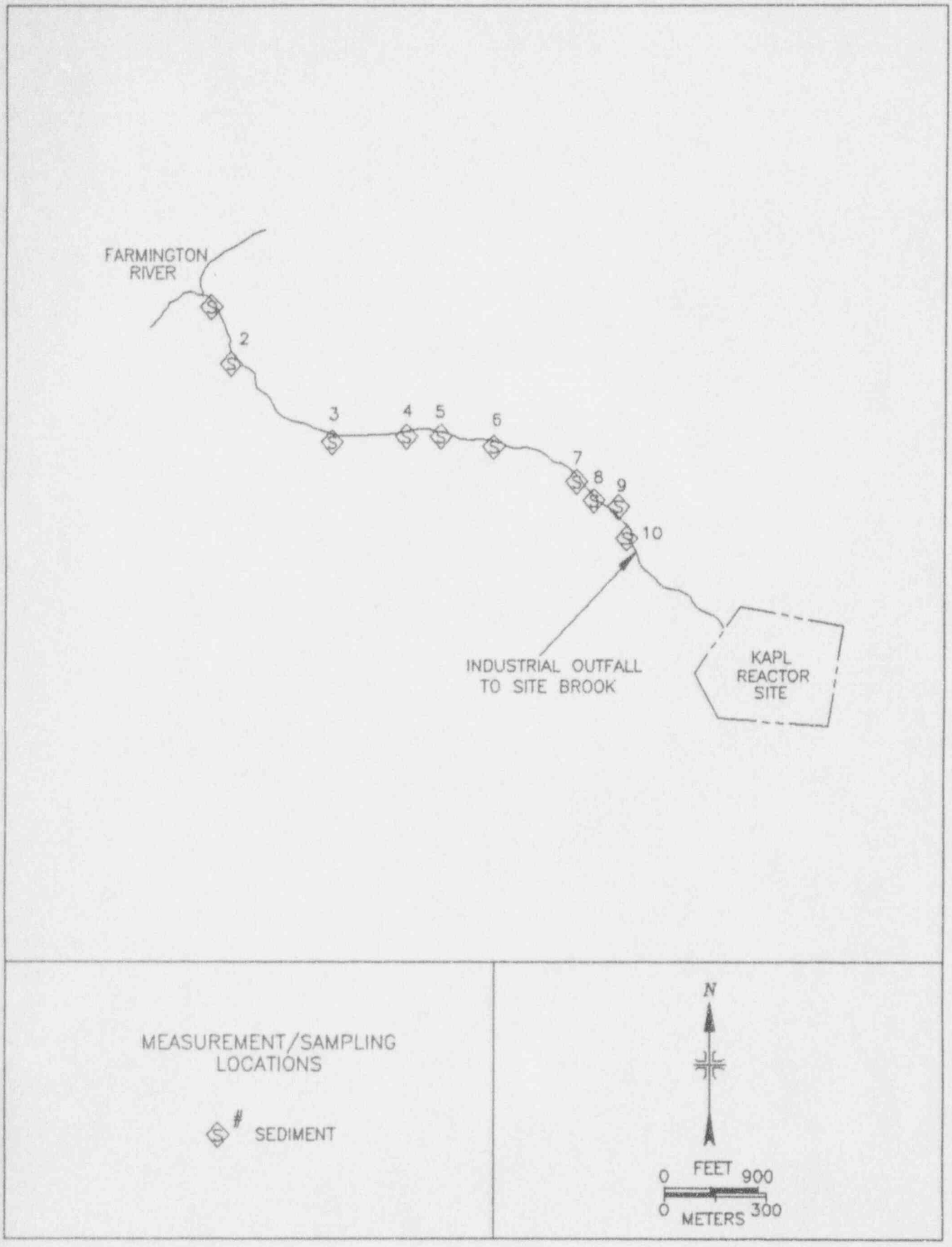


FIGURE 17: Site Brook – Measurement and Sampling Locations

TABLE 1

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Figure #	Number of Individual Measurements	Range of Total Activity (dpm/100 cm²)		Range of Removable Activity (dpm/100 cm²)	
			Alpha	Beta	Alpha	Beta
Building 3						
Drains	3	5	N/A	<1,500-2,700	<12	<16
West Wall	4, 6	7	<69-3,500	<1,500	<12	<16
East Wall	5	3	<69	<1,300	N/A	N/A
North Wall	7	2	120-3,200	3,300	N/A	N/A
South Wall	N/A	1	<69	<1,300	N/A	N/A
Roof Vents	N/A	5	<66-910	<1,500	<12-21	<16
Building 5						
Drains	8	3	N/A	<1,500	<12	<16
Building 6						
Basement	9	3	2,100-5,100	4,500-23,000	<12	<16
First Floor	N/A	1	1,200	1,900	17	<16
Roof	N/A	1	350	<1,500	<12	<16
Vent	N/A	1	<66	<1,500	<12	<16

TABLE 2

URANIUM CONCENTRATIONS IN MISCELLANEOUS SAMPLES
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Sample Type	Figure #	Uranium Concentrations (pCi/g)[a]	
			U-235	U-238
Building 3				
Drain #2	Residue	3	<1.3	14.9 ± 9.3
Drain #3	Residue	3	0.4 ± 0.1	2.1 ± 1.8
Drain #4	Residue	3	0.6 ± 0.1	2.2 ± 1.5
Roof Vent, 3rd from N. End	Residue	N/A	<2.3	<17
Roof Vent, 7th from N. End	Residue	N/A	0.8 ± 0.3	5.0 ± 3.7
Drop Tube Furnace #1	Pipe Insulation	6	97.8 ± 5.9	61 ± 33
W. Wall #3	Fiberglass	6	<35[b]	780 ± 490[b]
Building 6				
Location #1	Residue	9	385.5 ± 6.5	1418 ± 47
Location #2	Residue	9	228.7 ± 4.1	232 ± 31
Drum Burial Pit				
Adjacent to Surface Soil #2	Plastic	11	$307{,}400 \pm 2{,}800$[b]	$<19{,}000$[b]

[a]Uncertainties represent the 95% confidence level, based on counting statistics only.
[b]Units of pCi/sample.

TABLE 3

URANIUM CONCENTRATIONS IN SOIL
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Depth of Sample (cm)	Uranium Concentrations (pCi/g)[a]	
		U-235	U-238
Waste Storage Pad Area[b]			
Grid F3	0-15	0.4 ± 0.1	1.9 ± 1.5
F3	15-30	<0.1	<1.5
F3	30-45	<0.1	1.9 ± 1.7
H4	0-15	13.4 ± 0.4	<3.1
AA5	0-15	16.6 ± 0.4	<2.7
EE0	0-15	41.8 ± 0.6	5.8 ± 2.5
CC5	0-15	2169.0 ± 9.0	<72
CC5	15-30	77.7 ± 0.8	<5.3
A6	0-15	316.3 ± 1.4	11.1 ± 4.7
C6	0-15	724.9 ± 2.2	25.2 ± 8.0
C6	15-30	247.1 ± 2.4	<16
E6	0-15	98.6 ± 0.8	<4.9
K6	0-15	77.0 ± 0.8	<5.5
H8	0-15	23.9 ± 0.4	<3.5
H8	15-30	<0.1	1.6 ± 1.0
D8	0-15	358.2 ± 1.6	<8.7
L9	0-15	4.9 ± 0.2	0.9 ± 1.1
L9	15-30	0.9 ± 0.1	<1.4

TABLE 3 (Continued)

URANIUM CONCENTRATIONS IN SOIL
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Depth of Sample (cm)	Uranium Concentrations (pCi/g)[a]	
		U-235	U-238
Drum Burial Pit[c]			
Location 1	0-15	<0.1	<1.1
3	0-15	12.9 ± 0.3	1.6 ± 1.4
3	15-30	23.9 ± 0.4	<3.3
(inside drum) 5	0-15	620.1 ± 2.5	20.6 ± 8.9
6	0-30	30.1 ± 0.5	<3.4
Grounds North of Building 3[d]			
Location 2	15-30	0.7 ± 0.1	1.7 ± 1.1
3	0-15	148.0 ± 1.1	<7.7
4	0-15	<0.1	2.7 ± 1.3
5[e]	0-8	16.4 ± 0.5	<4.3
Septic Field[f]			
Location 1	0-15	<0.1	1.3 ± 1.8
1	15-30	<0.3	<4.0
1	30-45	<0.2	<2.5
Sewage Treatment Facility and Sludge Piles[g]			
Location 1	0-15	<0.1	<1.8
2	0-15	<0.1	<1.4
3	0-15	<0.2	<1.8
4	0-15	1.2 ± 0.3	9.5 ± 5.4

TABLE 3 (Continued)

URANIUM CONCENTRATIONS IN SOIL
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Depth of Sample (cm)	Uranium Concentrations (pCi/g)[a]	
		U-235	U-238
Site Brook Bank[h]			
Location 1	0-15	77.2 ± 0.9	<5.6
3	0-15	12.1 ± 0.3	1.2 ± 1.7

[a]Uncertainties represent the 95% confidence level, based only on counting statistics.
[b]Refer to Figure 10.
[c]Refer to Figure 11.
[d]Refer to Figure 12.
[e]CE archived sample K212.
[f]Refer to Figure 13. Total thorium (Th-228 + Th-232) from this borehole ranged from 7.7 to 32.6 pCi/g.
[g]Refer to Figure 14.
[h]Refer to Figure 15.

TABLE 4

URANIUM CONCENTRATIONS IN SEDIMENT
FROM MANHOLE ACCESS LOCATIONS
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Uranium Concentrations (pCi/g)[a]	
	U-235	U-238
Manholes[b]		
1	<0.2	2.4 ± 1.6
2	<0.1	0.6 ± 0.9
3	<0.2	<2.3
4	1.0 ± 0.1	2.1 ± 1.1
5	<0.1	2.5 ± 1.3
7	565.5 ± 1.9	64.7 ± 9.8
8	<0.1	<1.6
10	<0.2	1.3 ± 1.1
11	10.2 ± 0.5	<3.6
12	349.9 ± 4.1	1727 ± 58
13	3868 ± 39	<210
14	146.3 ± 3.8	459 ± 43
15	0.3 ± 0.1	1.8 ± 0.9

[a]Uncertainties represent the 95% confidence level, based only on counting statistics.
[b]Refer to Figure 16.

TABLE 5

URANIUM CONCENTRATIONS IN SEDIMENT
FROM SITE BROOK AND OUTFALL TO SMALL POND
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Uranium Concentrations (pCi/g)[a]	
	U-235	U-238
Site Brook[b]		
1	<0.1	<1.0
2	<0.1	1.2 ± 1.1
3	<0.1	1.3 ± 0.8
4	0.1 ± 0.1	0.5 ± 0.7
5	10.9 ± 0.6	11.3 ± 4.8
6	1.5 ± 0.1	3.4 ± 1.2
7	16.7 ± 1.0	21 ± 10
9	2.3 ± 0.2	8.6 ± 2.9
10	1.0 ± 0.1	2.0 ± 1.7
Outfall to Small Pond[c]		
Outfall	<0.1	<1.0

[a]Uncertainties represent the 95% confidence level, based only on counting statistics.
[b]Refer to Figure 17.
[c]Refer to Figure 12.

TABLE 6

ISOTOPIC URANIUM CONCENTRATIONS
COMBUSTION ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Figure #	Uranium Concentrations (pCi/g)[a]				% U-235 Enrichment
		U-234	U-235	U-238	Total U[b]	
Bldg 3, Drain #1	3	12,640 ± 250	465 ± 55	91 ± 22	13,190 ± 260	44
Bldg 3, High Bay, W. Wall	4	0.95 ± 0.13	0.02 ± 0.04	0.63 ± 0.10	1.60 ± 0.16	0.59
Bldg 3, E. Wall #1	5	48.13 ± 0.65	1.72 ± 0.14	1.10 ± 0.10	50.95 ± 0.67	20
Bldg 3, E. Wall #2	5	577.42 ± 9.57	19.16 ± 1.98	4.75 ± 0.89	601.33 ± 9.82	38
Bldg 3, E. Wall #3	5	1.28 ± 0.11	0.05 ± 0.02	0.73 ± 0.08	2.06 ± 0.13	0.94
Bldg 3, Drop Tube Furnace #2	6	10.48 ± 0.35	0.46 ± 0.08	0.50 ± 0.08	11.44 ± 0.37	12
Bldg 3, S. Wall	N/A	1.30 ± 0.12	0.07 ± 0.3	0.91 ± 0.10	2.28 ± 0.16	1.1
Bldg 3, N. Wall #1	7	782 ± 24	61.3 ± 7.6	20.0 ± 3.8	864 ± 25	32
Bldg 3, N. Wall #2	7	42.0 ± 1.8	1.53 ± 0.39	0.28 ± 0.16	43.8 ± 1.8	46
Bldg 6, Sump	9	12,780 ± 410	512 ± 92	554 ± 85	13,850 ± 430	13
Waste Storage Pad AA5, 15-30 cm	10	51.8 ± 1.2	2.49 ± 0.29	0.81 ± 0.15	55.1 ± 1.2	32
Waste Storage Pad A6, 15-30 cm	10	70.2 ± 1.3	3.17 ± 0.32	0.60 ± 0.12	74.0 ± 1.4	45
Waste Storage Pad E6, 15-30 cm	10	41.87 ± 0.97	2.00 ± 0.24	0.86 ± 0.14	44.7 ± 1.0	27
Waste Storage Pad EE0, 15-30 cm	10	1,119 ± 25	39.6 ± 5.3	15.0 ± 2.9	1,173 ± 25	29
Waste Storage Pad D8, 15-30 cm	10	611 ± 11	22.1 ± 2.4	3.69 ± 0.90	636 ± 12	48
Waste Storage Pad H4, 15-30 cm	10	57.7 ± 2.2	2.05 ± 0.47	1.06 ± 0.30	60.8 ± 2.2	23
Waste Storage Pad K6, 15-30 cm	10	19.68 ± 0.68	1.07 ± 0.18	0.27 ± 0.08	21.02 ± 0.70	38
Drum Burial Pit #2, 0-15 cm	11	882 ± 21	31.2 ± 4.5	3.5 ± 1.3	917 ± 22	58
Drum Burial Pit #4, 0-15 cm	11	23.5 ± 1.6	1.48 ± 0.46	0.48 ± 0.23	25.5 ± 1.7	33
N. of Bldg 3 #1, 0-15 cm	12	712 ± 20	44.0 ± 5.7	12.0 ± 2.6	768 ± 21	36
N. of Bldg 3 #2, 0-15 cm	12	31.1 ± 1.5	1.61 ± 0.39	6.42 ± 0.69	39.1 ± 1.7	3.7
Site Brook Bank #2, 0-15 cm	15	15,450 ± 320	4,860 ± 200	3,780 ± 160	24,090 ± 410	17

TABLE 6 (Continued)

ISOTOPIC URANIUM CONCENTRATIONS
COMBUSTIGN ENGINEERING SITE
WINDSOR, CONNECTICUT

Location	Figure #	Uranium Concentrations (pCi/g)[a]				% U-235 Enrichment
		U-234	U-235	U-238	Total U[b]	
Manhole #6, Old Industrial Line	16	4,680 ± 170	185 ± 38	36 ± 15	4,900 ± 170	44
Manhole #9, Industrial	16	1,989 ± 87	71 ± 19	8.8 ± 5.8	2,069 ± 89	55
Manhole #16, Industrial	16	310 ± 14	11.5 ± 3.0	11.8 ± 2.7	334 ± 14	13
Site Brook #8	17	16,160 ± 370	525 ± 75	59 ± 22	16,740 ± 380	58

[a]Uncertainties represent the 95% confidence level, based only on counting statistics.
[b]Total uranium concentrations based on the sum of U-234, U-235 and U-238 concentrations.

REFERENCES

1. U.S. Department of Energy, memorandum from A. Williams to file, "Tentative Authority Determination—Combustion Engineering Site, Windsor, Connecticut," June 22, 1993.

2. ORAU, "Follow-up Confirmatory Radiological Survey of the Drum Storage Area, Combustion Engineering Property, Windsor, Connecticut," M. Landis, May 1989.

3. Oak Ridge Institute for Science and Education, "Designation Survey Plan for the Combustion Engineering Site, Windsor, Connecticut," November 12, 1993.

4. U.S. Department of Energy, letter from A. Williams to E. Abelquist, November 15, 1993.

5. "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.

6. DOE Order 5400.5, "Radiation Protection of the Public and the Environment," Washington, D.C., February 8, 1990.

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 employer.

DIRECT RADIATION MEASUREMENT

Instruments

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

Eberline "Rascal" Ratemeter-Scaler
Model PRS-1
(Eberline, Santa Fe, NM)

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

Detectors

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

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

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

LABORATORY ANALYTICAL INSTRUMENTATION

Alpha Spectrometry System
Tennelec Electronics Model
(Tennelec, Oak Ridge, TN)
Used in conjunction with:
Surface Barrier and Ion Implanted Detectors
(Canberra, Meriden, CT and
Tennelec, Oak Ridge, TN) and
Multichannel Analyzer
3100 Vax Workstation
(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)

Low Background Gas Proportional Counter
Model LB-5110-W
(Oxford, Oak Ridge, TN)

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. Surfaces were scanned using small area (15.5 cm^2 or 59 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:

Alpha	—	ZnS scintillation detector with ratemeter-scaler
Beta	—	GM detector with ratemeter-scaler
Gamma	—	NaI scintillation detector with ratemeter

Surface Activity Measurements

Measurements for total alpha and total beta activity levels were performed using ZnS scintillation and GM detectors, respectively, with ratemeter-scalers.

Count rates (cpm), which were integrated over 1 minute in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net rate by the 4π efficiency and correcting for the active area of the detector. The alpha activity background count rates for the ZnS scintillation detectors averaged approximately 1 cpm for each detector. Alpha efficiency factors ranged from 0.18 to 0.19 for the ZnS scintillation detectors calibrated to Pu-239. The beta activity background count rates for the GM detectors averaged approximately 53 cpm for each detector.

Beta efficiency factors ranged from 0.16 to 0.18 for the GM detectors calibrated to Tc-99. The effective probe area for the ZnS scintillation and GM detectors is 59 cm^2 and 15.5 cm^2, respectively.

Removable Activity Measurements

Removable 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.

Miscellaneous Sampling

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.

Residue Sampling

Available residue (e.g., dust, dirt, etc.) was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled in accordance with ESSAP survey procedures.

Sediment Sampling

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

Paint Sampling

Paint samples were obtained by chipping the paint from 100 cm^2 of surface area. The sample was then placed in a plastic specimen cup, sealed, and labeled in accordance with ESSAP survey procedures.

ANALYTICAL PROCEDURES

Removable Activity

Smears were counted on a low background gas proportional system for gross alpha and gross beta activity.

Miscellaneous Samples

Gamma Spectrometry

Samples of solid materials (soil, sludge, cake, debris, residues, and construction material) 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 was chosen to reproduce a 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:

U-235	0.143 MeV or 0.186 MeV
U-238	0.063 MeV or 0.093 MeV from Th-234*

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

Alpha Spectrometry

Solid, soil, sludge and miscellaneous samples (debris, residues, tile, etc.) were crushed, homogenized and analyzed for isotopic uranium, plutonium, americium, etc. Samples were dissolved by potassium fluoride and pyrosulfate fusion and the elements of interest were precipitated with barium sulfate. The barium sulfate precipitate was redissolved and the uranium was 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 (ORTEC), alpha spectrometers (Tennelec and Canberra), and a multichannel analyzer (Canberra).

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. Additional uncertainties, associated with sampling and measurement procedures, have not been propagated into the data presented in this report.

Detection limits, referred to as minimum detectable activity (MDA), were based on 2.71 plus 4.66 times the standard deviation of the background count $2.71 + (4.66 \sqrt{BK}$. When the activity was determined to be less than the MDA of the measurement procedure, the result was reported as less than MDA. Because of variations in background levels, measurement efficiencies, 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. In cases where they were not available, standards of an industry recognized organization were used.

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 7.1 (September 1993)
- Laboratory Procedures Manual, Revision 8 (August 1993)
- Quality Assurance Manual, Revision 6 (July 1993)

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.

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/CH/8901, June 1989.