VERIFICATION SURVEY OF BUILDINGS 005, 023, AND 064 SANTA SUSANA FIELD LABORATORY ROCKWELL INTERNATIONAL VENTURA COUNTY, CALIFORNIA

T.J. VITKUS

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

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Environmental Survey and Site Assessment Program
Energy/Environment Systems Division

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T. J. Vitkus

Environmental Survey and Site Assessment Program
Energy/Environmental Systems Division
Oak Ridge Institute for Science and Education
Oak Ridge, Tennessee 37831-0117

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FINAL REPORT

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FIELD STAFF

T. D. Herrera
E. H. Montalvo
J. R. Morton

LABORATORY STAFF

R. D. Condra
J. S. Cox
M. J. Laudeman

CLERICAL STAFF

D. A. Cox
R. D. Ellis

ILLUSTRATOR

T. D. Herrera

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VENTURA COUNTY, CALIFORNIA

Prepared by: _____ Date: 10/26/94
T. J. Vitkus, Project Leader
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: 10/31/94
M. J. Laudeman, Radiochemistry Laboratory Supervisor
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: 11/3/94
A. T. Payne, Quality Assurance Officer
Environmental Survey and Site Assessment Program

Reviewed by: _____ Date: 11/3/94
W. L. Beck, Acting Program Director
Environmental Survey and Site Assessment Program

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ABBREVIATIONS AND ACRONYMS

AEC	Atomic Energy Commission
cm^2	square centimeter
cpm	counts per minute
DOE	Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
EML	Environmental Measurement Laboratory
EPA	Environmental Protection Agency
ERDA	Energy Research and Development Administration
ESSAP	Environmental Survey and Site Assessment Program
ETEC	Energy Technology Engineering Center
ha	hectare
GM	Geiger-Mueller
kg	kilogram
km	kilometer
m	meter
m^2	square meter
MDA	minimum detectable activity
mi	mile
mm	millimeter
NaI	sodium iodide
NIST	National Institute of Standards and Technology
ORISE	Oak Ridge Institute for Science and Education
pCi/g	picocuries per gram
PIC	pressurized ionization chamber
SSFL	Santa Susana Field Laboratory
ZnS	zinc sulfide
μR/h	microroentgens per hour

VERIFICATION SURVEY
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INTRODUCTION AND SITE HISTORY

Rockwell International's Rocketdyne Division operates the Santa Susana Field Laboratory (SSFL). The Energy Technology Engineering Center (ETEC) is that portion of the SSFL, operated for the Department of Energy (DOE), which performs testing of equipment, materials, and components for nuclear and energy related programs. Contract work for the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA), predecessor agencies to the DOE, began in the early 1950's. Specific programs conducted for AEC/ERDA/DOE involved the engineering, development, testing, and manufacturing operations of nuclear reactor systems and components. Other SSFL activities have also been conducted for the National Aeronautics and Space Administration, the Department of Defense, and other government related or affiliated organizations and agencies. Some activities have been licensed by the Nuclear Regulatory Commission.

Numerous buildings and land areas became radiologically contaminated as a result of the various operations which included ten reactors, seven criticality test facilities, fuel fabrication, reactor and fuel disassembly, laboratory work, and on-site storage of nuclear material. Potential radioactive contaminants identified at the site are uranium (in natural and enriched isotopic abundances), plutonium, americium-241, fission products (primarily cesium-137 and strontium-90), activation products (cobalt-60, europium-152, nickel-63, promethium-147, and tantalum-182), and tritium. Chemical contaminants, mainly chlorinated organic solvents, have also been identified in groundwater.

Decontamination and decommissioning of facilities began in the late 1960's and continues as other DOE sponsored projects are phased out and transitioned to EM-40. Rockwell/Rocketdyne has recently completed the decommissioning and final status radiological surveys of three SSFL facilities. These facilities are Buildings 005, 023, and 064.

Building 005 was built in the late 1950's for testing proposed coolants for the Organic Moderated Reactor Experiment and Piqua reactors. There was no radiological material use in the facility during this period; however, the facility was later converted for uranium carbide fuel fabrication. Fuel fabrication activities were performed from 1966 to 1967. At the conclusion of the fuel fabrication project, uranium contaminated equipment and surfaces were either removed or decontaminated to permit non-radiological use of the building. Additional facility decontamination was initiated during 1978 and completed in phases, ending in 1992. Decontamination activities included cleaning and/or removal of contaminated floors, equipment, duct work, drain pipes, and storage tanks. Rockwell/Rocketdyne performed the final radiological survey in 1993.

Studies of radioactive contamination transport in a sodium loop were performed in the portions of Building 023 constructed in 1962 (referred to as Old Building 023). A second section, 023A, was added on to the building in 1976. There were two fires documented within the facility that involved the sodium loop. Contaminants involved were Cs-137, Mn-54, and Co-60. In addition, the facility was also used to store a Dew-Point meter containing a Ra-226 source. Plans called for the disassembly of the meter; however, the disassembly was not attempted and the intact meter was removed from the facility. Most of the contamination identified in the building involved the radioactive liquid holdup tank and the associated drain lines and sink. Facility decontamination included the removal of the sodium loop, holdup tank, drain lines, sink, a fume hood and the ventilation exhaust system, and remediation of an area of the floor where the sodium loop was previously located. Rockwell/Rocketdyne's final radiological survey was conducted in 1993.

The third building, Building 064, was constructed in 1958 (a second bay was added on in 1963) to serve as a storage and repackaging facility for special nuclear and source radioactive material. Source and special nuclear material, including processed natural uranium, depleted uranium, enriched uranium, uranium-233, thorium, and plutonium, were stored in the building until 1980. Most recently, packaged soil contaminated with Cs-137 was stored in the facility. Exterior yard areas were occasionally used for storage of recoverable uranium scrap, irradiated fuel elements, and miscellaneous radioactive wastes. Interior surfaces were determined to be contaminated

from the uranium repackaging process. Initial facility decommissioning involved removal of equipment and fixtures, and finally, removal of the contaminated soil. Rockwell/Rocketdyne then performed the final radiological surveys of the interior and exterior grounds of the building.

DOE's Office of Environmental Restoration, Northwestern Area Programs is responsible for oversight of a number of remedial actions that have been or will be conducted at the SSFL. It is the policy of DOE to perform independent (third party) verification of remedial action activities conducted within Office of Environmental Restoration programs. The purpose of these independent verifications is to confirm that remedial actions have been effective in meeting established guidelines and that the documentation accurately and adequately describes the post-remedial action radiological conditions at the site. The Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) has been designated as the organization responsible for this task at SSFL.

SITE DESCRIPTION

The SSFL is located in the Simi Hills of southeastern Ventura County, California approximately 47 km (29 mi) northwest of downtown Los Angeles (Figure 1). The site is comprised of approximately 1090 hectares (2700 acres) and is divided into four administrative areas (Areas I through IV) and a Buffer Zone. DOE operations are conducted in Rockwell International-owned and DOE-owned facilities located within the 117 ha Area IV. The ETEC portion of Area IV consists of government-owned buildings that occupy 36 ha. The Area IV plot plan is provided in Figure 2 and indicates the locations of Buildings 005, 023, and 064.

Building 005 is located within the central portion of Area IV and is bordered on the north and northeast by B Street, to the southwest by 17th Street, and to the southeast by the Old Coal Storage Yard and G Street (Figure 3). The facility is a tilt-up concrete structure with Butler aluminum siding and has approximately 430 m^2 of floor space. A number of concrete pads are located on the east end of the building. These pads formerly held equipment used in the Molten Salt Oxidation Project and the filter plenums from the fuel fabrication project. The building interior is subdivided into an administration area, change rooms, chemistry laboratories, storage

rooms, and a high-bay area. Figure 4 shows those rooms that were included in the radiological control area.

Building 023 is located in the central section of Area IV. Facility boundaries are 12th Street to the north, B Street to the south and east and Building 032 to the west (Figure 5). Building 023 is a single story structure with galvanized steel walls and roof and a concrete slab floor. The sodium test loop was located in the western, or "old", portion of the building. The "new" building section held an analytical chemistry laboratory and a storage and set-up room. The waste holdup tank was formerly located in an exterior sub-grade vault at the east end of the building (Figure 6).

Building 064 is located in the northeast quadrant of Area IV. Facility boundaries include paved yard areas to the north, and west, "G" Street to the south, and a paved area and the Side-Yard to the east (Figure 7). This Side-Yard includes an excavated area from which the Cs-137 contaminated soil, previously stored in Building 064, originated. ESSAP performed the verification of the Side-Yard during a previous survey.[1] The 410 m^2 building is constructed of reinforced concrete with two large open bays, Rooms 110 and 114. Other rooms include a material handling area (Room 116), office and supply and storage space (Room 120), and a rest room (Figure 8).

OBJECTIVES

The objectives of the verification surveys were to provide independent document reviews and measurement and sampling data for use by the DOE in determining the radiological status of each facility and whether or not the facility meets the guideline requirements for release to unrestricted use.

DOCUMENT REVIEW

ESSAP reviewed Rockwell's radiological survey, decontamination and decommissioning, and final status survey reports for Buildings 005, 023, and 064.[2-12] Procedures and methods used by Rockwell were reviewed for adequacy and appropriateness. The post-remedial action data was reviewed for adequacy, completeness, and compliance with guidelines.

PROCEDURES

A survey team from ESSAP visited the SSFL during the period July 18 through 21, 1994 and performed visual inspections and independent measurements and sampling inside building structures as well as exterior areas. Survey activities were conducted in accordance with a site specific survey plan submitted to and approved by the DOE.[13] Additional information regarding major instrumentation and survey and analytical procedures may be found in Appendices A and B.

REFERENCE GRID

ESSAP used the 1 m × 1 m grid system established by Rockwell, where intact, for referencing measurement and sampling locations. Survey locations on upper walls, ceilings, or other ungridded surfaces were referenced to the floor or lower wall grid or to prominent building features. Survey references of exterior areas were made to either the existing grid or to prominent site features.

SURFACE SCANS

Interior surface scans for alpha, beta, and gamma activity were performed on floors, lower walls, upper walls, and ceilings of each building, and on portions of concrete exterior surfaces (ramps, walkways, and a tank vault). Exterior soil and paved areas, and the Building 005 and 064 roofs were scanned for gamma activity. Scans were performed using gas proportional, ZnS, GM, and/or NaI detectors coupled to ratemeters or ratemeter-scalers with audible indicators.

Scan coverage, with the exception of upper walls and ceilings, ranged from 25% in rooms or areas without a radiological use history, up to 100% for radiological use areas. Approximately 5% of accessible upper wall and ceiling surfaces were scanned. Locations of elevated direct radiation identified by surface scans were marked for further investigation.

SURFACE ACTIVITY MEASUREMENTS

Direct measurements to determine total alpha and total beta surface activity levels were performed in 68 floor and lower wall grid blocks. Grid blocks selected for survey were chosen either randomly or as a result of elevated direct radiation detected by surface scans. One set of five direct measurements was obtained from each grid block with measurements performed at the center and four points equidistant from the center and grid block corners. Since the time of the radioactive material use in Building 005, new tile had been placed over most of the original floor. Rather than addressing these areas with grid block measurements, tiles were removed from 10 randomly selected locations within 4 rooms (Rooms 108, 110, 113, and 114) associated with the fuel fabrication work and single-point measurements performed. An additional 165 single-point alpha and beta direct measurements were performed on floor, lower wall, upper wall and ceiling surfaces, as well as equipment, exterior paved areas around each building, the attic area in Building 005, and the tank vault outside of Building 023. All measurements were made using ZnS and GM detectors coupled to ratemeter-scalers. A smear sample for determining removable alpha and beta activity was collected from the location within each grid block that corresponded to the highest total direct measurement, and from each single-point measurement location. Figures 9 through 28 show measurement and sampling locations.

EXPOSURE RATE MEASUREMENTS

Quantitative site exposure rate measurements, at 1 m above the surface, were made at 7 locations within Building 005, 6 locations within Building 064, and at two soil sampling locations (Figures 20 and 21 and 26 through 28) using a pressurized ionization chamber (PIC). Exposure rates in all remaining areas were determined qualitatively and were based on gamma

surface scan data. Rockwell/Rocketdyne developed background exposure rate data, which was used by ESSAP for data comparisons.

SOIL SAMPLING

With the exception of the southeast side of Building 064, all exterior areas around the buildings were paved. One surface (0 to 15 cm) soil sample was collected from the southeast side of Building 064 and 2 samples were collected, through cores previously made by Rockwell, from beneath the asphalt to the northeast of Building 005. Figures 20 and 28 show sampling locations.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ESSAP's Oak Ridge, Tennessee laboratory for analysis and interpretation. Soil samples were analyzed by solid state gamma spectrometry. Spectrum were reviewed for uranium and gamma-emitting activation and fission products (primarily Cs-137). Results were reported in picocuries per gram (pCi/g). Smear samples were analyzed for gross alpha and gross beta activity using a low background proportional counter. These results were reported together with direct measurement data in units of disintegrations per minute per 100 cm^2 (dpm/100 cm^2). Exposure rates were reported in microroentgens per hour (μR/h).

Results were compared to the DOE guidelines which are provided in Appendix C.

FINDINGS AND RESULTS

DOCUMENT REVIEW

ESSAP identified a number of areas in the documentation submitted by Rockwell/Rocketdyne, principally related to guideline selection, survey methodology, and final status documentation where clarification or additional information was necessary. ESSAP provided these comments

to the DOE in March 22 and April 4, 1994 correspondences.[14,15] Rockwell/Rocketdyne subsequently issued a response to each comment in a June 2, 1994 correspondence.[16]

SURFACE SCANS

Alpha, beta, and gamma scans of the interior and exterior areas of each building identified 4 locations of elevated direct beta radiation requiring additional investigation. One location, measuring less than 15 cm^2, was in Building 064 Room 114 grid block F,8 (Figure 26). The second location was in Building 005 Room 105/112 grid block Q,19 (Figure 10). The remaining two locations were identified in the Control Room of Building 023. One area was contiguous with the area which Rockwell/Rocketdyne had previously remediated (grid blocks D,1 and D,2 Figure 22). The second location measured less than 15 cm^2 and was located in grid block B,5 (Figure 22). The location in Building 064 Room 114 and the small area of contamination in grid block B,5 of Building 023 Control Room were decontaminated by Rockwell/Rocketdyne. ESSAP personnel performed post-remedial action surface scans at each location and found the beta surface activity to be comparable to background levels. Additional investigation of the residual activity detected in Building 005 Room 105/112 grid block Q,19 and Building 023 Control Room grid blocks D,1 and D,2 determined that the activity could be averaged over 1 m^2 for guideline comparison.

SURFACE ACTIVITY LEVELS

Surface activity levels for each of the buildings surveyed are summarized in Table 1. Total activity levels for the interior of Building 005 ranged from less than 66 to 360 dpm/100 cm^2 for alpha and less than 1,500 to 7,100 dpm/100 cm^2 for beta. The average activity in 1 m^2 grid blocks was less than 66 dpm/100 cm^2 for alpha and less than 1,500 to 2,100 dpm/100 cm^2 for beta. Total activity levels for the exterior areas of Building 005 ranged from less than 66 to 360 dpm/100 cm^2 and less than 1,500 to 1,900 dpm/100 cm^2 for alpha and beta, respectively.

Final survey results for total surface activity levels inside of Building 023, listed in Table 1, were less than 66 to 400 dpm/100 cm^2 for alpha and less than 1,400 to 6,700 dpm/100 cm^2 for

beta. The average activity in 1 m^2 grid blocks was less than 66 dpm/100 cm^2 for alpha and less than 1,400 to 2,400 dpm/100 cm^2 for beta. The activity levels on exterior surfaces, including the holdup waste tank vault, were less than 66 dpm/100 cm^2 to 120 dpm/100 cm^2 for alpha and less than 1,500 to 1,600 dpm/100 cm^2 for beta. Prior to remediation, the activity level of the "hot spot" in the Control Room was 20,000 dpm/100 cm^2. Post-remedial activity was less than 1,400 dpm/100 cm^2.

Building 064 final survey results for total activity, provided in Table 1, ranged from less than 66 to 290 dpm/100 cm^2 for alpha and less than 1,500 to 2,400 dpm/100 cm^2 for beta. The 1 m^2 grid block averages were less than 66 dpm/100 cm^2 and less than 1,500 dpm/100 cm^2 for alpha and beta, respectively. Exterior surface activity levels were less than 66 dpm/100 cm^2 for alpha and ranged from less than 1,400 to 2,200 dpm/100 cm^2 for beta. The beta activity level of the "hot spot" in Room 114 was 46,000 dpm/100 cm^2 prior to additional remediation, and 1,500 dpm/100 cm^2 after decontamination.

Removable activity levels for all measurement locations, summarized in Table 1, were less than the minimum detectable activities of the procedure which were 12 dpm/100 cm^2 for gross alpha and 16 dpm/100 cm^2 for gross beta.

EXPOSURE RATES

Background exposure rates as measured by Rockwell/Rocketdyne were 8 μR/h (in Building 038 for comparison with Buildings 005 and 023), 15 μR/h (in Building 445 for comparison with Building 064), and 15 μR/h for exterior areas. Building and exterior exposure rates are summarized in Table 2. Exposure rates ranged from 10 to 11 μR/h and 14 to 17 μR/h for the interiors of Buildings 005 and 064, respectively. Exterior exposure rates ranged from 12 to 14 μR/h. Qualitative verification exposure rates in Building 023 were comparable to background levels.

RADIONUCLIDE CONCENTRATIONS IN SOIL

The radionuclide concentrations in the soil samples collected from Buildings 005 and 064 are summarized in Table 3. Concentration ranges were as follows: Cs-137, less than 0.1 to 2.7 pCi/g; U-235, 0.1 to 0.5 pCi/g; and U-238, 0.7 to 3.8 pCi/g. There were no other gamma-emitting radionuclides of significance, other than naturally occurring radionuclides.

COMPARISON OF RESULTS WITH GUIDELINES

Surface activity levels in each of the three buildings were compared to the appropriate residual radioactive material guidelines specified in DOE Order 5400.5. These guidelines are summarized in Appendix C. The applicable guidelines for Building 005 and 064 are those for uranium which are as follows:

Total Activity

5,000 α dpm/100 cm^2, average in a 1 m^2 area

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

Removable Activity

1000 α dpm/100 cm^2

The guidelines for Building 023 are those for beta-gamma emitters which are:

Total Activity

5,000 β-γ dpm/100 cm^2, average in a 1 m^2 area

15,000 β-γ dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

1,000 β-γ dpm/100 cm^2

The uranium guidelines noted above specify alpha activity. However, because rough, dirty, damp, or porous materials may selectively attenuate the alpha radiation emitted by uranium, the beta radiation (emitted by the uranium daughters) was also measured, in addition to alpha activity, and used for guideline comparison. Alpha to beta decay ratios range from 1:1 for natural and low-enriched (<1%) uranium to as high as 9:1 for the reported 12.67% enriched uranium used in the fuel fabrication project. ESSAP previously requested additional information from Rockwell/Rocketdyne that would define the expected alpha-to-beta decay ratios for the various isotopic uranium compositions used in the facility.[14] Based on Rockwell/Rocketdyne's response, a 1:1 alpha to beta activity ratio was used for comparing beta surface activity levels, as well as the alpha surface activity levels, to the alpha guidelines for this survey.[16] All of the final ESSAP independent measurements were below both sets of guideline levels.

Soil concentration guidelines for uranium and Cs-137 are developed on a site-specific basis using the RESRAD computer code developed for that process. The Cs-137 guideline developed for the Building 064 Side Yard was 7.08 pCi/g average in a 100 m^2 area and a maximum "hot spot" concentration level of 70.8 pCi/g. Cesium-137 levels in verification samples were well below the average concentration guideline. Uranium levels in verification samples were comparable to expected background levels.

The DOE exposure rate guideline, identified in Appendix C, is 20 μR/h above background, at 1 m. However, Rockwell/Rocketdyne has elected to perform decommissioning work to meet a more restrictive exposure rate criteria of less than 5 μR/h above background. All exposure rates were below this guideline.

SUMMARY

The Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education has conducted verification activities for Buildings 005, 023, and 064 at the Santa Susana Field Laboratory in Ventura County, California. Verification activities included document reviews and during the period July 18 through 21, 1994 ESSAP personnel visited the site and performed independent surface scans, surface activity measurements, exposure rate measurements, and soil sampling.

ESSAP identified two small areas of above guideline contamination, one each in Buildings 023 and 064, during the verification survey. Rockwell/Rocketdyne personnel subsequently decontaminated both areas to below guideline levels. All remaining ESSAP measurements and sampling support Rockwell/Rocketdyne's conclusion that Building 005, 023, and 064 meet the DOE requirements for release to unrestricted use.

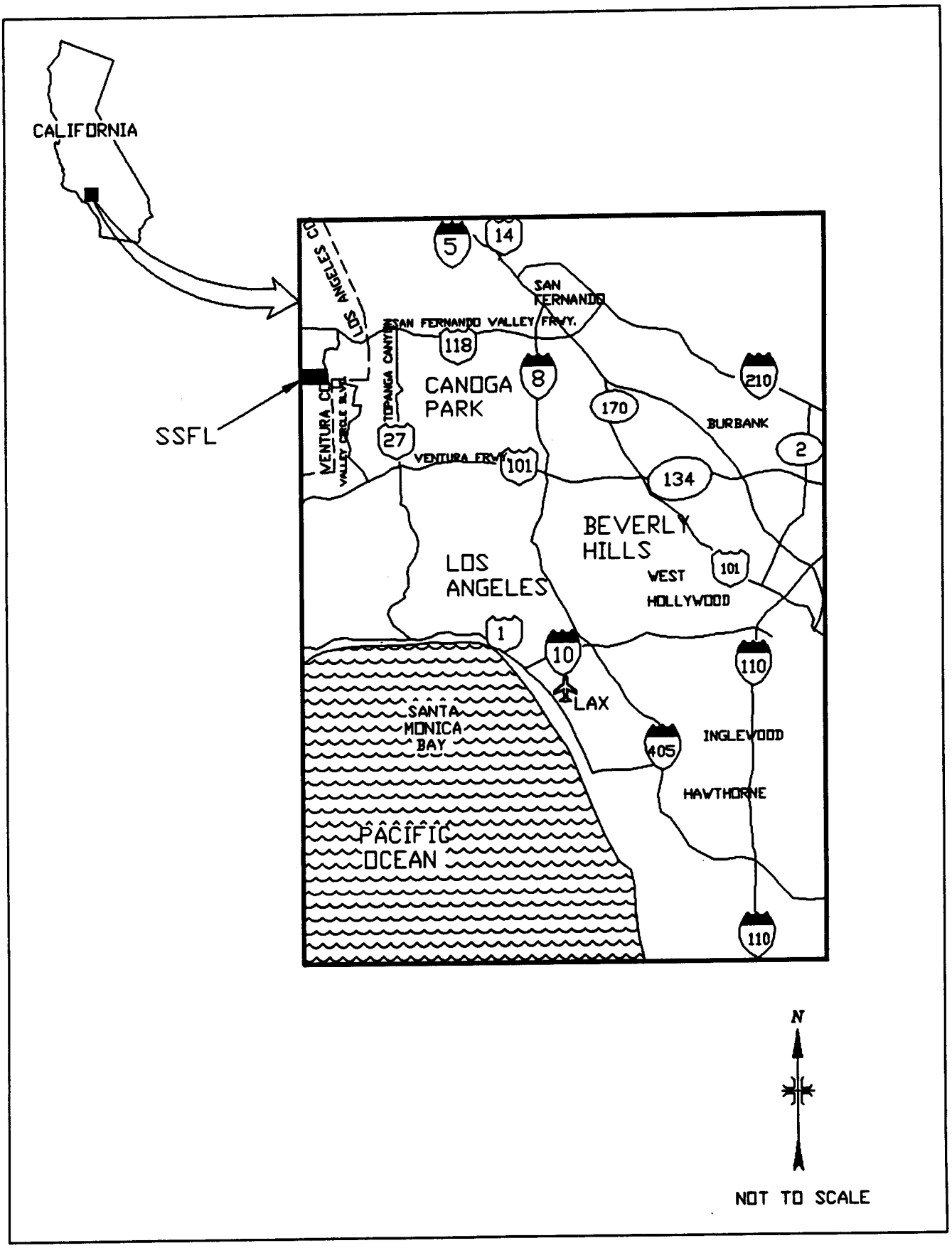


FIGURE 1: Los Angeles California Area - Location of Santa Susana Field Laboratory Site

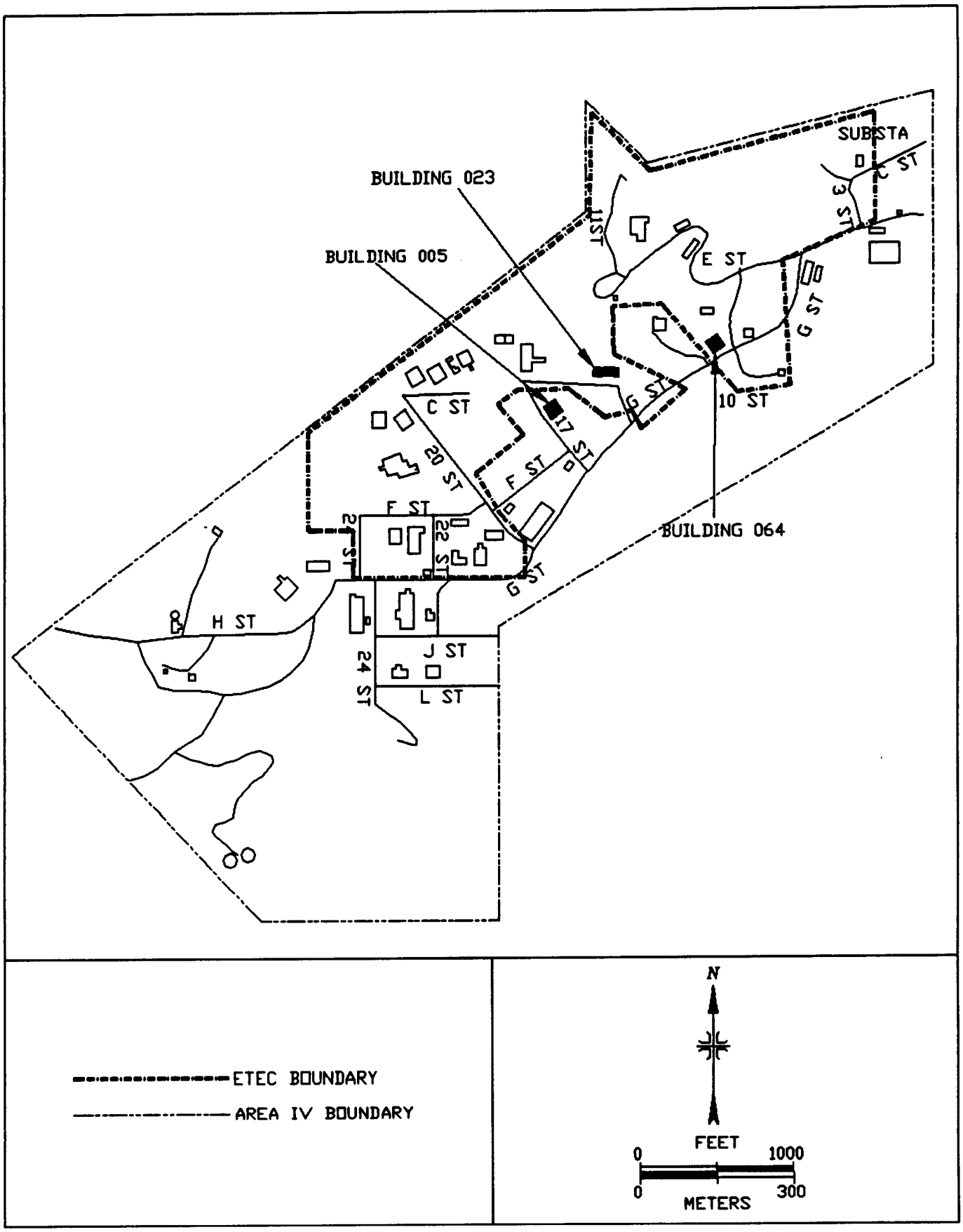


FIGURE 2: Santa Susana Field Laboratory Area IV, Plot Plan - Locations of Buildings 005, 023, and 064

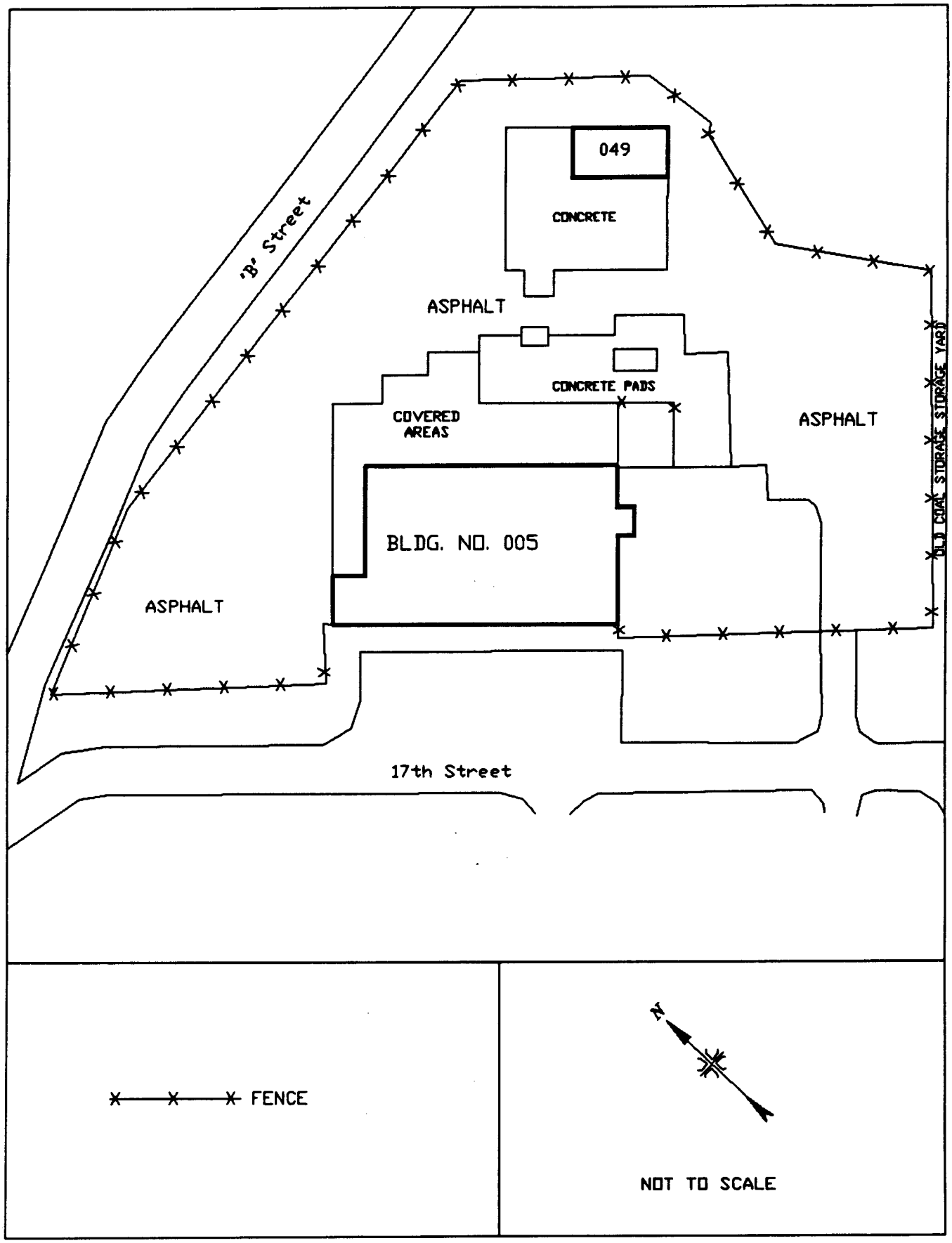


FIGURE 3: Building 005 - Plot Plan

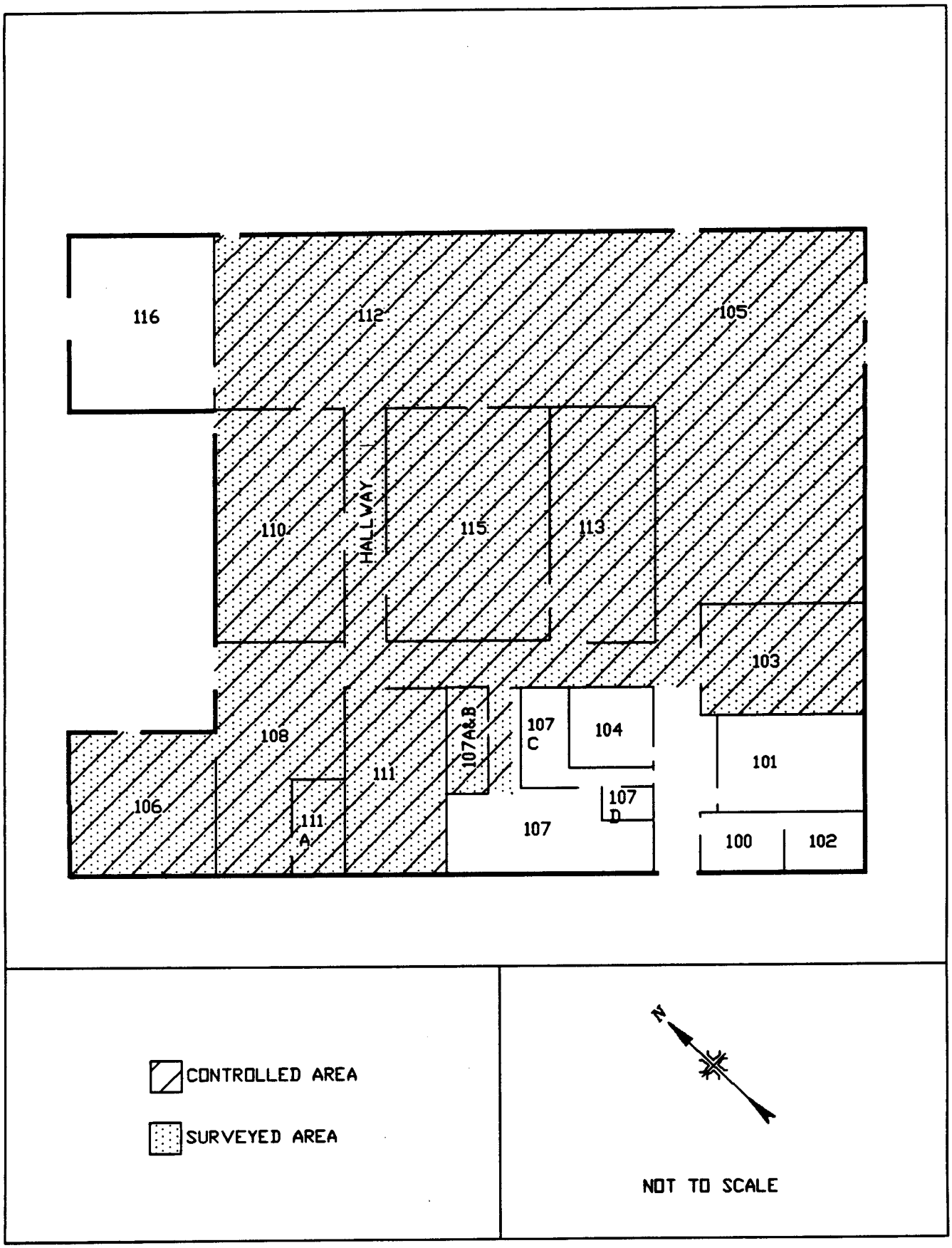


FIGURE 4: Building 005 - Floor Plan, Controlled Area, and Surveyed Areas

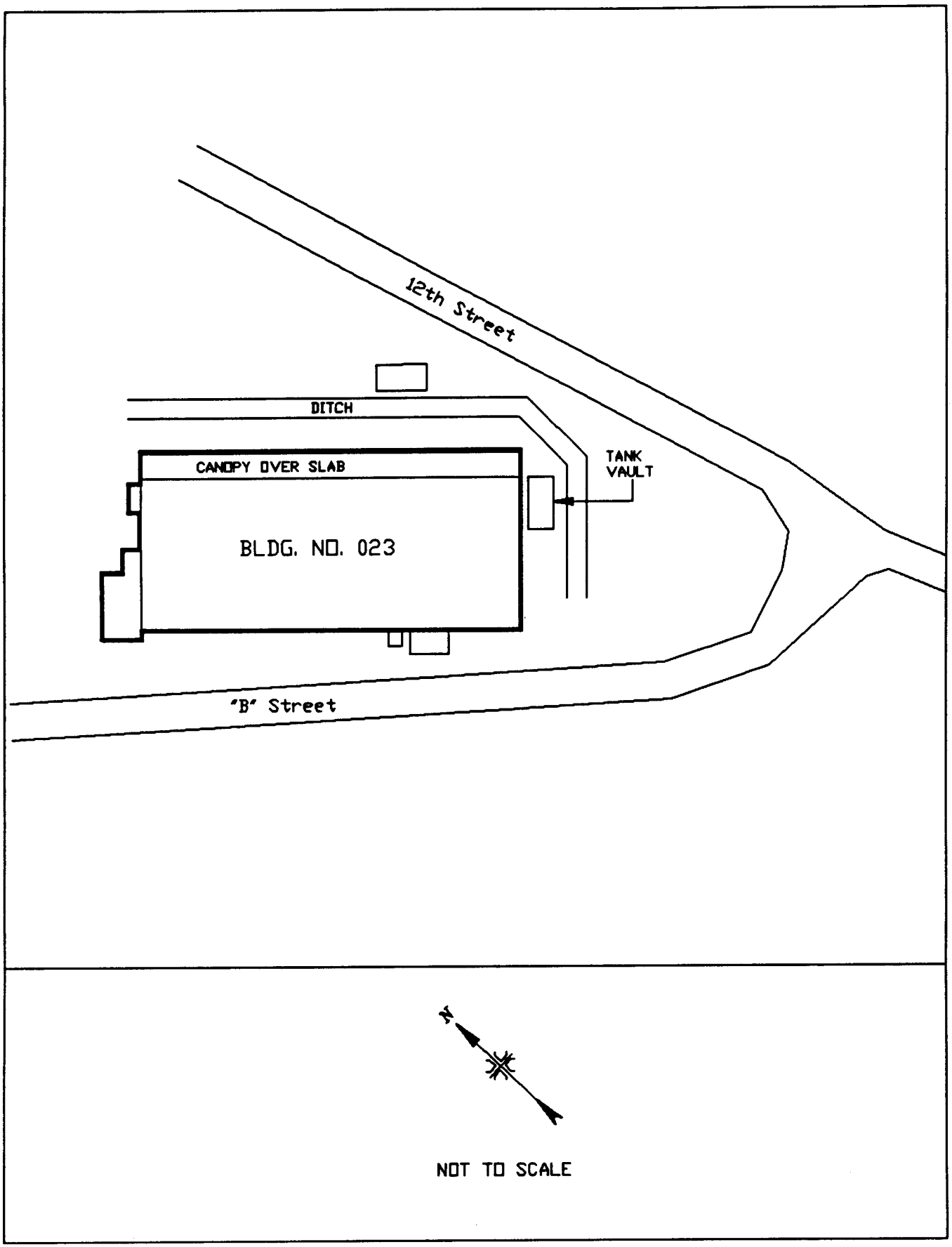


FIGURE 5: Building 023 - Plot Plan

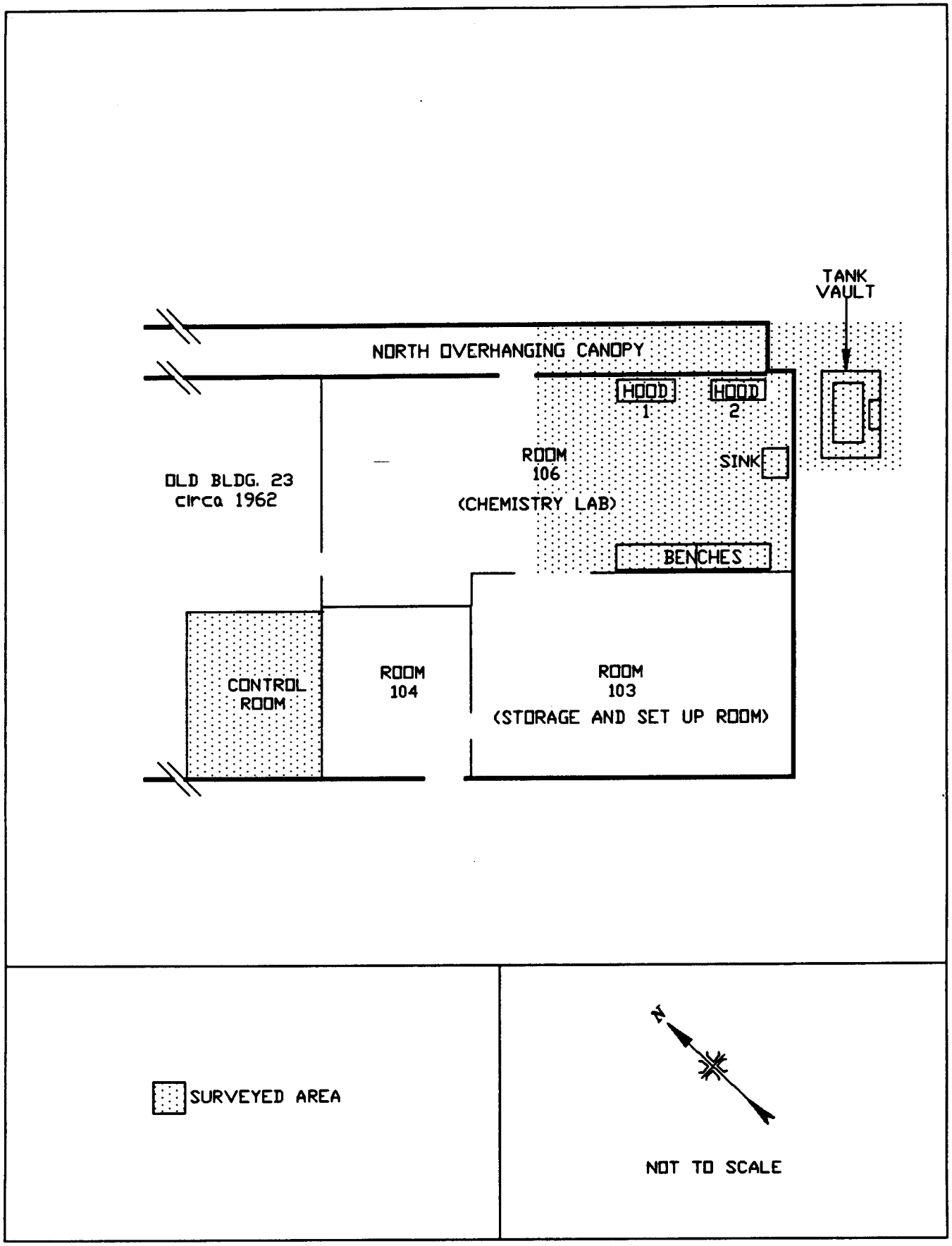


FIGURE 6: Building 023 - Floor Plan and Surveyed Areas

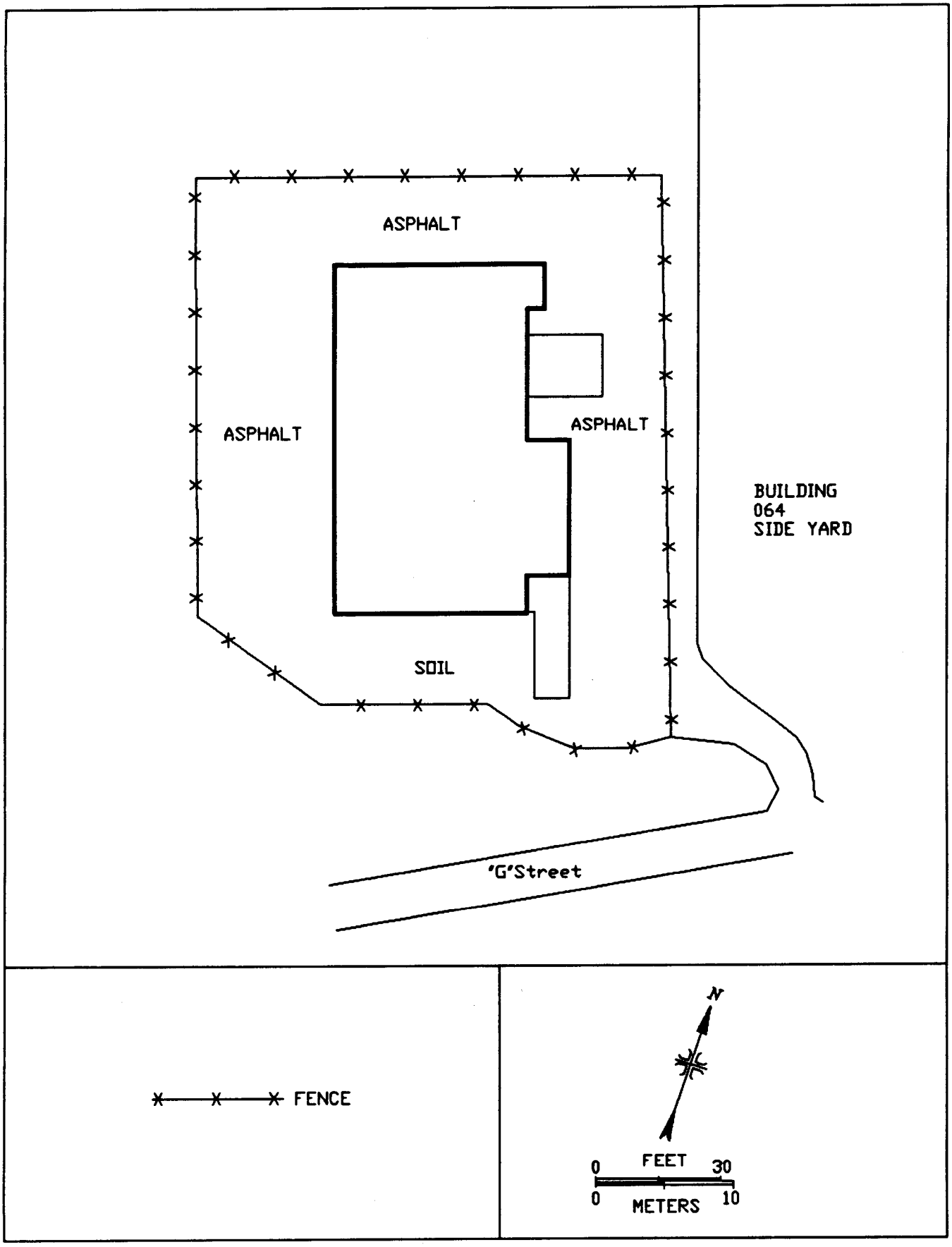


FIGURE 7: Building 064 - Plot Plan

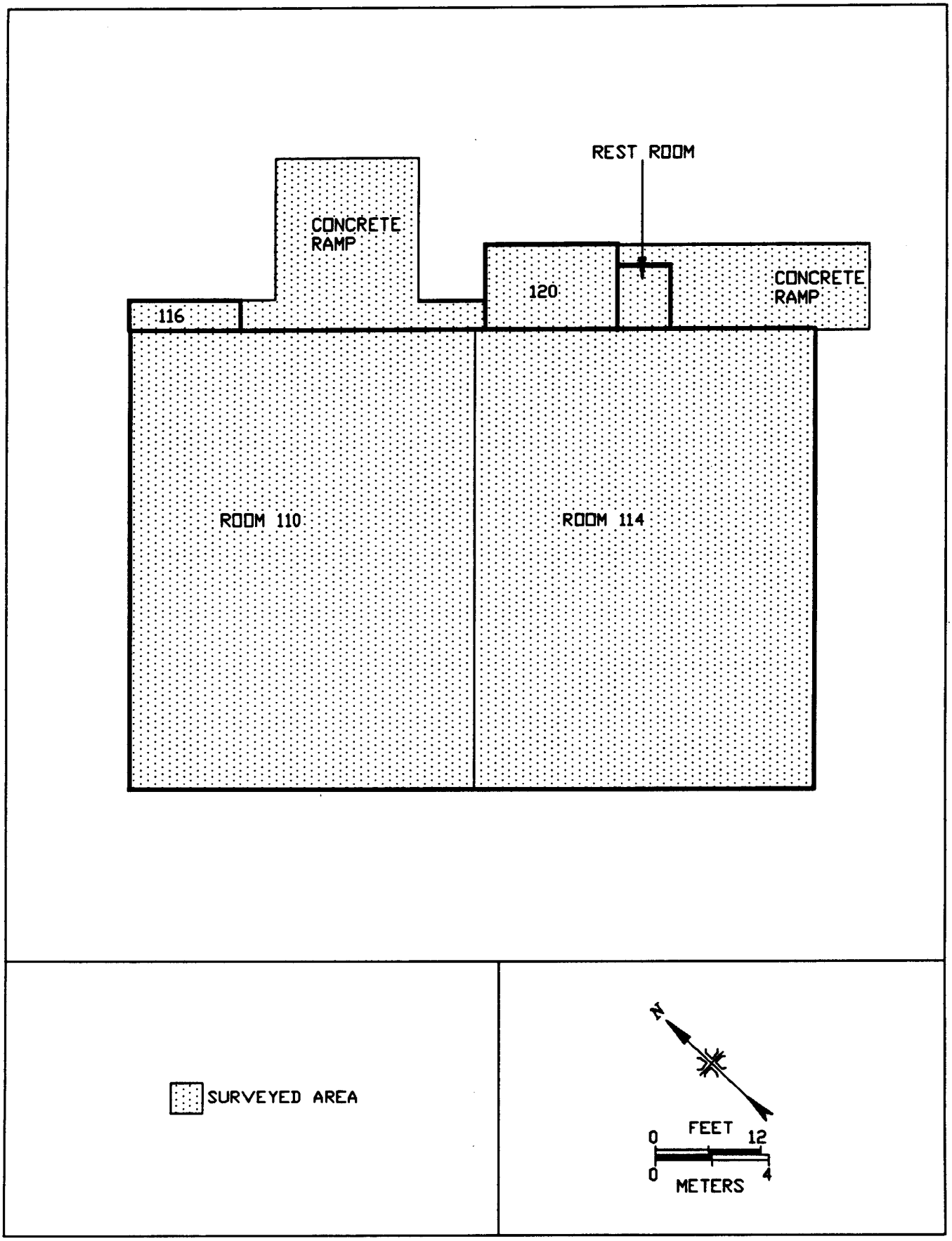
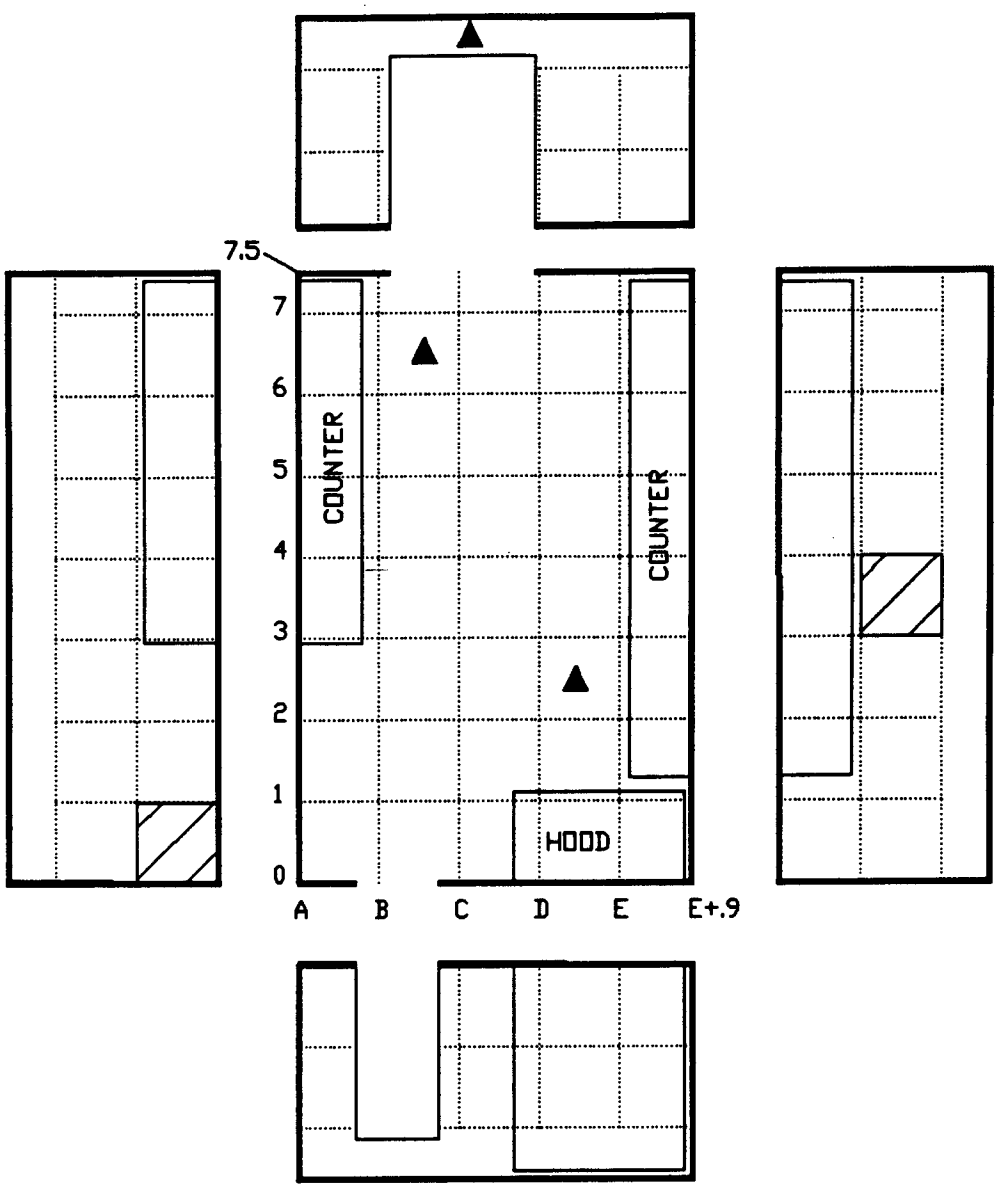


FIGURE 8: Building 064 - Floor Plan and Surveyed Areas



MEASUREMENT/SAMPLING LOCATIONS

GRID BLOCK

SINGLE-POINT UPPER WALLS AND CEILING

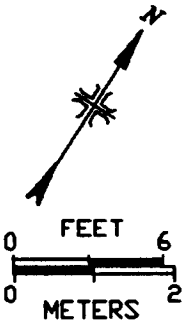


FIGURE 9: Building 005, Room 103 - Measurement and Sampling Locations

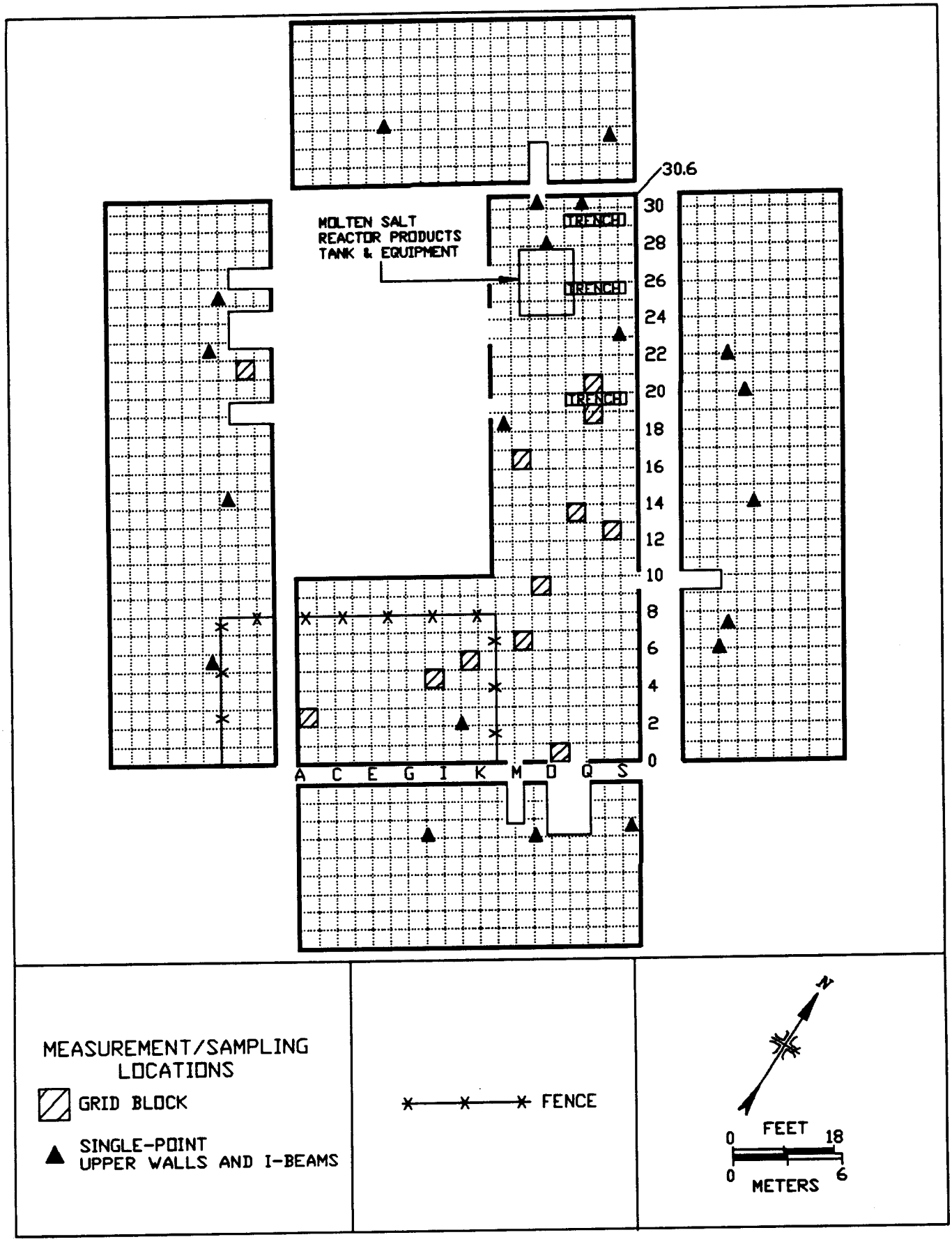
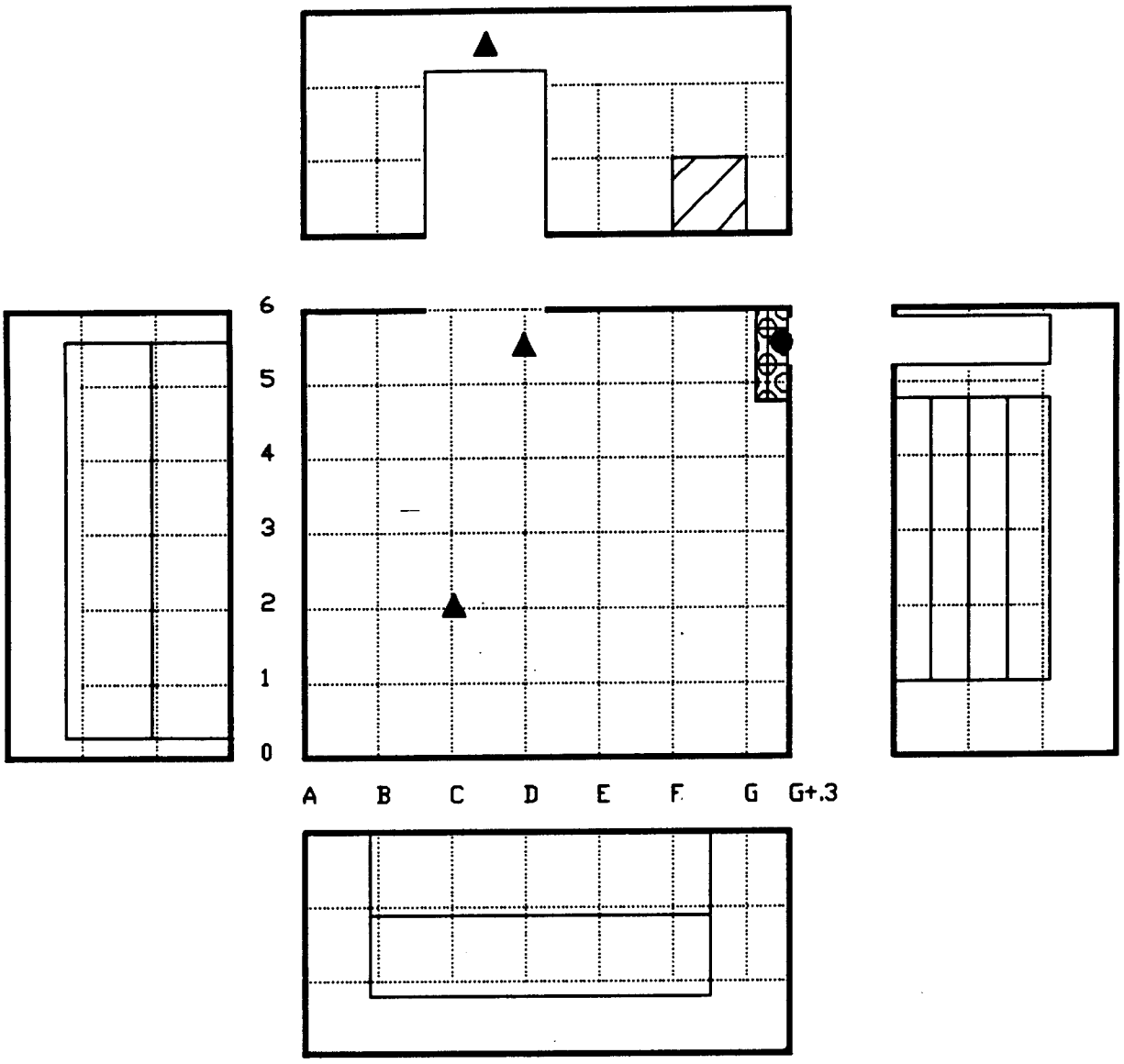


FIGURE 10: Building 005, Room 105/112 - Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

GRID BLOCK

SINGLE-POINT LOWER WALLS AND FLOOR

SINGLE-POINT UPPER WALLS AND CEILING

FLOOR TILE REMOVED

N

FEET 0 6

METERS 0 2

FIGURE 11: Building 005, Room 106 - Measurement and Sampling Locations

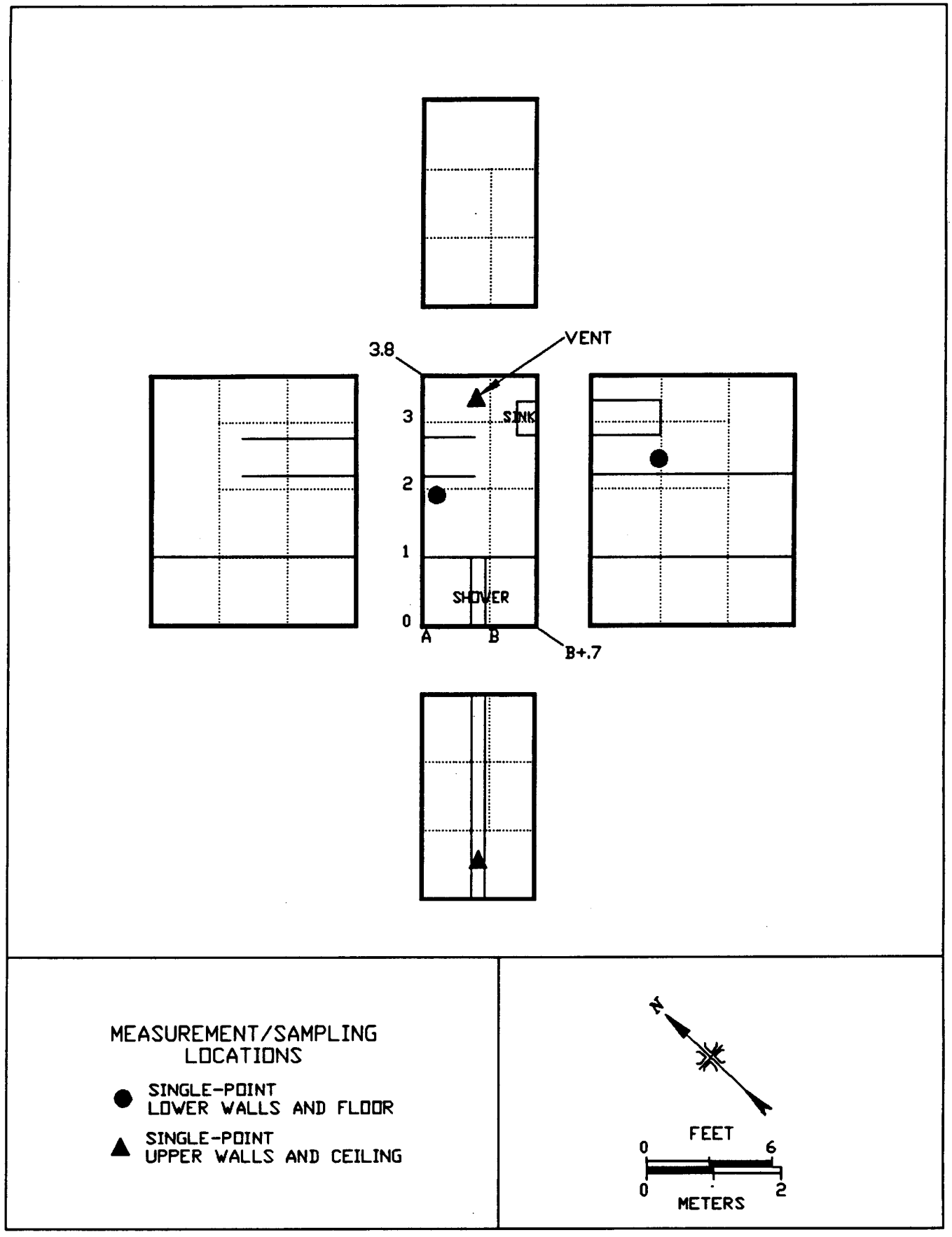


FIGURE 12: Building 005, Room 107A&B - Measurement and Sampling Locations

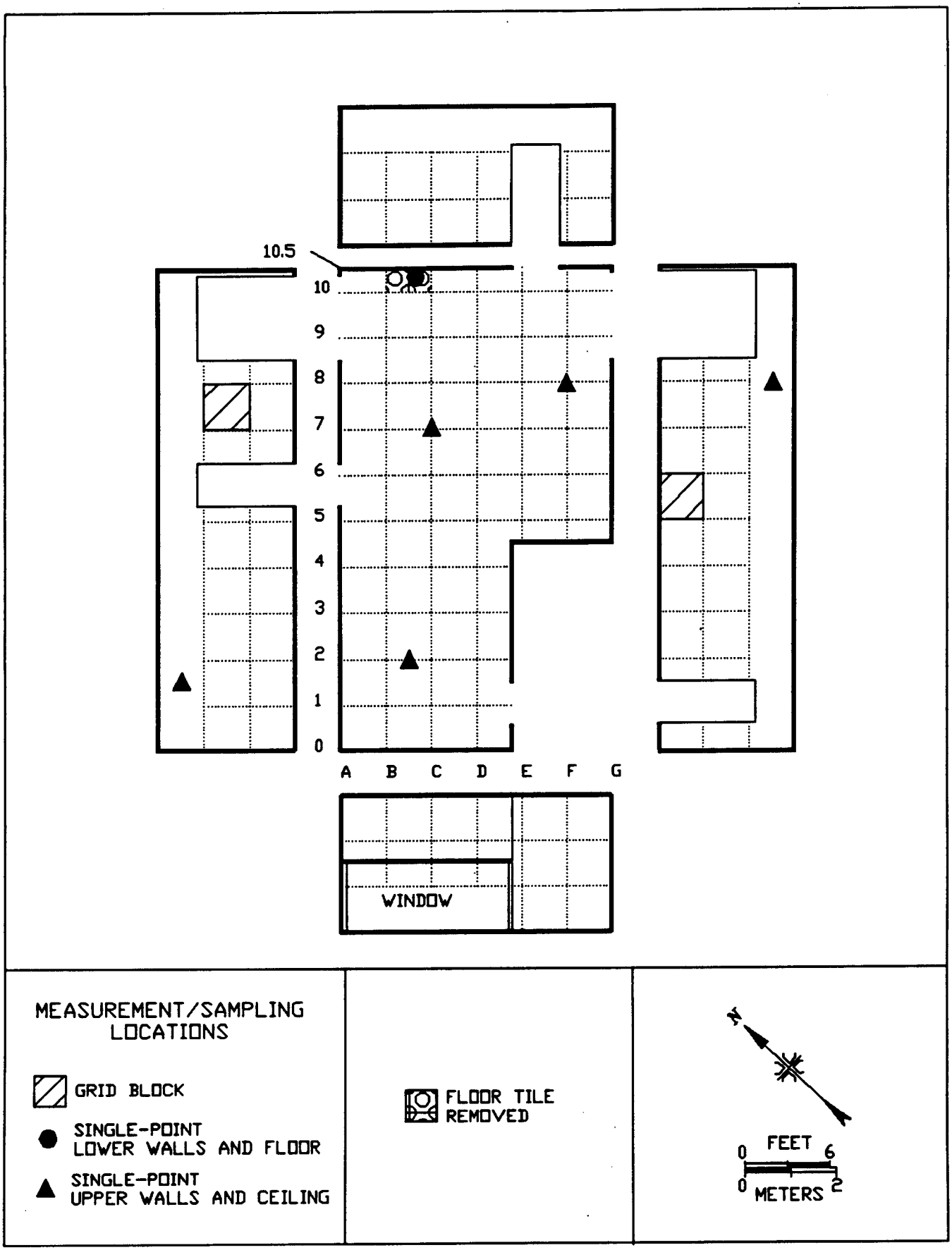


FIGURE 13: Building 005, Room 108 - Measurement and Sampling Locations

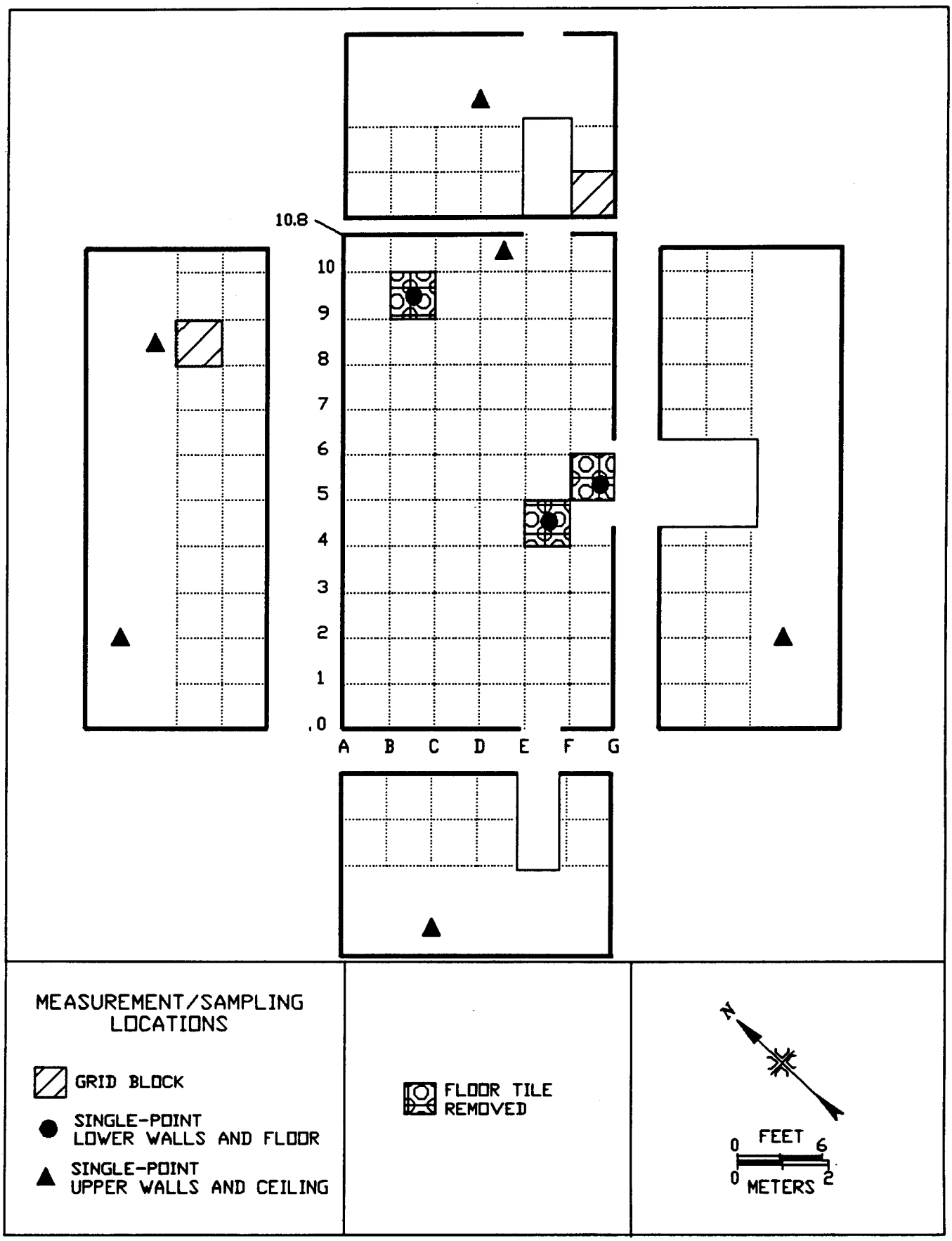


FIGURE 14: Building 005, Room 110 - Measurement and Sampling Locations

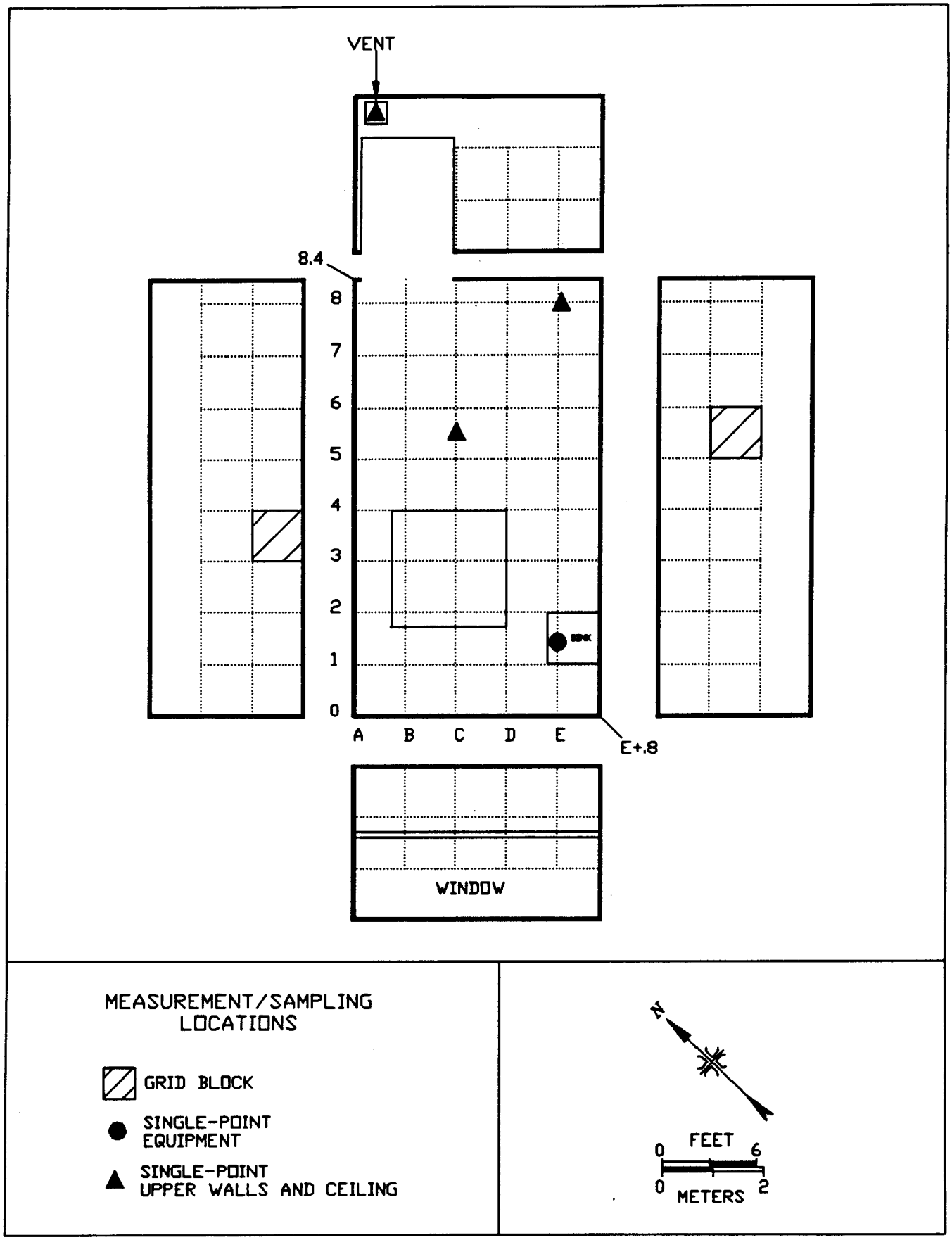


FIGURE 15: Building 005, Room 111 - Measurement and Sampling Locations

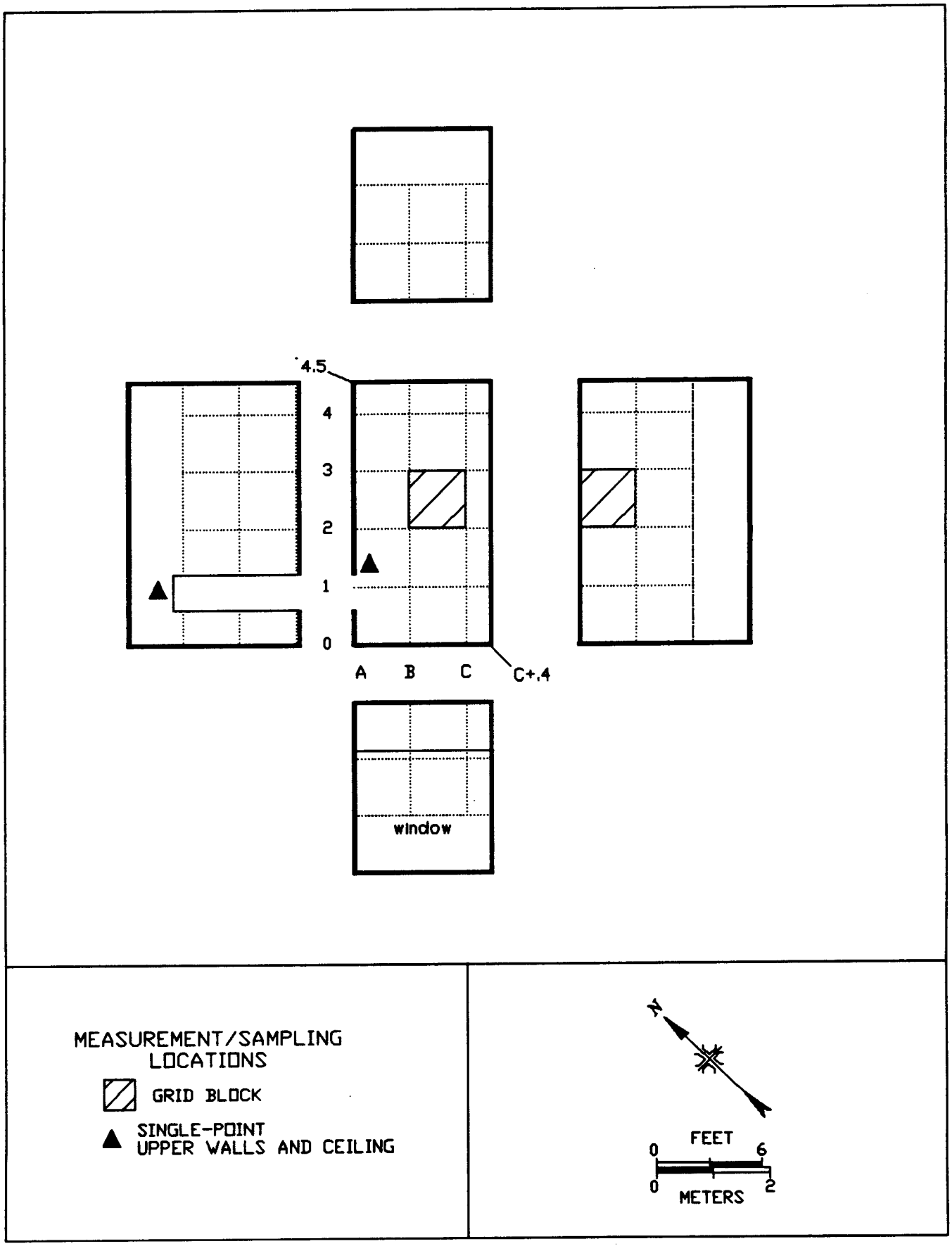


FIGURE 16: Building 005, Room 111A - Measurement and Sampling Locations

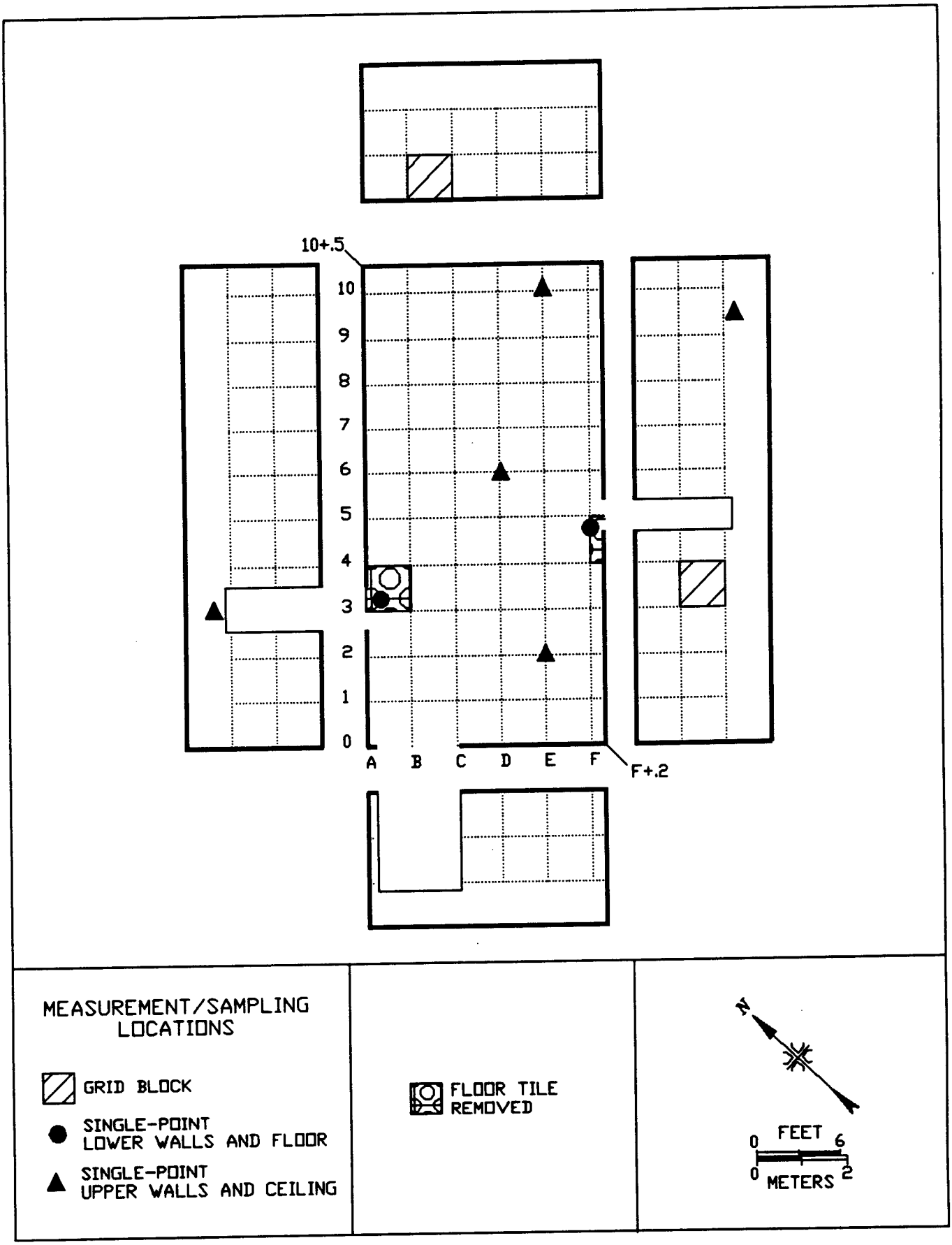


FIGURE 17: Building 005, Room 113 - Measurement and Sampling Locations

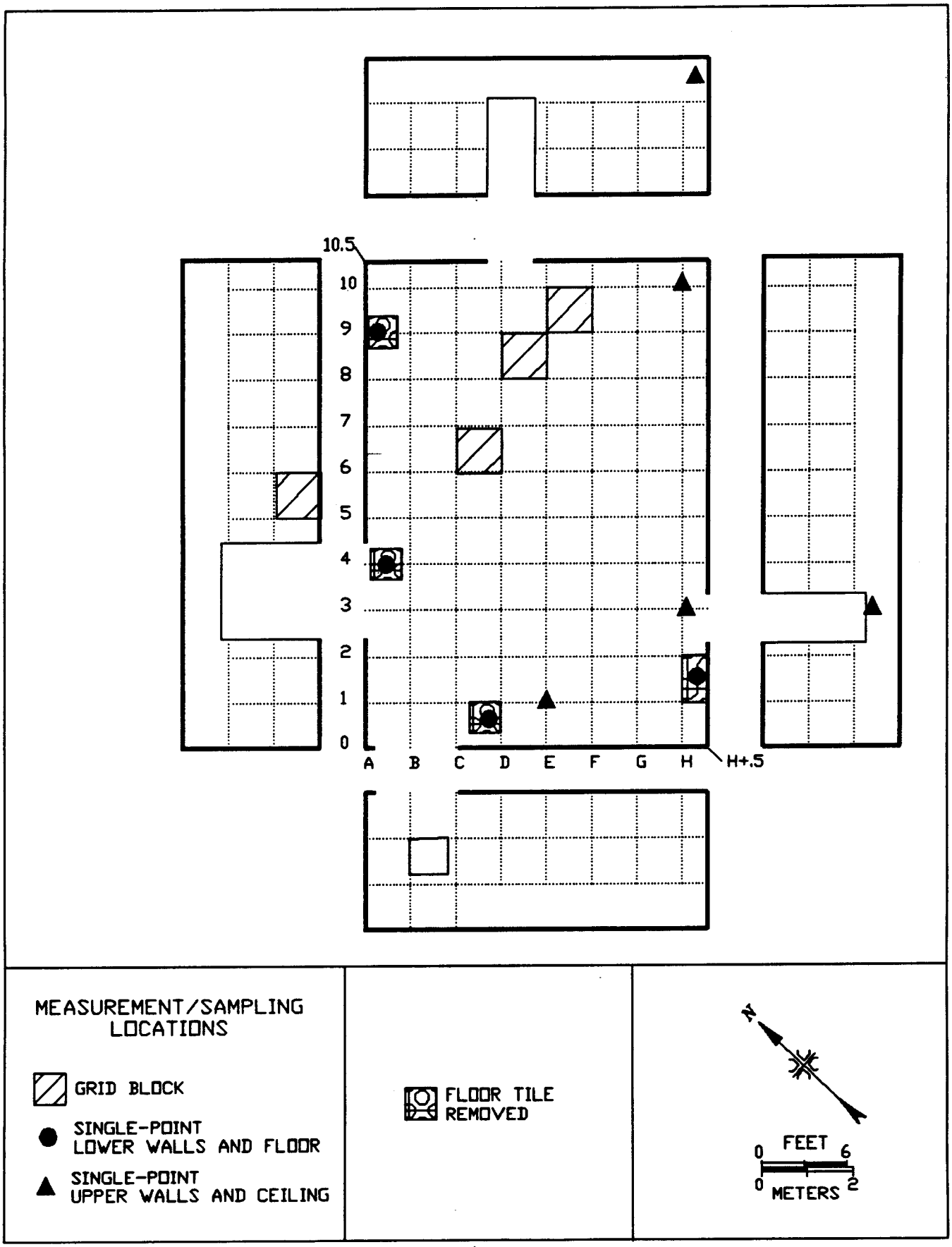


FIGURE 18: Building 005, Room 115 - Measurement and Sampling Locations

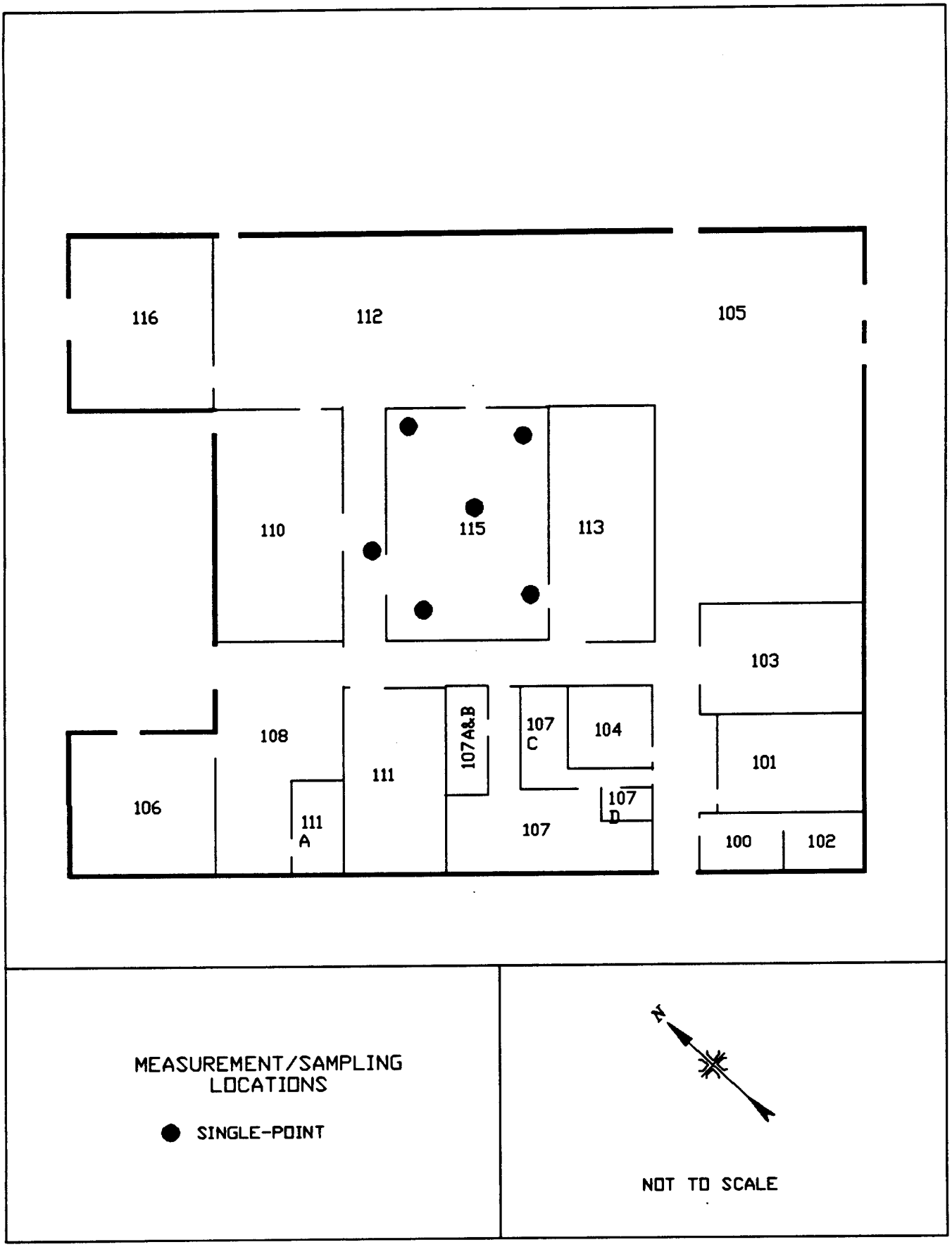


FIGURE 19: Building 005, Attic - Measurement and Sampling Locations

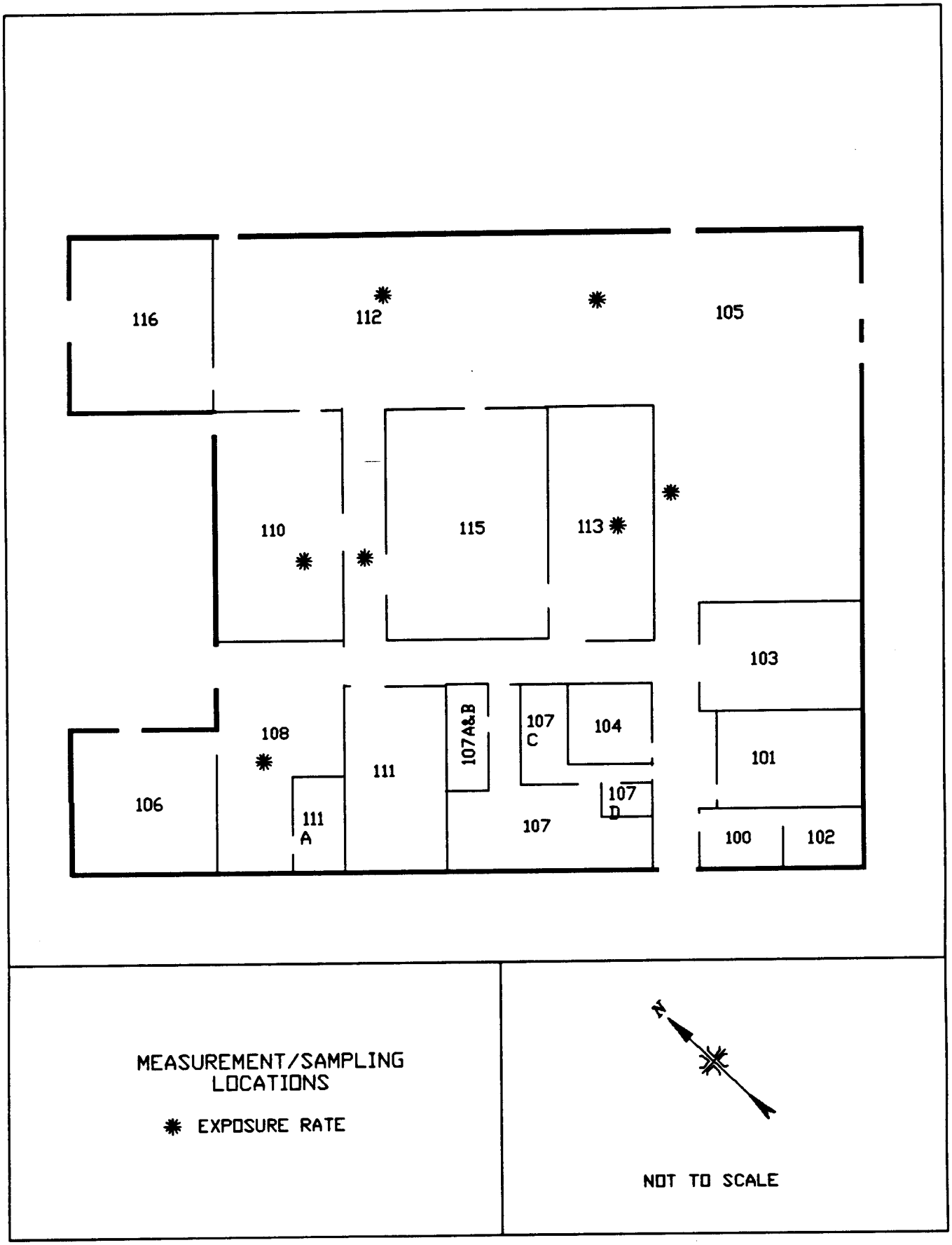


FIGURE 20: Building 005, Interior - Measurement Locations

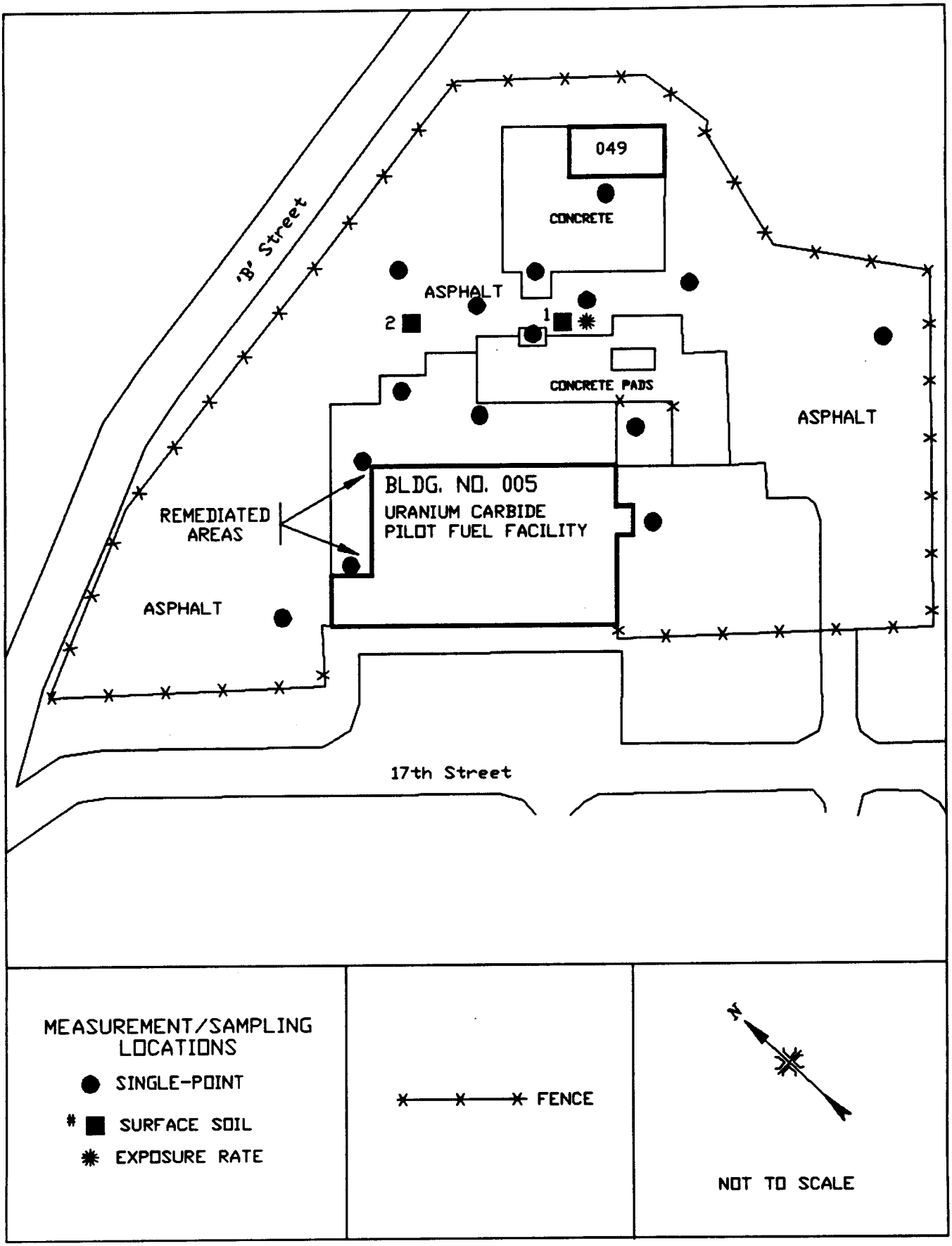


FIGURE 21: Building 005, Exterior Area - Measurement and Sampling Locations

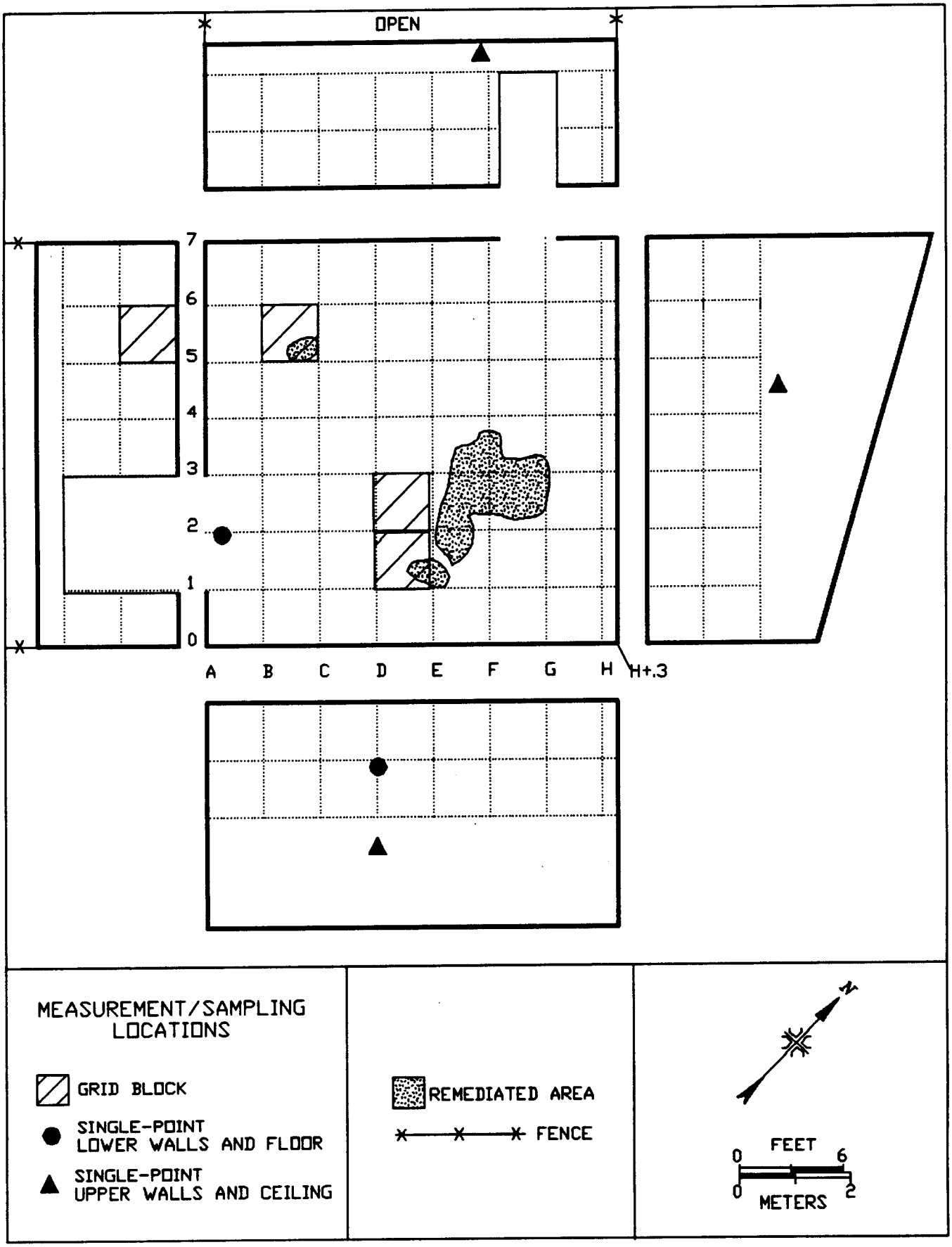


FIGURE 22: Building 023, Control Room - Measurement and Sampling Locations

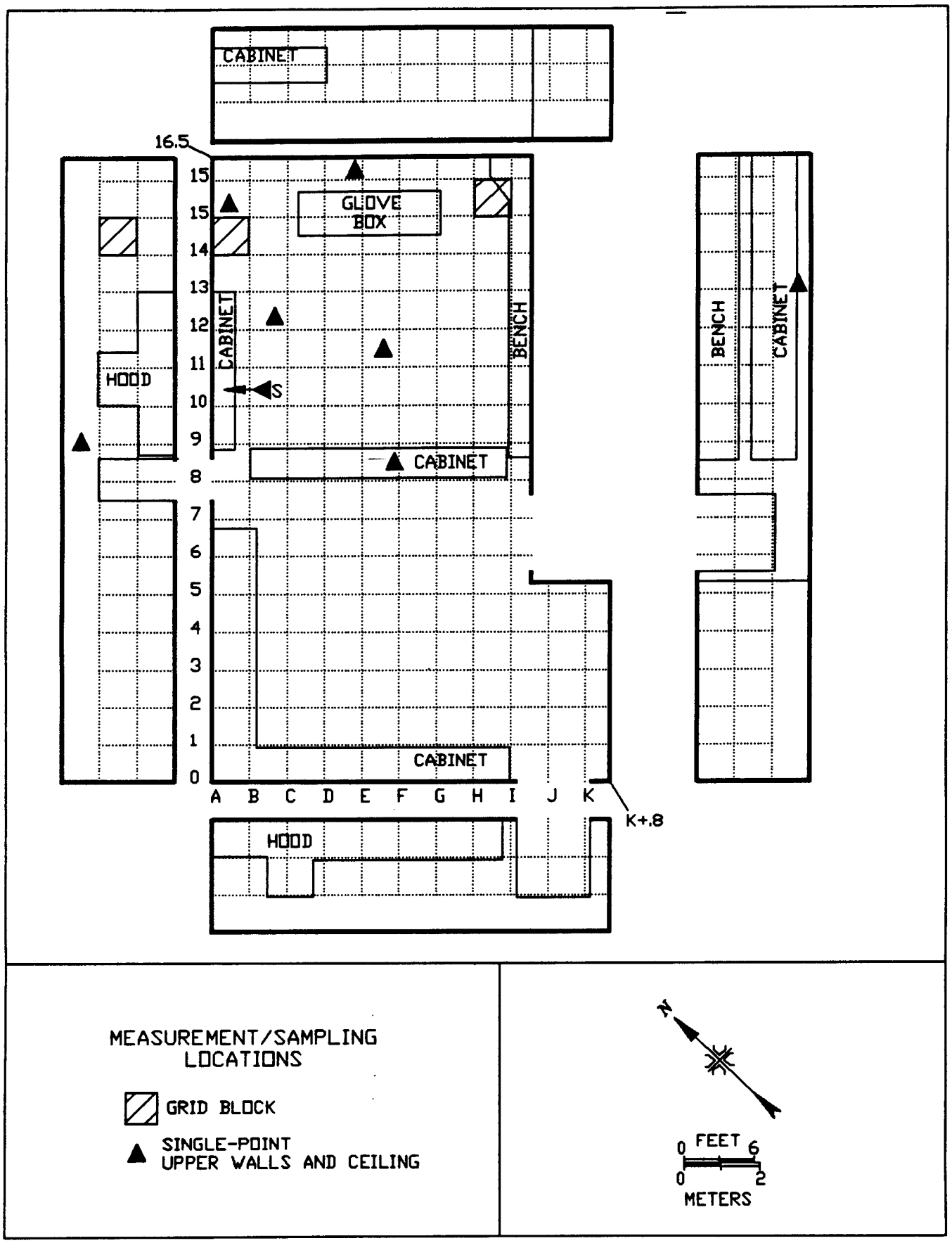


FIGURE 23: Building 023, Room 106 - Measurement and Sampling Locations

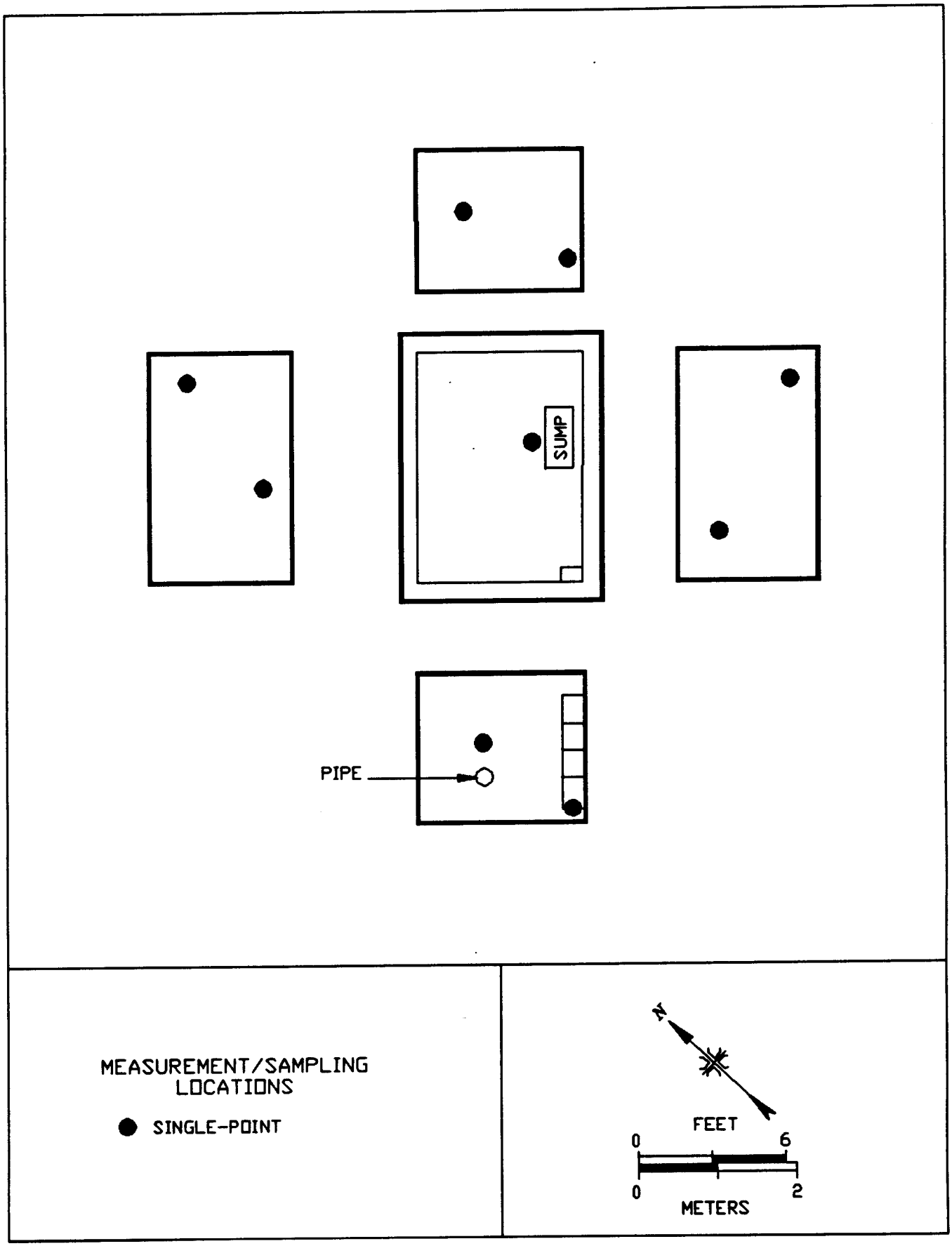


FIGURE 24: Building 023, Rad-Waste Tank Vault - Measurement and Sampling Locations

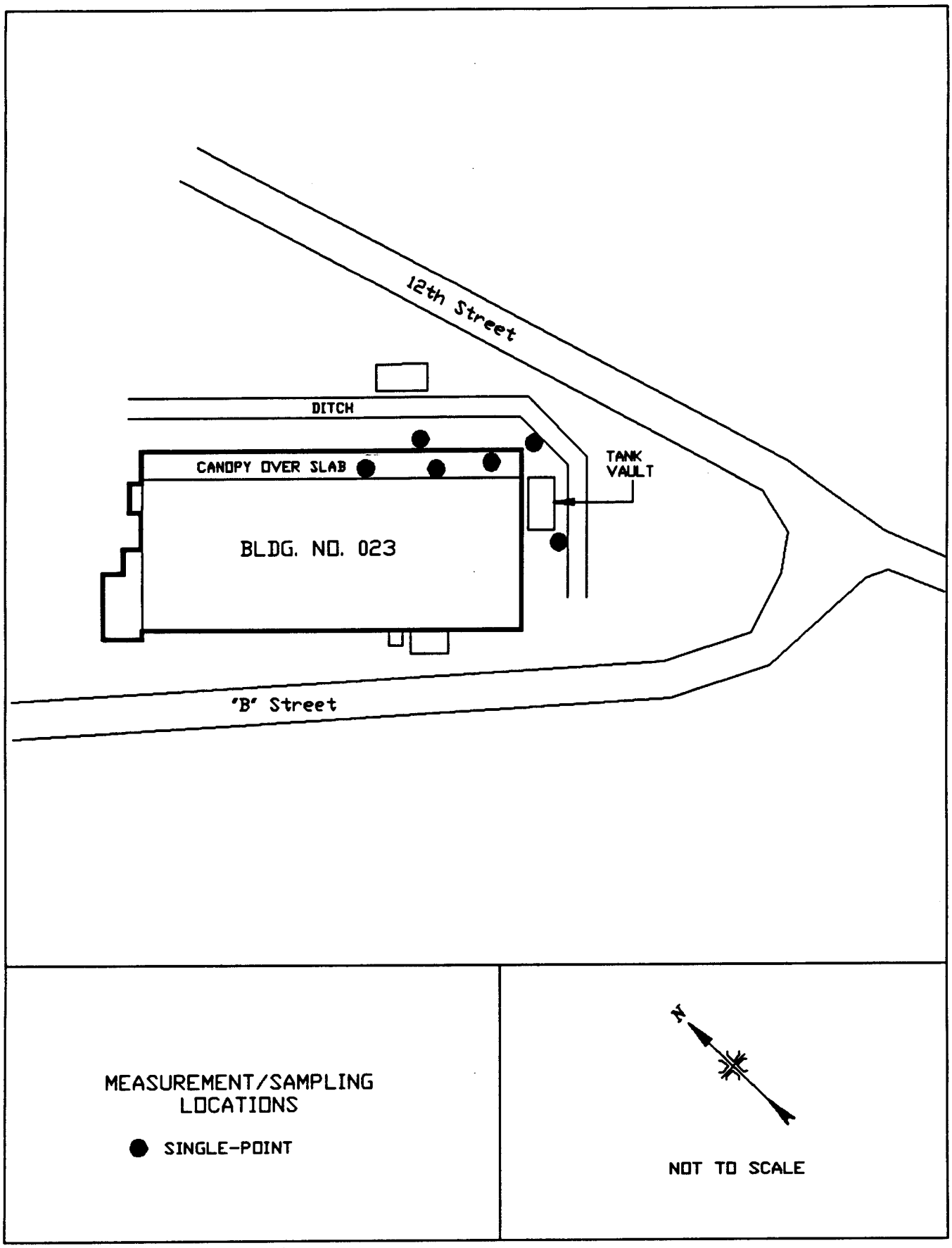
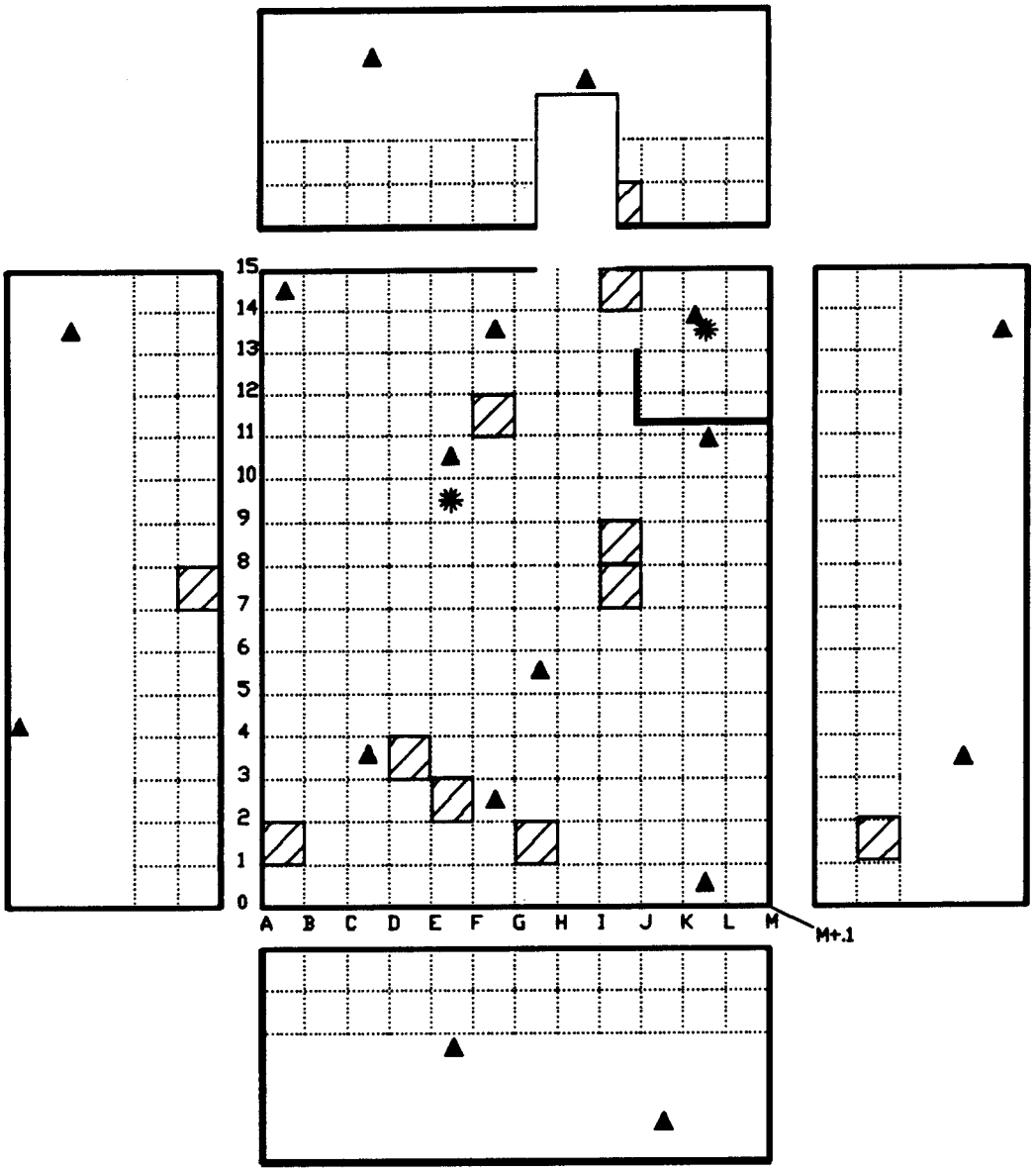


FIGURE 25: Building 023, Exterior Area - Measurement and Sampling Locations



MEASUREMENT/SAMPLING LOCATIONS

GRID BLOCK

SINGLE-POINT UPPER WALLS AND CEILING

EXPOSURE RATE

N

FEET 0 12

METERS 0 4

FIGURE 26: Building 064, Room 110 - Measurement and Sampling Locations

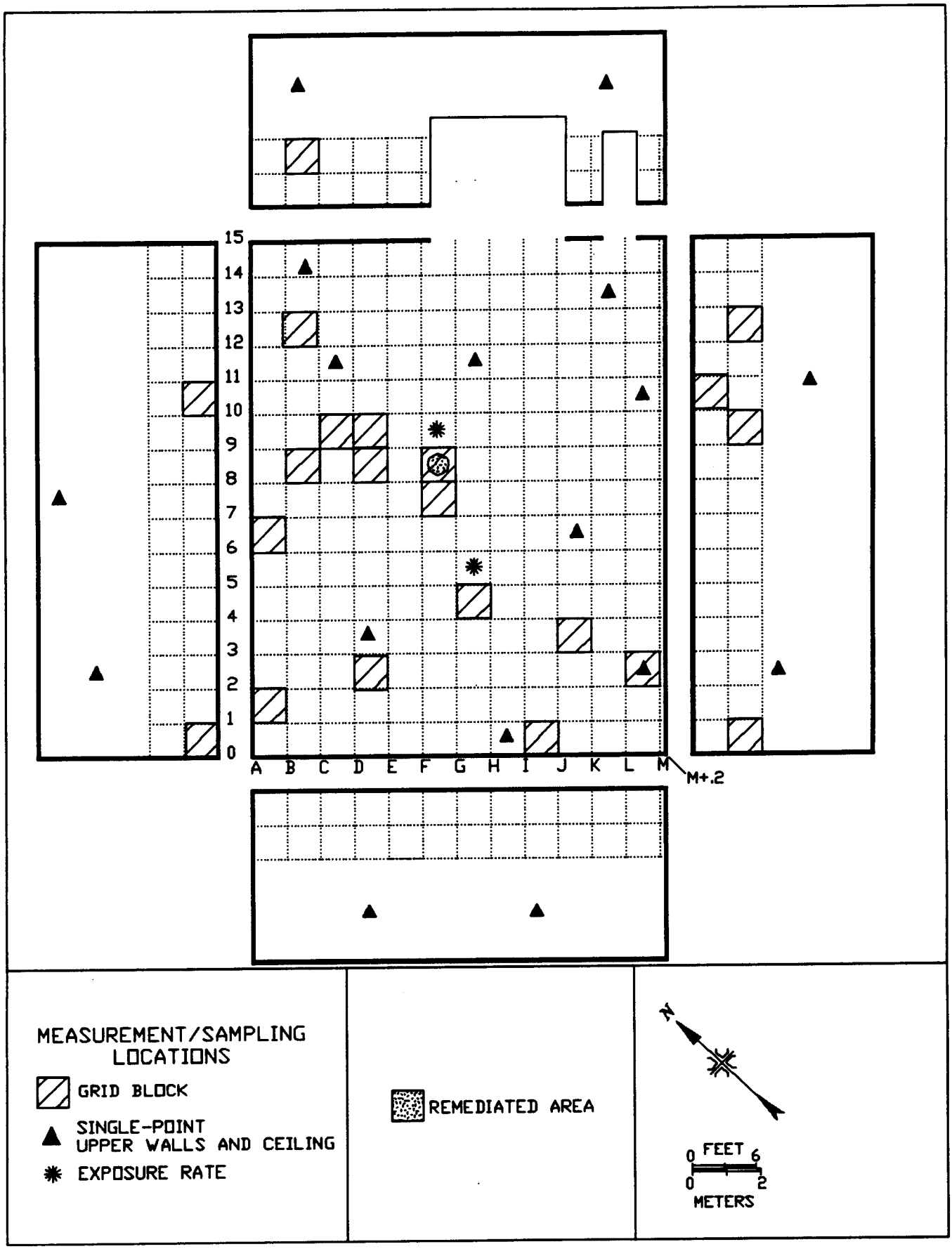


FIGURE 27: Building 064, Room 114 - Measurement and Sampling Locations

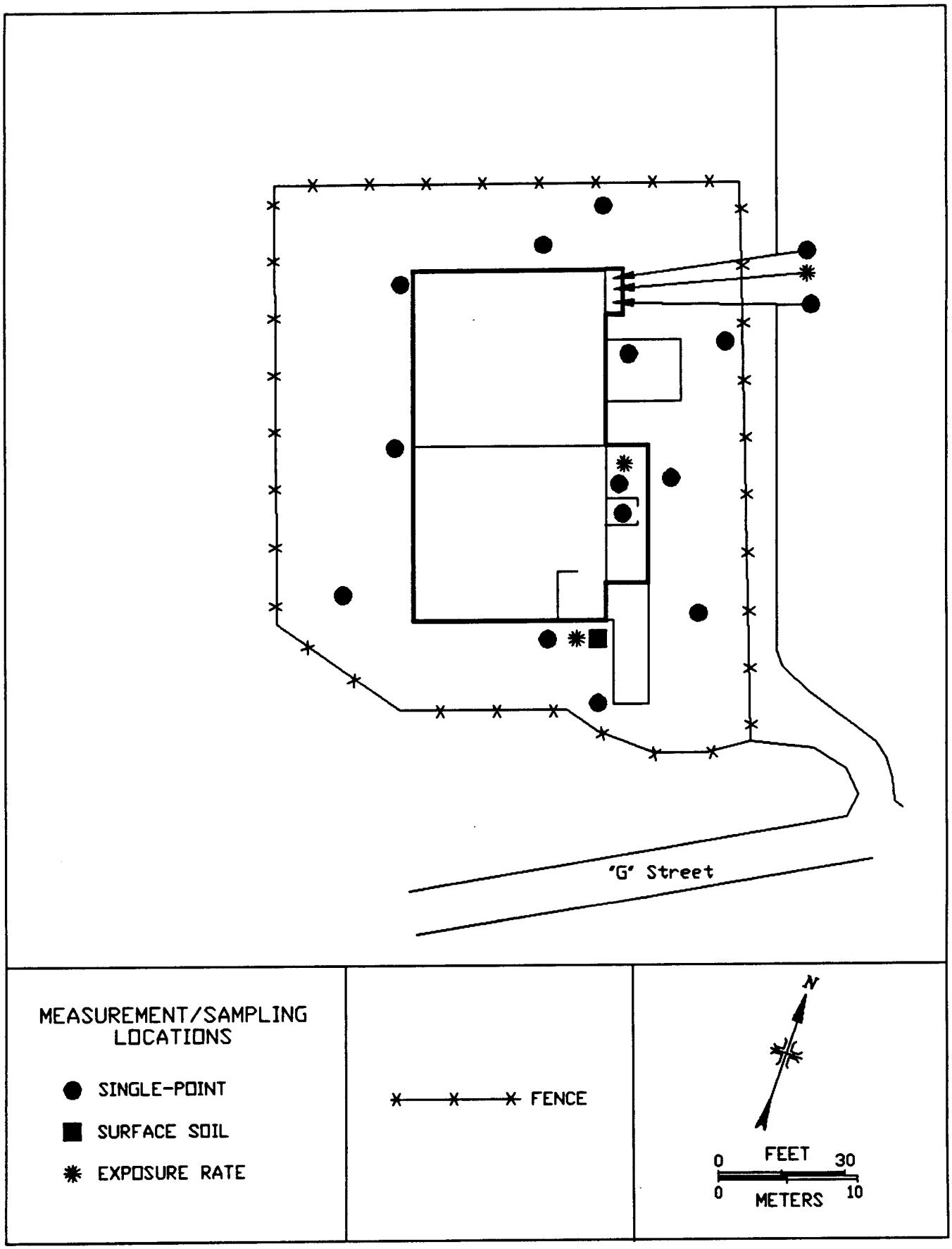


FIGURE 28: Building 064, Outer Rooms and Exterior Area - Measurement and Sampling Locations

TABLE 1

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Number of Measurement Locations		Range of Total Activity (dpm/100 cm^2)				Range of Removable Activity (dpm/100 cm^2)	
			Single Measurements		Grid Block Average			
	Single Points	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Building 005								
Room 103								
Lower Walls	NA[b]	2	<66	<1,500	<66	<1,500	<12	<16
Upper Walls and Ceilings	3	NA	<66	<1,500	NA	NA	<12	<16
Room 105/112								
Floor	NA	11	<66	<1,400 to 7,100	<66	<1,400 to 2,100	<12	<16
Lower Walls	NA	1	<66	<1,400	<66	<1,400	<12	<16
Upper Walls, I-Beams and Equipment[c]	27	NA	<66 to 110	<1,500	NA	NA	<12	<16
Room 106								
Floor	1	NA	<66	<1,400	NA	NA	<12	<16
Lower Wall	NA	1	<66	<1,400	<66	<1,400	<12	<16
Upper Walls and Ceiling	3	NA	<66	<1,400	NA	NA	<12	<16
Room 107A and 107B								
Floor	1	NA	<66	<1,500	NA	NA	<12	<16
Lower Wall	1	NA	<66	<1,500	NA	NA	<12	<16
Upper Walls and Ceiling	2	NA	89 to 360	<1,500 to 4,400	NA	NA	<12	<16
Room 108								
Floor	1	NA	<66	<1,500	NA	NA	<12	<16
Lower Walls	NA	2	<66	<1,400	<66	<1,400	<12	<16
Upper Walls and Ceiling	5	NA	<66	<1,400	NA	NA	<12	<16

TABLE 1 (Continued)

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Number of Measurement Locations		Range of Total Activity (dpm/100 cm^2)				Range of Removable Activity (dpm/100 cm^2)	
			Single Measurements		Grid Block Average			
	Single Points	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Building 005 (Continued)								
Room 110								
Floor	3	NA	<66	<1,500	NA	NA	<12	<16
Lower Walls	NA	2	<66 to 89	<1,500	<66	<1,500	<12	<16
Upper Walls and Rafter	6	NA	<66	<1,500	NA	NA	<12	<16
Room 111 and 111A								
Floor	NA	1	<66	<1,400	<66	<1,400	<12	<16
Lower Walls and Equipment	NA	3	<66 to 80	<1,500	<66	1,500	<12	<16
Upper Walls and Ceiling	6	NA	<66	1,500	NA	NA	<12	<16
Room 113								
Floor	2	NA	<66	<1,500	NA	NA	<12	<16
Lower Wall	NA	2	<66	<1,400	<66	<1,400	<12	<16
Upper Walls and Ceiling	5	NA	<66	<1,400	NA	NA	<12	<16
Room 115								
Floor	4	3	<66	<1,500	<66	<1,500	<12	<16
Lower Wall	NA	1	<66	<1,500	<66	<1,500	<12	<16
Upper Walls and Ceiling	5	NA	<66	<1,400	NA	NA	<12	<16
Attic	6	NA	<66	<1,500	NA	NA	<12	<16
Outdoor Area	15	NA	<66 to 360	<1,500 to 1,900	NA	NA	<12	<16

TABLE 1 (Continued)

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Number of Measurement Locations		Range of Total Activity (dpm/100 cm^2)				Range of Removable Activity (dpm/100 cm^2)	
			Single Measurements		Grid Block Average			
	Single Points	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Building 023								
Control Room								
Floor	1	3	<66	<1,400 to 6,700	<66	<1,400 to 2,400	<12	<16
Lower Walls	1	1	<66	<1,400	<66	<1,400	<12	<16
Upper Walls and Ceiling	3	NA	<66 to 110	<1,400	NA	NA	<12	<16
Room 106								
Floor	NA	2	<66	<1,400	<66	<1,400	<12	<16
Lower Walls	NA	1	<66	<1,400	<66	<1,400	<12	<16
Upper Walls, Ceiling, and Equipment	8	NA	<66 to 400	<1,400 to 3,100	NA	NA	<12	<16
Exterior								
Tank Vault	9	NA	<66 to 71	<1,500	NA	NA	<12	<16
Paved Areas and Walkways	6	NA	<66 to 120	<1,400 to 1,600	NA	NA	<12	<16
Building 064								
Room 110								
Floor	NA	8	<62 to 80	<1,400 to 2,400	<66	<1,500	<12	<16
Lower Walls	NA	3	<66 to 98	<1,500	<66	<1,500	<12	<16
Upper Walls and Ceiling	17	NA	<66 to 290	<1,500	NA	NA	<12	<16

TABLE 1 (Continued)

SUMMARY OF SURFACE ACTIVITY MEASUREMENTS
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Number of Measurement Locations		Range of Total Activity (dpm/100 cm^2)				Range of Removable Activity (dpm/100 cm^2)	
			Single Measurements		Grid Block Average			
	Single Points	Grid Blocks	Alpha	Beta	Alpha	Beta	Alpha	Beta
Building 064 (Continued)								
Room 114								
Floor	1	14	<66	<1,400 to 1,500	<66	<1,500	<12	<16
Lower Walls	NA	7	<66 to 89	<1,500	<66	<1,500	<12	<16
Upper Walls and Ceiling	17	NA	<66	<1,500	NA	NA	<12	<16
Room 116	2	NA	<66 to 98	<1,400 to 1,500	NA	NA	<12	<16
Room 120	1	NA	<66	<1,400	NA	NA	<12	<16
Rest Room	1	NA	<66	<1,400	NA	NA	<12	<16
Exterior								
Paved Areas and Ramps	11	NA	<66	<1,400 to 2,200	NA	NA	<12	<16

[a]Refer to Figures 9 through 18 and 20 through 28.
[b]NA = Not Applicable.
[c]All Measurements not shown on Figure 10. Seven measurements made on Molten Salt Reaction Products Tank and Equipment are not shown.

TABLE 2

EXPOSURE RATES
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Number of Exposure Rate Measurements	Exposure Rate Range (μR/h)[b]
Interior		
Building 005	7	10 to 11
Building 064	6	14 to 17
Exterior		
Building 005	1	12
Building 064	1	14

[a]Refer to Figures 20, 21, and 26 through 28.
[b]Reported exposure rates are inclusive of background.

TABLE 3

RADIONUCLIDE CONCENTRATIONS IN SOIL
SANTA SUSANA FIELD LABORATORY
ROCKWELL INTERNATIONAL
VENTURA COUNTY, CALIFORNIA

Location[a]	Radionuclide Concentration (pCi/g)[b]		
	Cs-137	U-235	U-238
Building 005 Loc. 1	<0.1	0.1 ± 0.1[c]	1.7 ± 1.4
Building 005 Loc. 2	<0.1	0.1 ± 0.1	0.7 ± 1.1
Building 064	2.7 ± 0.2	0.5 ± 0.1	3.8 ± 1.7

[a]Refer to Figures 21 and 28.
[b]Only radionuclides of concern reported. Gamma spectrometry results did not identify any photo peaks other than from those radionuclides occurring in nature.
[c]Uncertainties represent the 95% confidence level, based only on counting statistics.

REFERENCES

1. T. J. Vitkus, ORISE, "Verification Survey of the Old Conservation Yard, Building T064 Side Yard, and Building T028, Santa Susana Field Laboratory, Rockwell International, Ventura County, California," October 1993.

2. Energy Technology Engineering Center, "Radiological Survey of Building T005," November 16, 1987.

3. Energy Technology Engineering Center, "Building T005 Decontamination and Decommissioning Operations Plan," January 24, 1992.

4. Energy Technology Engineering Center, "Building 005 Final Survey Procedure," December 9, 1992.

5. Energy Technology Engineering Center, "Final Radiological Survey of Building 005," September 21, 1993.

6. Energy Technology Engineering Center, "Final Radiological Survey Report of Building 023," March 1, 1994.

7. Energy Technology Engineering Center, "Radiological Survey of Source and Special Nuclear Material Storage Vault Building T064," August 19, 1988.

8. Energy Technology Engineering Center, "D&D Work Plan for Building 064, Environmental Restoration," February 18, 1992.

9. Energy Technology Engineering Center, "Building T064 Interior Final Survey Procedure," November 18, 1992.

10. Energy Technology Engineering Center, "Building 064 D&D Operations Final Report," August 13, 1993.

11. Energy Technology Engineering Center, "Radiological Assessment of the Building T064 Fenced-In Yard," December 23, 1993.

12. Energy Technology Engineering Center, "Final Radiological Survey Report of Building 064 Interior," January 14, 1994.

13. Letter from T. J. Vitkus, ORISE, to A. F. Kluk, U.S. Department of Energy, "Revised Verification Survey Plan for Buildings 005, 023, and 064, Santa Susana Field Laboratory, Ventura County, California," July 11, 1994.

REFERENCES (Continued)

14. Letter from T. J. Vitkus, ORISE, to A. F. Kluk, U.S. Department of Energy, "Comments on the Radiological Survey, Decontamination and Decommissioning and Final Status Survey Documentation for Building T005 and T064, Santa Susana Field Laboratory, Ventura County, California," March 22, 1994.

15. Letter from T. J. Vitkus, ORISE, to A. F. Kluk, U.S. Department of Energy, "Comments on the Decontamination and Decommissioning and Final Status Survey Documentation for Building 023, Santa Susana Field Laboratory, Ventura County, California," April 4, 1994.

16. Letter from G. Gaylord, Rockwell International, to J. Cullen, U.S. Department of Energy, "Response to Comments by ORISE and OAK on Rocketdyne Final Survey Reports for Building T005, T023, and T064," June 2, 1994.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A

MAJOR INSTRUMENTATION

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

DIRECT RADIATION MEASUREMENT

Instruments

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

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

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

Detectors

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

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

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

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

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
3100 Vax Workstation
(Canberra, Meriden, CT)

Low Background Gas Proportional Counter
Model LB-5100-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 in accordance with ESSAP Surface Scanning procedures by passing the probes slowly over the surface; the distance between the probe and the surface was maintained at a minimum - nominally about 1 cm. A large surface area, gas proportional floor monitor was used to scan the floors of the surveyed areas. Other surfaces were scanned using small area (15.5 cm^2 and 59 cm^2) hand-held detectors. Identification of elevated surface activity levels was based on increases in the audible signal from the recording and/or indicating instrument. Combinations of detectors and instruments used for the scans were:

Alpha — gas proportional detector with ratemeter-scaler
— ZnS scintillation detector with ratemeter-scaler

Beta — gas proportional detector with ratemeter-scaler
— pancake GM detector with ratemeter-scaler

Gamma — NaI scintillation detector with ratemeter

Surface Activity Measurements

Alpha and beta activity measurements were performed in accordance with Alpha Radiation Measurement and Beta Radiation Measurement procedures on floors, walls, upper room surfaces, some equipment, and at locations of elevated direct radiation, using ZnS scintillation and GM detectors 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 4 π efficiency and correcting for the active area of the detector. The alpha activity background countrates for the ZnS scintillation detectors averaged approximately 1 cpm for each detector. Alpha efficiency factors, based on calibration with Pu-239, ranged from 0.19 - 0.20 for the ZnS scintillation detectors. The beta activity background count rates for the GM detectors averaged approximately 55 cpm. Beta efficiency factors for Tc-99 ranged from 0.16 - 0.17 for the GM detector. The effective window for the ZnS scintillation and GM detectors were 59 cm^2 and 15.5 cm^2, respectively.

Removable Activity Measurements

Removable activity levels were determined in accordance with ESSAP Determination of Removable Activity procedures, using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear with two or three fingers, and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

Exposure Rate Measurements

Quantitative measurements of gamma exposure rates, at 1 m above surfaces, were performed in accordance with ESSAP Gamma Radiation (Exposure Rate) Measurement procedures using a pressurized ionization chamber (PIC). Qualitative exposure rates were determined by comparing gamma count rates, from NaI detector ratemeter combinations, and cross calibrating to site exposure rates obtained using the PIC.

Soil Sampling

Approximately 1 kg of soil was collected at each sample location. Collected samples were placed in a plastic bag, sealed, and labeled. Sampling and labeling was in accordance with ESSAP Surface Soil Sampling and Sample Identification and Labeling procedures.

ANALYTICAL PROCEDURES

Removable Activity

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

Gamma Spectrometry

Soil samples were dried, mixed, crushed, and/or homogenized as necessary, and a portion sealed in 0.5-liter Marinelli beaker or other appropriate container. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry and ranged from 757 to 888 g of material. Net material weights were determined and the samples counted using intrinsic germanium detectors coupled to a pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Energy peaks used for determination of radionuclides of concern were:

Cs-137	0.662 MeV
U-235	0.143 MeV (or 0.186 MeV)
U-238	0.063 MeV from Th-234*

*Secular equilibrium assumed.

Spectra were also reviewed for other identifiable photopeaks.

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:

$$2.71 + (4.66 \sqrt{BKG})$$

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. Calibration of pressurized ionization chambers was performed by the manufacturer.

Analytical and field survey activities were conducted in accordance with procedures from the following documents:

- Survey Procedures Manual, Revision 8 (December 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 for Quality Assurance and NQA-1 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

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

APPENDIX C

RESIDUAL RADIOACTIVE MATERIAL GUIDELINES SUMMARIZED FROM DOE ORDER 5400.5

BASIC DOSE LIMITS

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

STRUCTURE GUIDELINES

Indoor/Outdoor Structure Surface Contamination

Radionuclides[a]	Allowable Total Residual Surface Contamination (dpm/100 cm^2)[b] Average[c,d]	Maximum[d,e]	Removable[f]
Transuranics, Ra-226, Ra-228, Th-230 Th-228, Pa-231, Ac-227, I-125, I-129 [g]	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 [h]	5,000β-γ	15,000β-γ	1,000β-γ

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.

SOIL GUIDELINES

Radionuclides	Soil Concentration (pCi/g) Above Background[i,j,k]
Cesium-137 and Uranium	Soil guidelines are calculated on a site-specific basis, using the DOE manual developed for this use.

[a] 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.

[b] 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.

[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. It is not necessary to use wiping techniques to measure removable contamination levels, if direct scan surveys indicate that total residual surface contamination levels are within the limits for removable contamination.

[g] Guidelines for these radionuclides are not given in DOE Order 5400.5; however, these guidelines are considered applicable until guidance is provided.

[h] This category of radionuclides includes mixed fission products, including the Sr-90 which is present in them. It does not apply to Sr-90, which has been separated from the other fission products, or mixtures where the Sr-90 has been enriched.

[i] 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").

[j] 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.

[k] 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 $(100/A)^{½}$, 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, DOE/CH/8901. 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. "U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Revision 2, March 1987.

2. "DOE Order 5400.5, Radiation Protection of the Public and the Environment," February 1990.