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CONFIRMATORY RADIOLOGICAL SURVEY OF BUILDING C LYNCHBURG RESEARCH CENTER BABCOCK & WILCOX COMPANY LYNCHBURG, VIRGINIA

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

FINAL REPORT
JULY 1988

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CONFIRMATORY RADIOLOGICAL SURVEY
OF
BUILDING C
LYNCHBURG RESEARCH CENTER
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

INTRODUCTION AND SITE HISTORY

The Lynchburg Research Center (LRC), located on the Babcock and Wilcox Company site east of Lynchburg, Virginia, is a facility used to test and study nuclear cycles, under Nuclear Regulatory Commission license number SNM-778. Building C was formerly used as a research and development facility for uranium, thorium, and plutonium fuels. The existing structure is the result of several additions to the original laboratory building constructed in 1962. The building consists of approximately 950 m^2 of laboratories, office space and support facilities.

The decommissioning of Building C occurred in three phases. Phase I consisted of former laboratories (rooms 25, 26, 27, 43, 44, 50, 51, 52, 53, and 54), offices associated with rooms 43, 44, and 50, the western portion of hallway 23, and the Central Stores area. Research conducted in these locations involved uranium, thorium, and plutonium solutions and powders.

Phase II included former laboratories 15, 16, and 17; and, offices and hallways along the eastern side of the building. Research in these areas involved plutonium and uranium oxides in powder form.

Phase III included former laboratories 19 and 20, two waste tanks, two special nuclear material vaults, hallway 24, the remainder of hallway 23, change rooms, ventilation equipment, and three penthouse locations. These areas primarily served to support and perform analytical chemistry on plutonium fuels.

Babcock and Wilcox submitted three final survey reports (Phase I, II, and III)[1], which indicate that the site meets the NRC guidelines for release for unrestricted use. During the decontamination procedure all contaminated

materials, equipment, drain lines, soil, and ductwork were removed from the facility for commercial disposal.

At the request of the Nuclear Regulatory Commission (NRC), Region II, the Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU) conducted a radiological survey from August 17 to September 2, 1987, and April 26, 1988 to confirm that the radiological status of Building C meets the NRC guidelines for release for unrestricted use.

SITE DESCRIPTION

The Lynchburg Research Center is located on the Mt. Athos, Babcock and Wilcox property, west of Route 726, 16 kilometers east of Lynchburg, Virginia (Figures 1 and 2). The facility is located in Campbell County and is bounded on three sides by the James River. Babcock and Wilcox Mt. Athos maintains 212.5 hectares, and the LRC occupies approximately 5.5 ha. Other Babcock and Wilcox facilities operated on the site are the Commercial Nuclear Fuels Plant and the Naval Nuclear Fuels Division (Figure 3). Building C is located on the northeast corner of the LRC site (Figure 4). The floor plan for Building C is presented in Figure 5.

Building C contains two vaults, formerly used for the storage of special nuclear material, and two waste tanks, buried beneath the building. An operating fan room and exhaust stack serve the ventilation systems of Buildings B and C. A small basement area is located beneath the fan room and Room 50.

PURPOSE

The purpose of the survey was to confirm the licensee's final survey results, by measuring surface contamination levels and radionuclide concentrations in soil and other media, relative to release of the facility to unrestricted use.

SURVEY PROCEDURES

Document Review

ORAU reviewed the final survey reports (Phases I, II, and III), and supporting documentation for the facility. Approximately 10% of the raw data on a room by room basis was compared to the data presented in the final survey report.

Survey Method

A proposed survey plan (Appendix A) was submitted to NRC Region II for approval prior to beginning survey work at the site. The plan outlines site specific survey and sample collection procedures. The facility was divided into two areas for survey [High Probability of Contamination (HPC) and Low Probability of Contamination (LPC)], based on history of radioactive material use, licensee characterization data, level of effort required for remedial action, and final survey data.

Facility Survey

Gridding

Confirmatory measurements were referenced to a 1 m x 1 m grid system installed by ORAU on the floors and lower walls (up to 2 m), in the HPC areas. Measurements collected from ungridded surfaces (upper walls and ceilings) were referenced to the floor and lower wall grid or to prominent building features. Figure 6 identifies the areas where the grid was installed. No grid was established in the LPC areas.

Surface Scans

Alpha, beta-gamma and gamma scans were performed on 100% of the floors (both HPC and LPC areas) and 50% of the lower walls in the HPC area and random surfaces in the LPC areas, using an alpha/beta floor monitor, "pancake" GM detectors, and NaI(Tl) scintillation detectors coupled to scaler/ratemeters

with audible indicators. Representative overhead surfaces (above 2 m) such as ledges, beams, pipes, ductwork, and miscellaneous equipment were also scanned.

Exposure Rate Measurements

Gamma exposure rates at one meter above the floor, were measured at 12 locations inside the facility, using NaI(Tl) gamma scintillation detectors cross calibrated onsite with a pressurized ionization chamber (Figure 7).

Measurement of Total and Removable Contamination

Two hundred twenty one (221) grid blocks on the floors and lower walls of the HPC area were randomly selected for surface contamination measurements (Figures 8 to 83). Total measurements of alpha and beta-gamma contamination levels were systematically performed at the center and four points midway between the center and block corners. Smears for removable contamination levels were performed at the location in each grid block where the highest direct reading was obtained. Single point total contamination levels were also measured at 87 locations on the upper walls, ceilings, and miscellaneous overhead objects. Smears were collected at each single point measurement location.

Two hundred twenty (220) single point measurements were performed on the floors and lower walls, upper walls and ceilings, and miscellaneous overhead objects of the LPC area. Smears for removable contamination levels were performed at each single point location.

Indoor Soil Sampling

Fifty one (51) soil samples were collected from exposed trenches inside Building C, where drain lines had been removed during remedial action. Figures 84 to 101 indicate the soil sampling locations, with the trench locations overlaid on the individual room outline.

Drain Sampling

Three drain residue samples were collected from "cold" drains remaining in Building C. Six swipes were run through the "cold" drain lines and returned for analysis. Figure 102 presents the drain residue and swipe sampling locations.

Water Sampling

One standing water sample was collected from a pit located in room 52.

Roof

Systematic gamma scans and eight random beta-gamma measurements were performed on the Building C roof (Figure 103), using "pancake" GM detectors and NaI(Tl) scintillation detectors coupled to ratemeters with audible indicators. Four gravel samples were collected from random locations on the roof.

Outdoor Survey

Gridding

The immediate area surrounding Building C was enclosed by chain link fence located approximately 5 to 10 meters from the building walls. The area was not gridded, and all samples collected were referenced to prominent building features or existing landmarks. The follow-up survey performed on April 26 used a 5 m grid established on the northeast side of Building C.

Surface Scans

ORAU performed walkover surface scans at 1 to 2 meter intervals on the areas adjacent to Building C, using NaI(Tl) scintillation detectors coupled to ratemeters with audible indicators.

Soil Sampling

Sixteen (16) surface soil samples (0 - 15 cm) were collected at random around Building C (Figure 104). A large portion of the area was covered by asphalt/concrete/gravel walkways, parking lots or driveways, and available soil sampling locations were limited. Ten surface soil samples (0 - 15 cm) were collected at 5 m grid intervals from the area north of Building C to provide additional soil concentration data on the follow-up survey (Figure 107). Twenty-three (23) surface and/or shallow borehole soil samples were collected from the locations where the "hot" waste drain line connected Building C to the liquid waste holding tank (Figure 108). Two sediment samples were collected from the storm drain located near the loading dock on the north side of Building C (Figure 108).

Background Samples and Measurements

Samples of surface soil were collected and exposure rates were measured at 6 offsite locations (Figure 109) in the area around the Babcock and Wilcox facility, to establish baseline radionuclide concentrations and exposure rates. This data was collected during the ORAU confirmatory survey of Building A performed in July 1986, and presented in the ORAU June 1987 final report[2].

Sample Analysis and Interpretation of Results

Soil, sediment, swipes, drain residues, and gravel samples were analyzed by gamma spectrometry, and the spectra were reviewed for identifiable photopeaks, with particular attention to U-238, U-235, Th-232, Co-60 and Cs-137. Alpha spectroscopy was performed in selected samples for Pu-238 and Pu-239/240. The water sample and smears were analyzed for gross alpha and gross beta activity. Additional information concerning major instrumentation, sampling equipment, and analytical procedures is provided in Appendices B and C. Results were compared with NRC guidelines for release of facilities for unrestricted use (Appendix D).

RESULTS

Document Review

In general, the decontamination plan appears to be adequately developed and implemented to assure that NRC guidelines are met, and the final survey report adequately documented the radiological status of the site. Babcock and Wilcox used a statistically based sampling approach, and the data presented in section 5 of the reports were within the NRC guidelines. No significant discrepancies were identified in the documents reviewed.

Background Levels and Baseline Concentrations

Background exposure rates and baseline radionuclide concentrations in soil from the vicinity of the Babcock and Wilcox site were determined in a July 1986 ORAU survey of Building A, Lynchburg Research Center[2]. Table 1 summarizes the exposure rates (range 8 to 11 μR/h) and radionuclide concentrations. Uranium 235 concentrations were less than 0.3 pCi/g, and U-238 concentrations ranged from <0.4 to 2.1 pCi/g. Cobalt 60 and Cs-137 concentrations were <0.1 pCi/g and <0.2 pCi/g, respectively; Th-232 concentrations ranged from 0.4 to 2.8 pCi/g.

Facility Survey

Surface Scans

A few minor areas of contamination were identified during the survey. The areas were brought to the immediate attention of Babcock and Wilcox, and additional remedial action was performed. Rescanning the identified areas indicated no residual elevated radiation levels.

Exposure Rate Measurements

Gamma exposure rate data are presented in Table 2. The indoor measurements at one meter ranged from 13 to 29 μR/h with an average of 17 μR/h. The exposure rate in Room 20 was elevated due to the presence of

packaged waste, which was stored approximately 10 meters beyond the north wall of the room. With the exception of this area, the exposure rates in the building ranged from 13 to 19 μR/h, with an average of 16 μR/h. Additional measurements in April 1988 indicated exposure rates in the storage shed ranged from 63 to 130 μR/h, and 24 to 51 μR/h at six locations in Room 20 (Figure 106).

Measurement of Total and Removable Contamination

Results of total and removable contamination measurements are summarized in Tables 3 (HPC areas) and 4 (LPC areas). Alpha and beta-gamma levels were generally well below the release criteria, and, in many instances, less than the detection sensitivities of the procedures. The maximum alpha measurement was 400 dpm/100 cm^2, measured on the upper wall vent of the men's change room. The vent was removed by the licensee and packaged as waste. The maximum alpha measurement after vent removal was 180 dpm/100 cm^2, measured on the floor of the East Waste/Sump tank in Room 19. The maximum beta-gamma reading was 13000 dpm/100 cm^2, measured on the north wall of the storage shed and the east waste/sump tank in Room 19. The storage shed (Figure 5) is located on the north wall of Building C. Approximately 10 meters due north of the storage shed, is a controlled access radioactive waste storage area. All beta-gamma measurements in this area are elevated due to the radiation levels from the waste. The levels are not uniform because of shielding from materials stored in the shed. Additional remedial action was performed in the east waste/sump tank, reducing both the alpha and beta-gamma contamination levels within the NRC guidelines. The maximum removable alpha and beta contamination levels were 10 dpm/100 cm^2 and 21 dpm/100 cm^2, respectively.

Radionuclide Concentrations in Trench Soil

The radionuclide concentrations in 51 trench soil samples are presented in Table 5. In general the concentrations are similar to baseline concentrations from the surrounding soil. The sample from Room 1 had slightly elevated concentrations as follows: Co-60, 13 pCi/g; Cs-137, 2.9 pCi/g; U-235, 0.2 pCi/g; U-238, 5.7 pCi/g; and Th-232, 0.7 pCi/g.

Drain Samples

The radionuclide concentrations in "cold" drain residues are presented in Table 6. The maximum residue concentration was collected from the drain in Room 50, grid block F,1: Co-60, 0.4 pCi/g; Cs-137 0.2 pCi/g; U-235, 0.9 pCi/g; U-238, 8.3 pCi/g; and Th-232, 1.3 pCi/g. Plutonium 238 concentrations ranged from <0.1 to 0.2 pCi/g and Pu-239/240 concentrations ranged from 2.4 to 4.5 pCi/g. Swipes were collected from 9 "cold" drain lines and scanned for gross alpha and gross beta contamination. No removable activity was detected.

Water Sample

The water sample from the pit in Room 52 was analyzed for gross alpha (60 $\pm$ 10 pCi/l) and gross beta (490 $\pm$ 17 pCi/l) concentrations. Gamma spectroscopy indicated the presence of natural uranium.

Roof

Systematic gamma scans of the roof area indicated generally elevated exposure rates. The general levels decreased when going from the north to the south edge of the roof. This is attributed to the waste stored along the north side of the building. No elevated areas, which could be associated with contamination on the roof surface or other structures, were detected.

Results of contamination measurements on roof structures and ventilation stacks are presented in Table 7. The maximum total contamination measurement was 8200 dpm/100 cm^2, at the base of a stack on the north edge of the roof. This measurement is elevated due to the waste stored approximately 15 meters north.

Table 8 presents the results of radionuclide concentrations in gravel samples collected from the roof of Building C. The concentrations were typical of natural background soil samples. Plutonium measurements were not determined for the background soils; however, the plutonium concentrations in the gravel samples are insignificant in comparison with the soil release guidelines.

Outdoor Survey

Surface Scans and Exposure Rate Measurements

Elevated radiation levels were found on the west, north and east sides of Building C. A large volume of waste is stored approximately 7 meters north of the building, and elevated radiation levels from this area increased the difficulty of identifying potential surface contamination. Figure 104 presents the direct radiation levels measured around Building C in the initial survey. Levels ranged from 22 to 450 μR/h. A follow-up survey was performed on April 26. Although radiation levels remained elevated, use of a shielded detector system, a pressurized ion chamber and an in-situ gamma ray spectrometry system permitted ORAU to collect additional data. Figure 105 presents isopleth exposure rate levels associated with the waste stored in and around Building J. Levels outside Building C ranged from 150 to 460 μR/h (Figure 106).

Radionuclide Concentrations in Surface Soil

The radionuclide concentrations in 16 soil samples collected around the outside of Building C are presented in Table 9. The concentrations are within the ranges for baseline samples from the vicinity of the Babcock and Wilcox facility. An additional 10 soil samples were collected during the April 1988 survey (Table 10 and Figure 107). The concentrations are also within the ranges for baseline samples.

Radionuclide Concentrations in Soil from Shallow Boreholes

The radionuclide concentrations measured in soil samples from 14 boreholes along the waste drain lines from Building C to the Liquid Waste Building are presented in Table 11. In general, the samples are within normal background ranges. However, samples 5A, 13A and 13B had Co-60 and Cs-137 concentrations which were elevated. The highest levels were Co-60, 1.9 pCi/g; and Cs-137, 11.5 pCi/g.

COMPARISON OF RESULTS WITH GUIDELINES

NRC surface contamination guidelines for release of facilities for unrestricted use are outlined in Appendix D. Because the principal radionuclides of interest are plutonium, thorium, uranium, Co-60, Cs-137 and fission products, the more restrictive criteria for plutonium have been applied for residual contamination:

Total Contamination

300 dpm/100 cm^2 (maximum in a 100 cm^2 area)
100 dpm/100 cm^2 (averaged over 1 m^2)

Removable Contamination

20 dpm/100 cm^2

For residual beta-gamma contamination, the NRC guidelines are:

Total Contamination

15,000 dpm/100 cm^2 (maximum in a 100 cm^2 area)
5,000 dpm/100 cm^2 (averaged over 1 m^2)

Removable Contamination

1,000 dpm/100 cm^2

All total and removable alpha and beta-gamma contamination measurements were within these guidelines.

Soil sample data was compared to the NRC guideline of 10 pCi/g of natural thorium, 30 pCi/g of total uranium, and 25 pCi/g plutonium. All soil concentrations (surface and subsurface) collected inside and outside Building C were within the guideline levels. The maximum soil concentrations for Co-60 (13 pCi/g) and Cs-137 (11.5 pCi/g) are comparable to guidelines developed by

the NRC (Co-60, 10 pCi/g and Cs-137, 15 pCi/g). Although the Co-60 (13 pCi/g) exceeds the guidelines, this sample is one of three samples from the same trench, and the average concentration over the trench length (~7 m) is 4.5 pCi/g, which meets the guidelines.

Water sample data indicates the presence of alpha (60 pCi/l) and beta (490 pCi/l) contamination, identified as uranium. 10 CFR 20[3], Appendix B, Table II provides uranium isotopic concentrations in water for unrestricted areas ranging from 30,000 to 40,000 pCi/l.

Elevated direct radiation levels associated with radioactive waste stored north of Building C, are responsible for elevated radiation levels detected in the storage shed and Room 20. Additional data collected in April 1988, indicates that the radiation levels are directly related to the waste, not to surface contamination. Isopleth exposure rate data generated in April correlates to exposure rates which would be attributed to the stored waste. No evidence of anomalies are noted that would indicate surface contamination inside or outside the building. All radiation levels are within the units specified in 10 CFR 20.105 for an unrestricted area.

SUMMARY

On August 17 to September 2, 1987, and April 26, 1988, ORAU performed a confirmatory radiological survey of Building C, located at the Babcock and Wilcox Lynchburg Research Center, Lynchburg, Virginia. The survey included surface alpha, gamma and beta-gamma scans, measurement of direct and removable contamination levels, and the measurement of direct radiation levels and radionuclide concentrations in soil, gravel, and water samples. The findings support the closeout survey performed by the licensee, and confirm that the radiological conditions satisfy the NRC guidelines established for release for unrestricted use.

REFERENCES

1. Report, "Decontamination and Decommissioning of Building C - Phase 1 at Lynchburg Research Center Lynchburg, Virginia," RDD:85:8604-01:01, May 1985.

   Report, "Decontamination and Decommissioning of Building C - Phase 2 at Lynchburg Research Center Lynchburg, Virginia," RDD:85:8604-01:02, October 1985.

   Report, "Decontamination and Decommissioning of Building C - Phase 3 at Lynchburg Research Center Lynchburg, Virginia," RDD:87:8604-01:03.

2. Confirmatory Radiological Survey of the SNM-778 Area, Building A Lynchburg Research Center Lynchburg, Virginia, by E.J. Deming, Oak Ridge Associated Universities, June 1987.

3. Title 10, Code of Federal Regulations, Part 20, dated January 1, 1985.

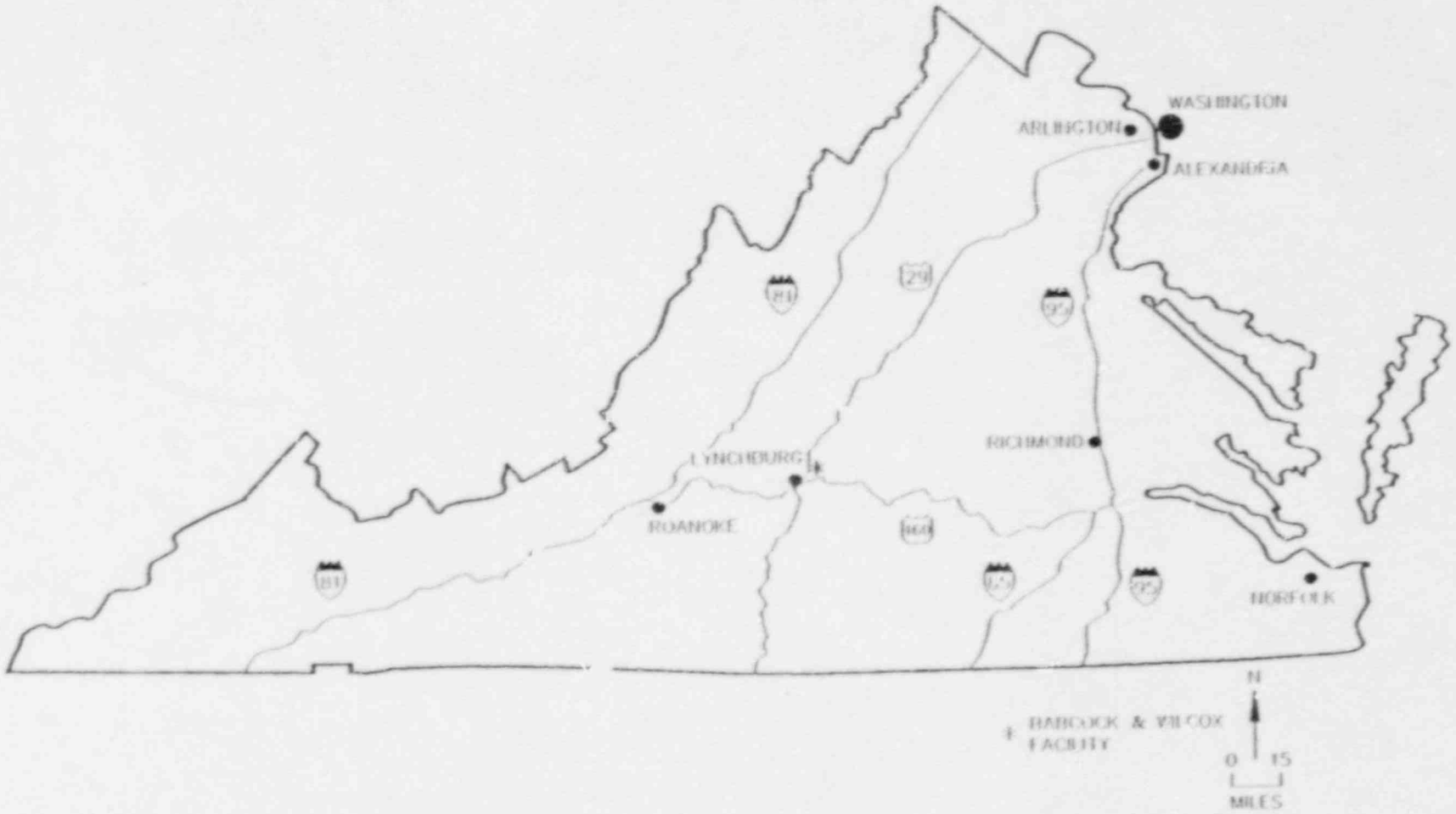

FIGURE 1: Map of Virginia, Showing Approximate Location of Babcock and Wilcox Facility

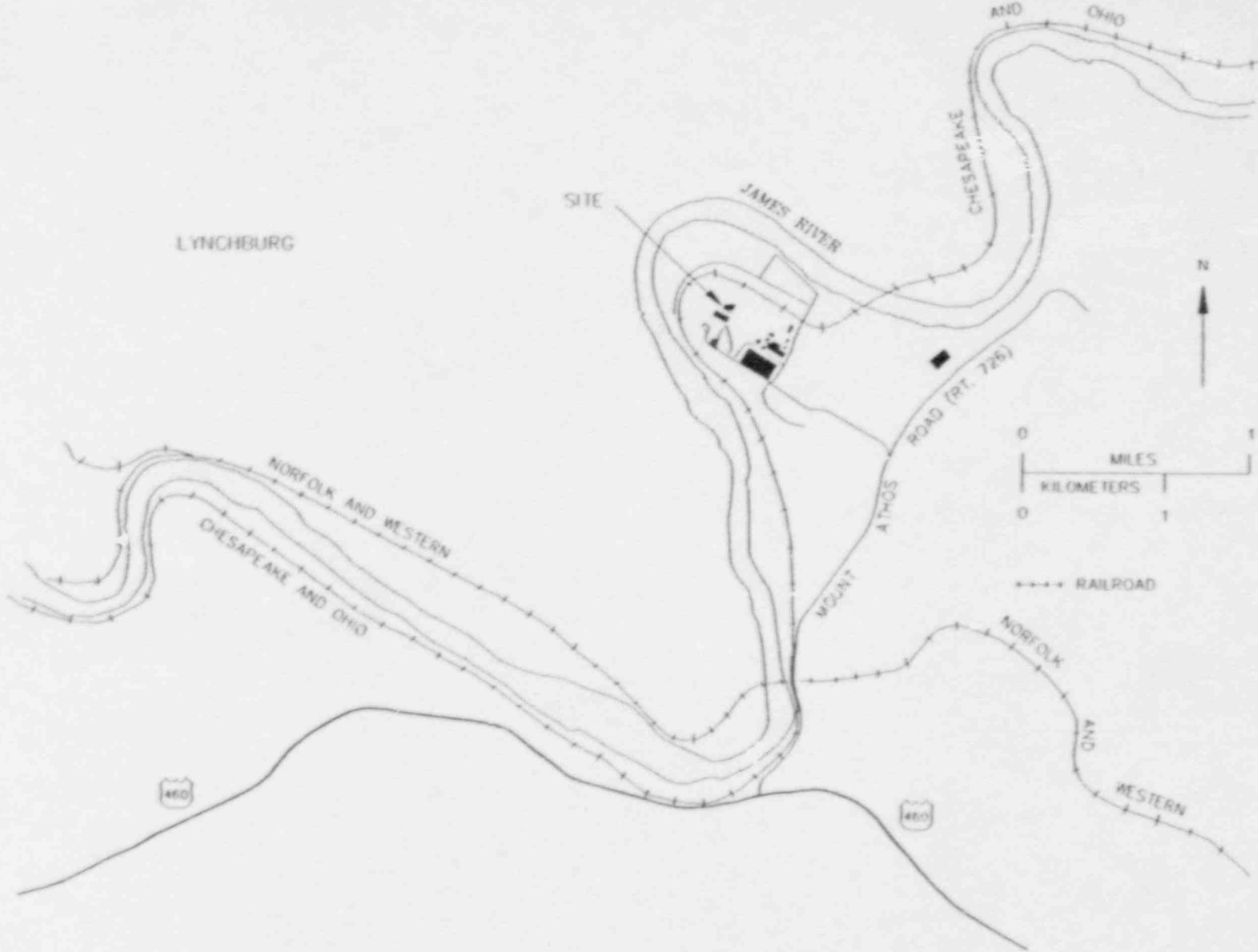

FIGURE 2: Map of Area Surrounding Babcock and Wilcox Facility

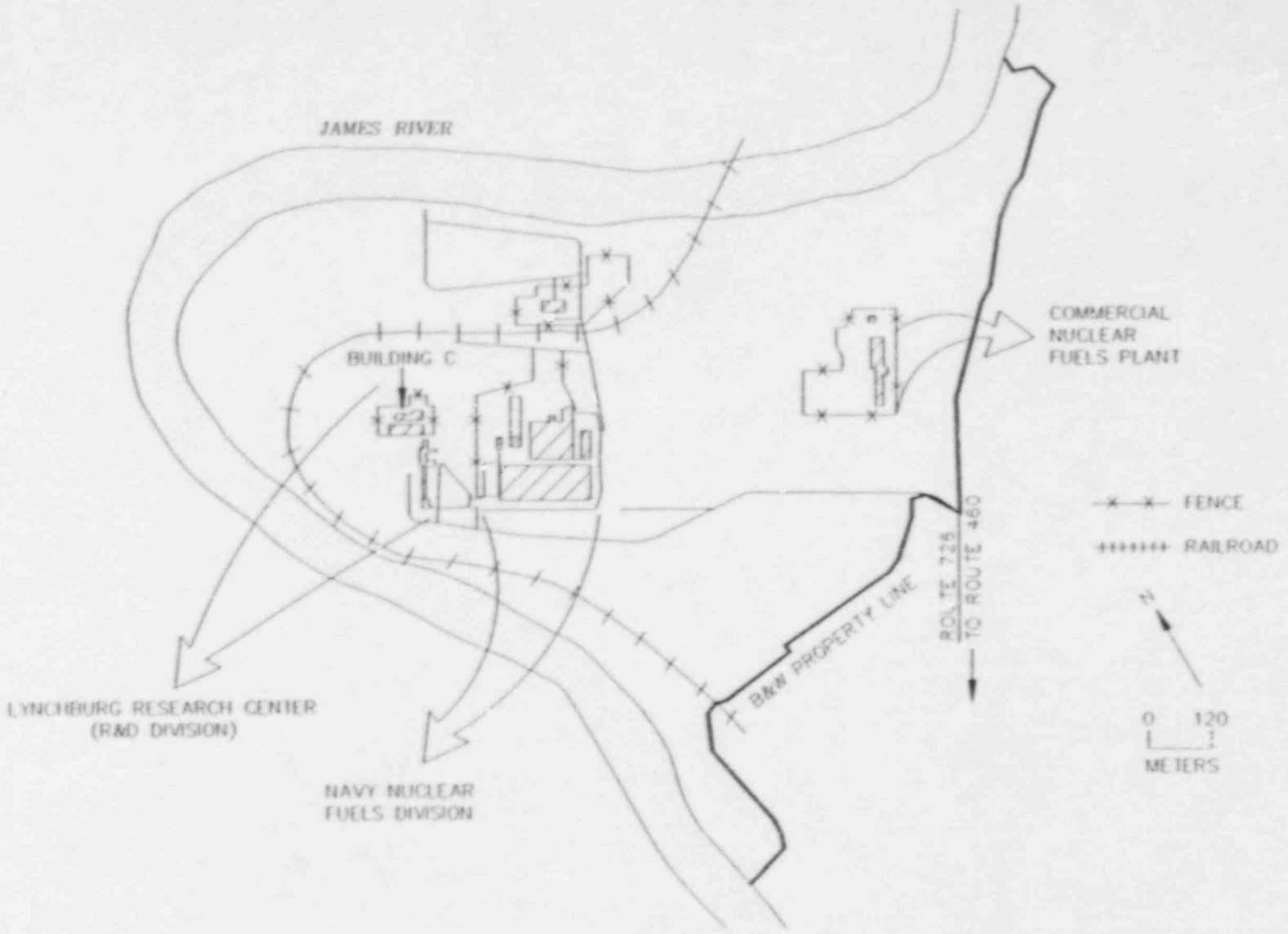

FIGURE 3: General Site Plan of the Mt. Athos Babcock and Wilcox Facility

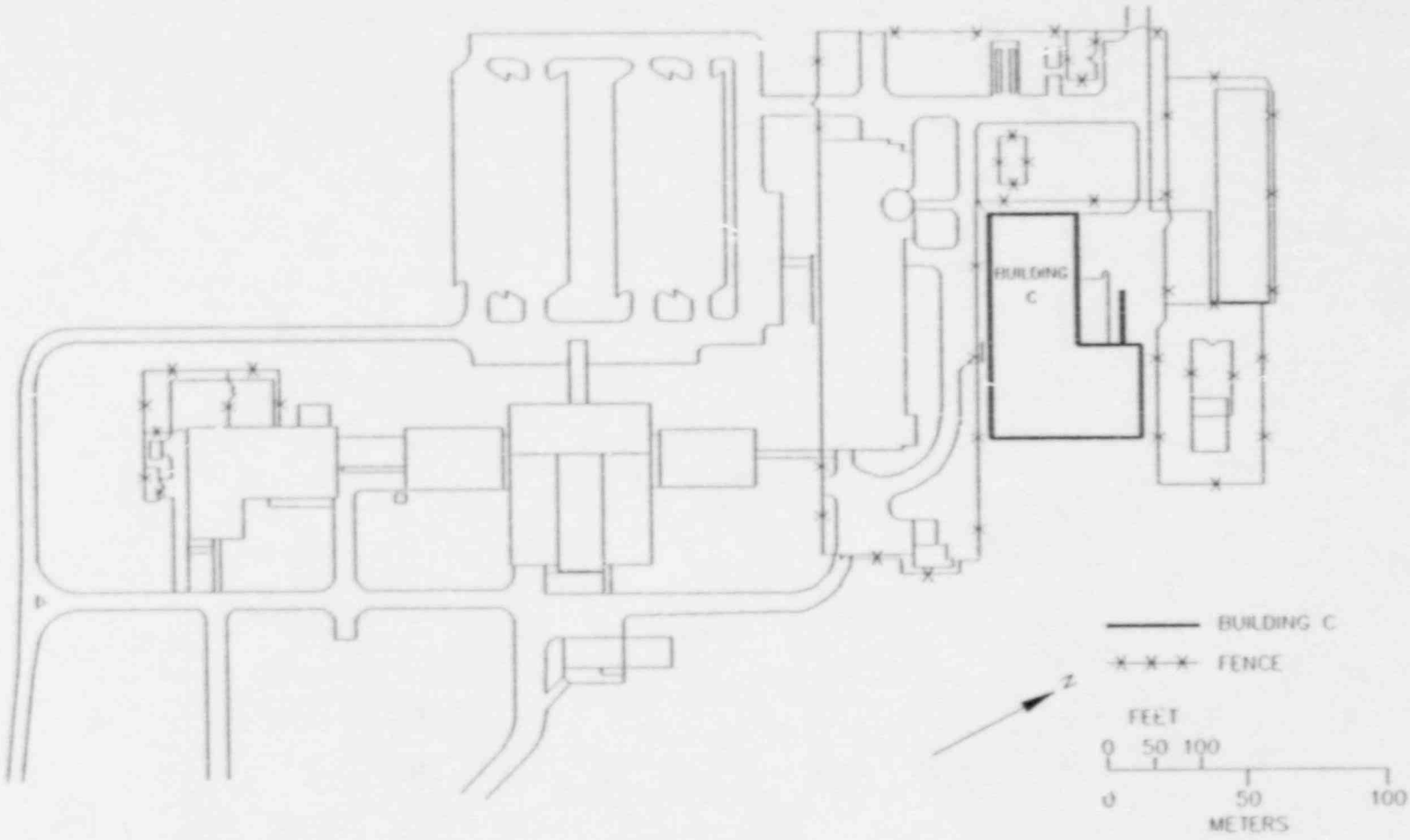

FIGURE 4: Plan View of the Lynchburg Research Center Indicating Location of Building C

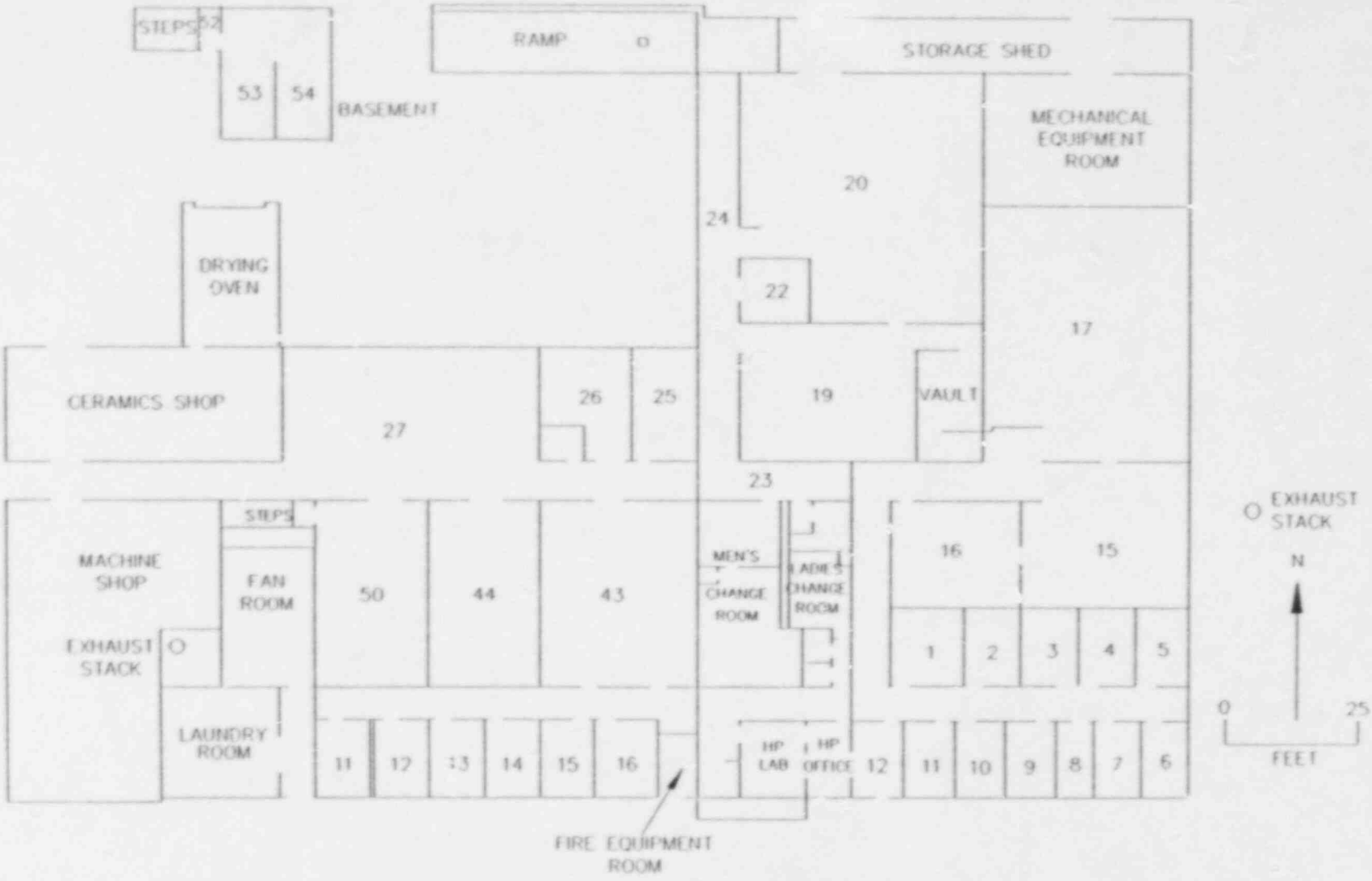

FIGURE 5: Floor Plan of Building C

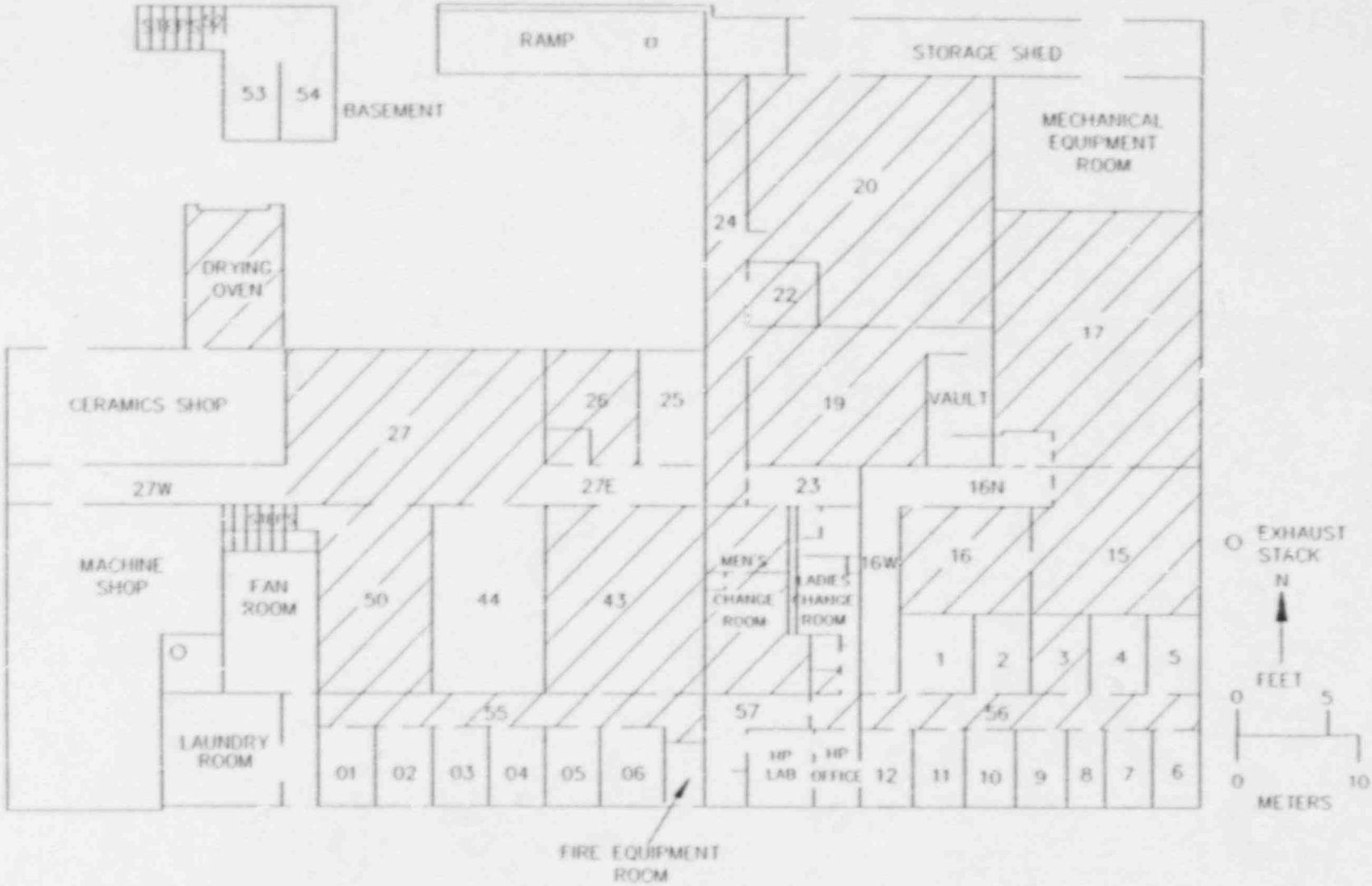

FIGURE 6: Location of Rooms Where 1M x 1M Grid War Installed

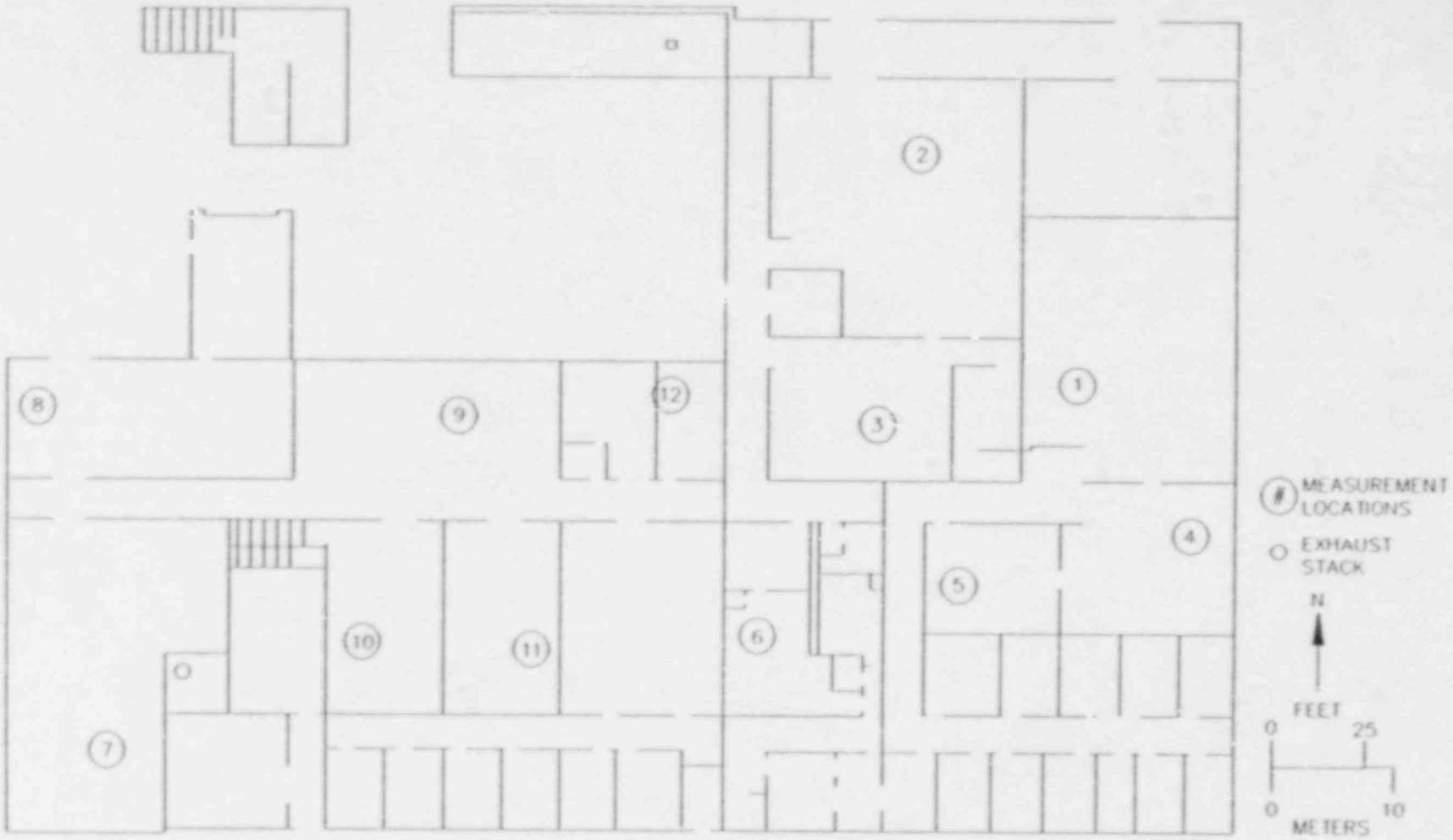

FIGURE 7: Indoor Gamma Exposure Rate Measurement Locations

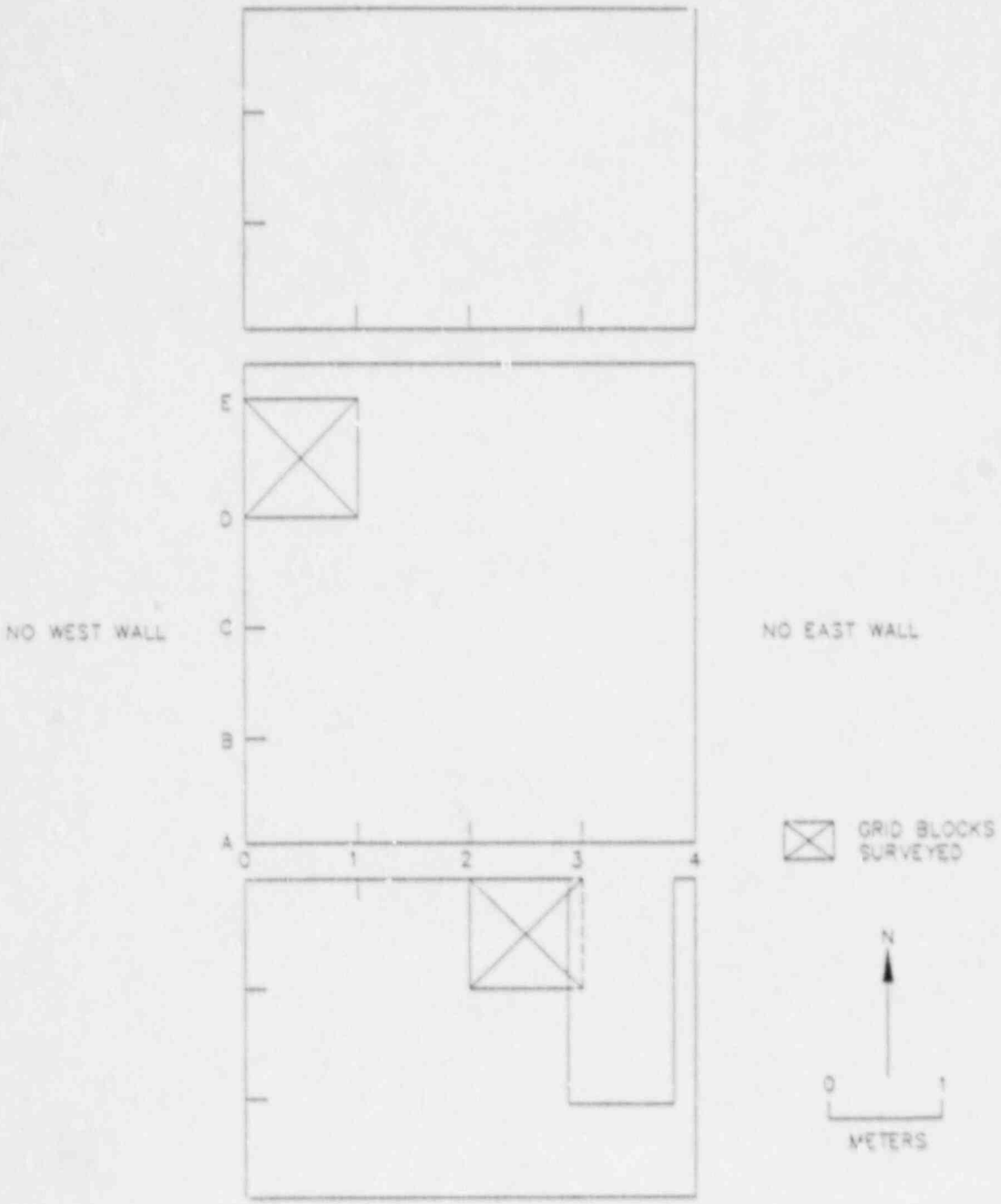

FIGURE 8: Room 3 Showing Locations of 5-point Grid Blocks Surveyed

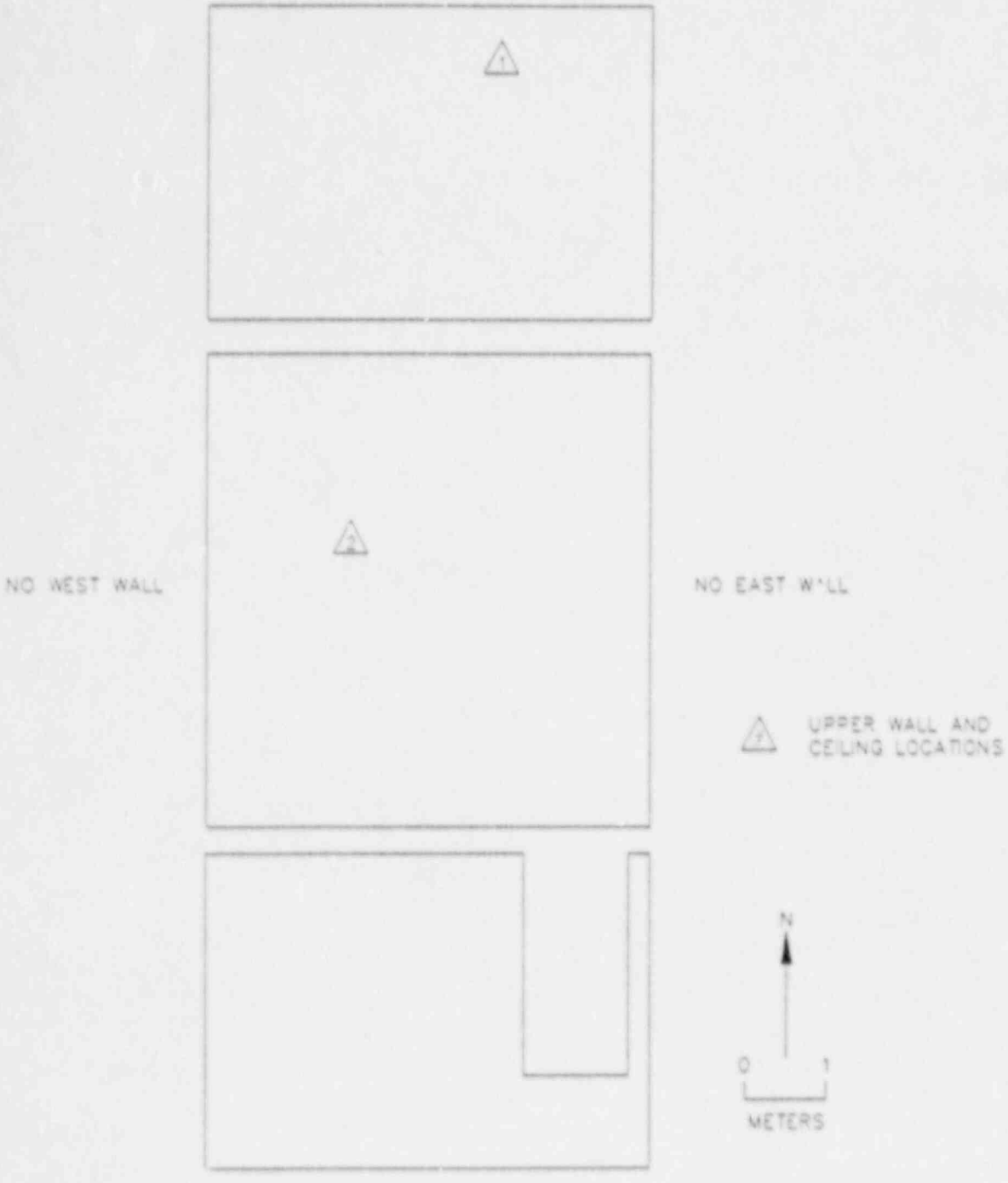

FIGURE 9: Room 3 Showing Locations of Upper Wall and Ceiling Single-point Measurements

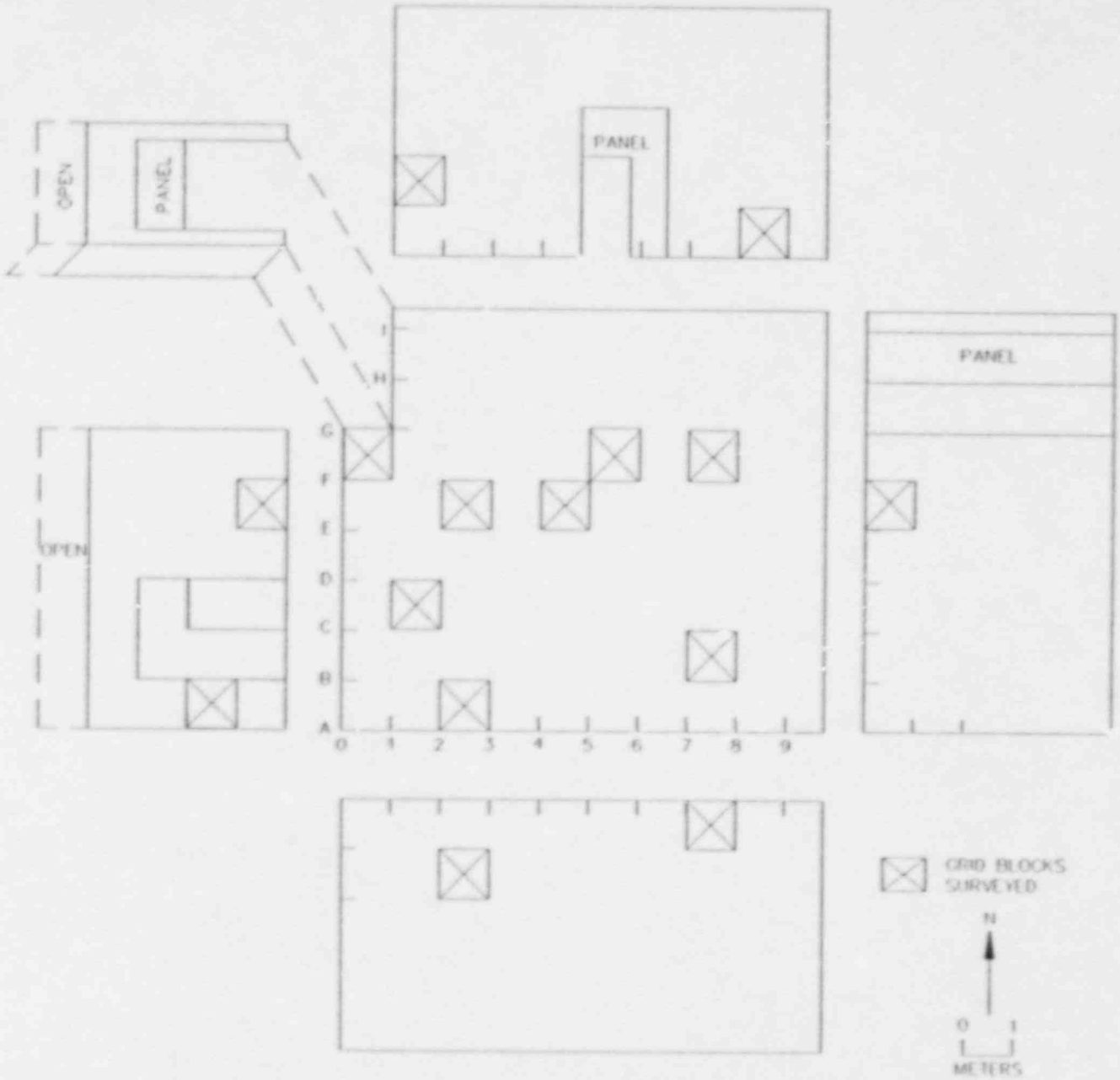

FIGURE 10: Room 15 Showing Locations of 5-point Grid Blocks Surveyed

BWV36a

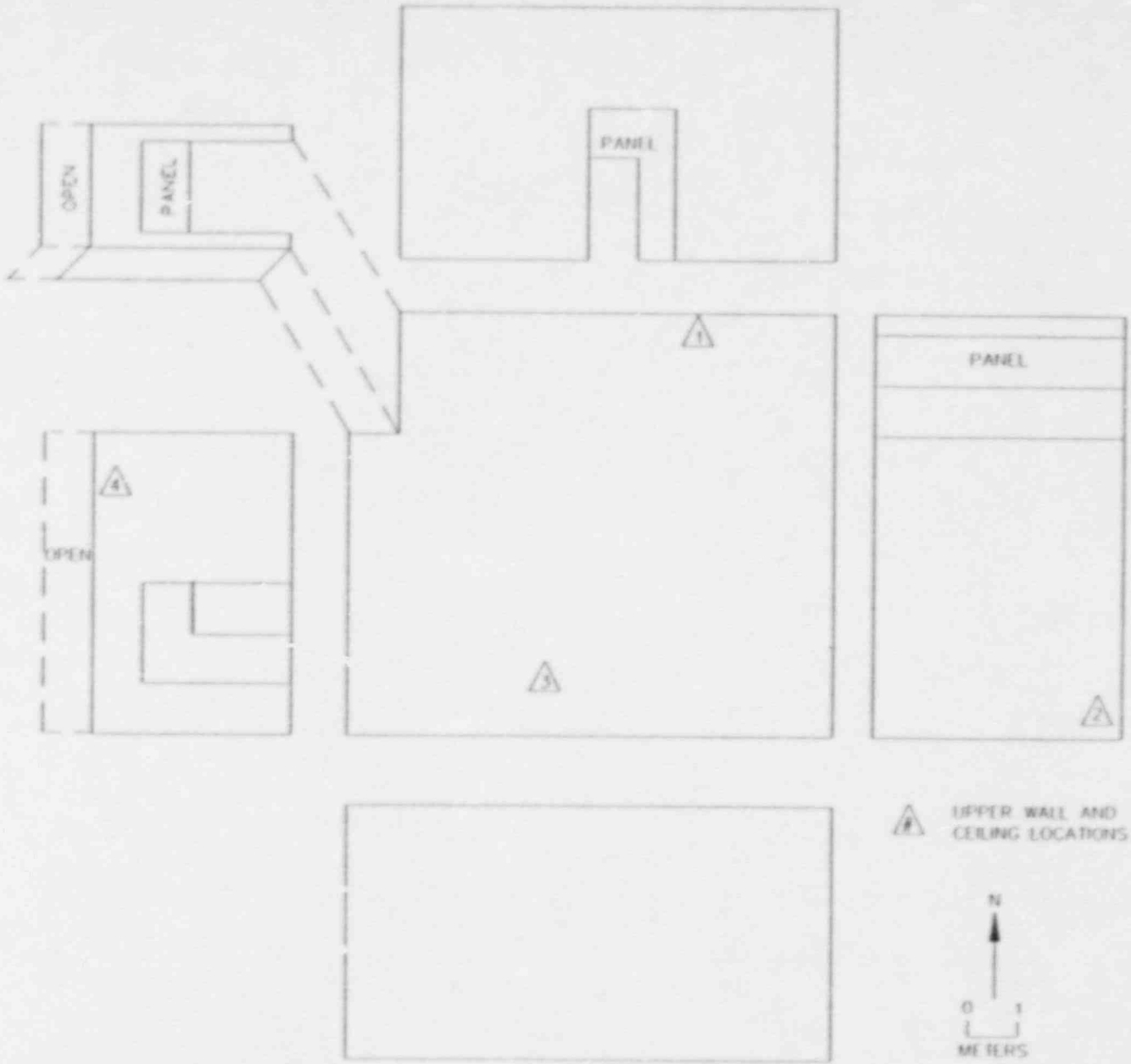

FIGURE 11: Room 15 Showing Locations of Upper Wall and Ceiling Single-point Measurements

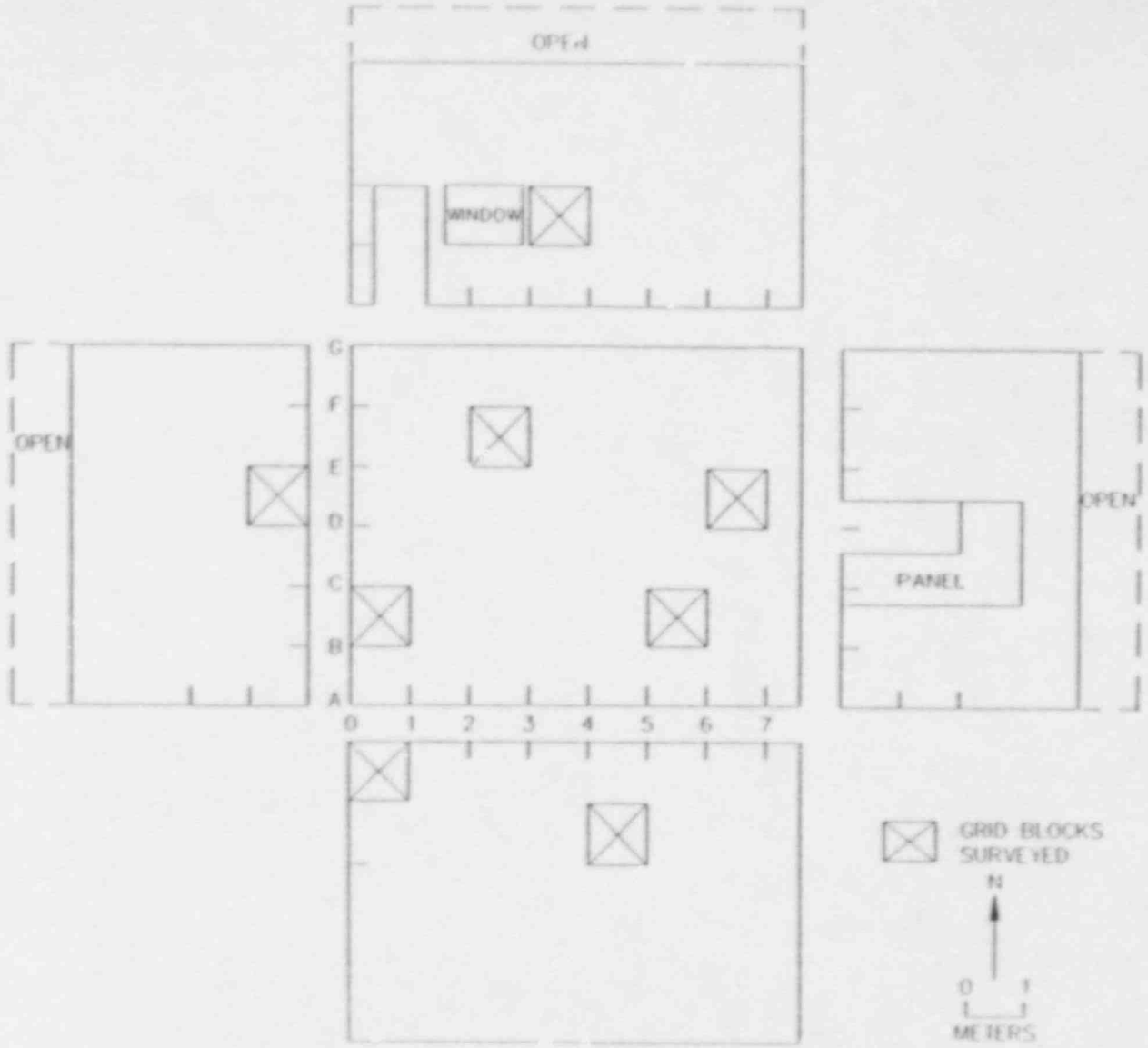

FIGURE 12: Room 16 Showing Locations of 5-point Grid Blocks Surveyed

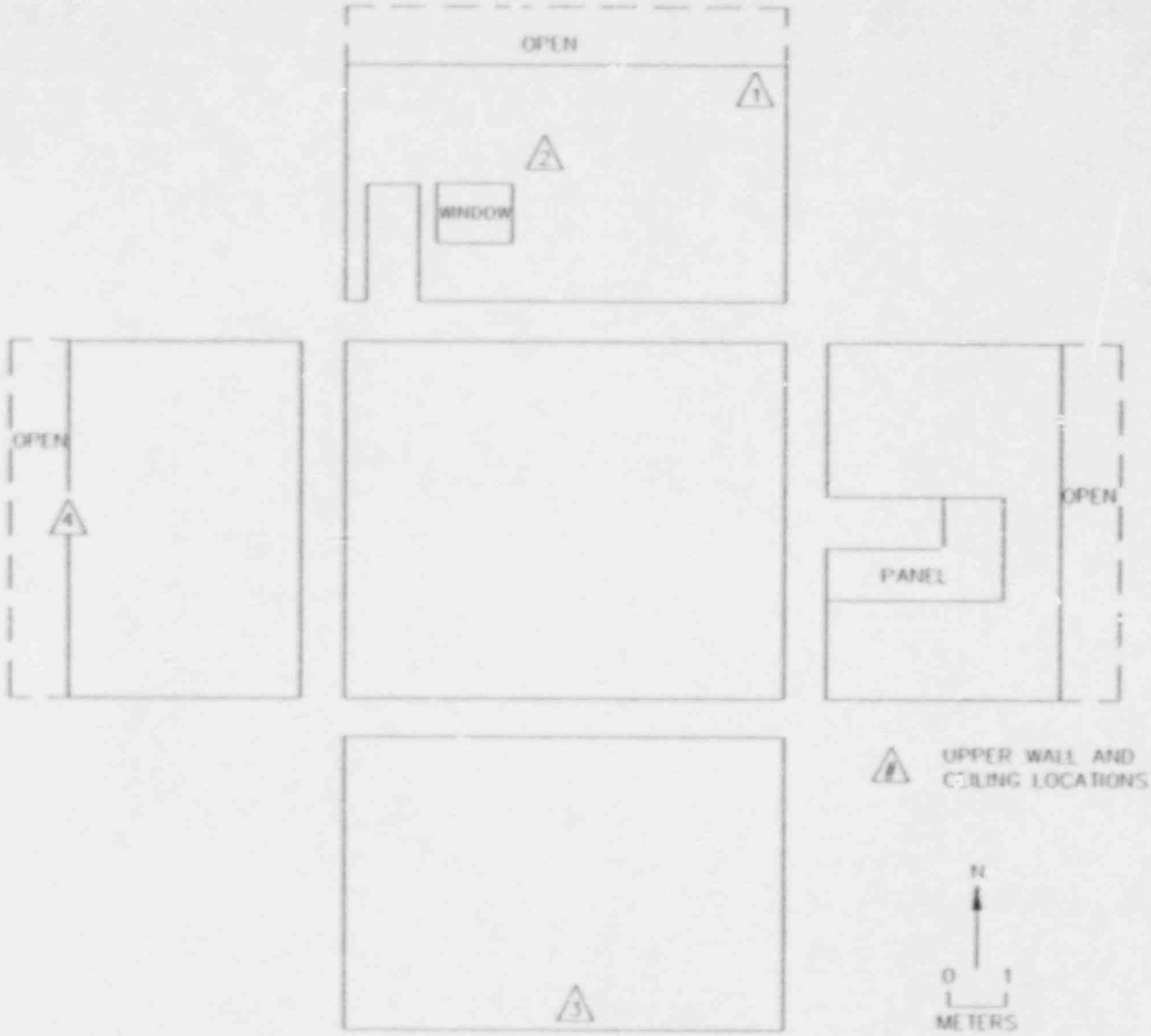

FIGURE 13: Room 16 Showing Locations of Upper Wall and Ceiling Single-point Measurements

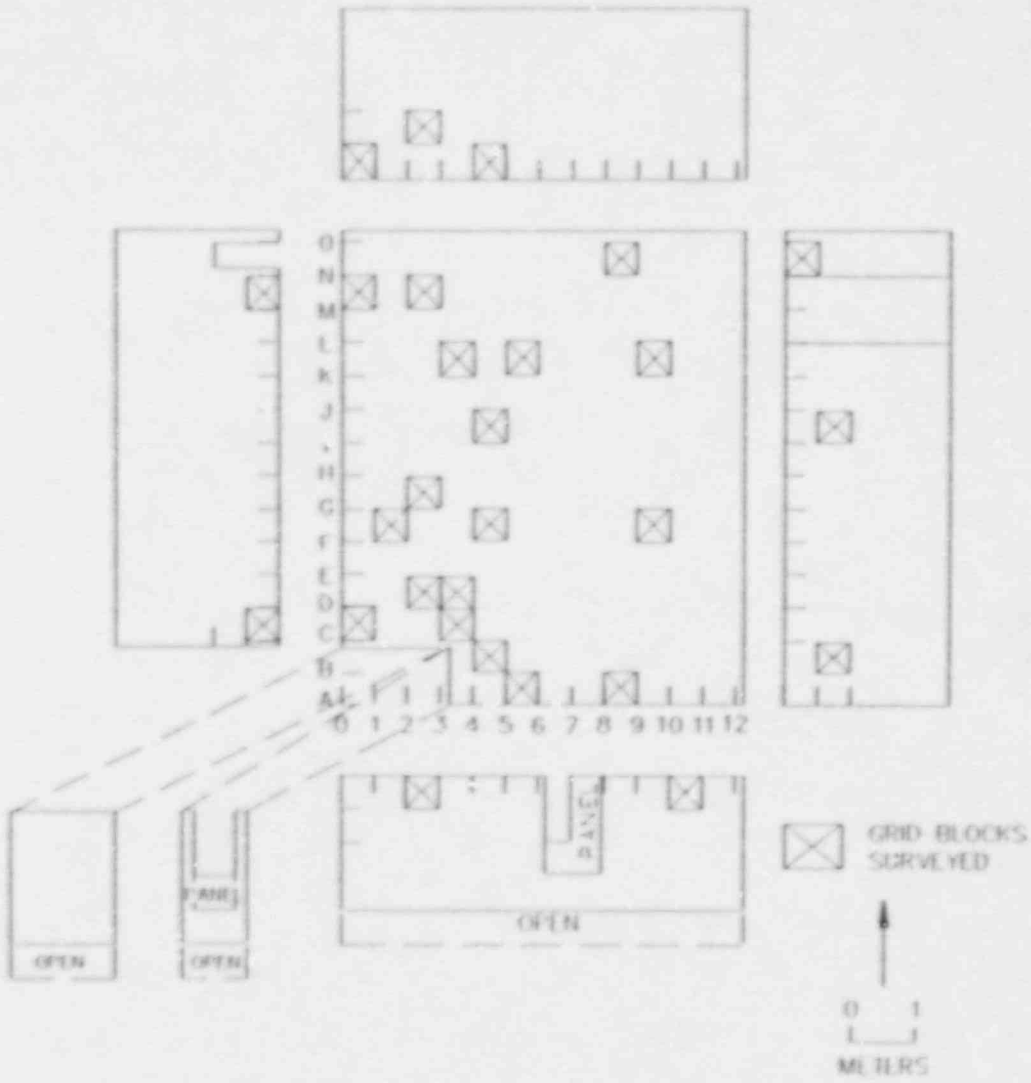

FIGURE 14: Room 17 Showing Locations of 5-point Grid Blocks Surveyed

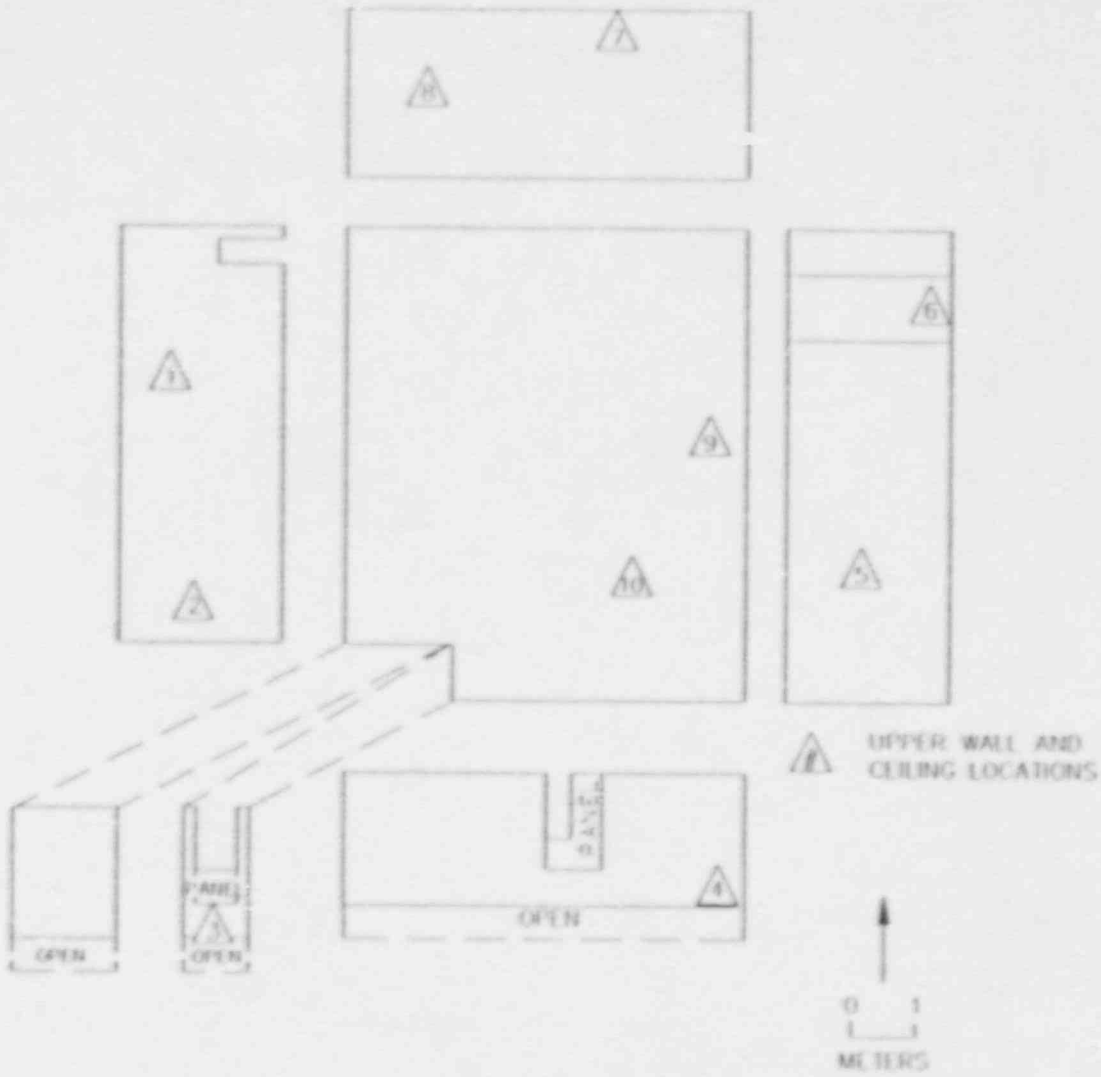

FIGURE 15: Room 17 Showing Locations of Upper Wall and Ceiling Single-point Measurements

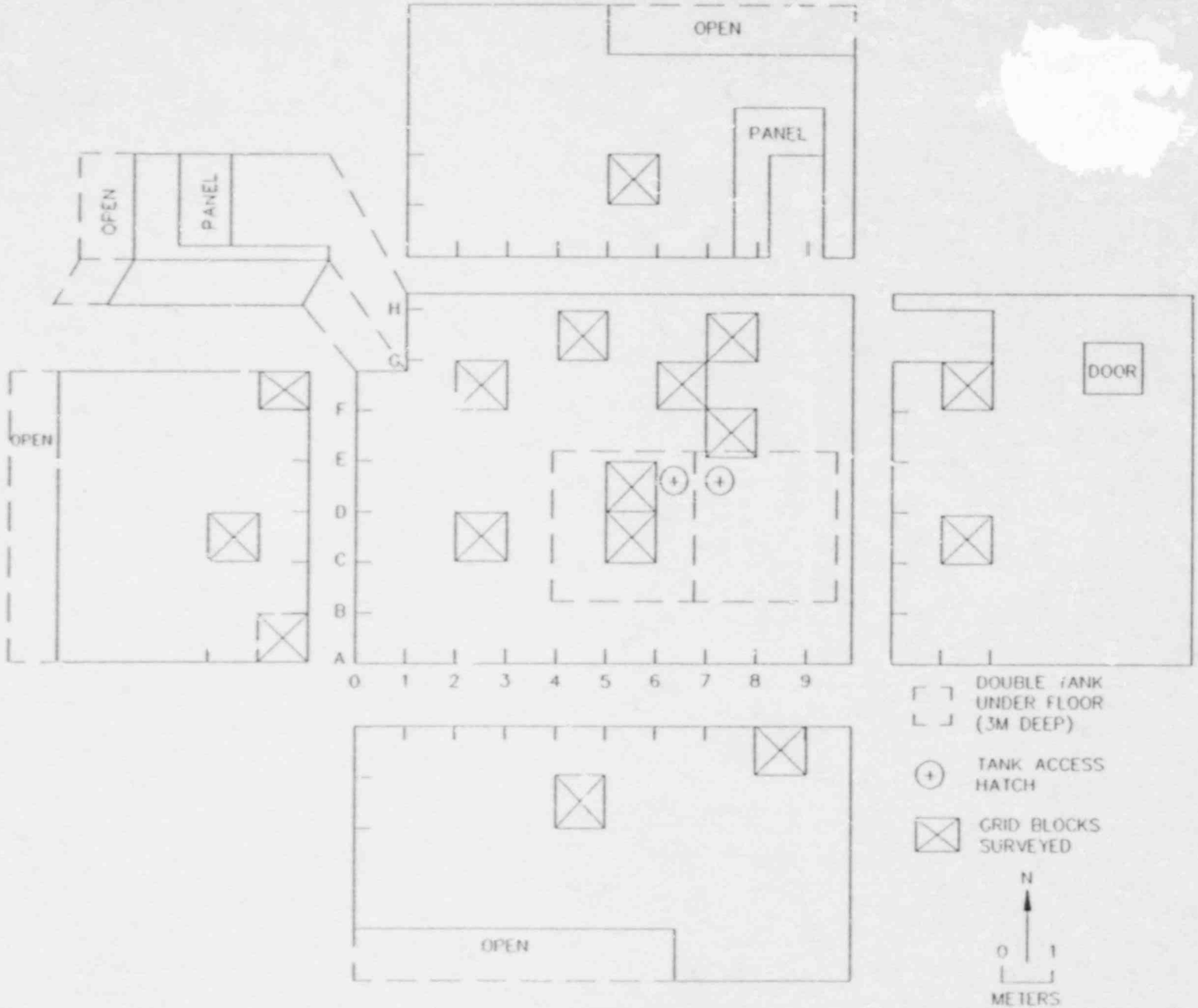

FIGURE 16: Room 19 Showing 5-point Grid Blocks Surveyed

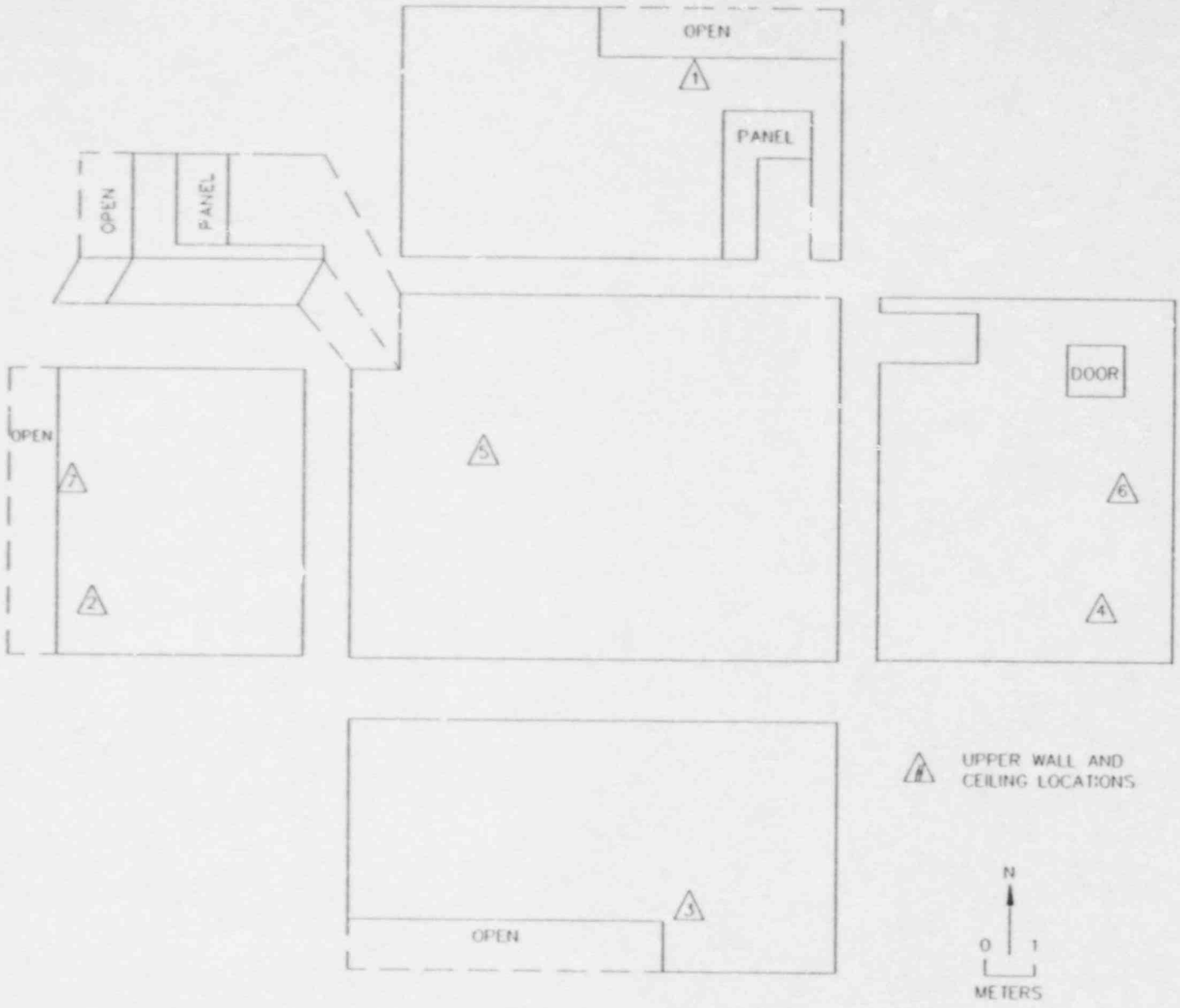

FIGURE 17: Room 19 Showing Locations of Upper Wall and Ceiling Single-point Measurements

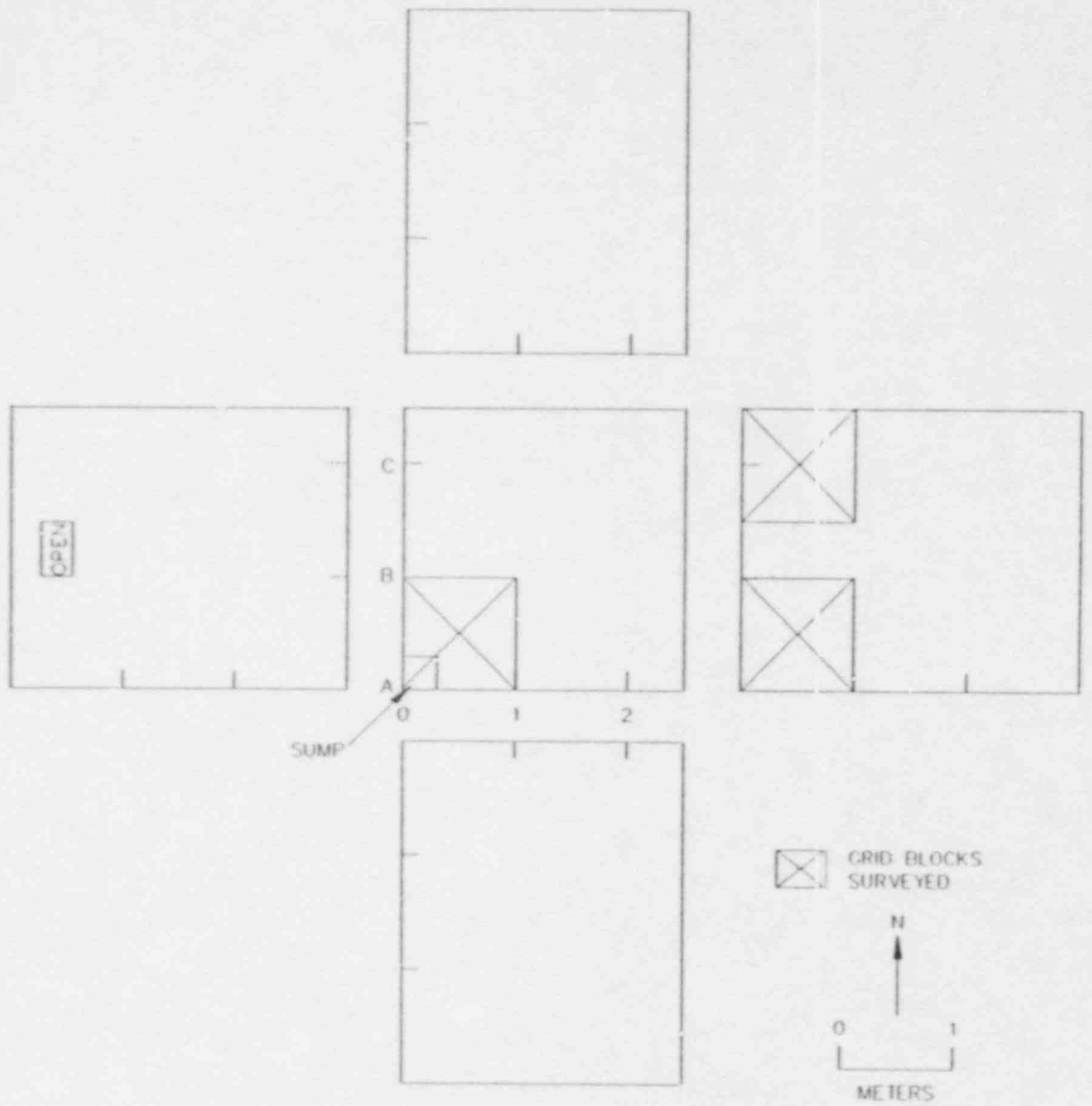

FIGURE 18: Room 19 Showing Locations of 5-point Grid Blocks Surveyed (East Waste/Sump Tank)

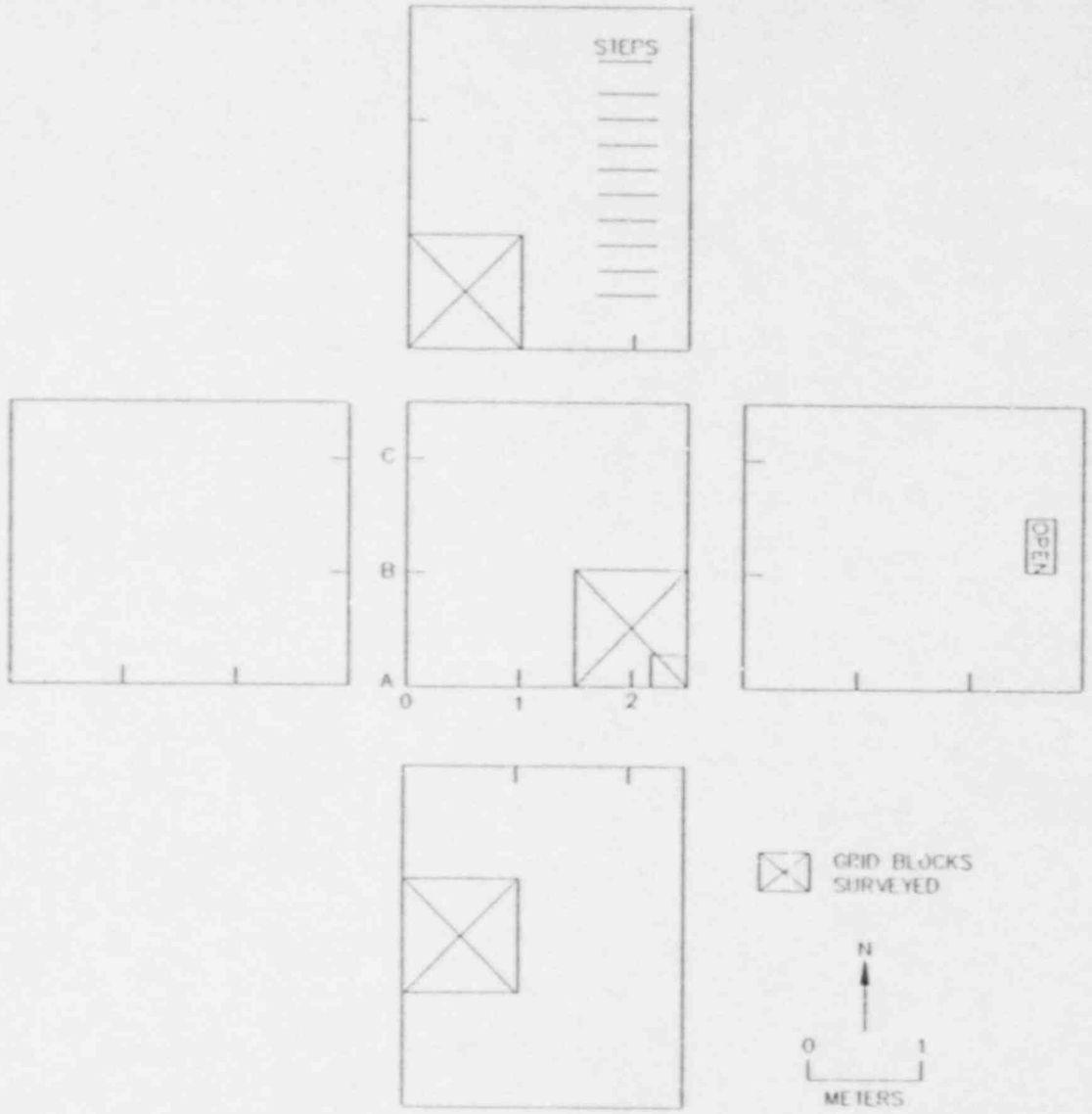

FIGURE 19: Room 19 Showing Locations of 5-point Grid Blocks Surveyed (West Waste/Sump Tank)

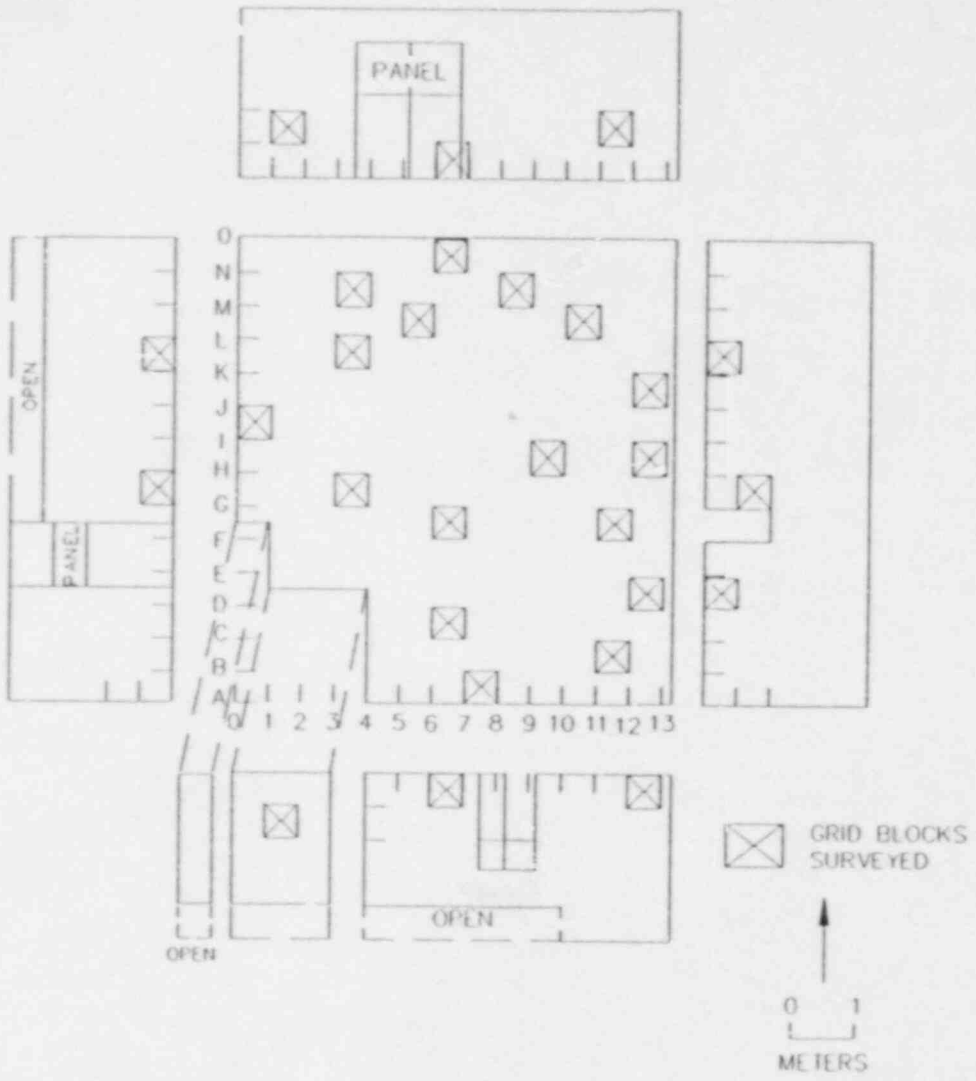

FIGURE 20: Room 20 Showing Locations of 5-point Grid Blocks Surveyed

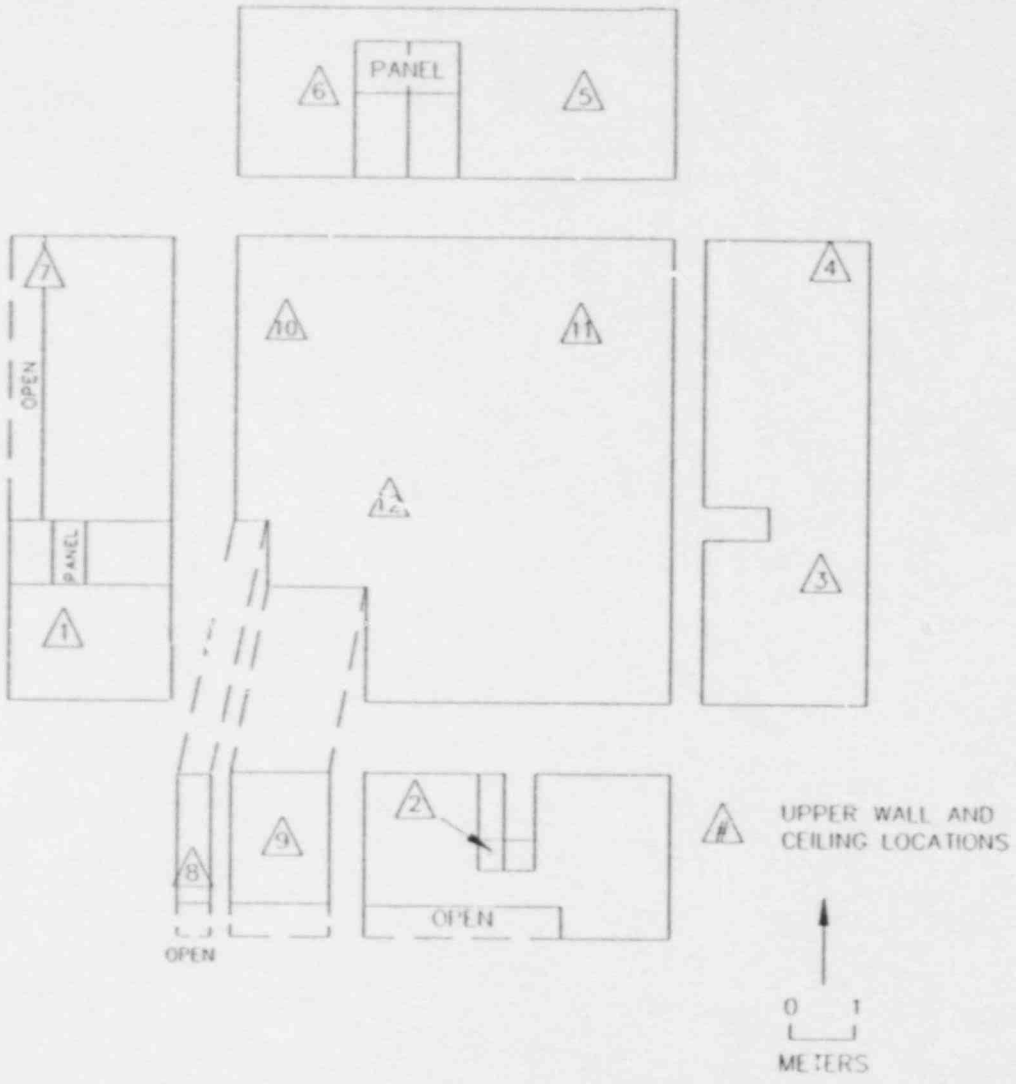

FIGURE 21: Room 20 Showing Locations of Upper Walls and Ceiling Single-point Measurements

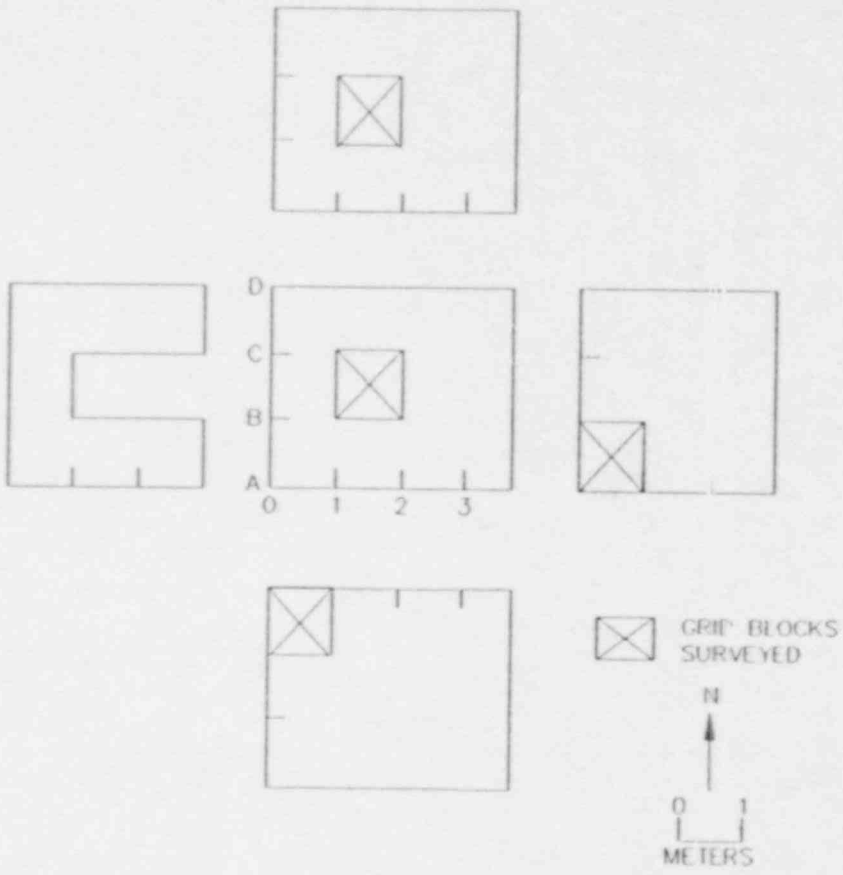

FIGURE 22: Room 22 Showing Locations of 5-point Grid Blocks Surveyed

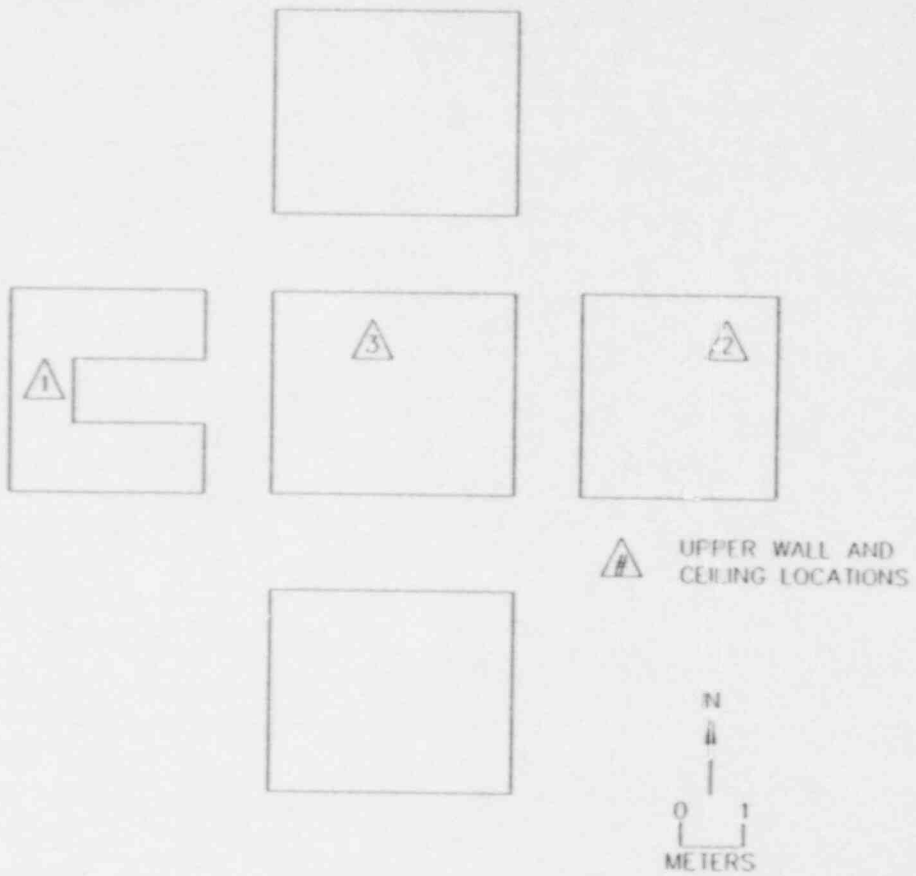

FIGURE 23: Room 22 Showing Locations of Upper Wall and Ceilings Single-point Measurements

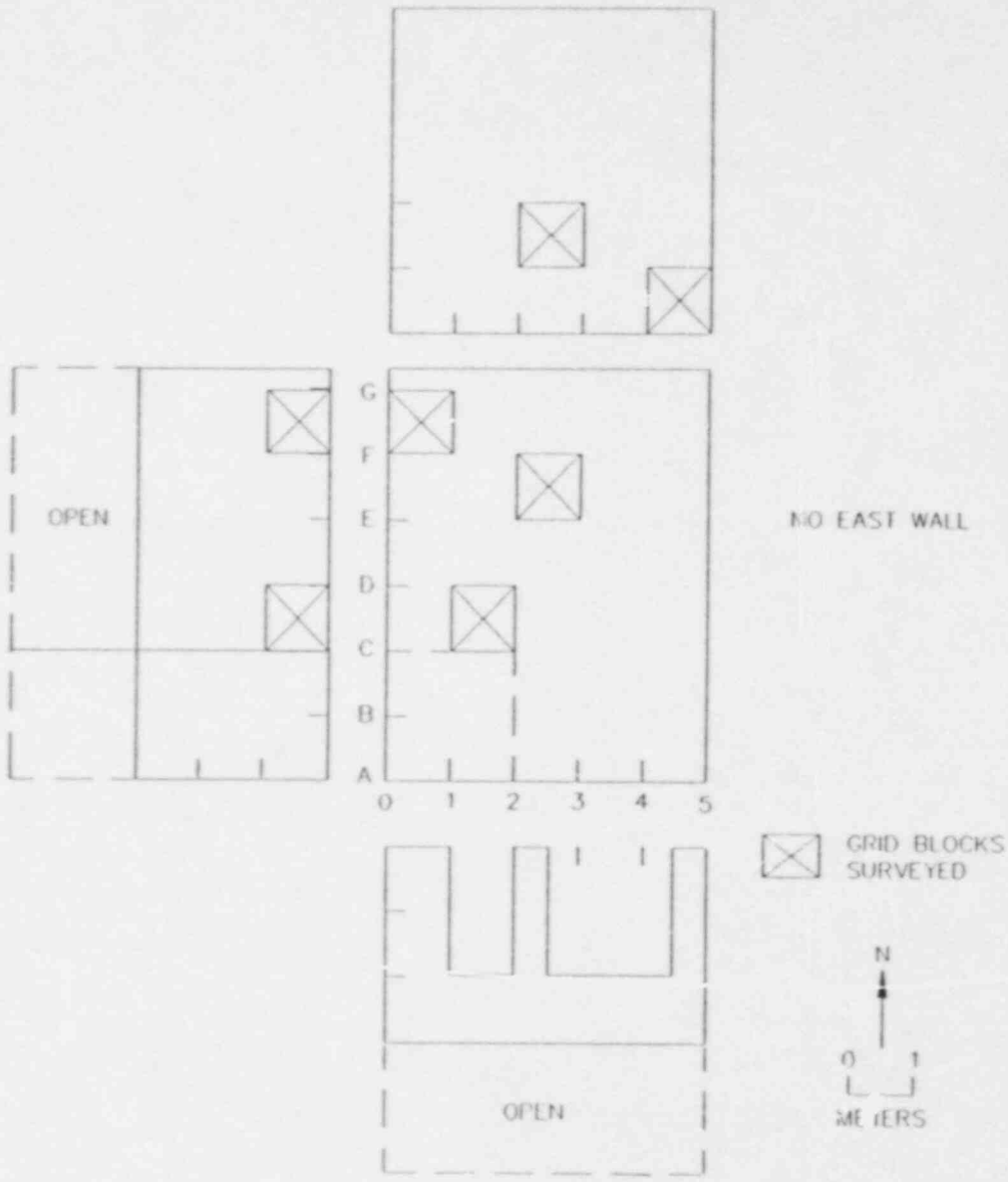

FIGURE 24: Room 26 Showing Locations of 5-point Grid Blocks Surveyed

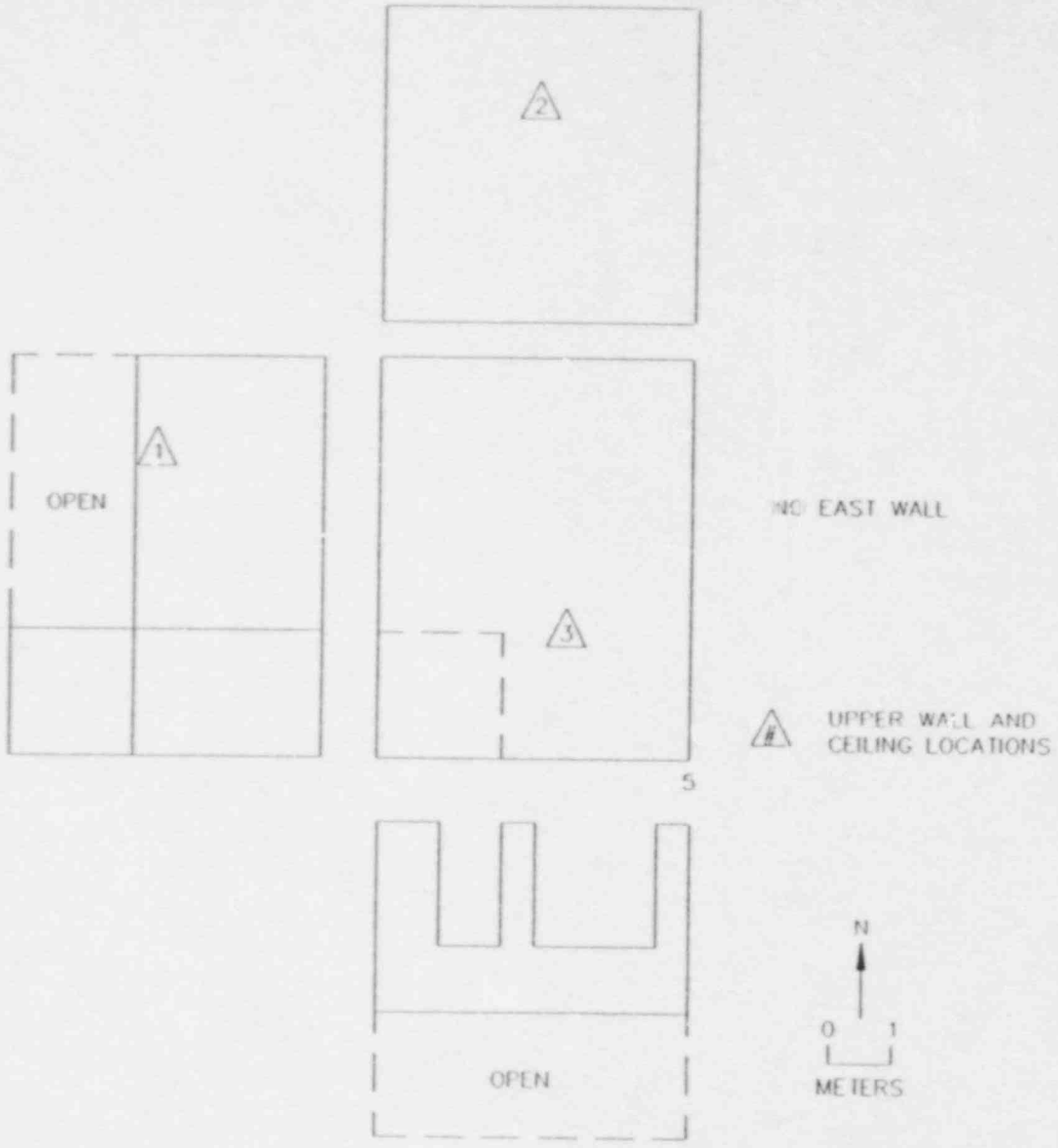

FIGURE 25: Room 26 Showing Locations of Upper Wall and Ceiling Single-point Measurements

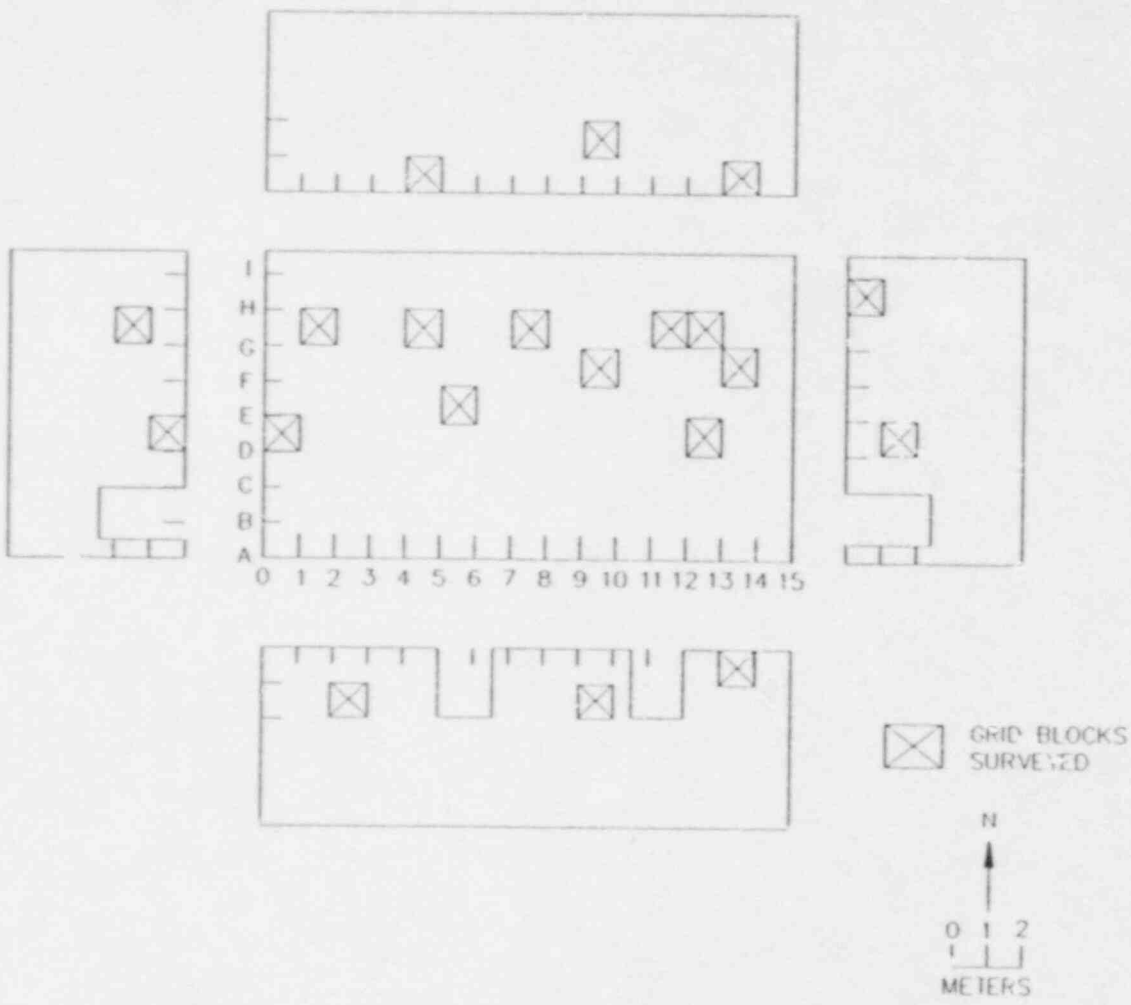

FIGURE 26: Room 27 Showing Locations of 5-point Grid Blocks Surveyed

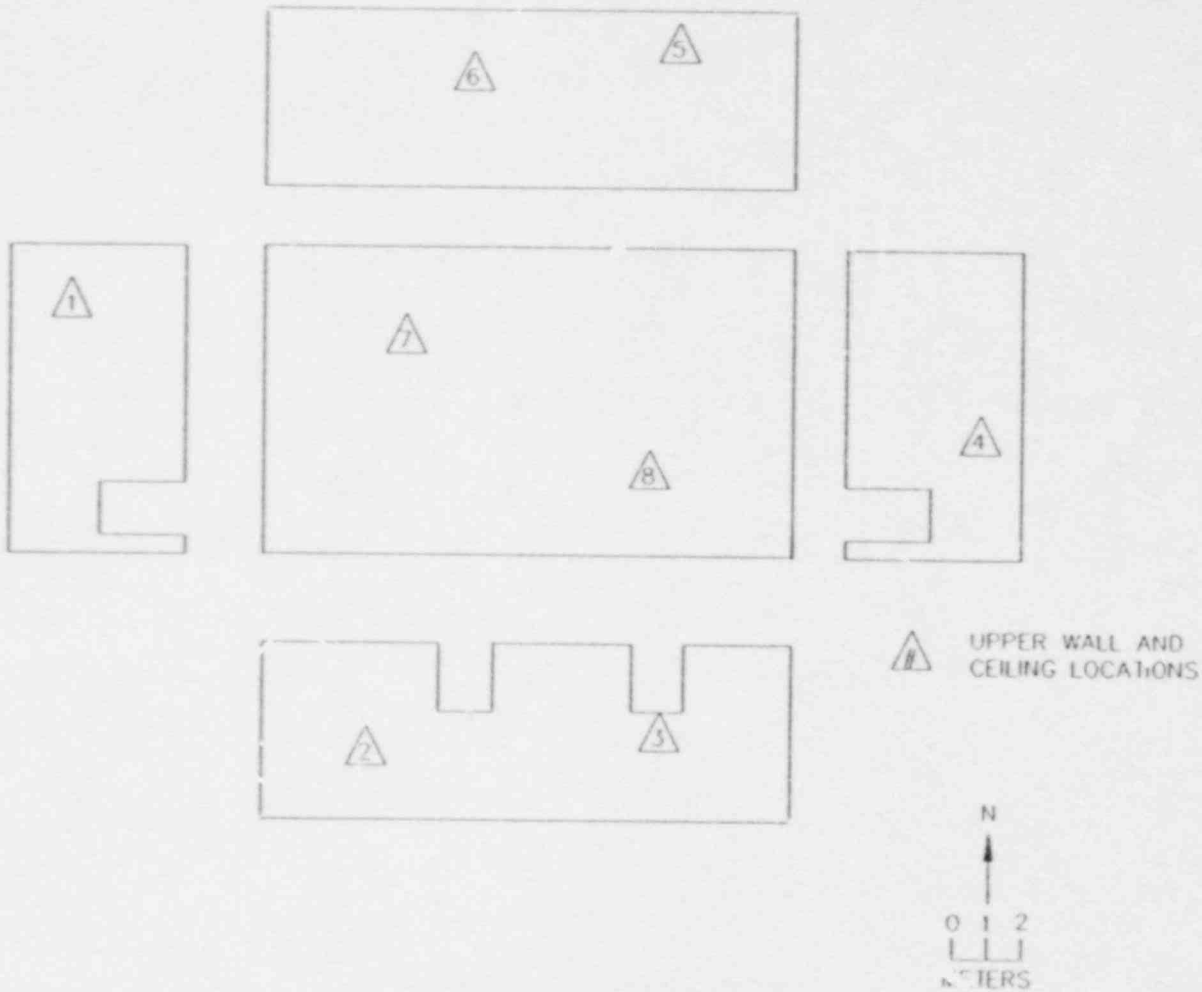

FIGURE 27: Room 27 Showing Locations of Upper Wall and Ceiling Single-point Measurements

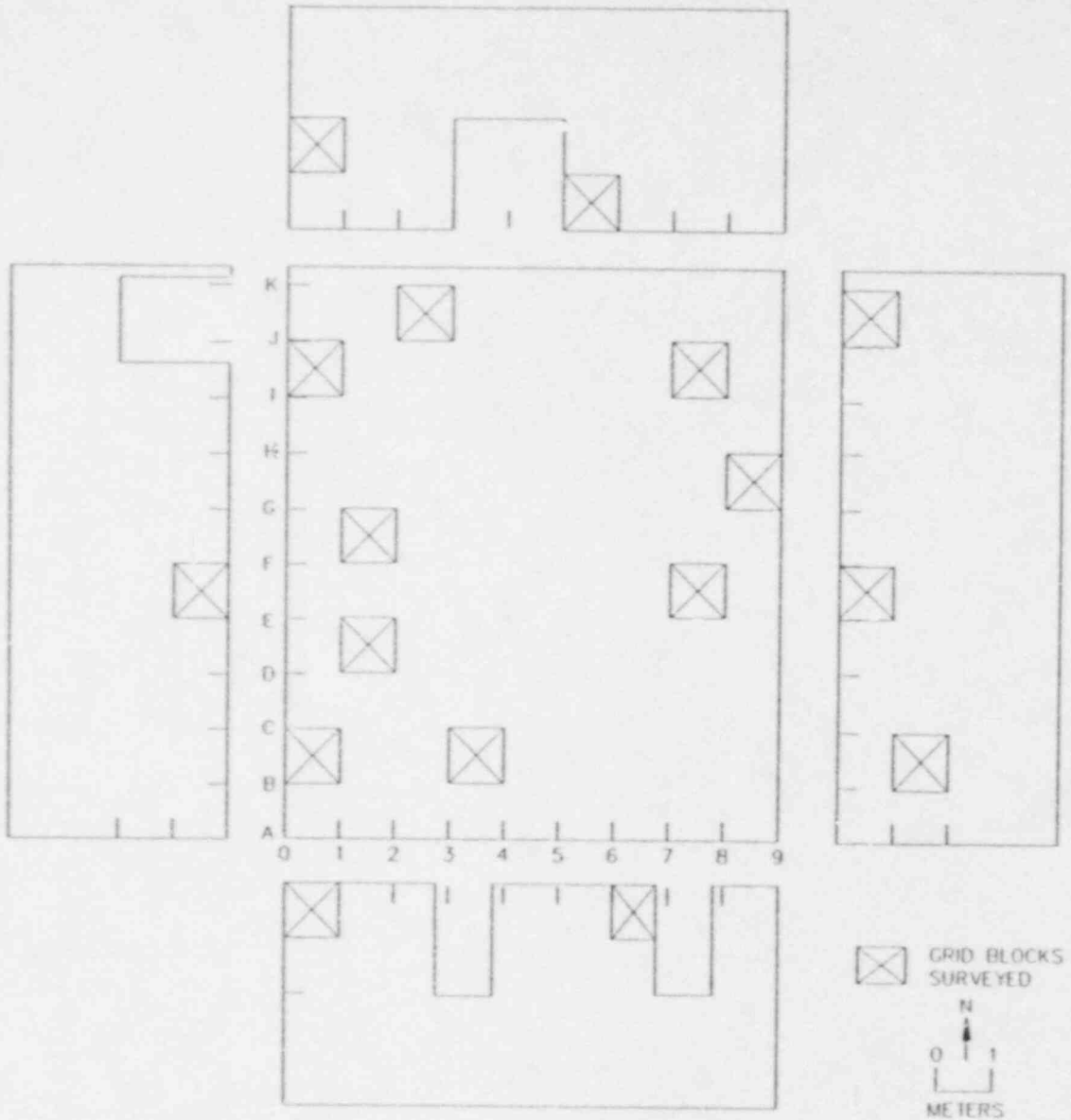

FIGURE 28: Room 43 Showing Locations of 5-point Grid Blocks Surveyed

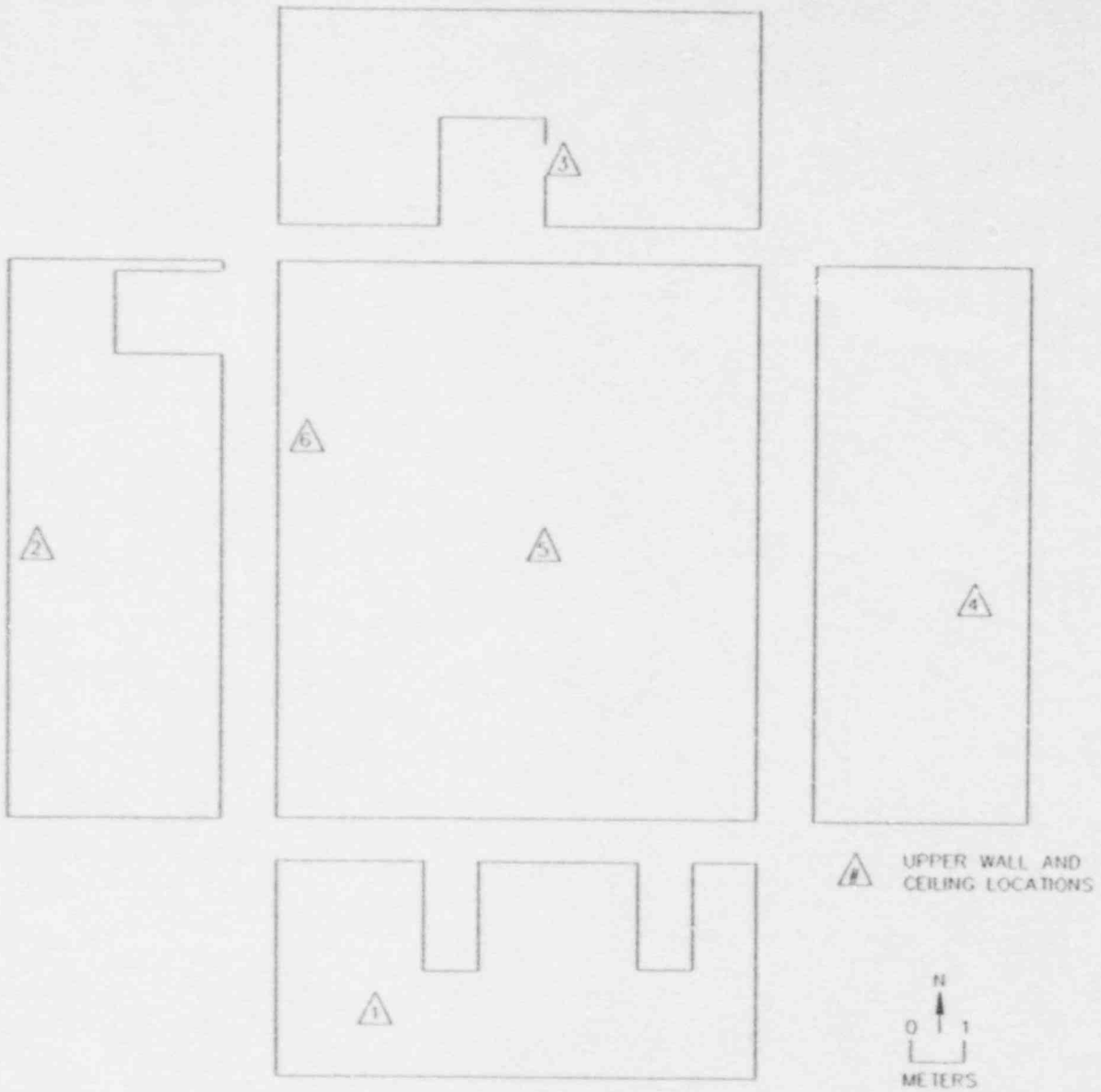

FIGURE 29: Room 43 Showing Locations of Upper Wall and Ceiling Single-point Measurements

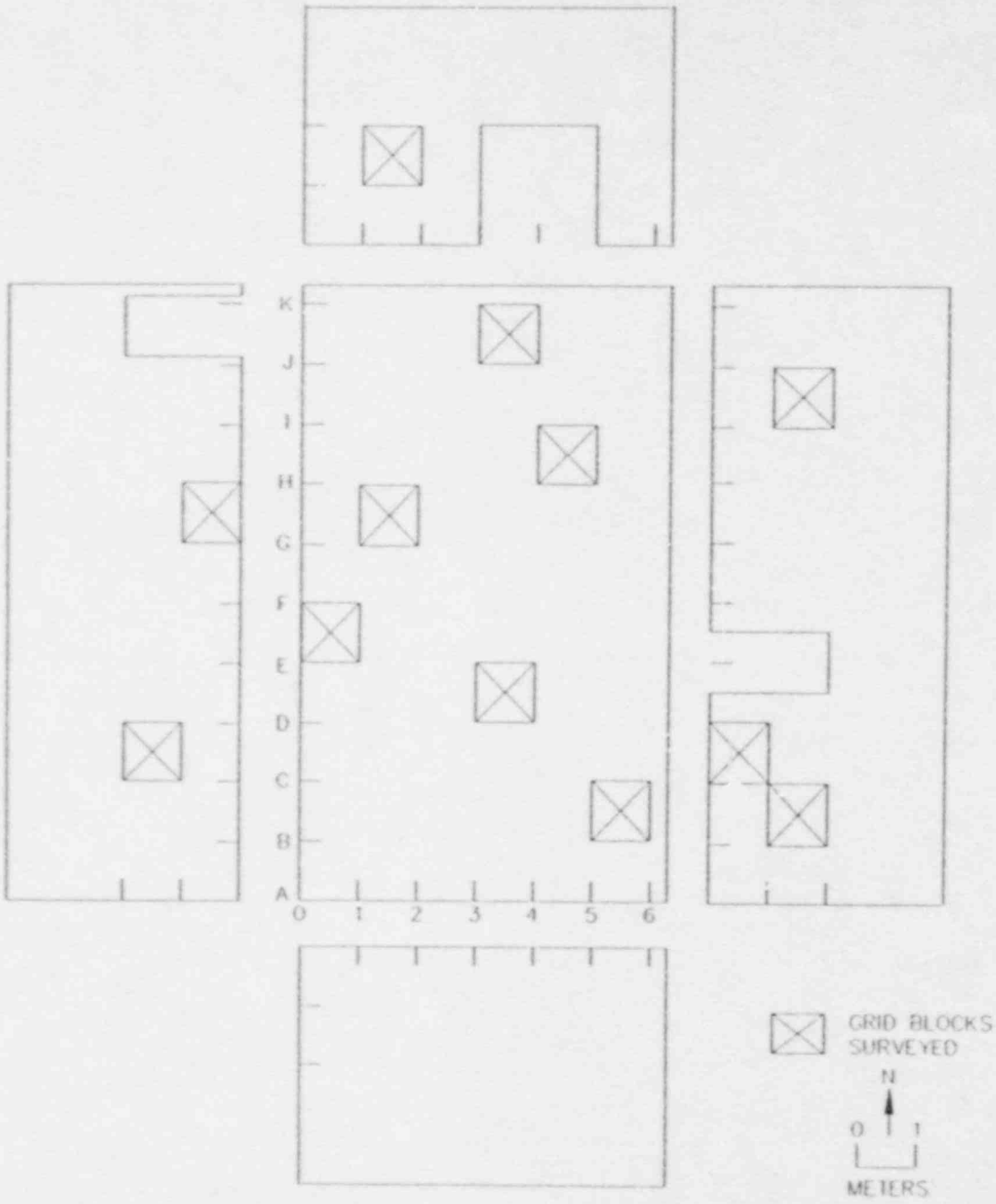

FIGURE 30: Room 50 Showing Locations of 5-point Grid Blocks Surveyed

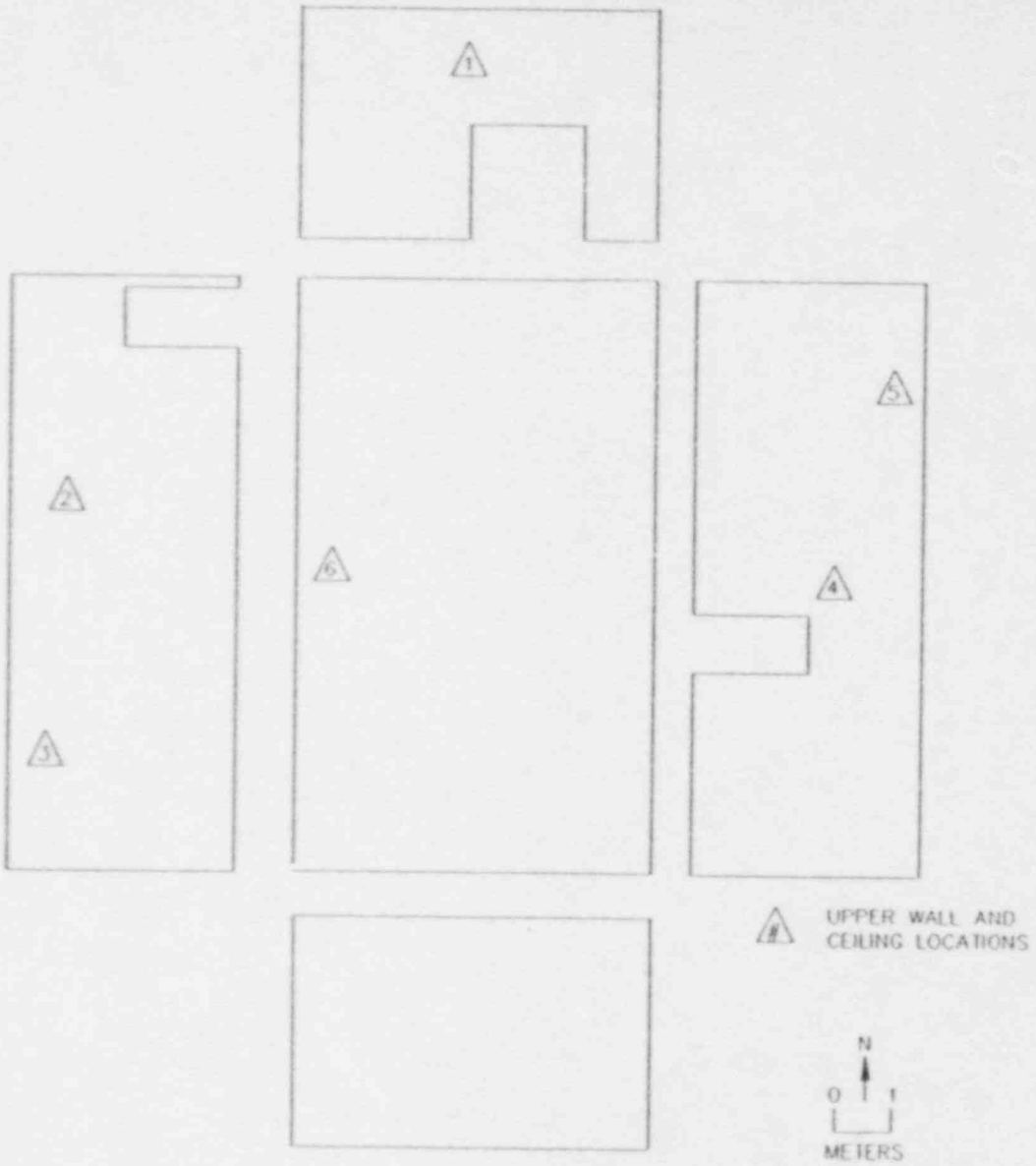

FIGURE 31: Room 50 Showing Locations of Upper Wall and Ceiling Single-point Measurements

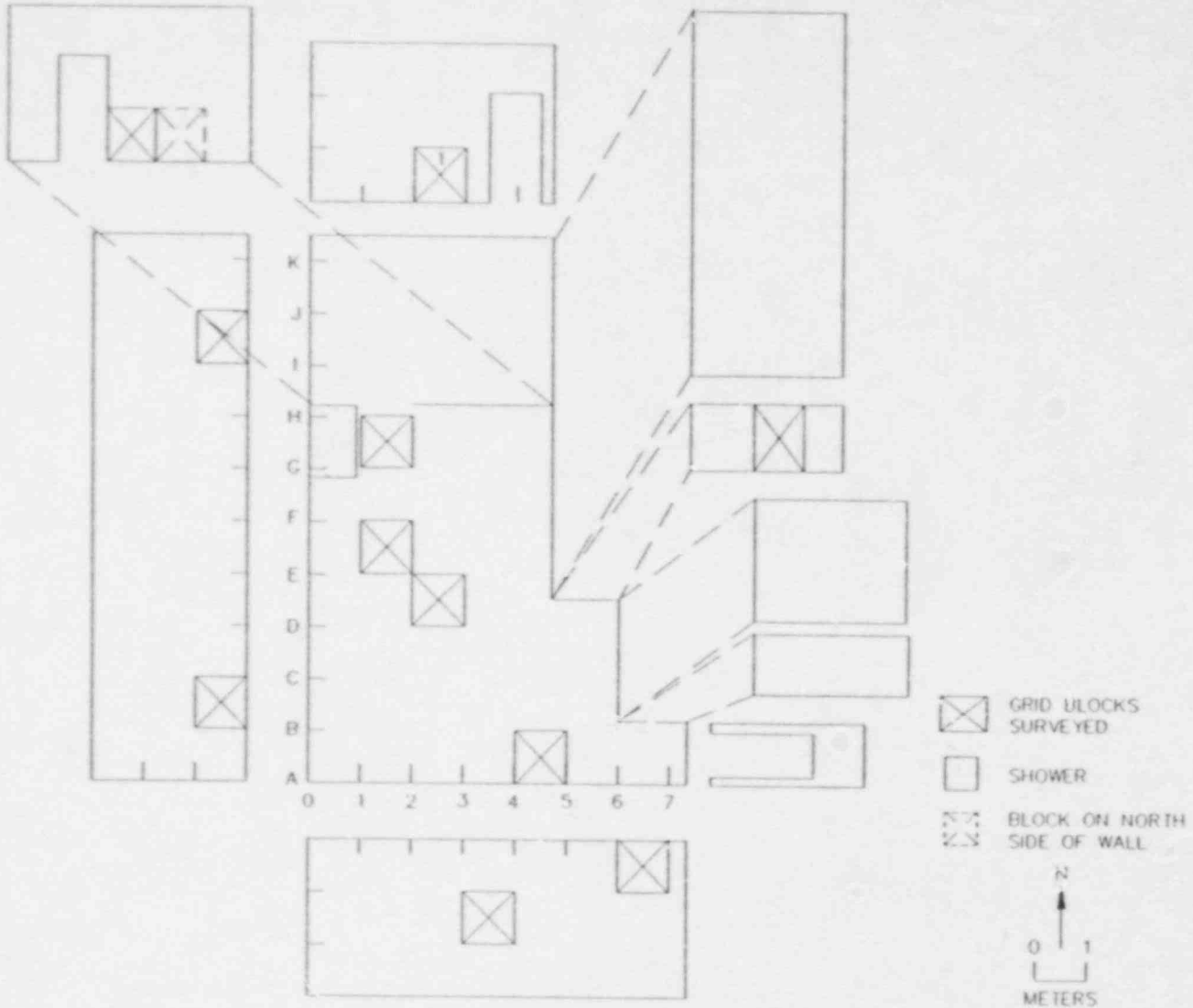

FIGURE 32: Men's Change Room Showing Locations of 5-point Grid Blocks Surveyed

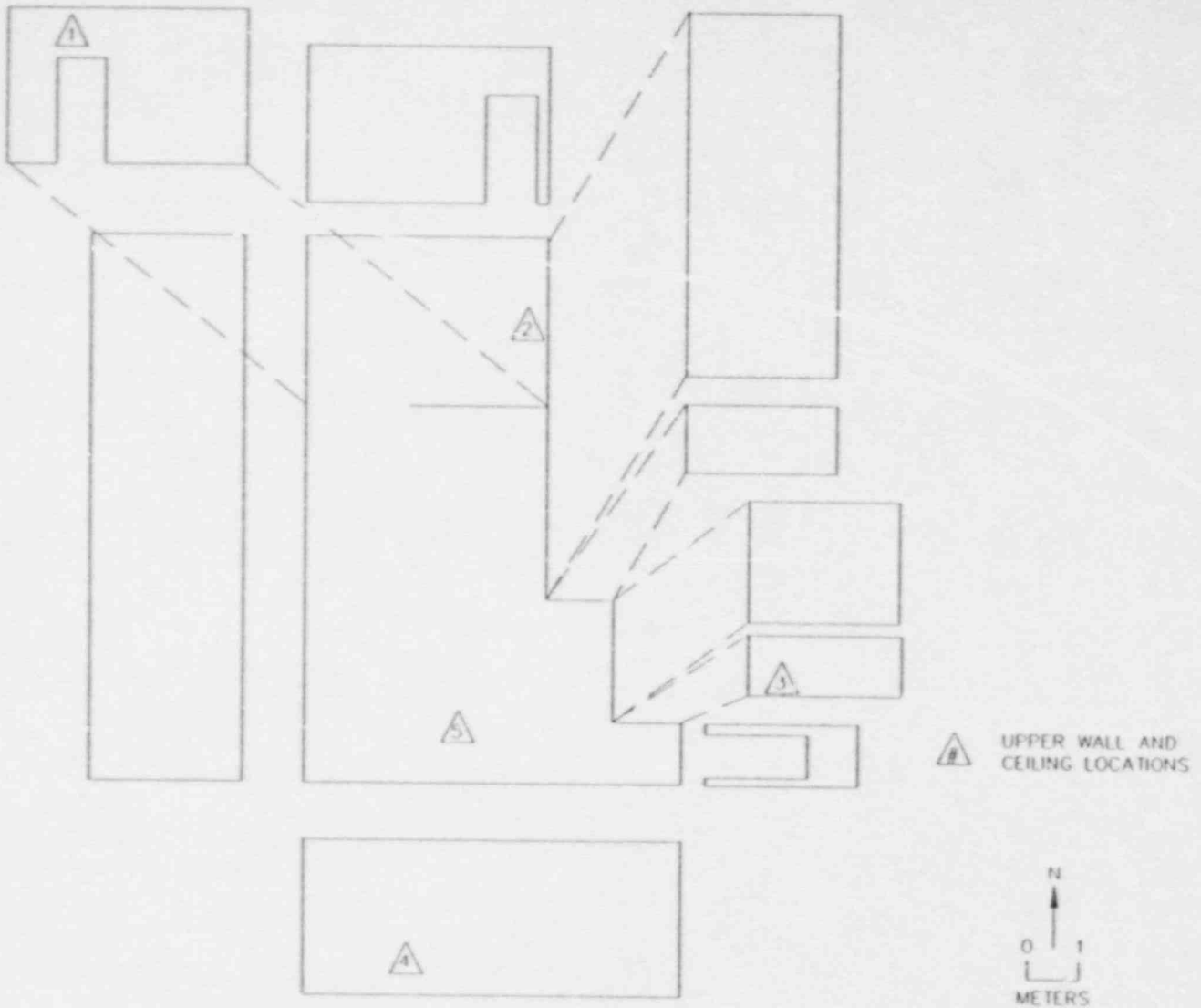

FIGURE 33: Men's Change Room Showing Locations of Upper Wall and Ceiling Single-point Measurements

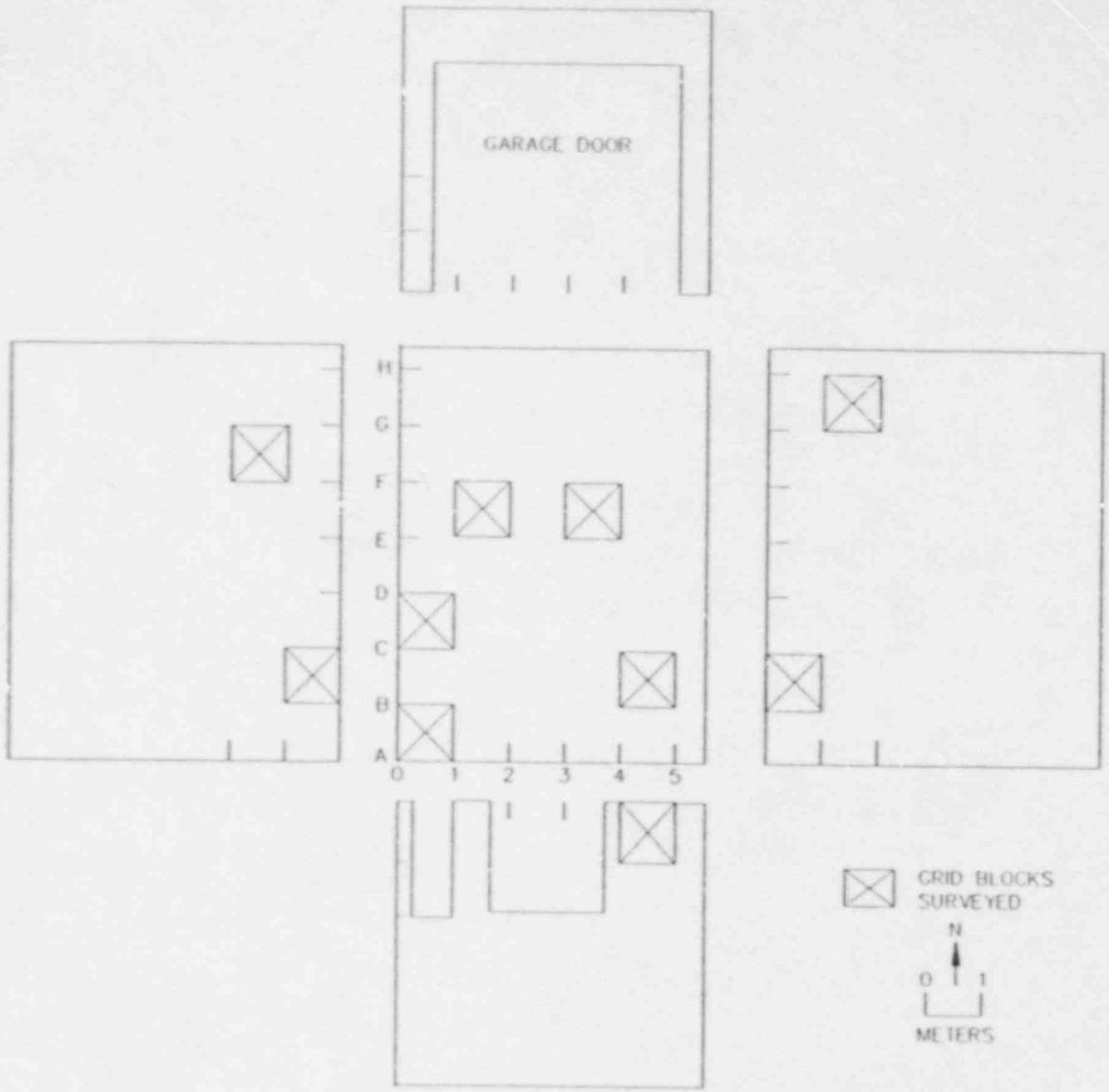

FIGURE 34: Drying Oven Showing Locations of 5-point Grid Blocks Surveyed

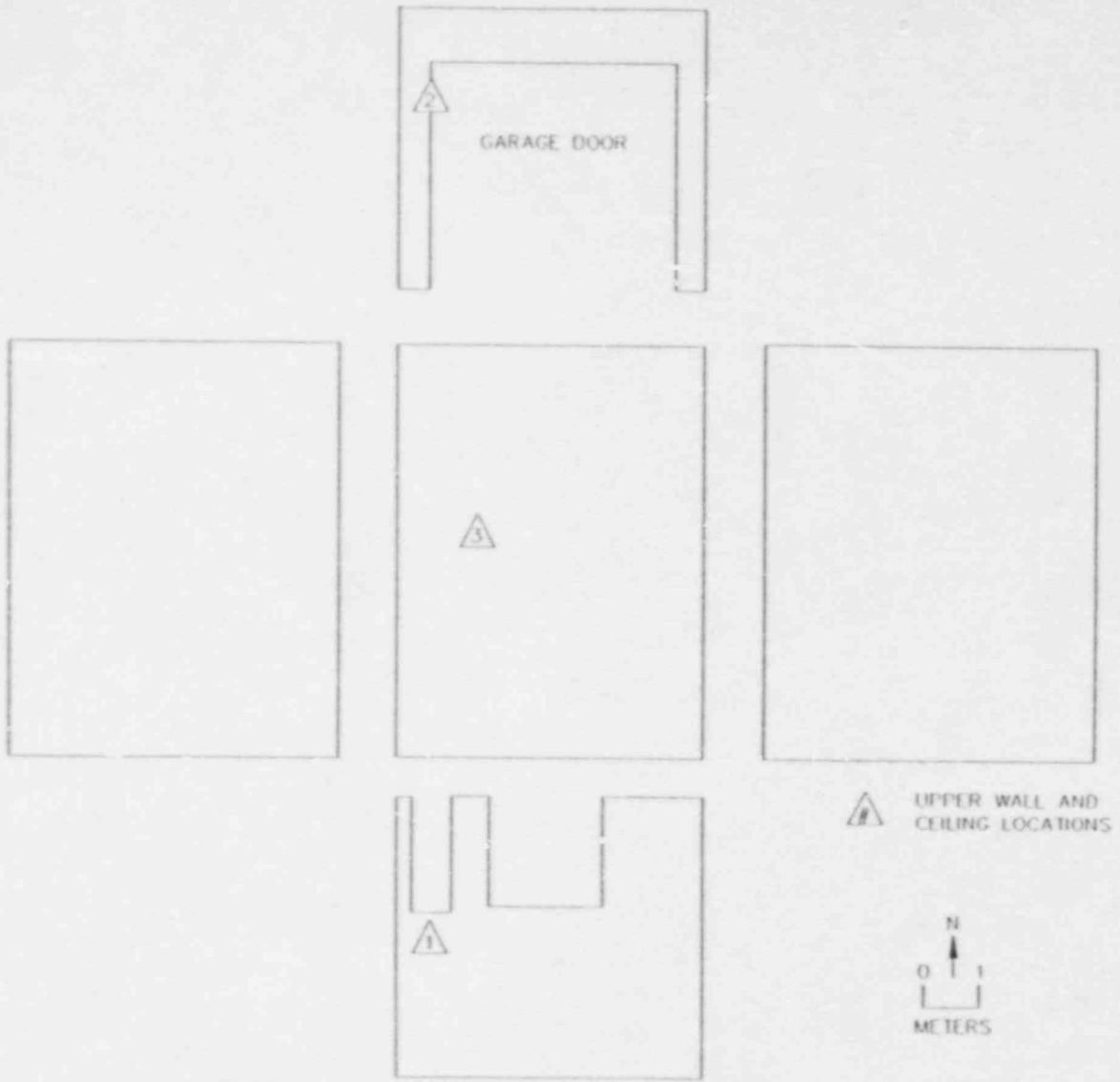

FIGURE 35: Drying Oven Showing Locations of Upper Wall and Ceiling Single-point Measurements

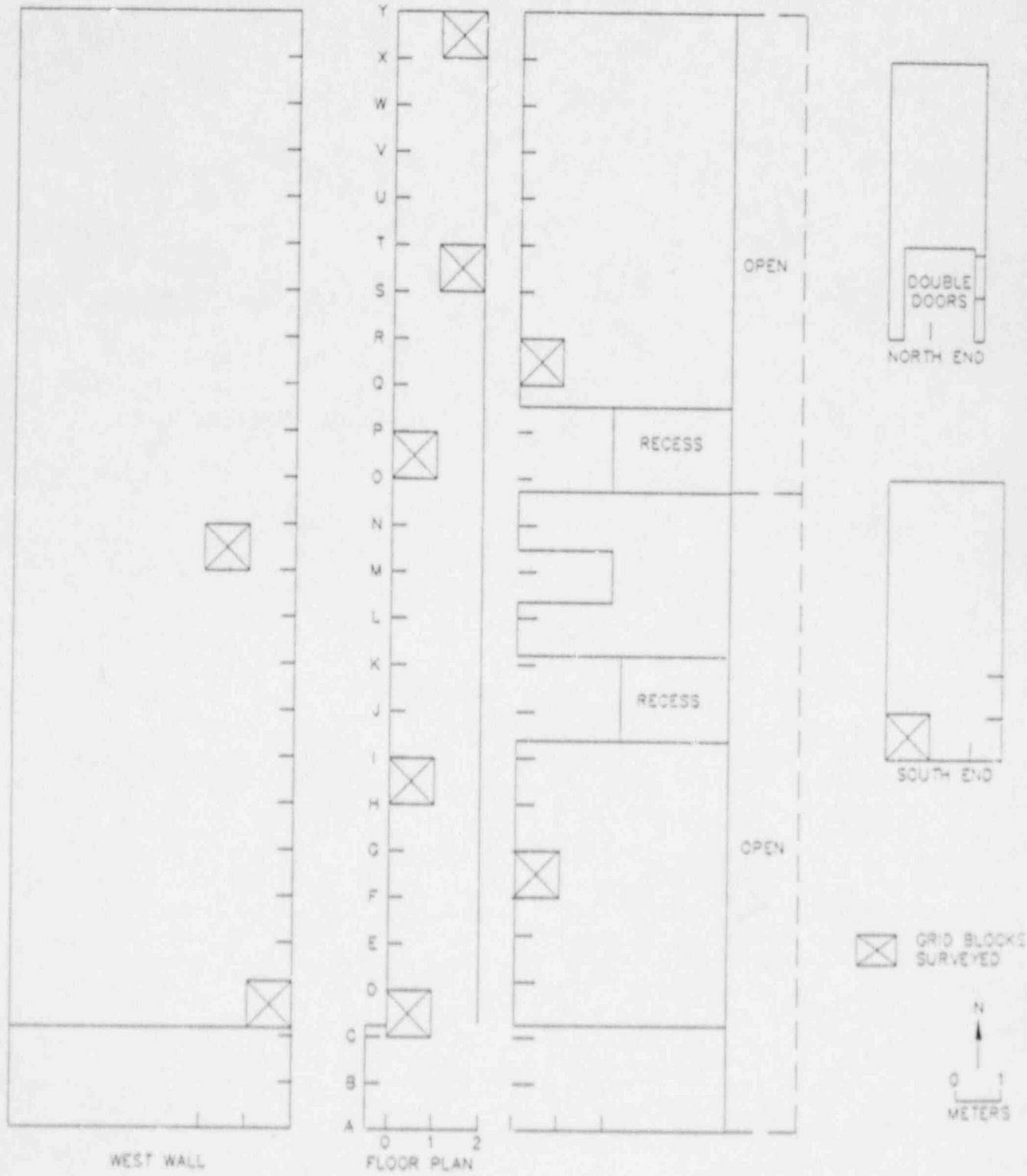

FIGURE 36: Hallway (Area 24) Showing Locations of 5-point Grid Blocks Surveyed

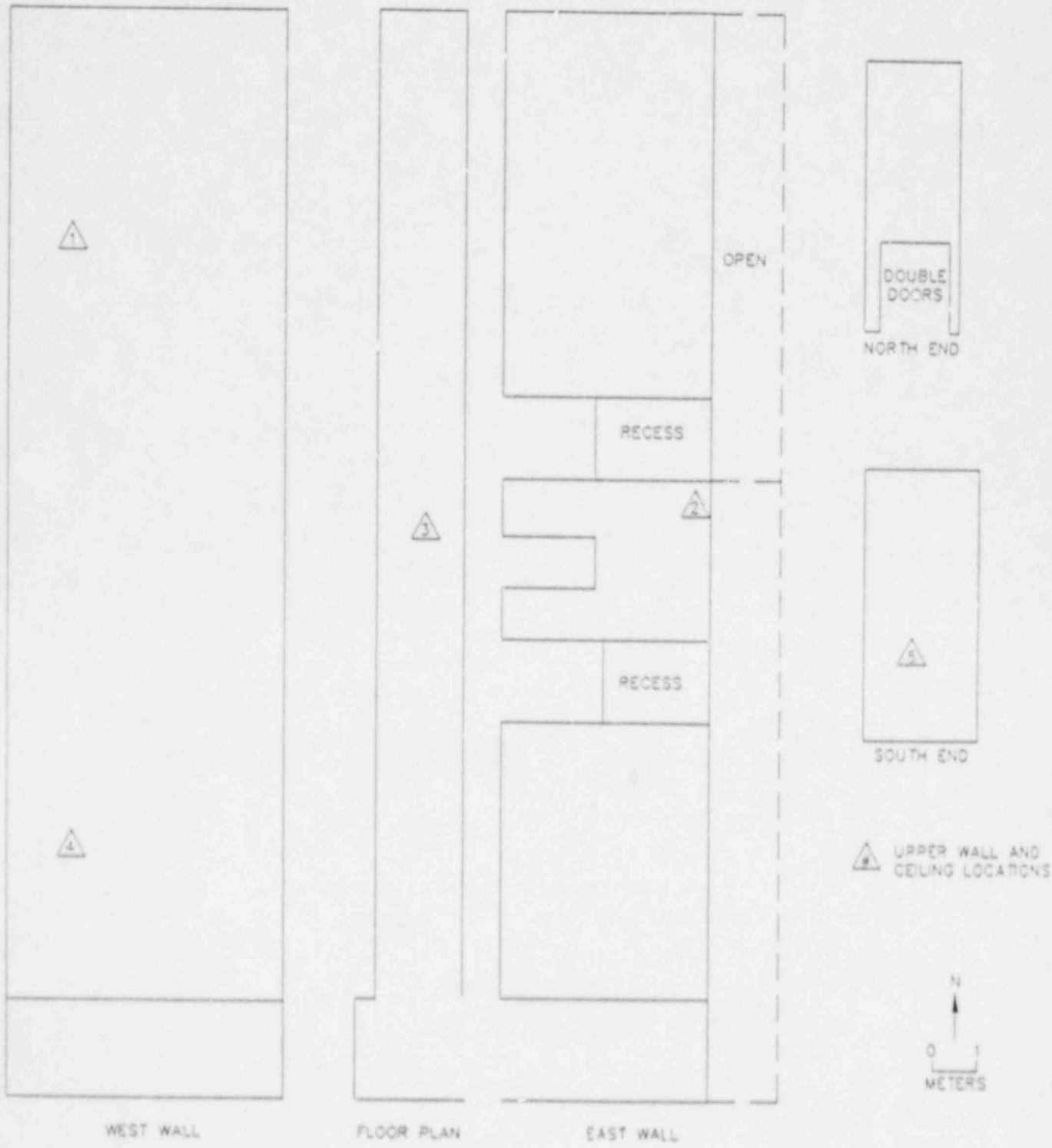

FIGURE 37: Hallway (Area 24) Showing Locations of Upper Wall and Ceiling Single-point Measurements

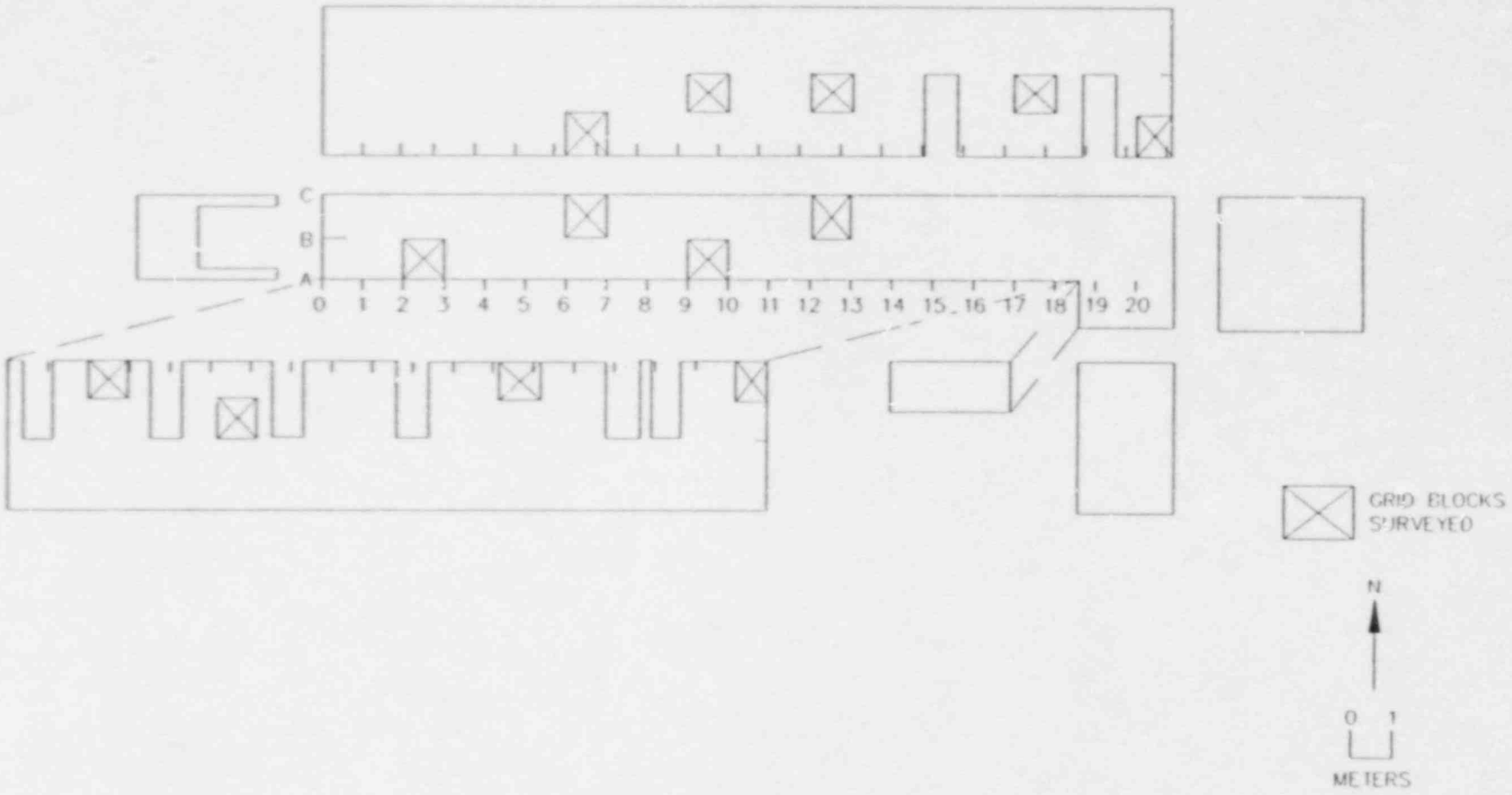

FIGURE 38: Hallway (Area 55) Showing Locations of 5-point Grid Blocks Surveyed

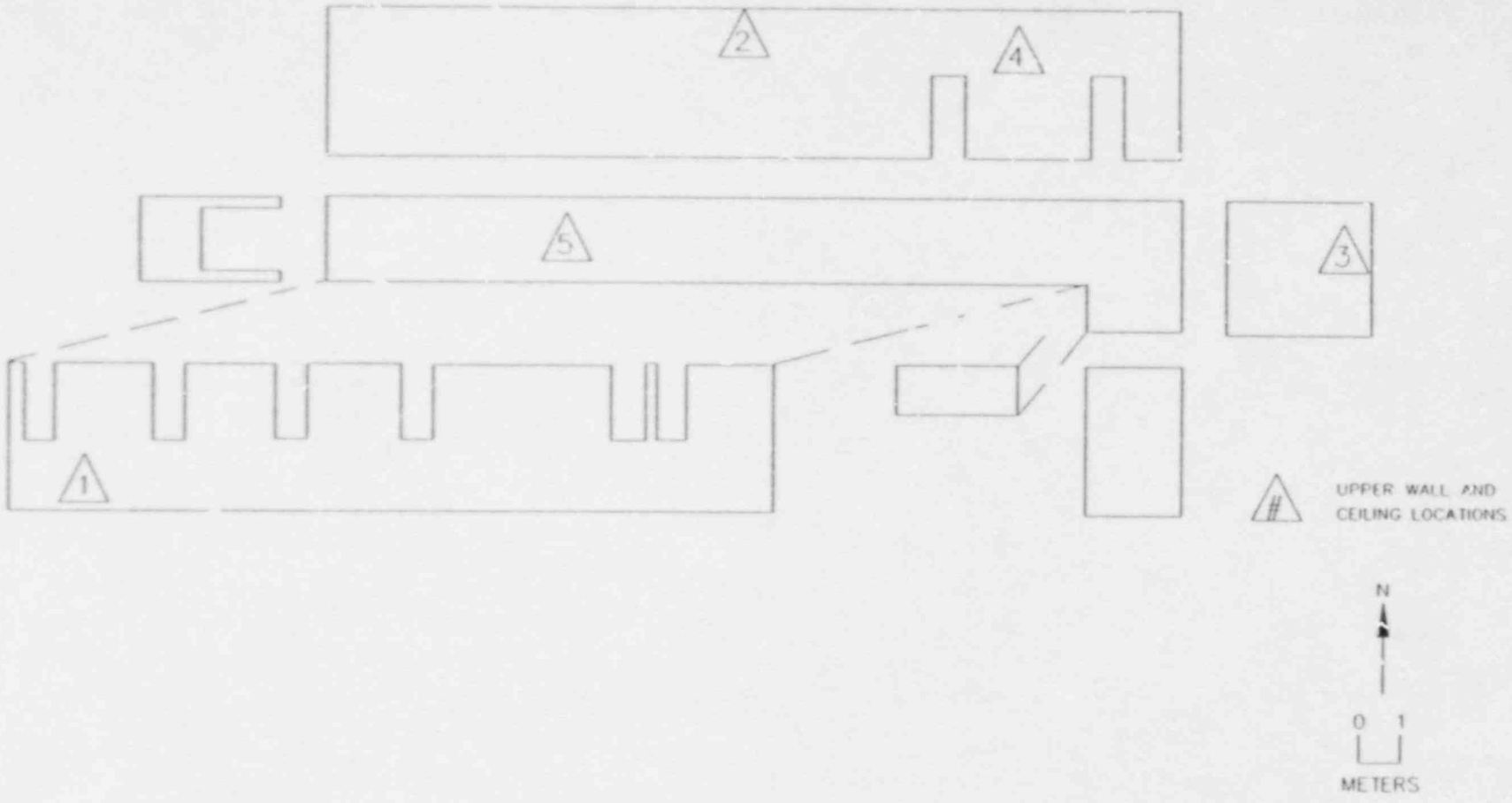

FIGURE 39: Hallway (Area 55) Showing Locations of Upper Wall and Ceiling Single-point Meesurements

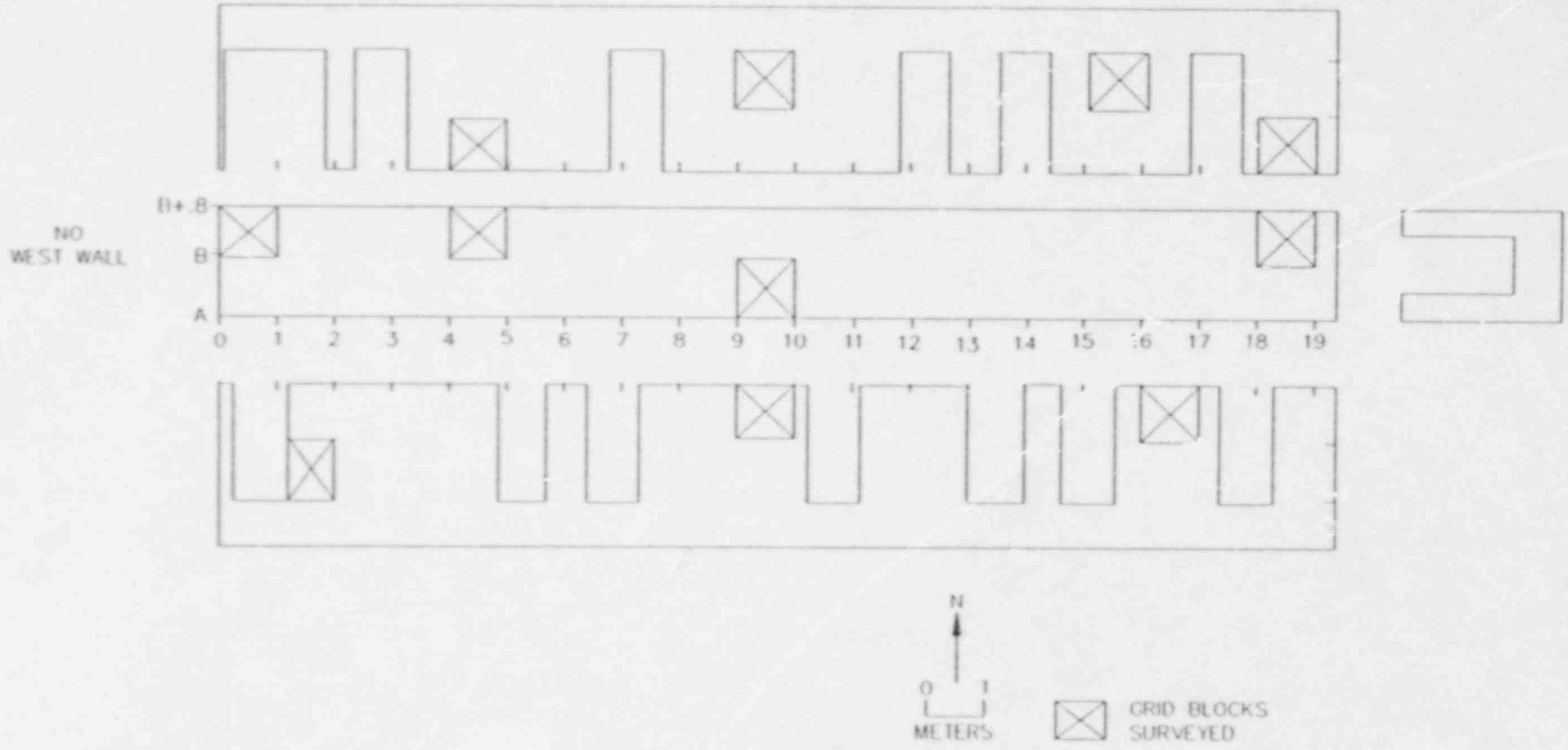

FIGURE 40: Hallway (Area 56) Showing Locations of 5-point Grid Blocks Surveyed

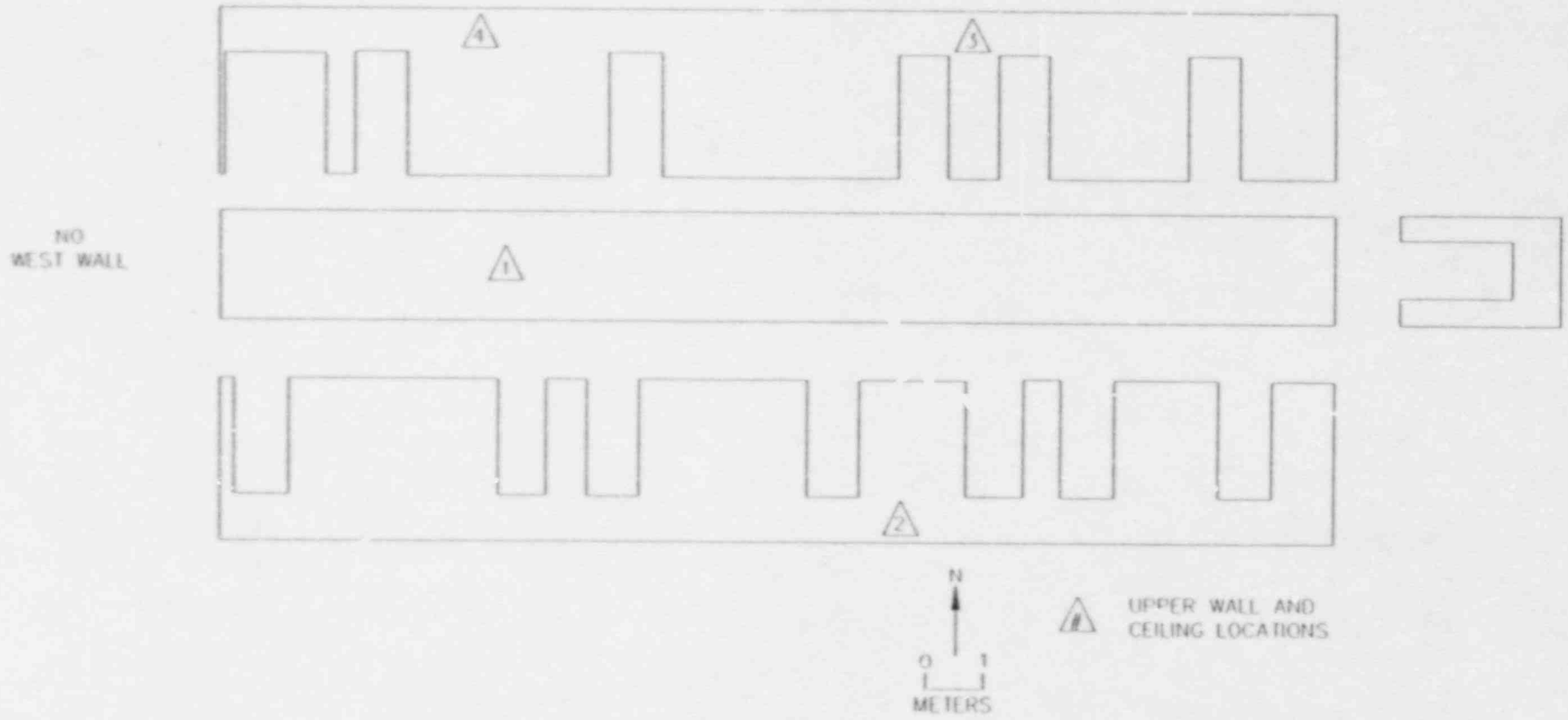

FIGURE 41: Hallway (Area 56) Showing Locations of Upper Wall and Ceiling Single-point Measurements

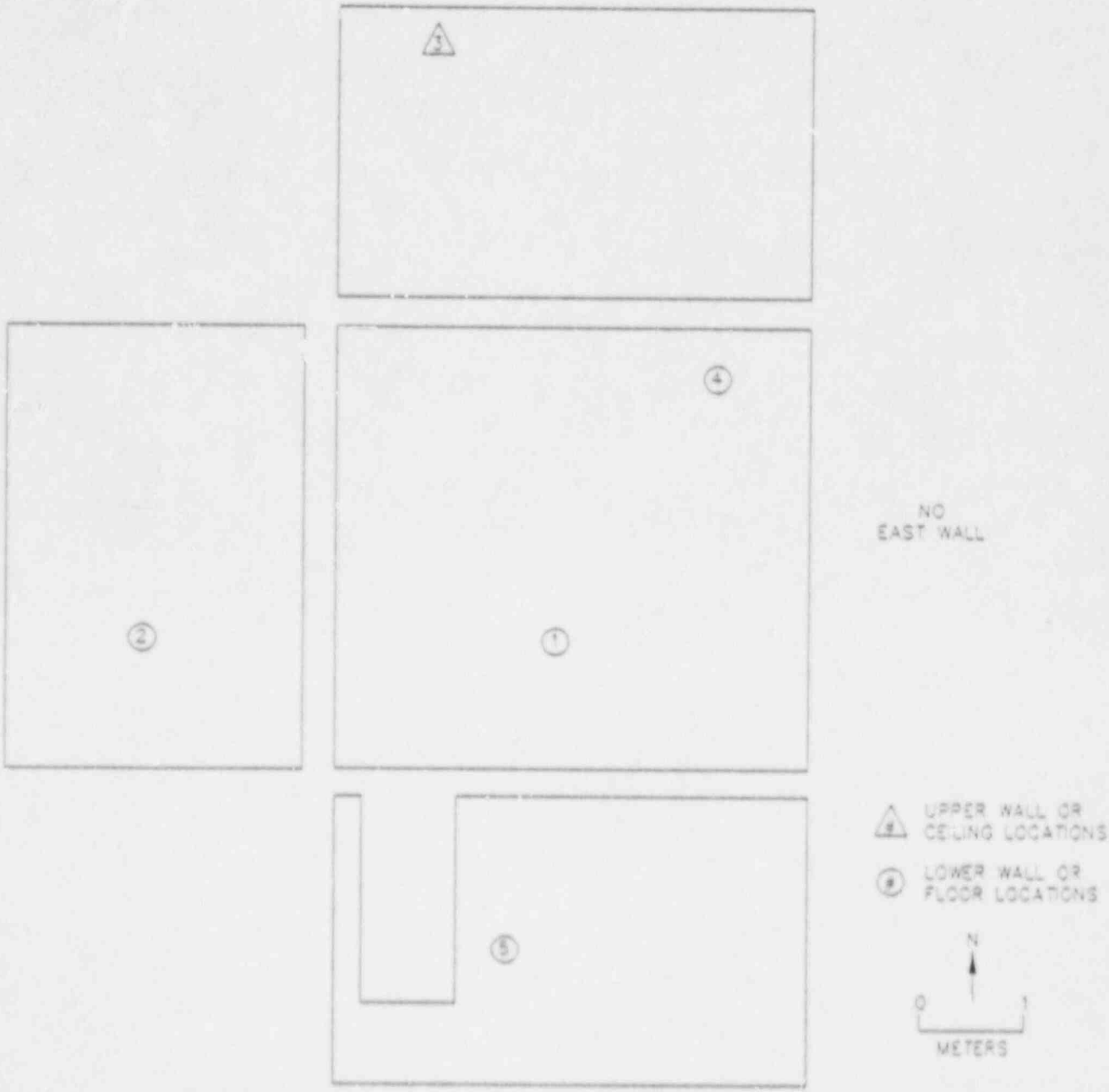

FIGURE 42: Room 1 Showing Locations of Single-point Measurements

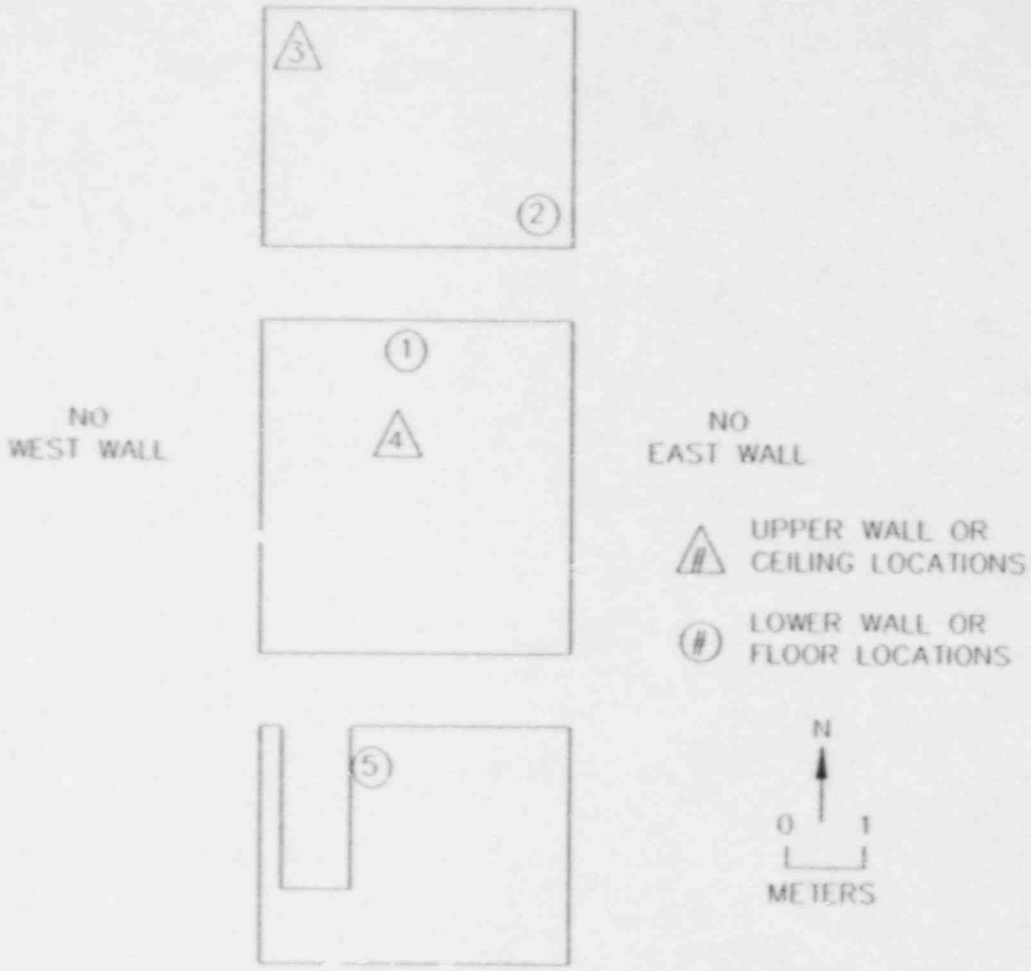

FIGURE 43: Room 2 Showing Locations of Single-point Measurements

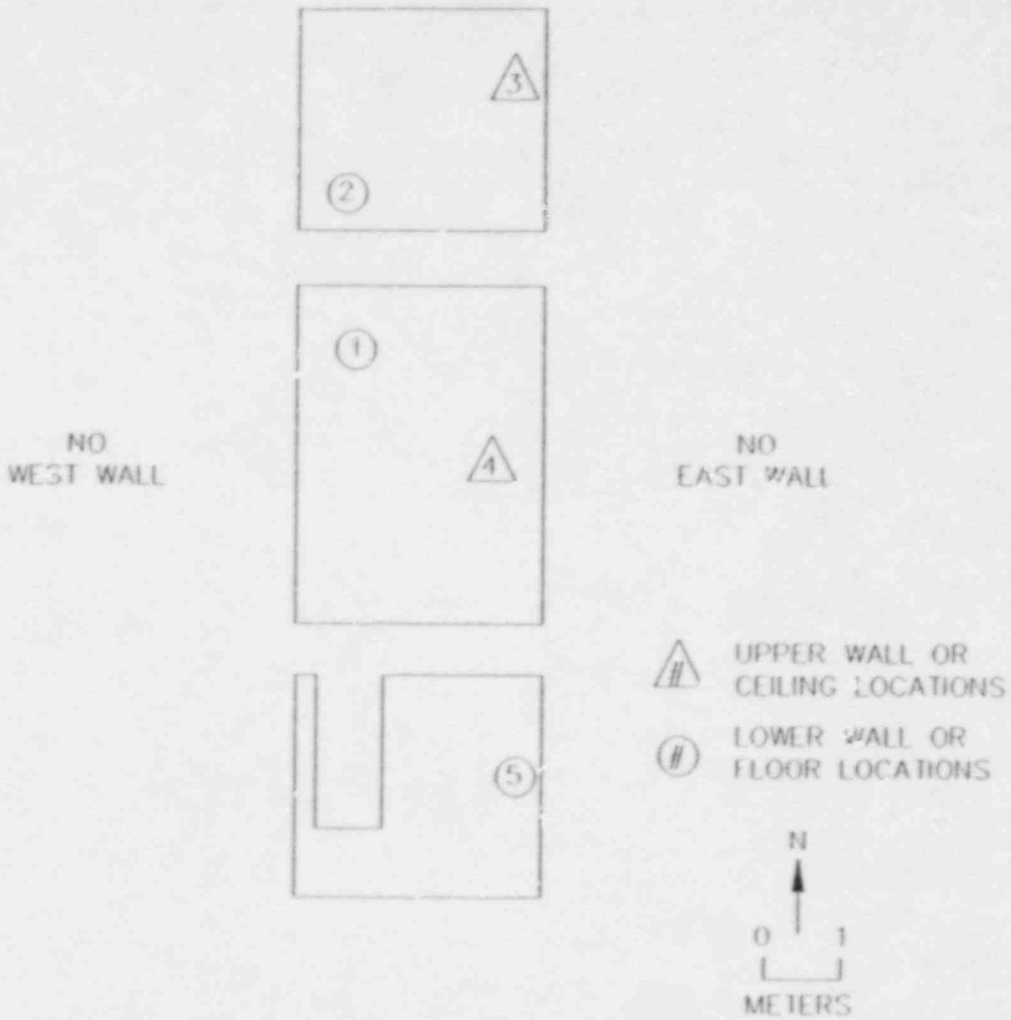

FIGURE 44: Room 4 Showing Locations of Single-point Measurements

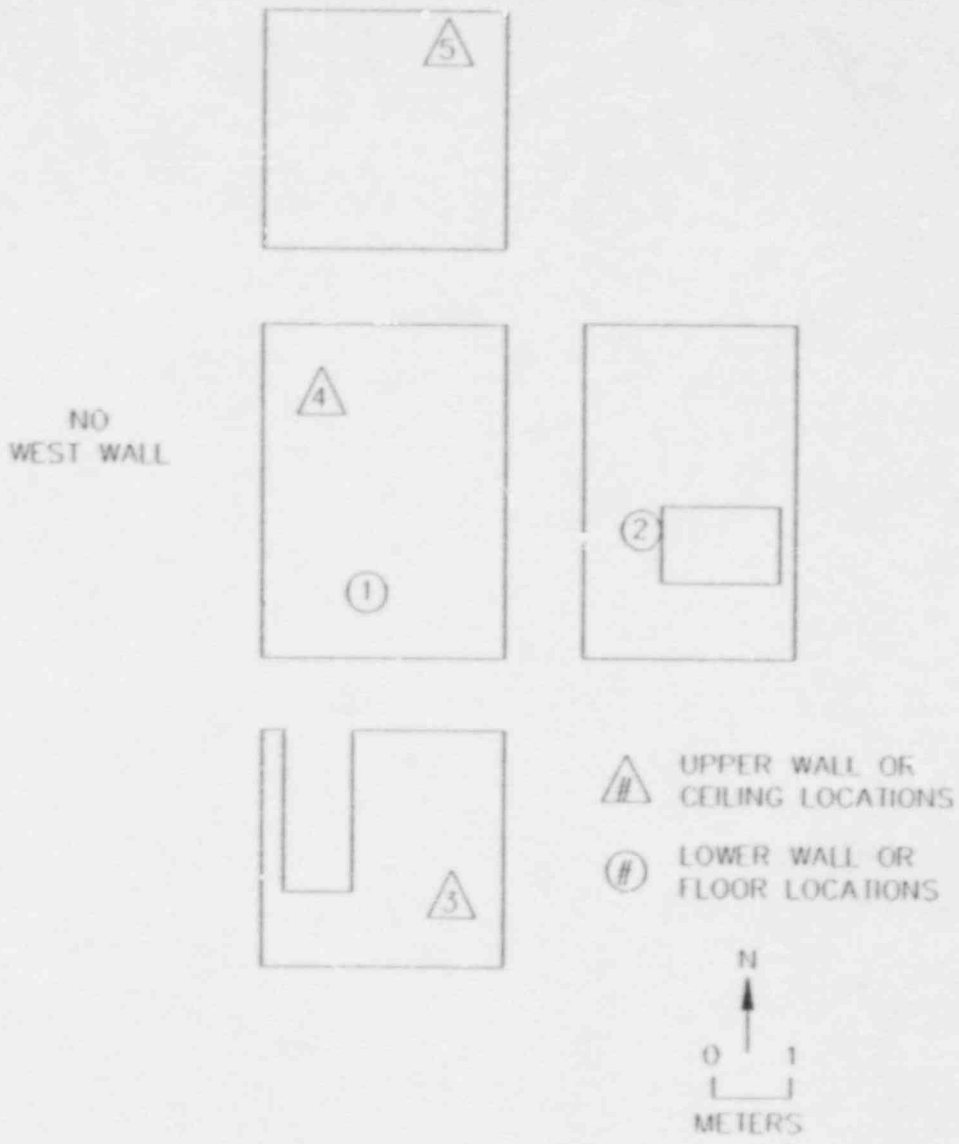

FIGURE 45: Room 5 Showing Locations of Single-point Measurements

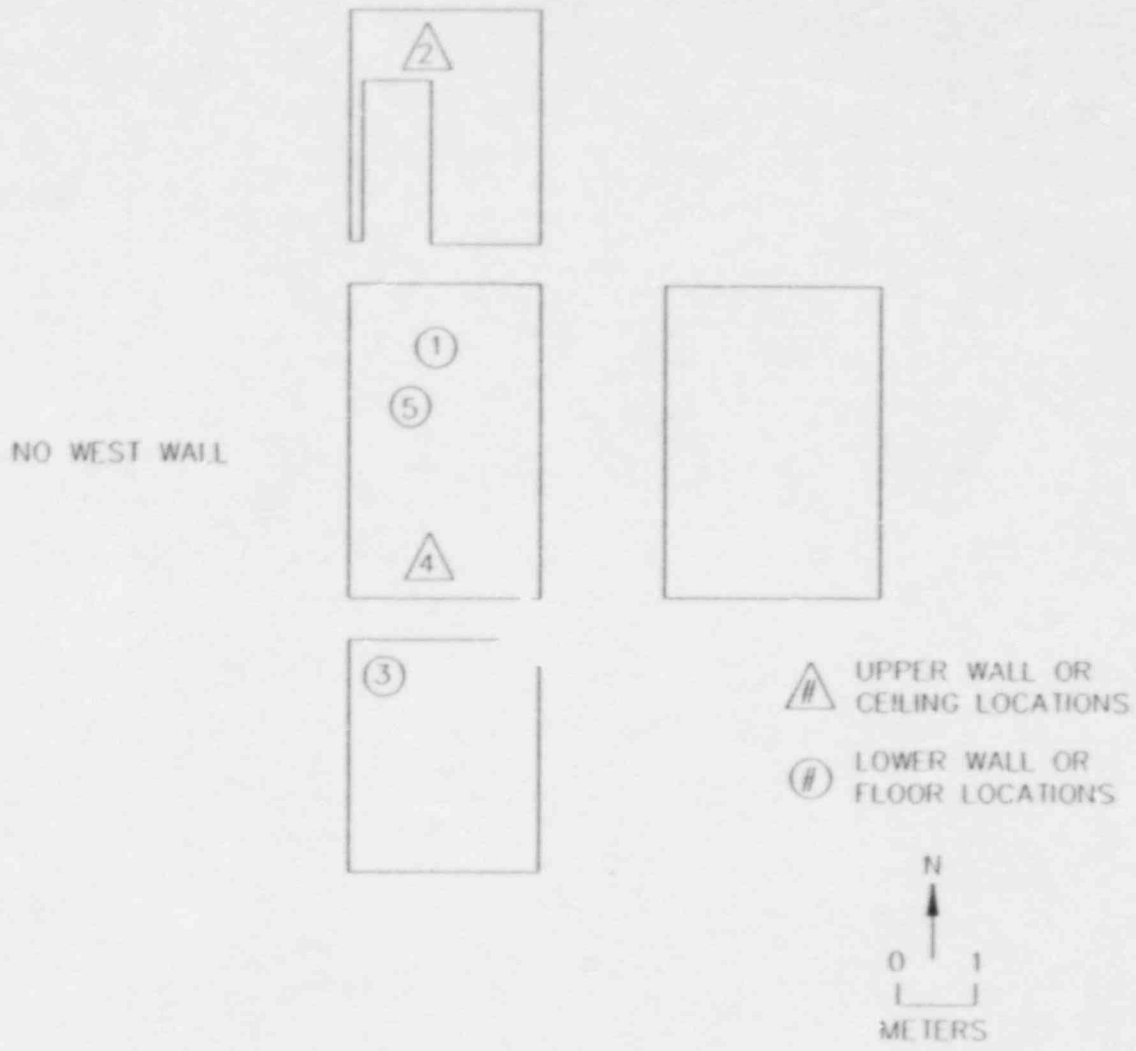

FIGURE 46: Room 6 Showing Locations of Single-point Measurements

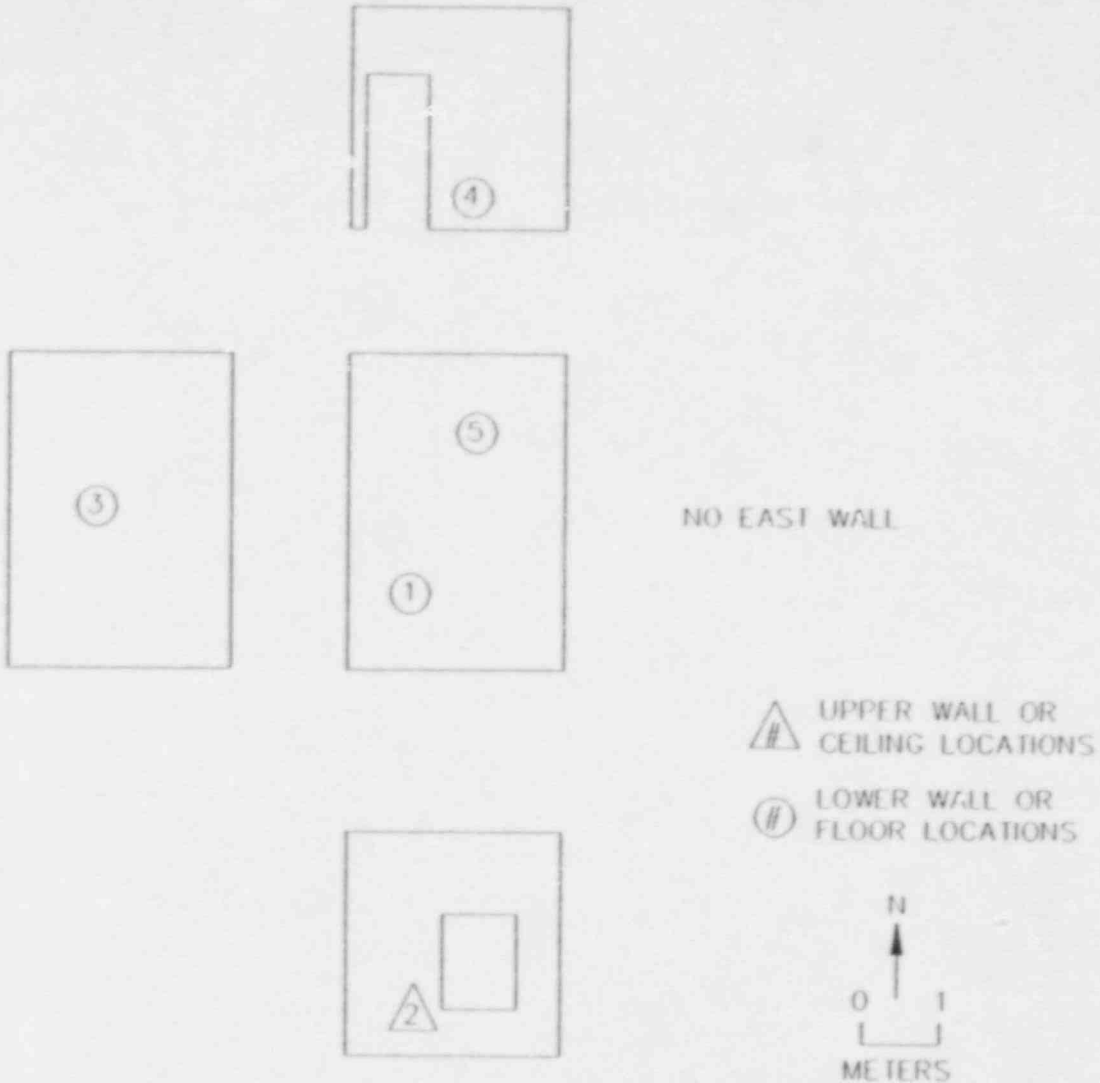

FIGURE 47: Room 7 Showing Locations of Single-point Measurements

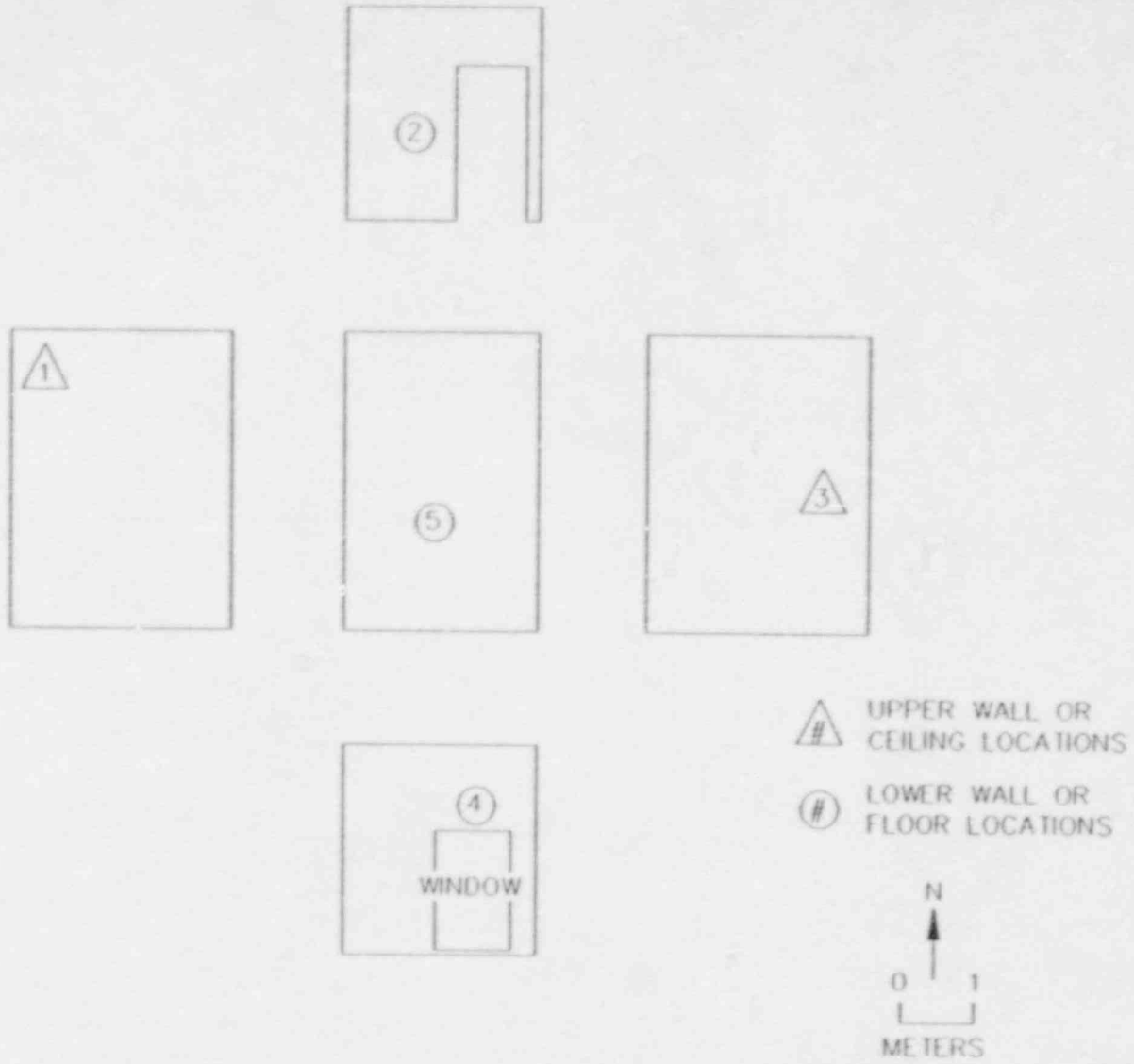

FIGURE 48: Room 8 Showing Locations of Single-point Measurements

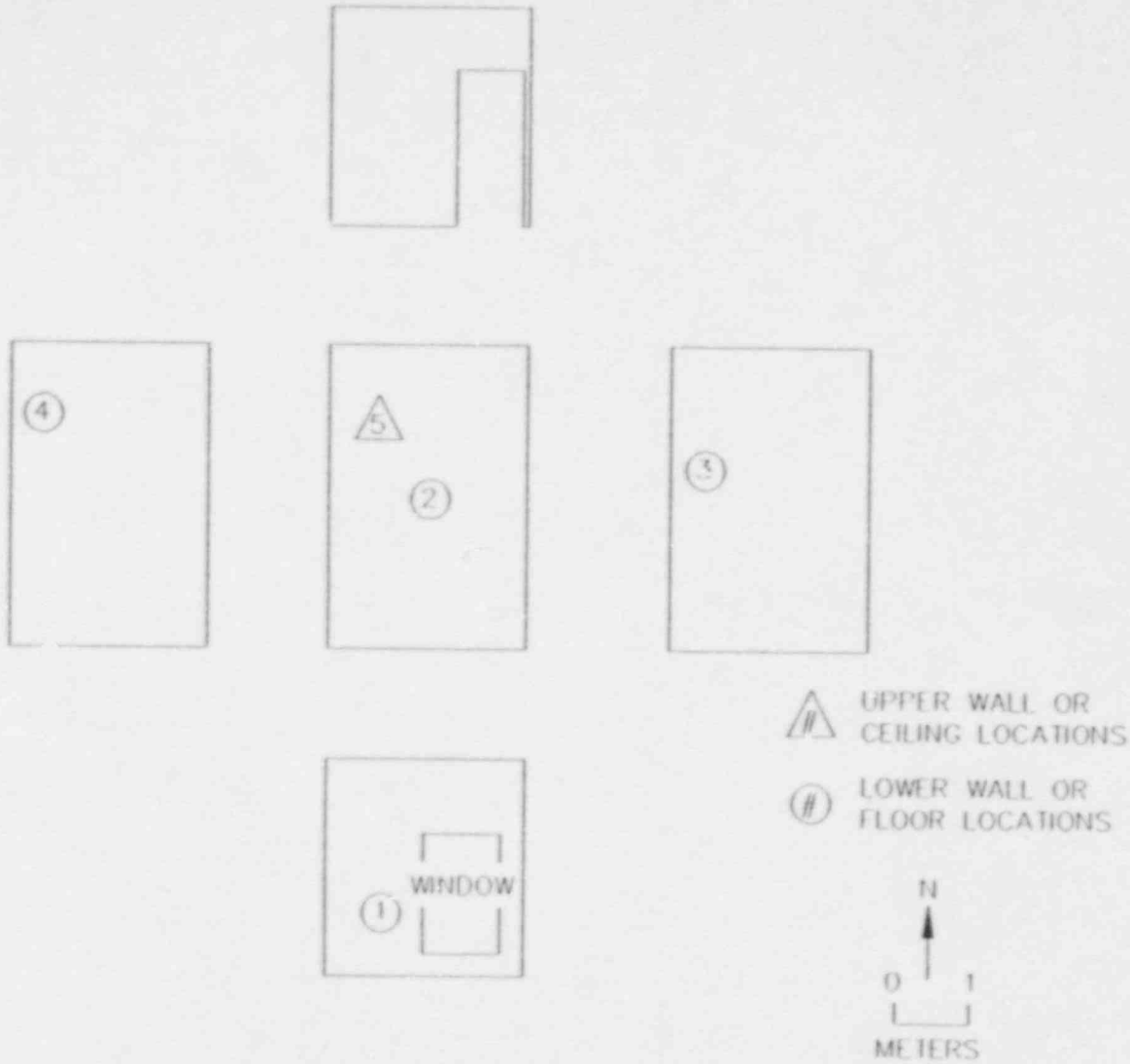

FIGURE 49: Room 9 Showing Locations of Single-point Measurements

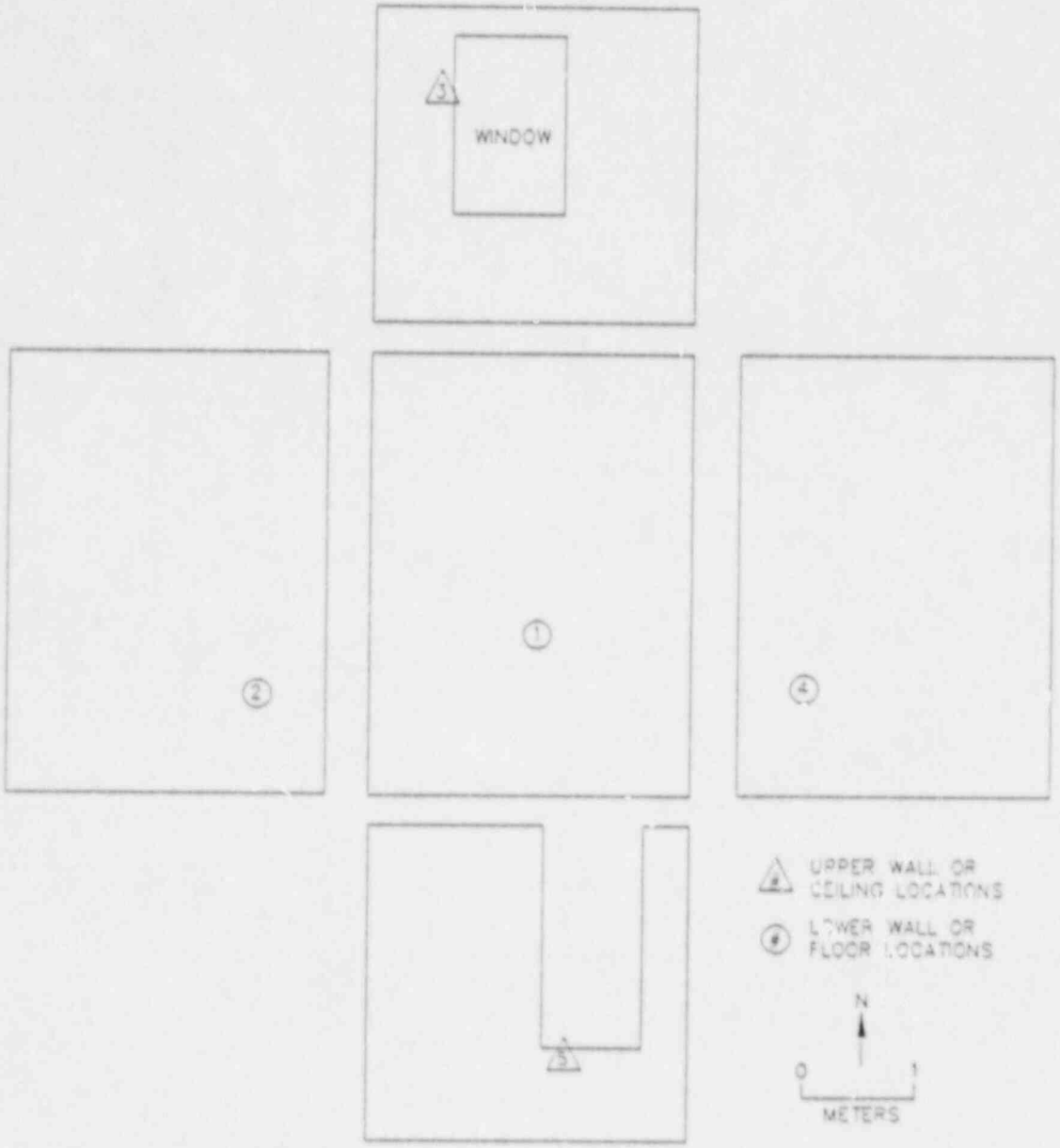

FIGURE 50: Room 10 Showing Locations of Single-point Measurements

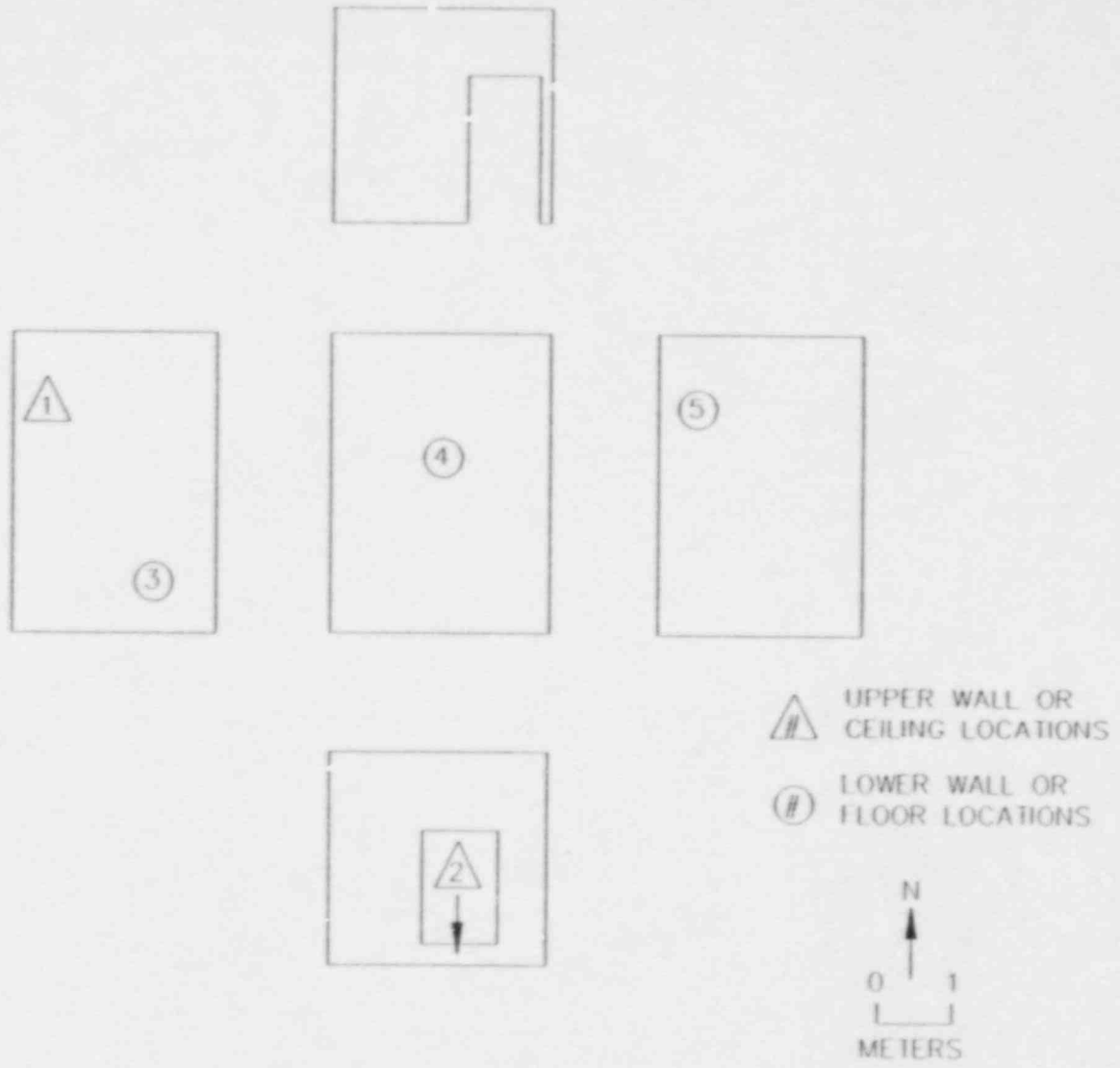

FIGURE 51: Room 11 Showing Locations of Single-point Measurements

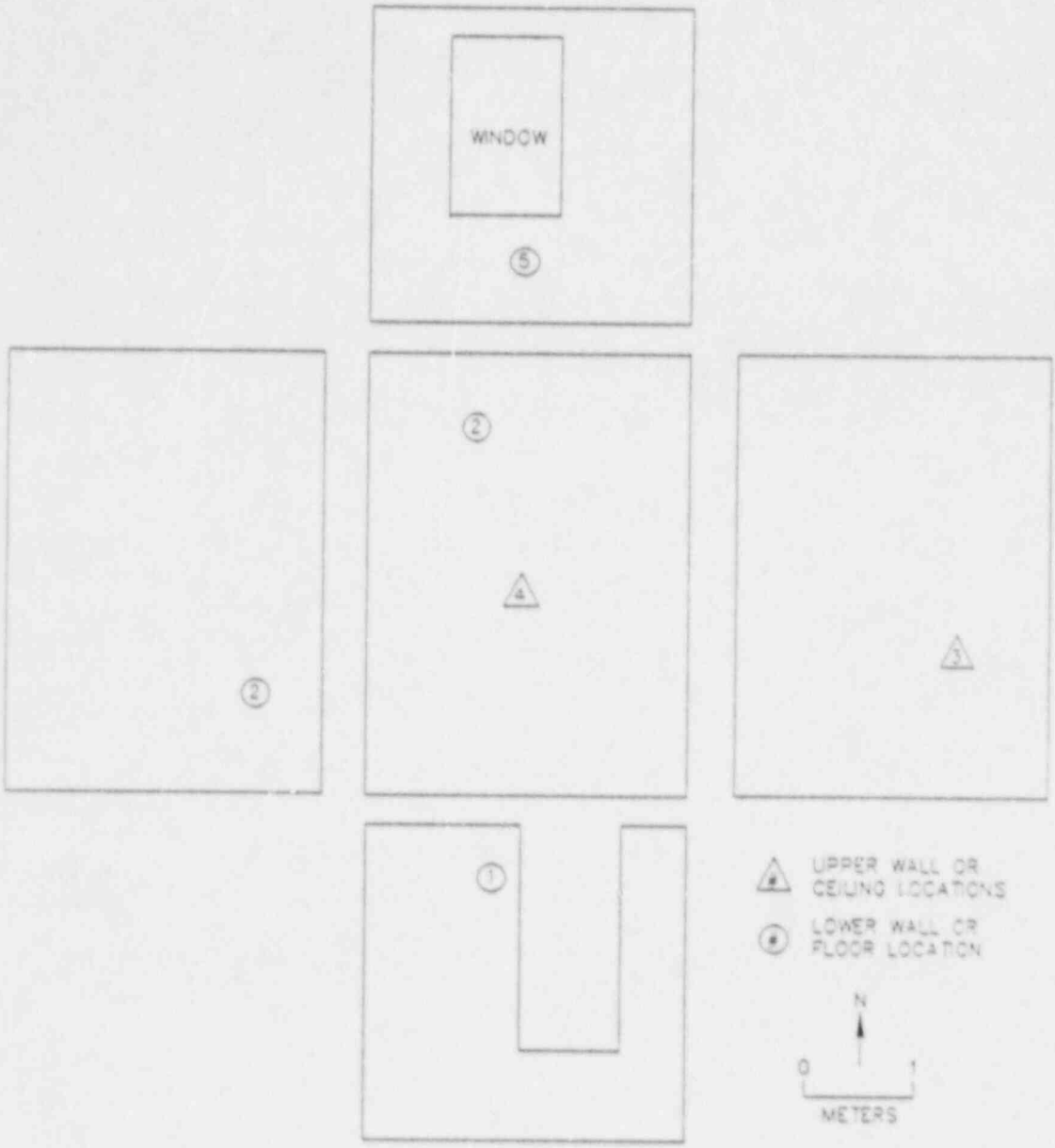

FIGURE 52: Room 12 Showing Locations of Single-point Measurements

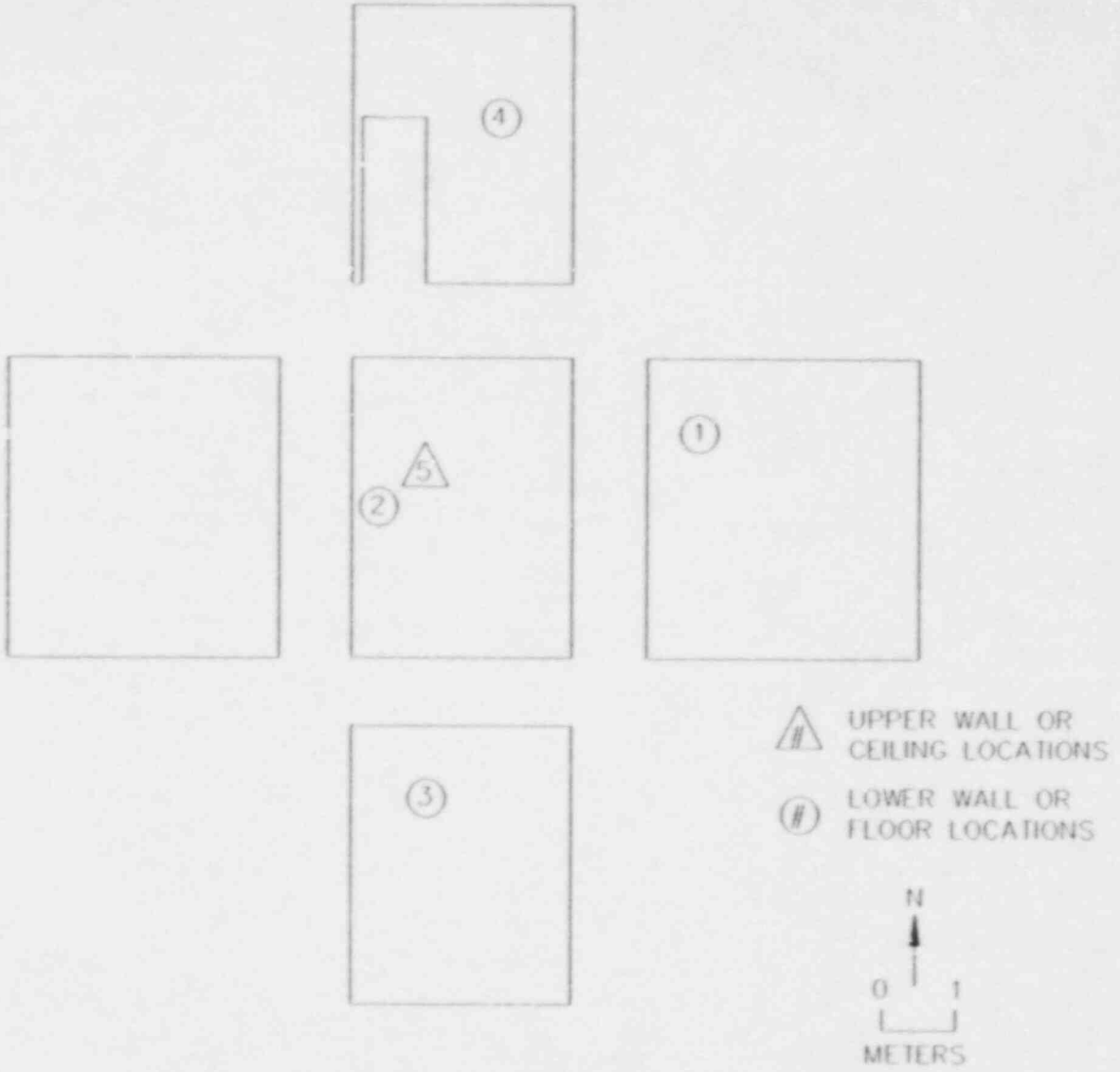

FIGURE 53: Room 01 Showing Locations of Single-point Measurement

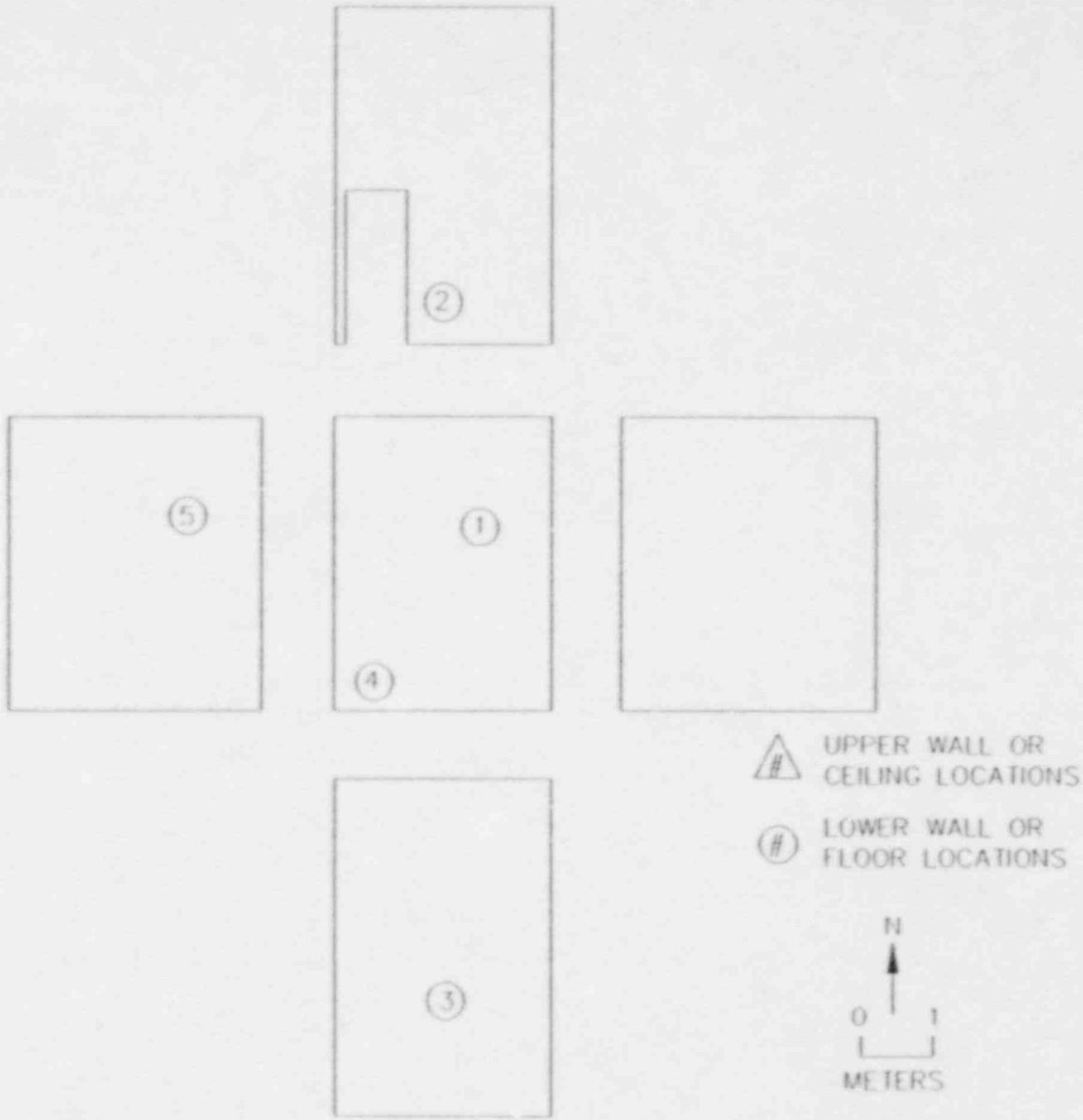

FIGURE 54: Room 02 Showing Locations of Single-point Measurements

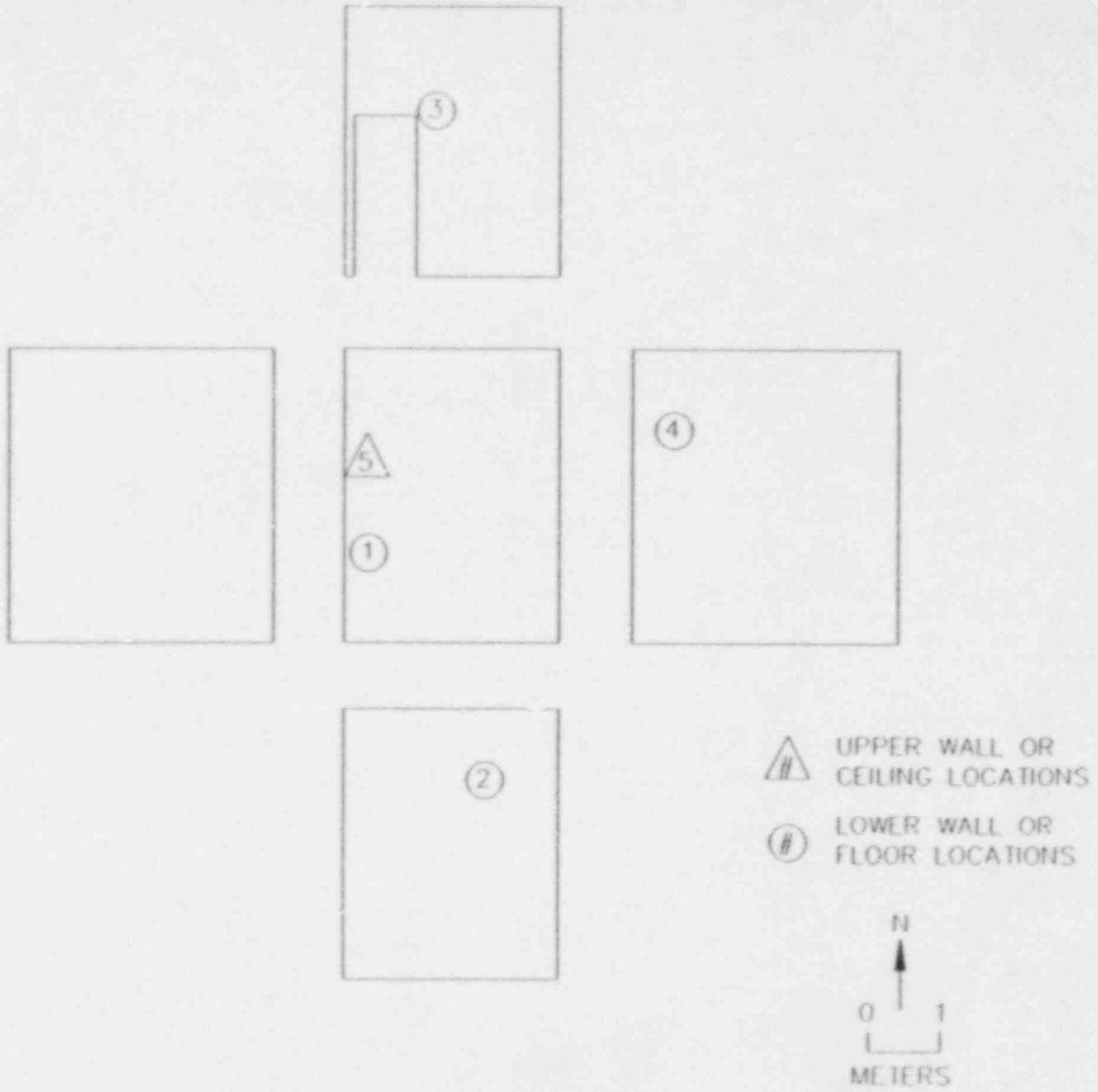

FIGURE 55: Room 03 Showing Locations of Single-point Measurements

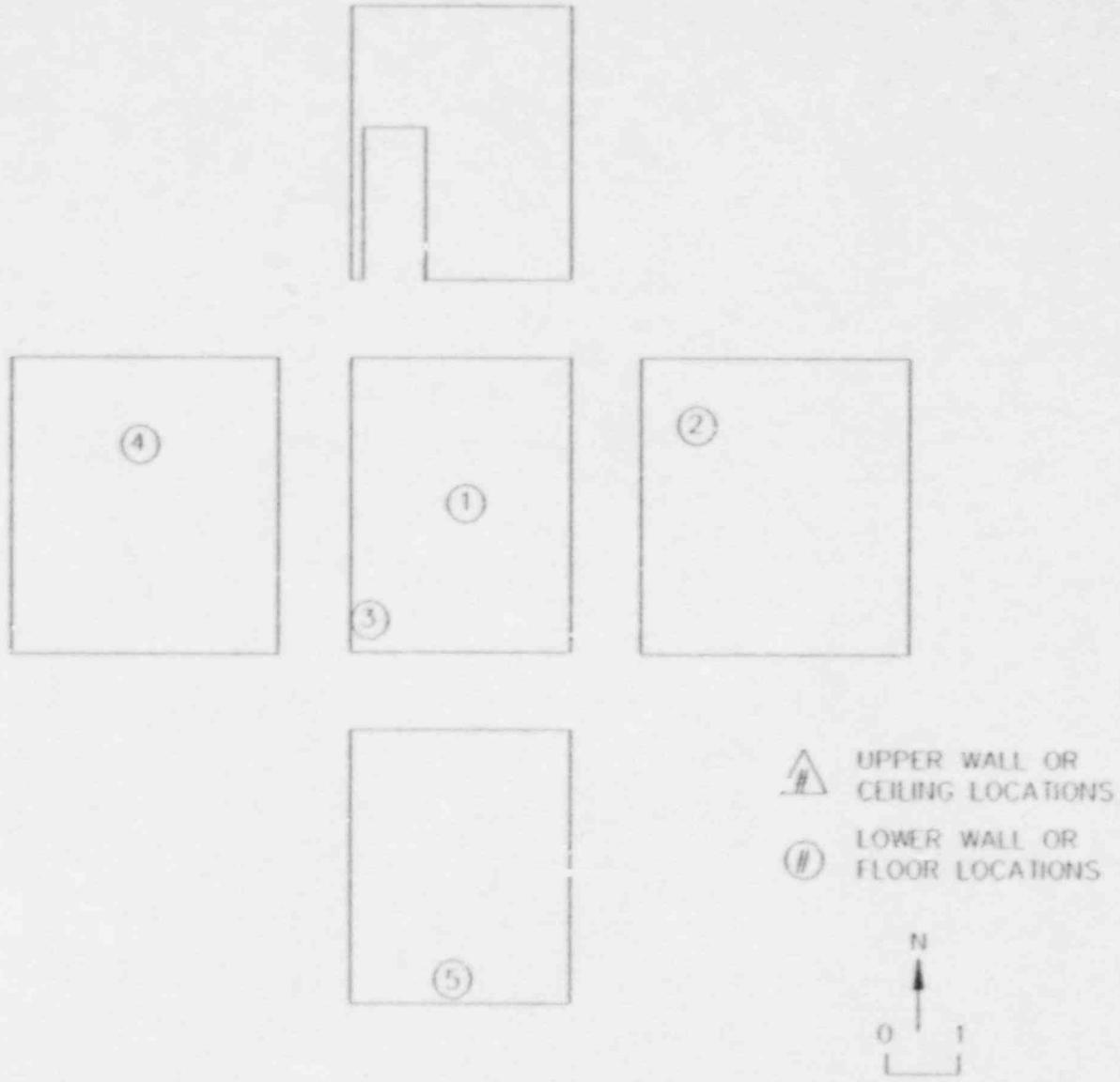

FIGURE 56: Room 04 Showing Locations of Single-point Measurements

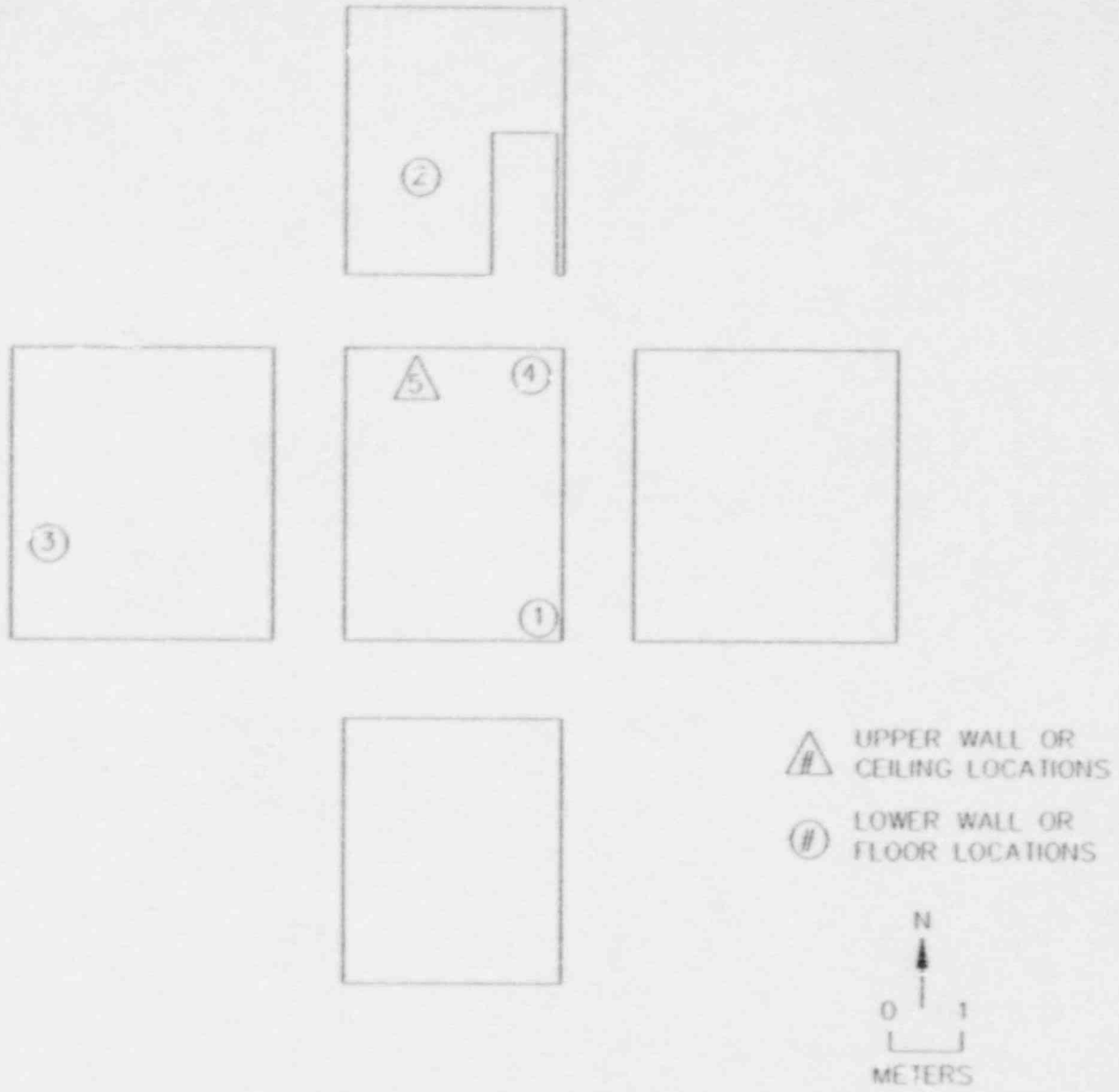

FIGURE 57: Room 05 Showing Locations of Single-point Measurements

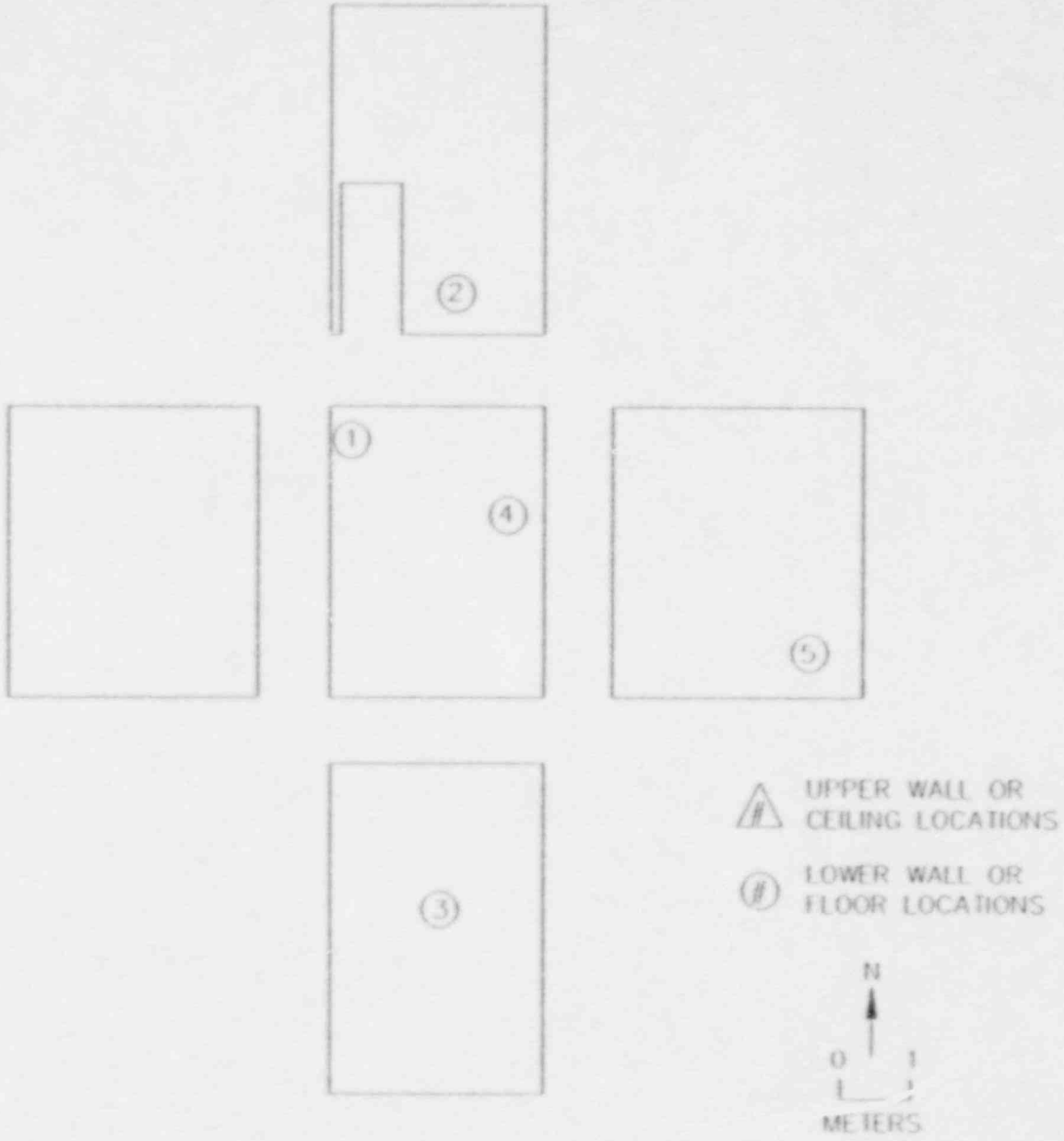

FIGURE 58: Room 06 Showing Locations of Single-point Measurements

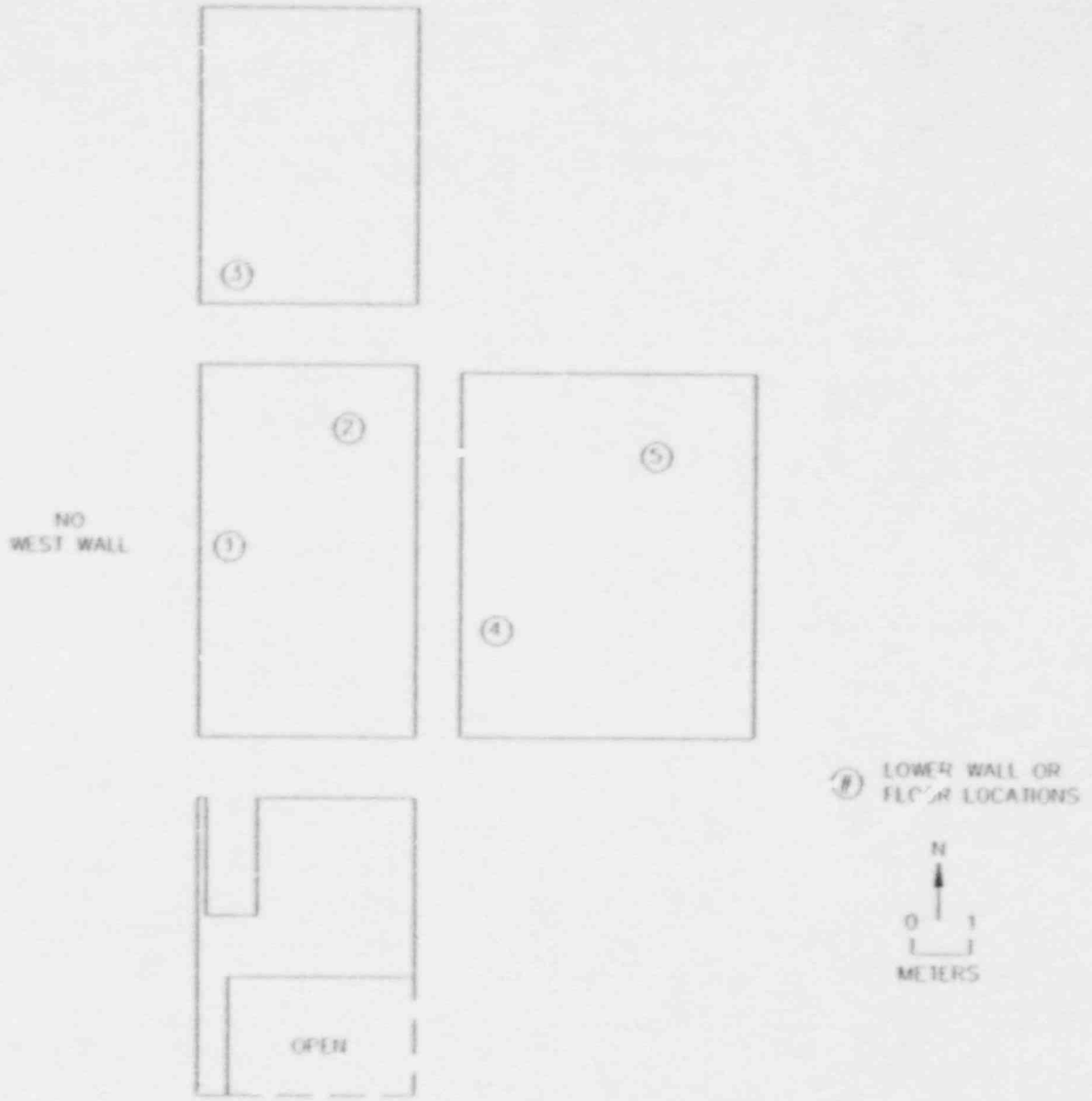

FIGURE 59: Room 25 Showing Locations of Single-point Measurements

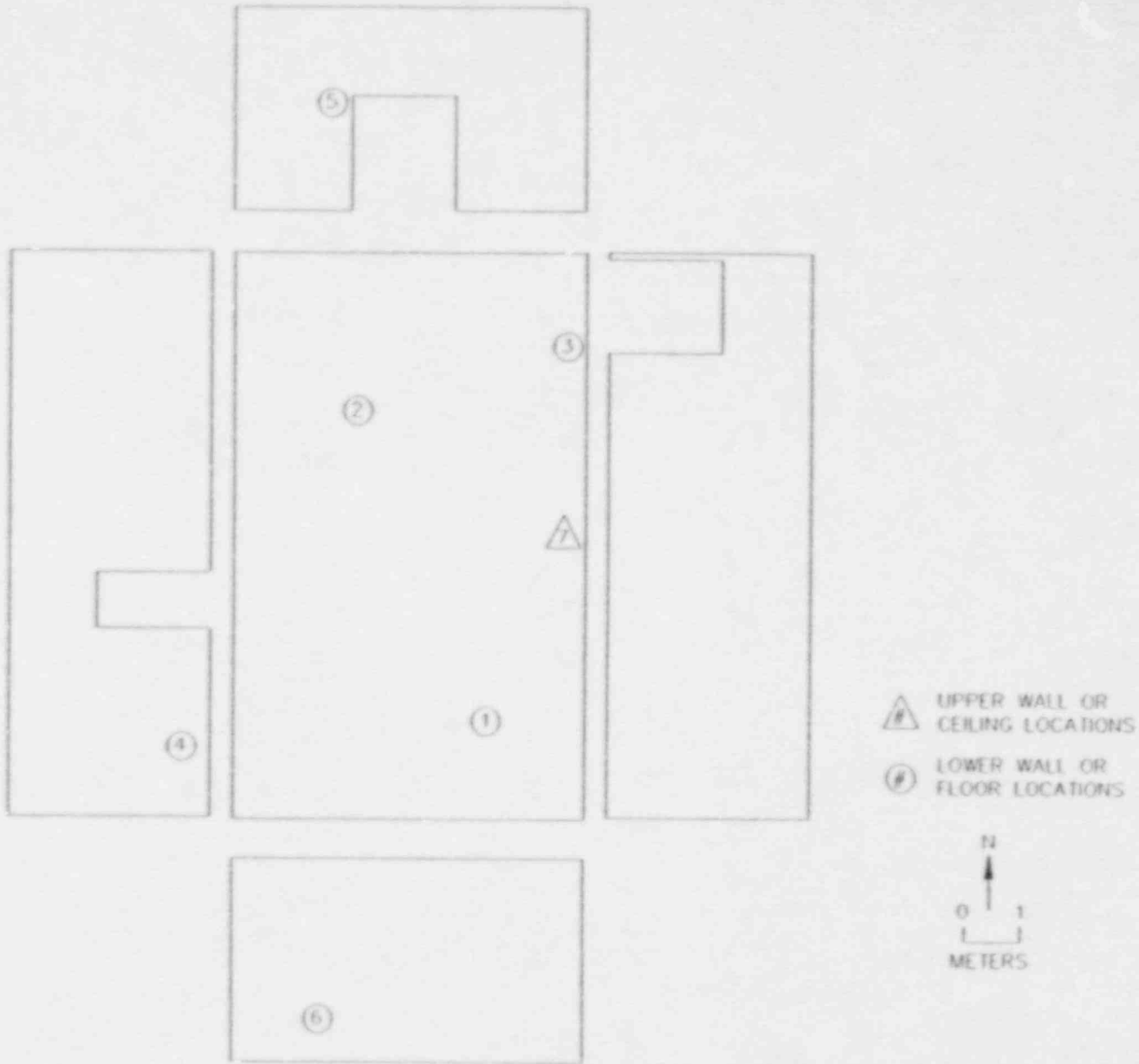

FIGURE 60: Room 44 Showing Locations of Single-point Measurements

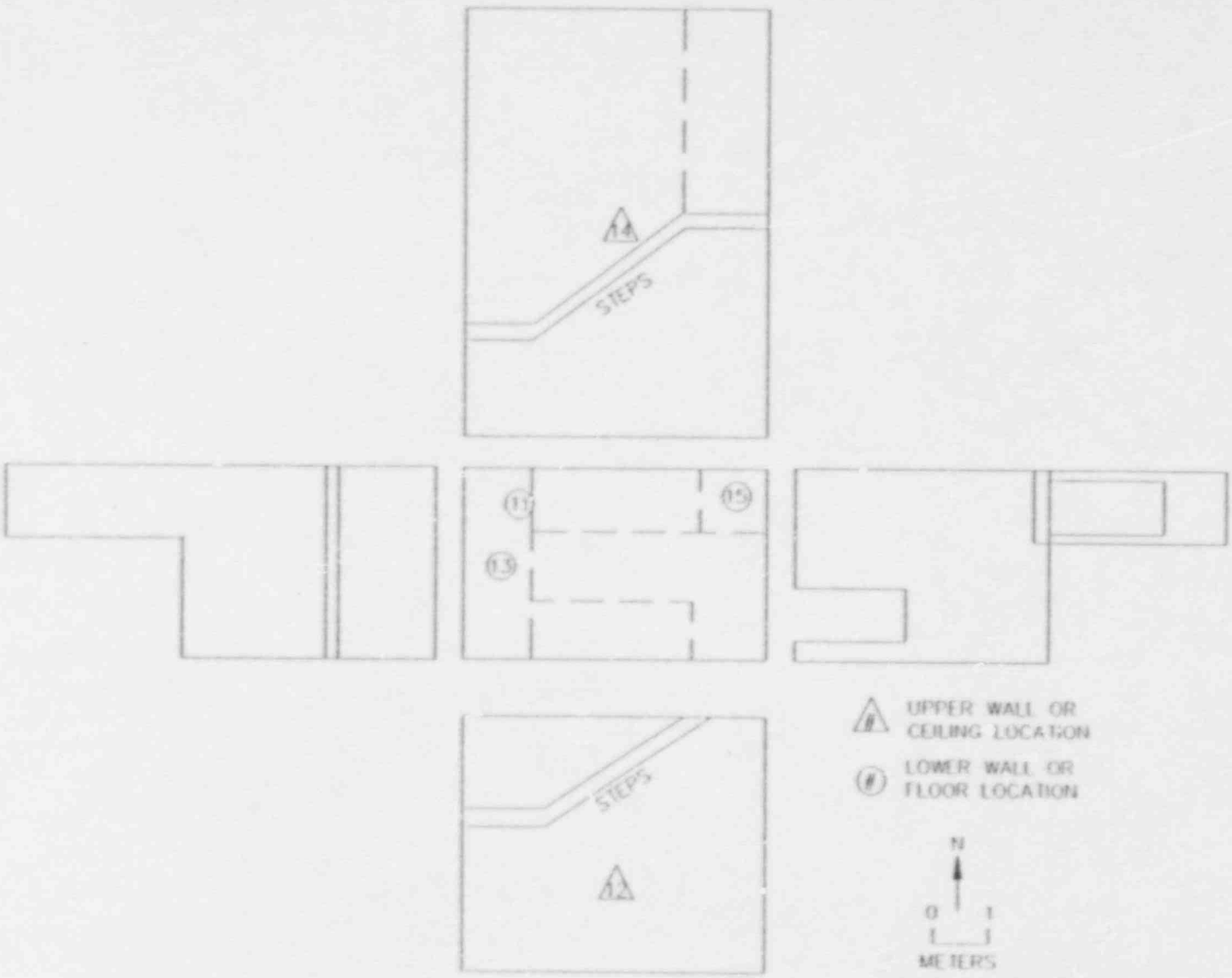

FIGURE 61: Room 32 Showing Locations of Single-point Measurements

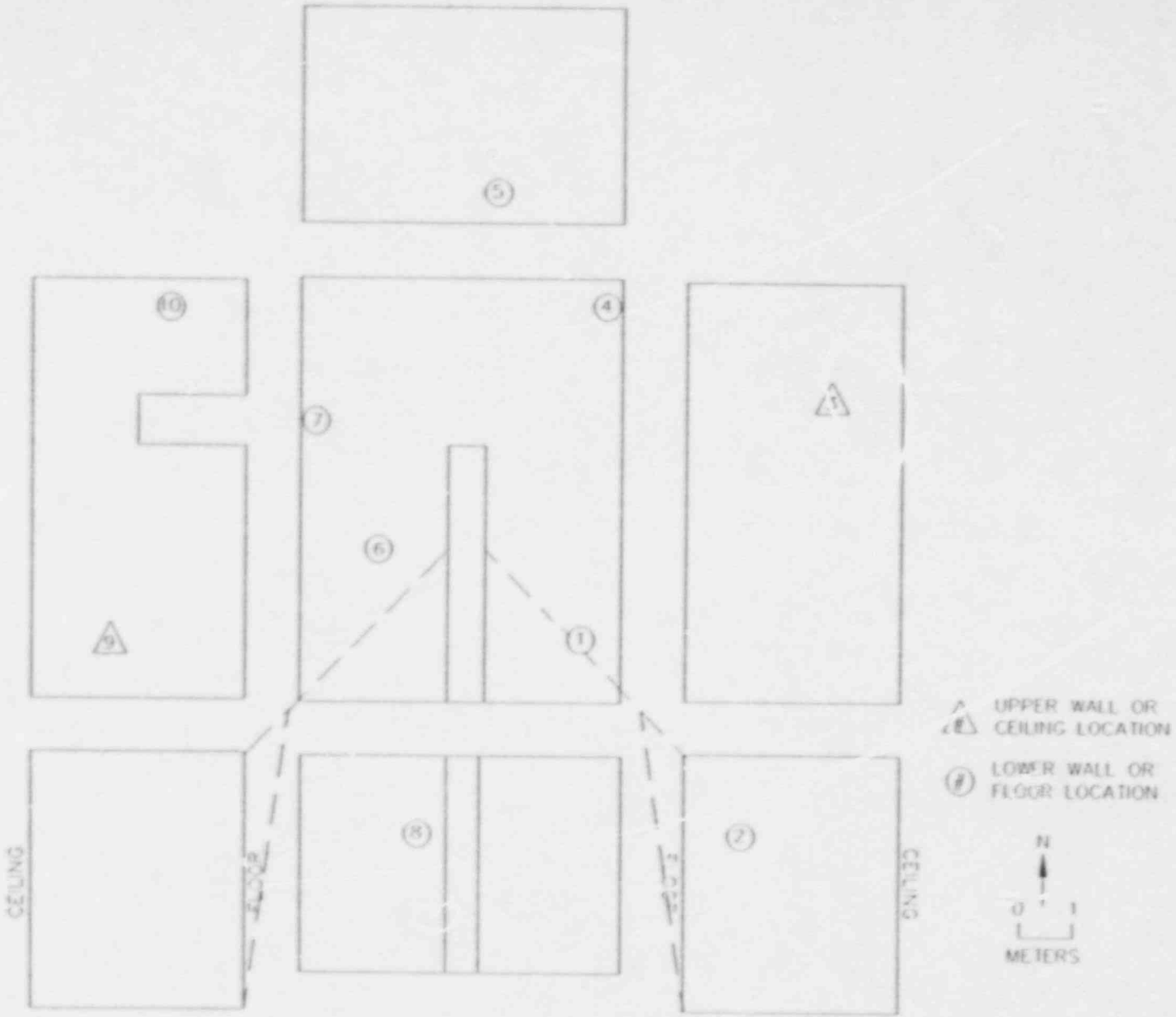

FIGURE 62: Rooms 53 and 54 Showing Locations of Single-point Measurements

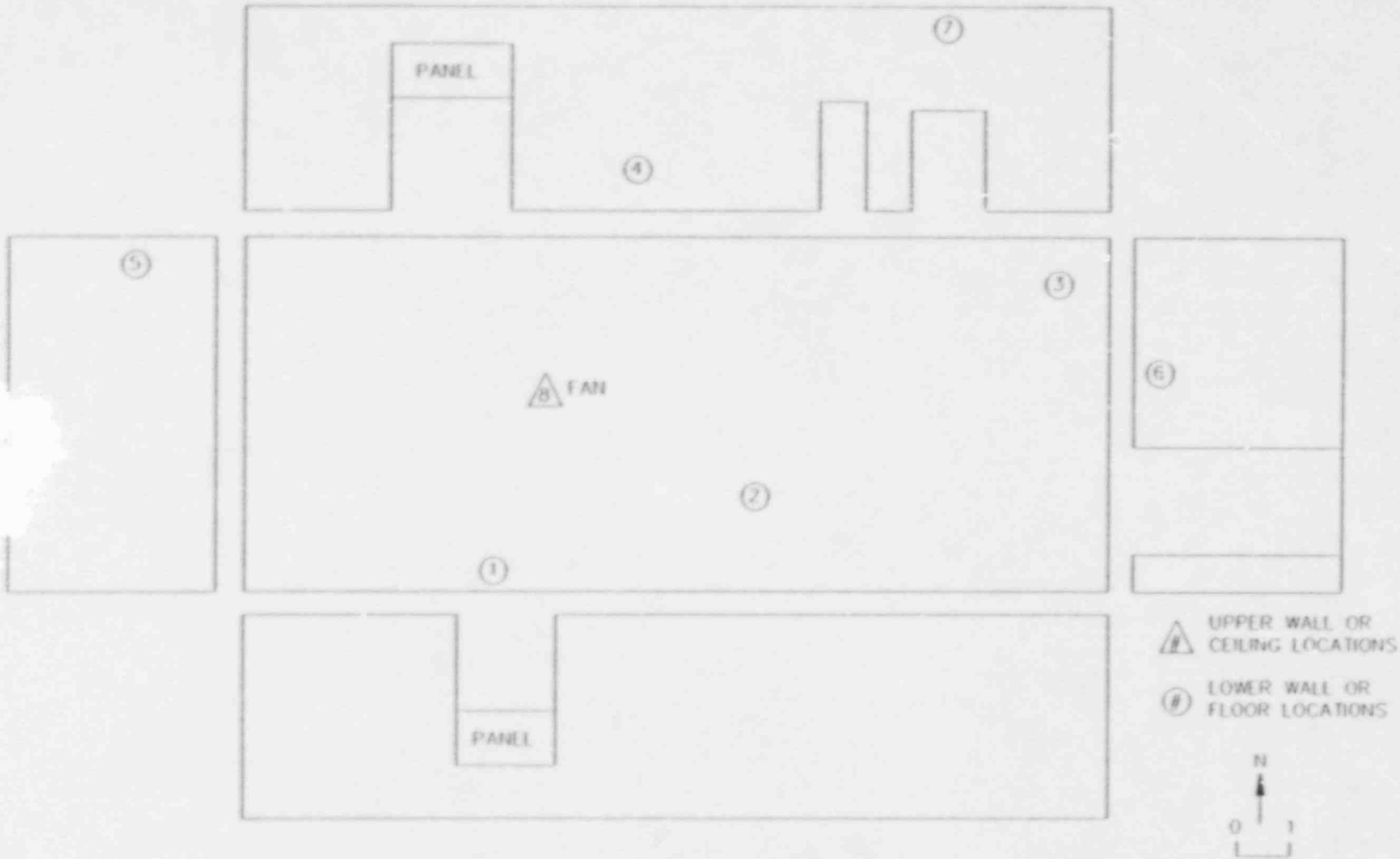

FIGURE 63: Ceramic Lab Showing Locations of Single-point Measurements

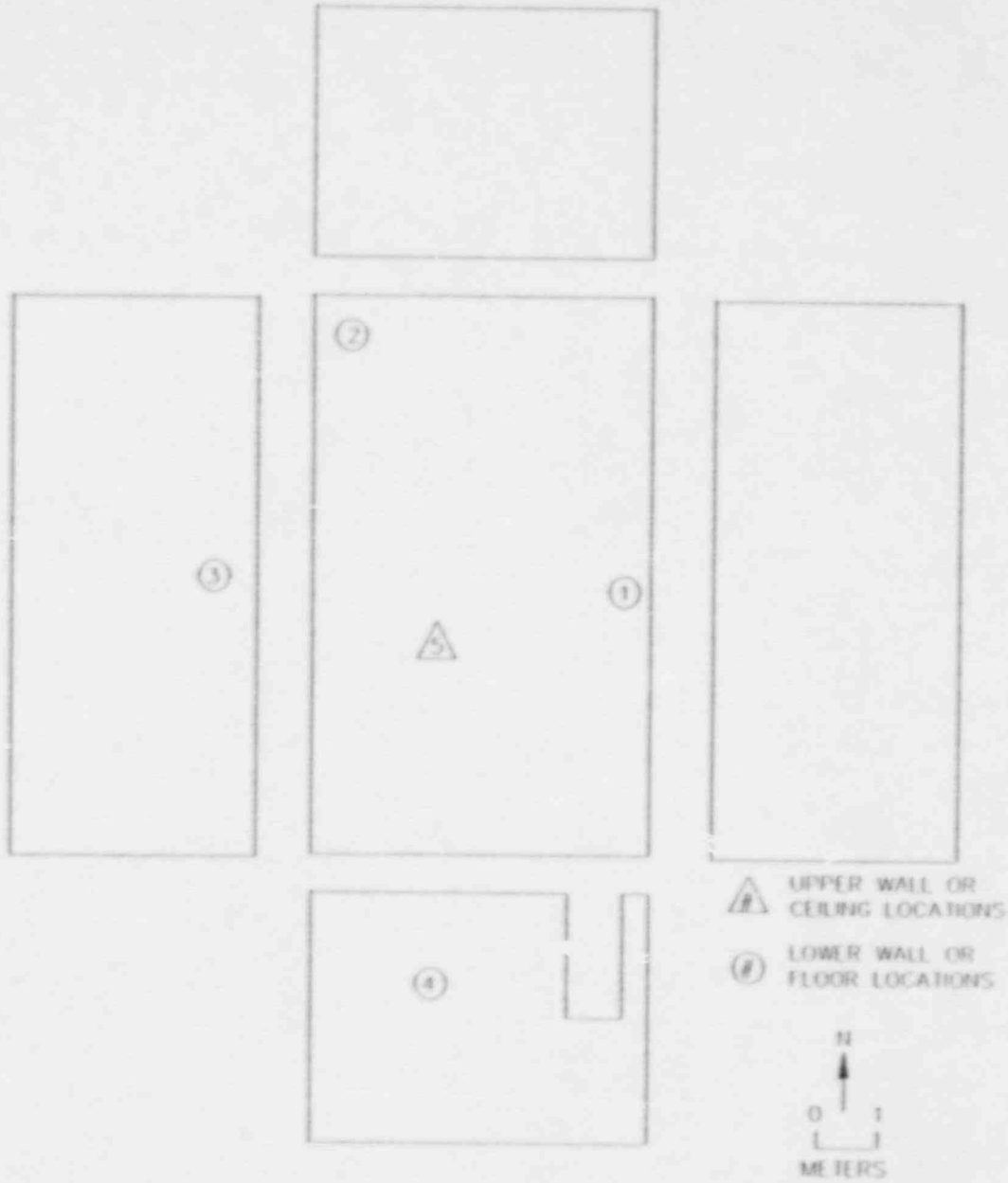

FIGURE 64: an Room Showing Locations of Single-point Measurement

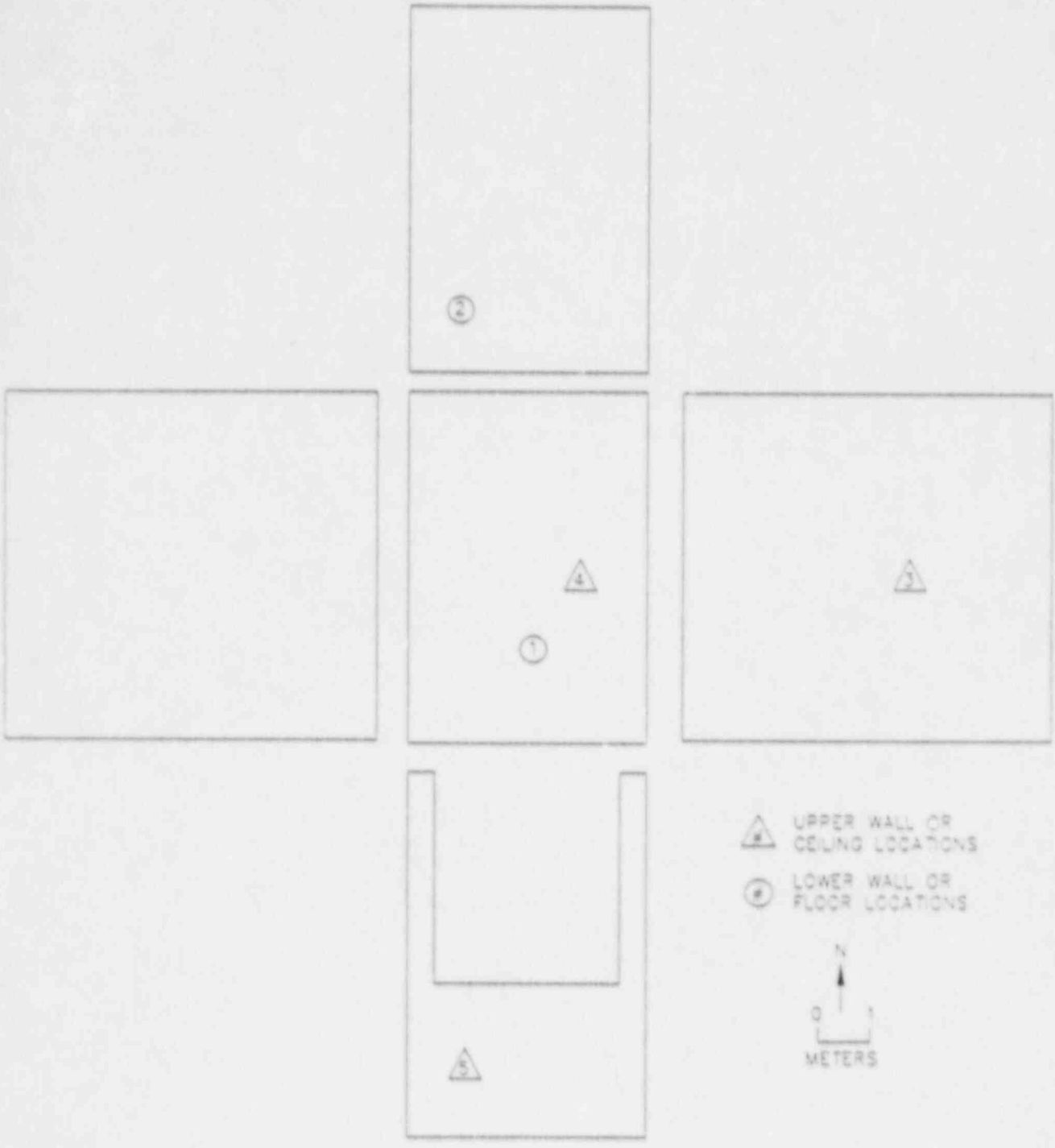

FIGURE 65: Fire Equipment Room Showing Locations of Single-point Measurements

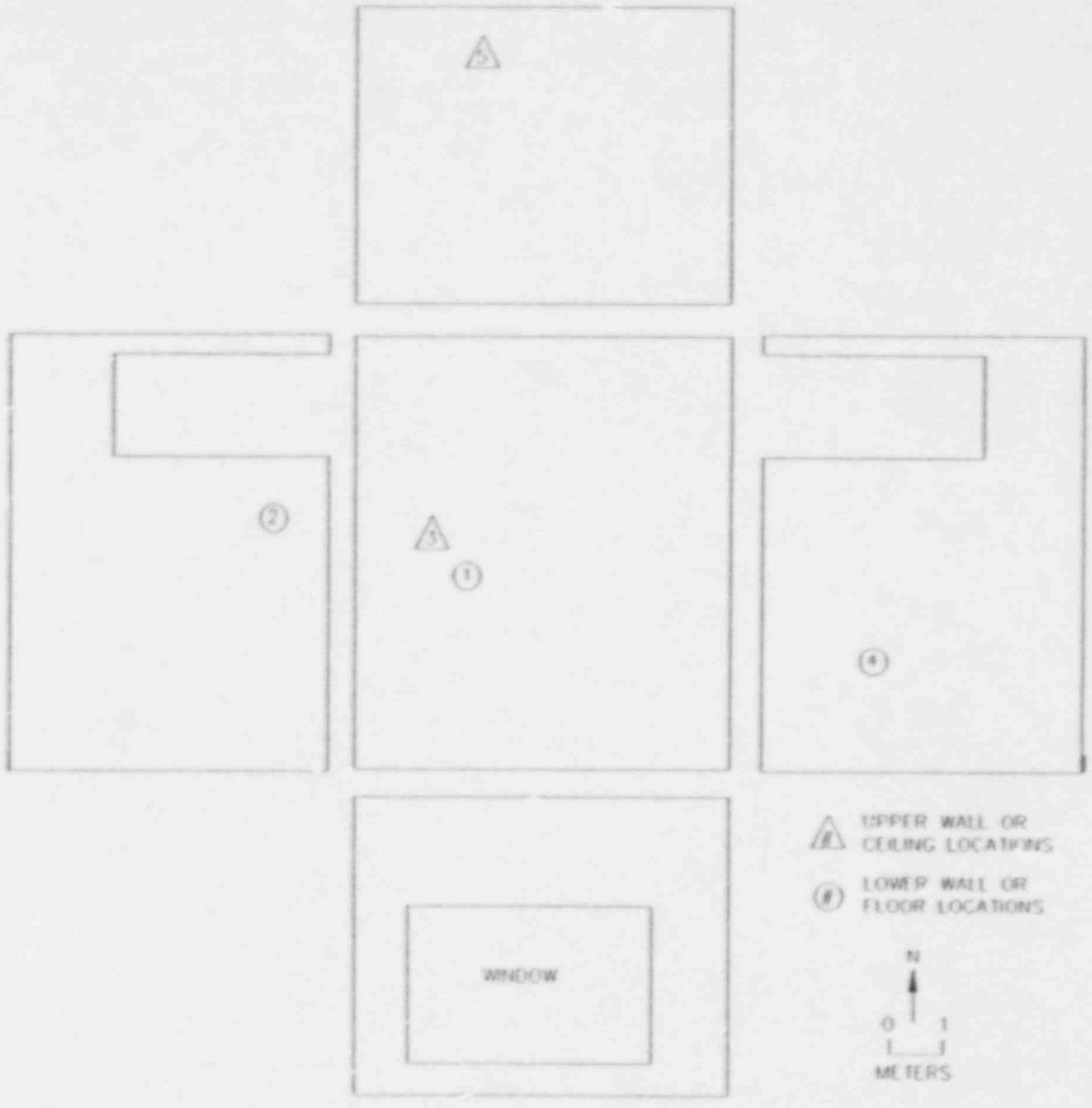

FIGURE 66: HP Lab Showing Locations of Single-point Measurements

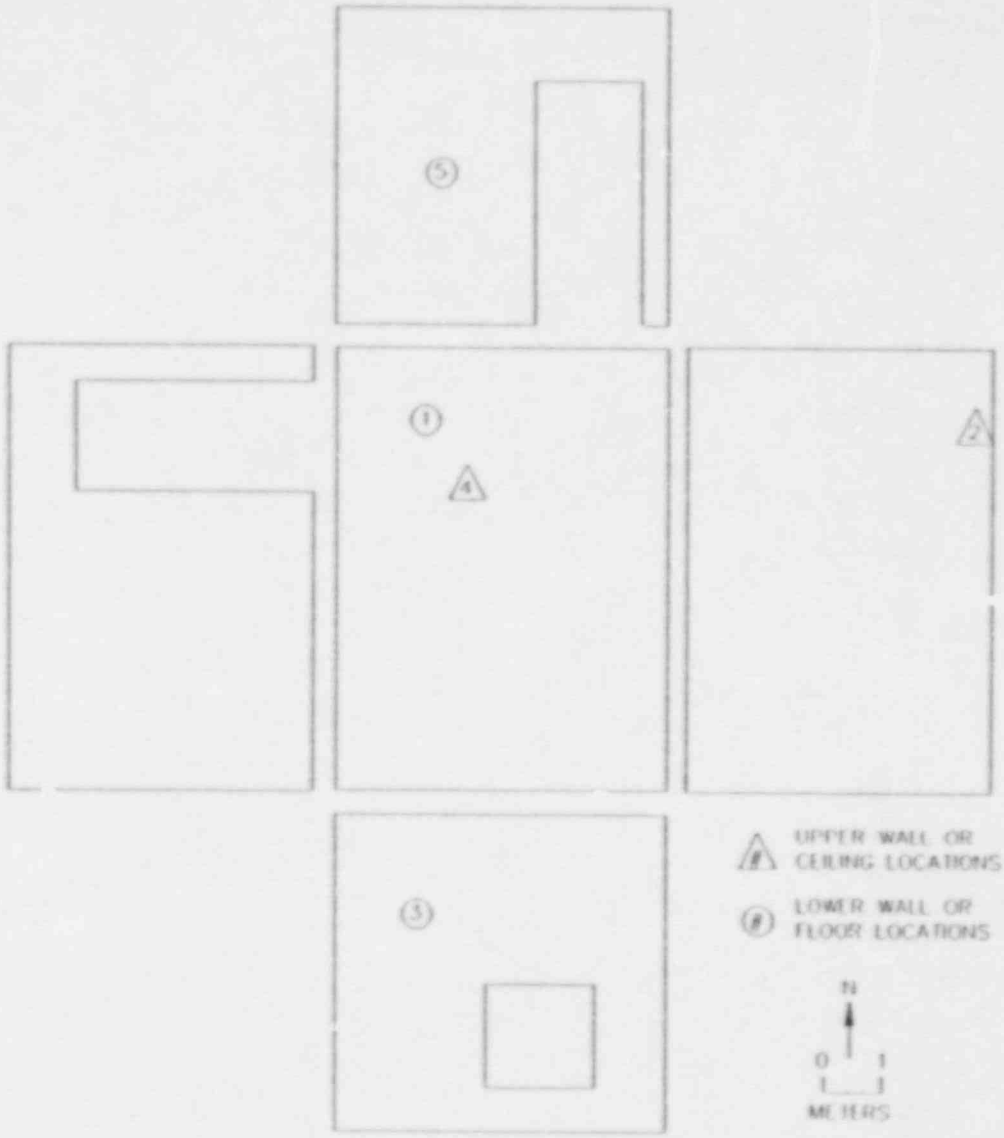

FIGURE 67: HP Office Showing Locations of Single-point Measurements

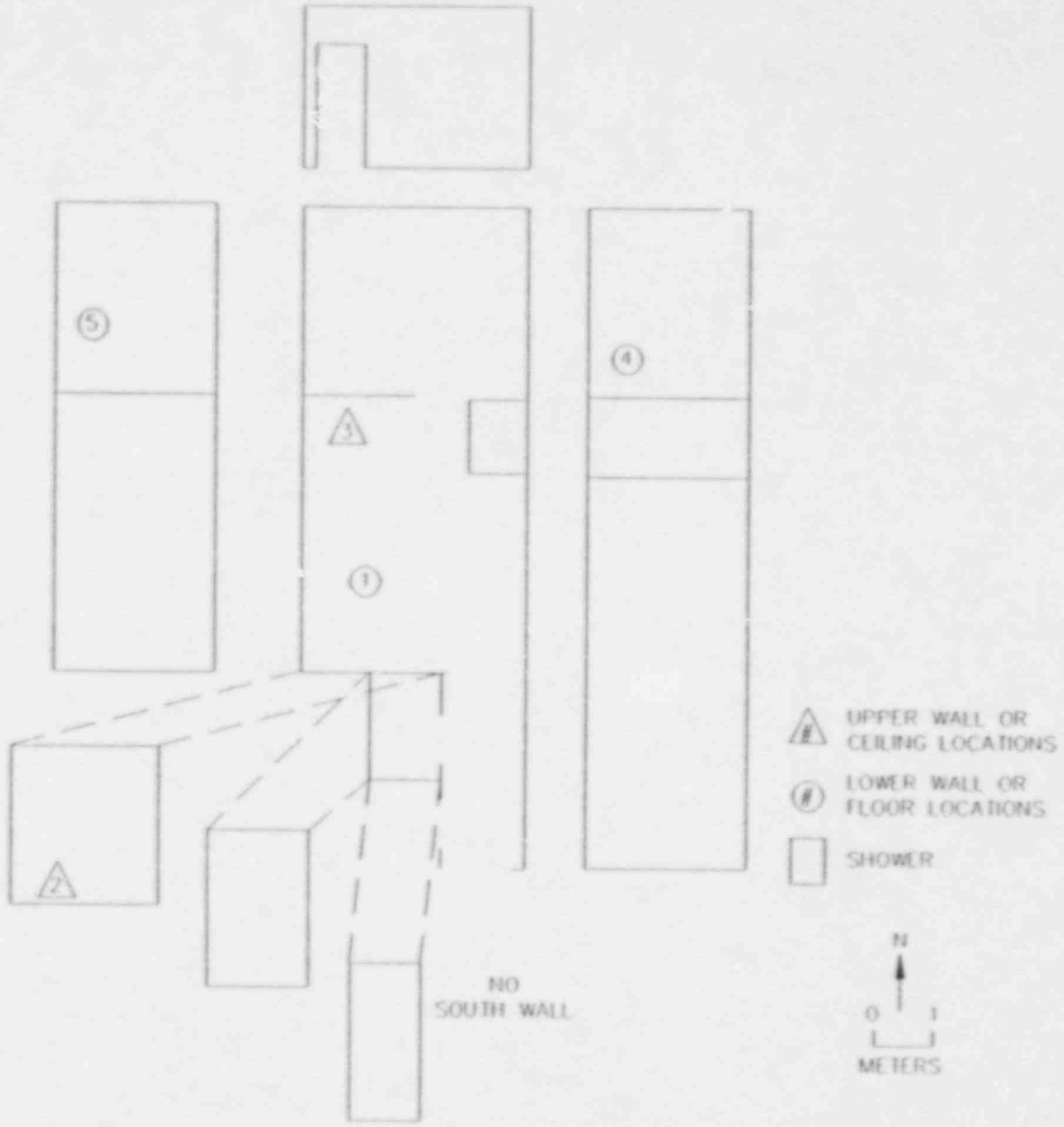

FIGURE 68: Ladies Change Room Showing Locations of Single-point Measurements

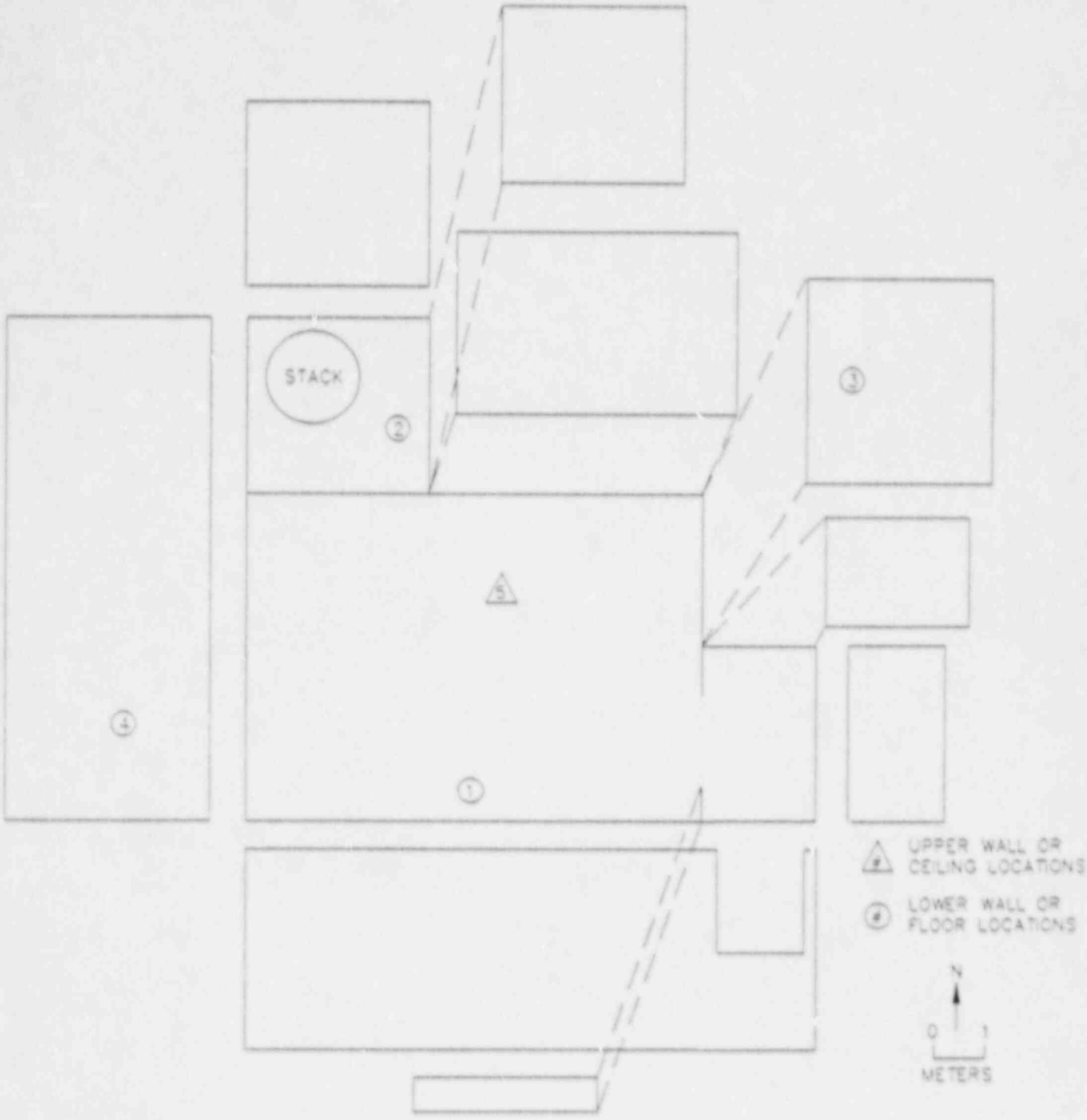

FIGURE 69: Laundry Room Showing Locations of Single-point Measurements

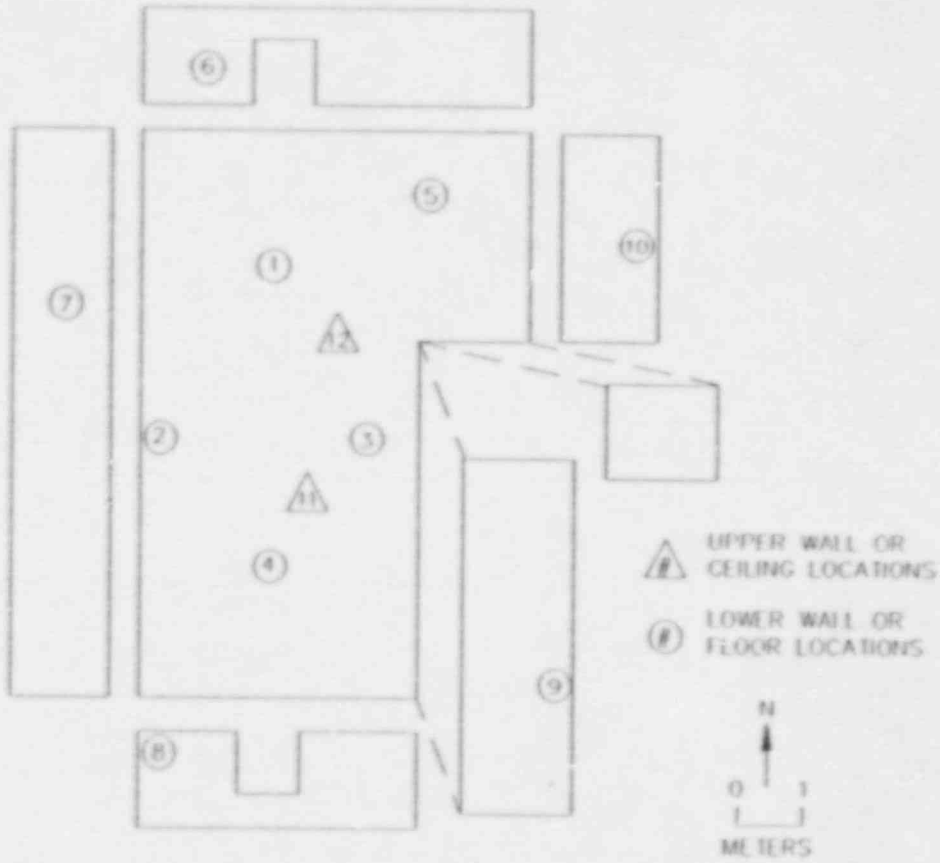

FIGURE 70: Machine Shop Showing Locations of Single-point Measurements

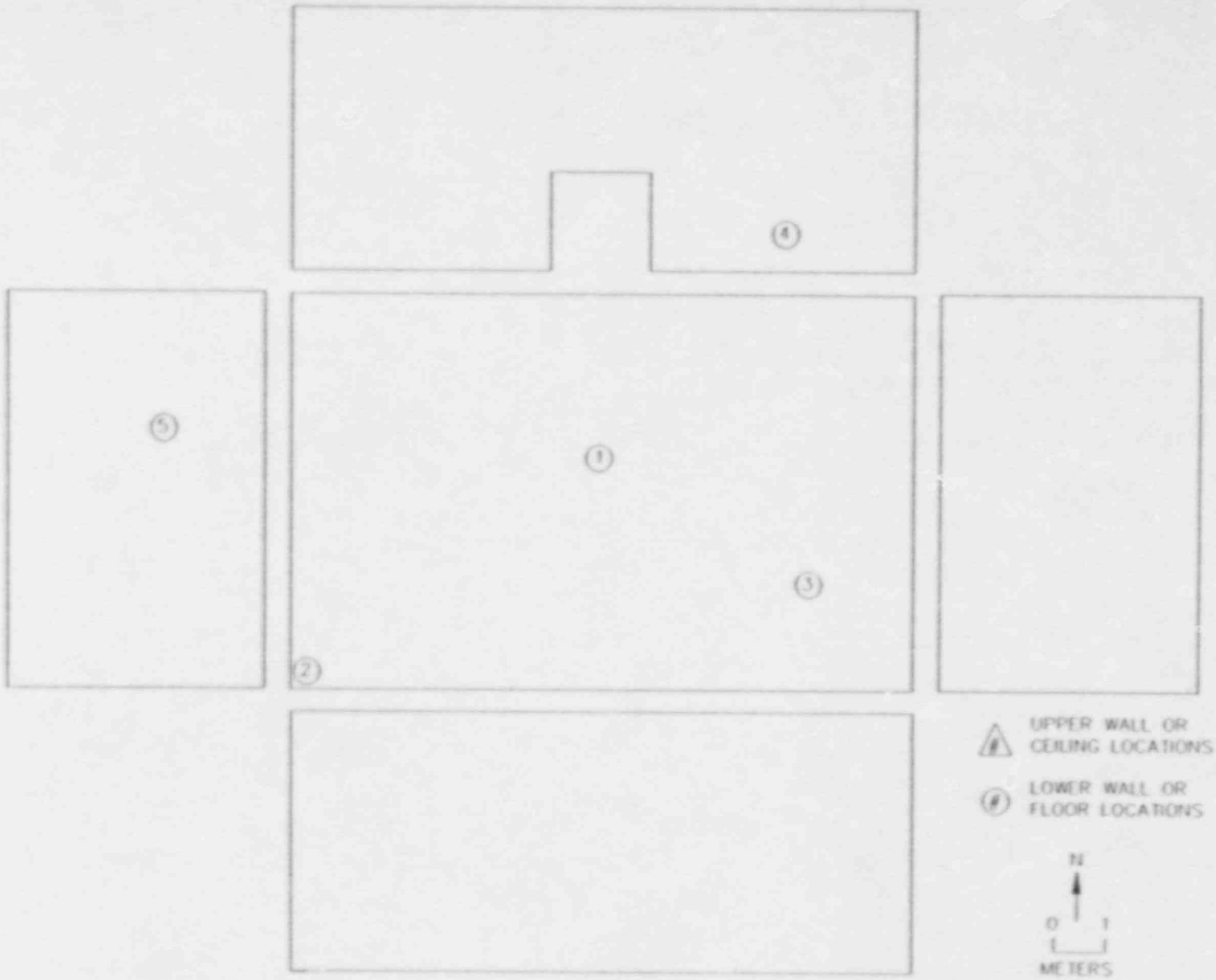

FIGURE 71: Mechanical Equipment Room Showing Locations of Single-point Measurements

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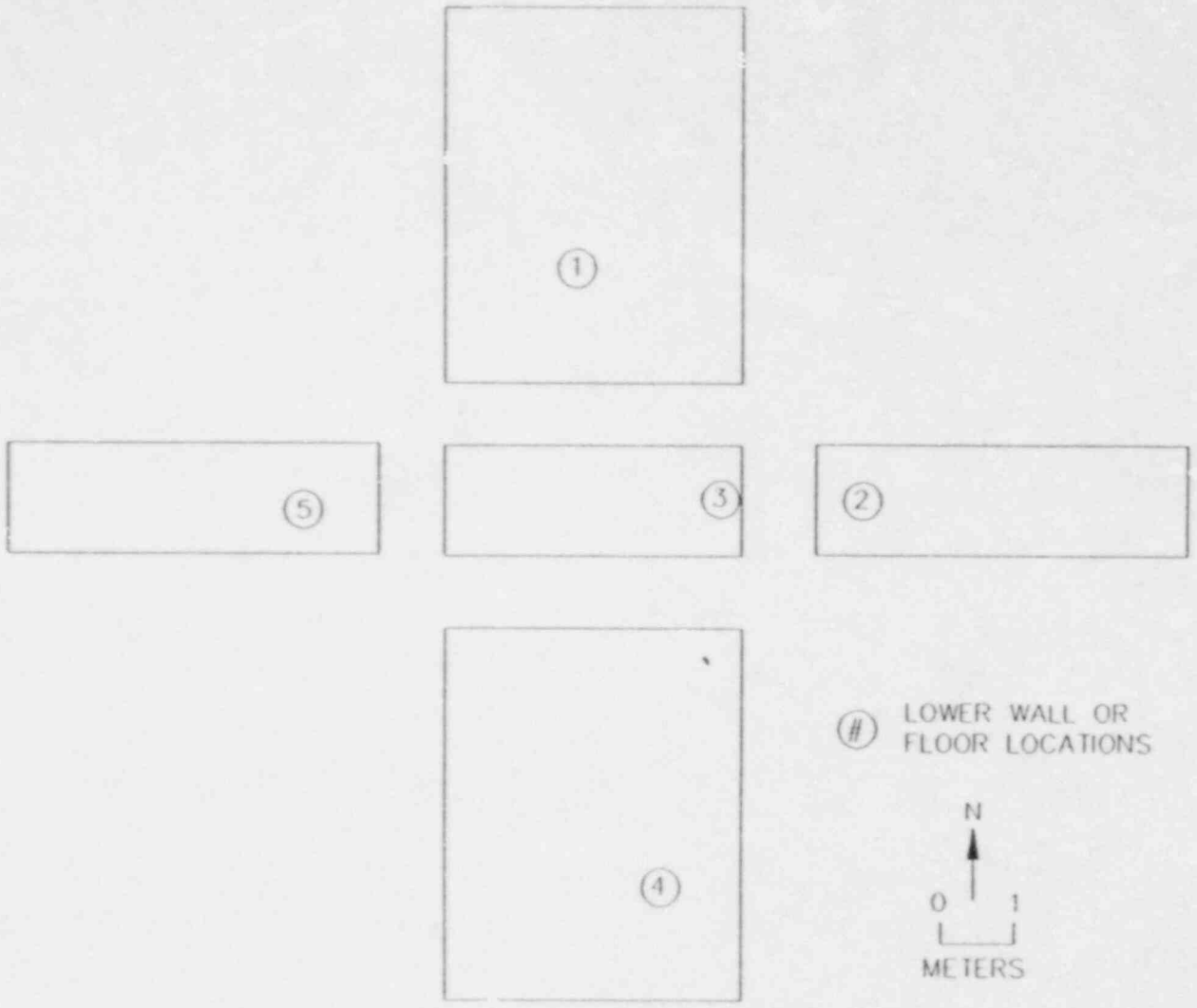


FIGURE 72: Pit (Basement Area) Showing Locations of Single-point Measurements

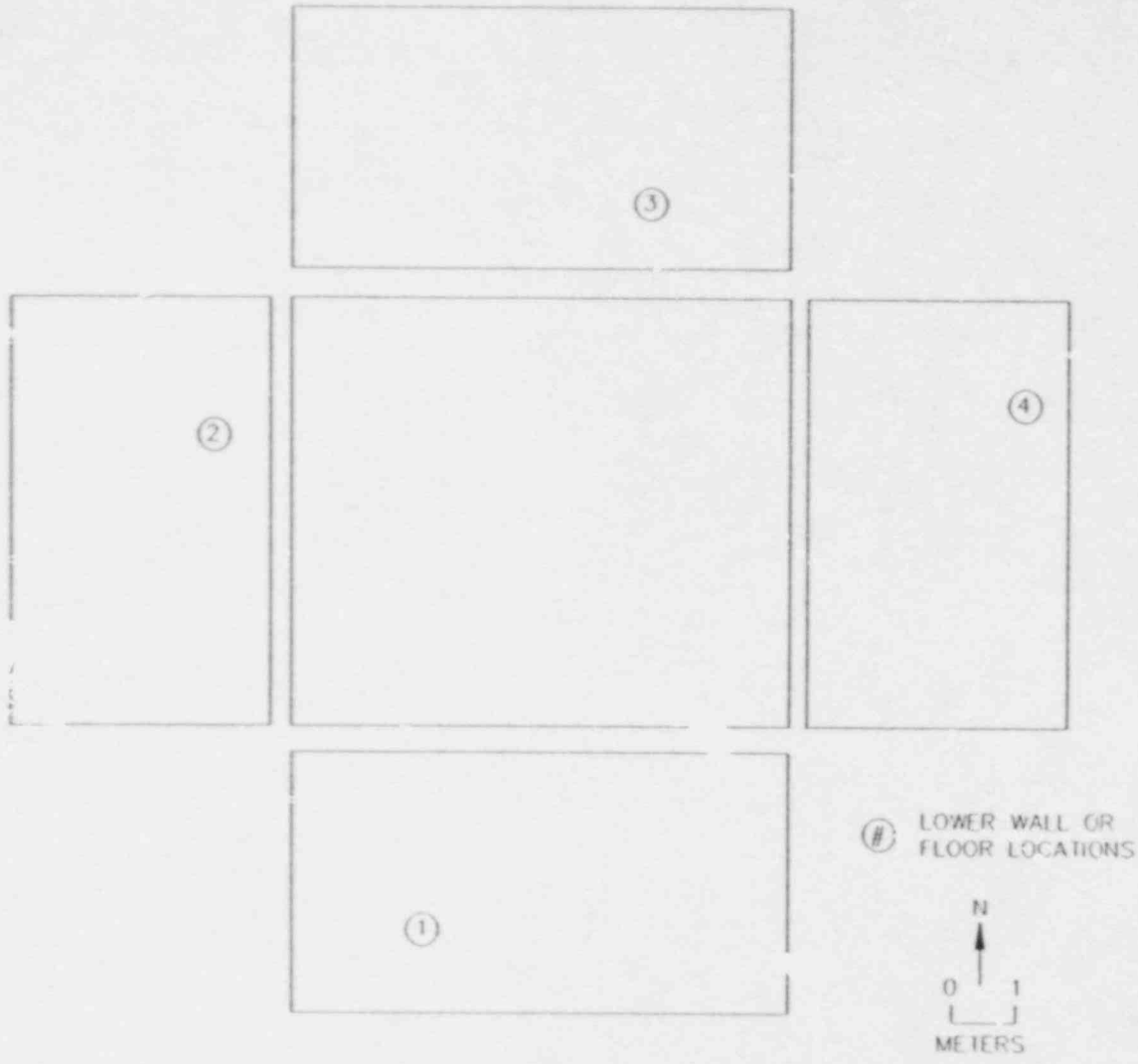


FIGURE 73: Penthouse (Above Room 22) Showing Locations of Single-point Measurements

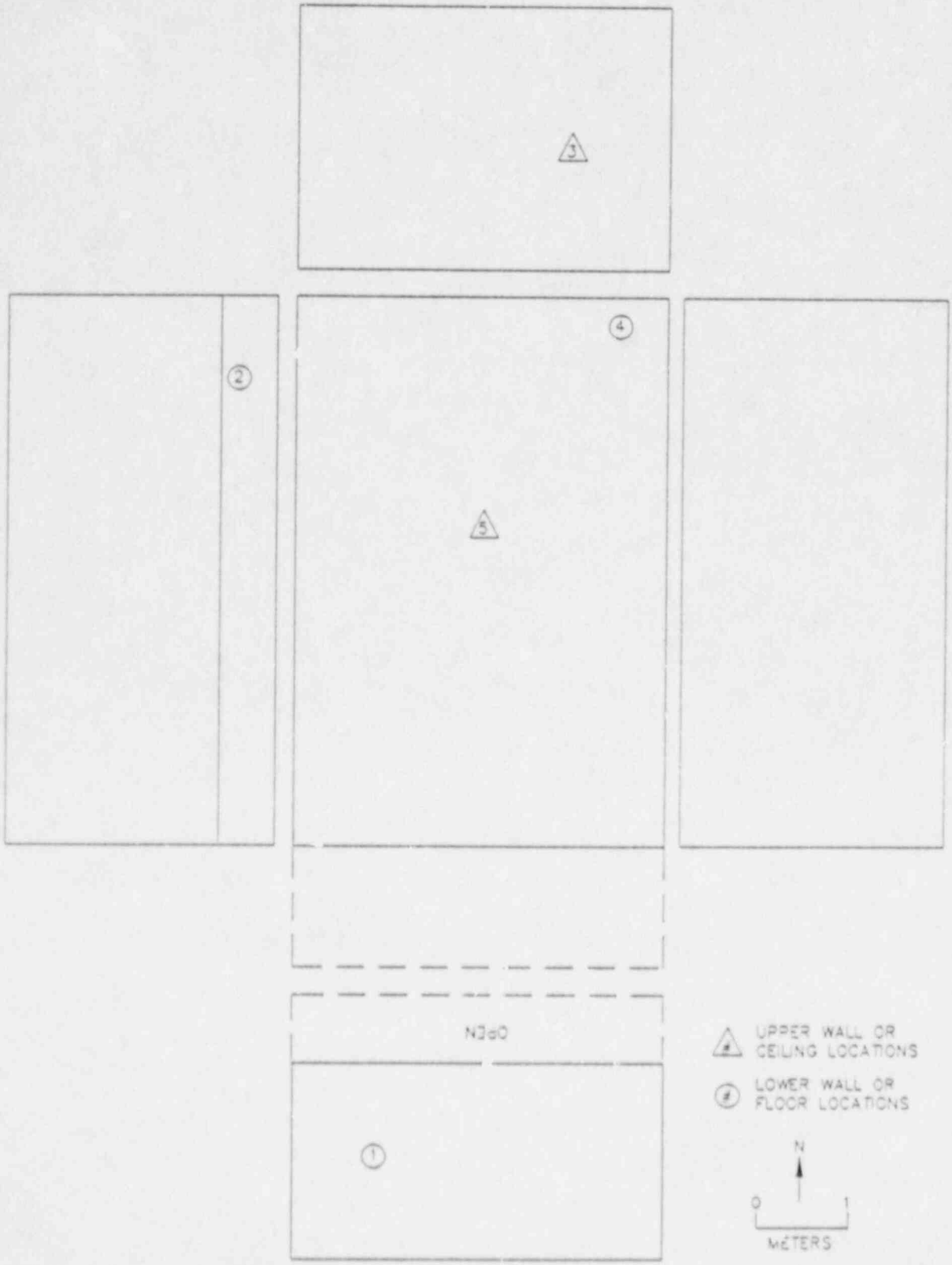


FIGURE 74: Penthouse (Above Ladies' Change Room) Showing Locations of Single-point Measurements

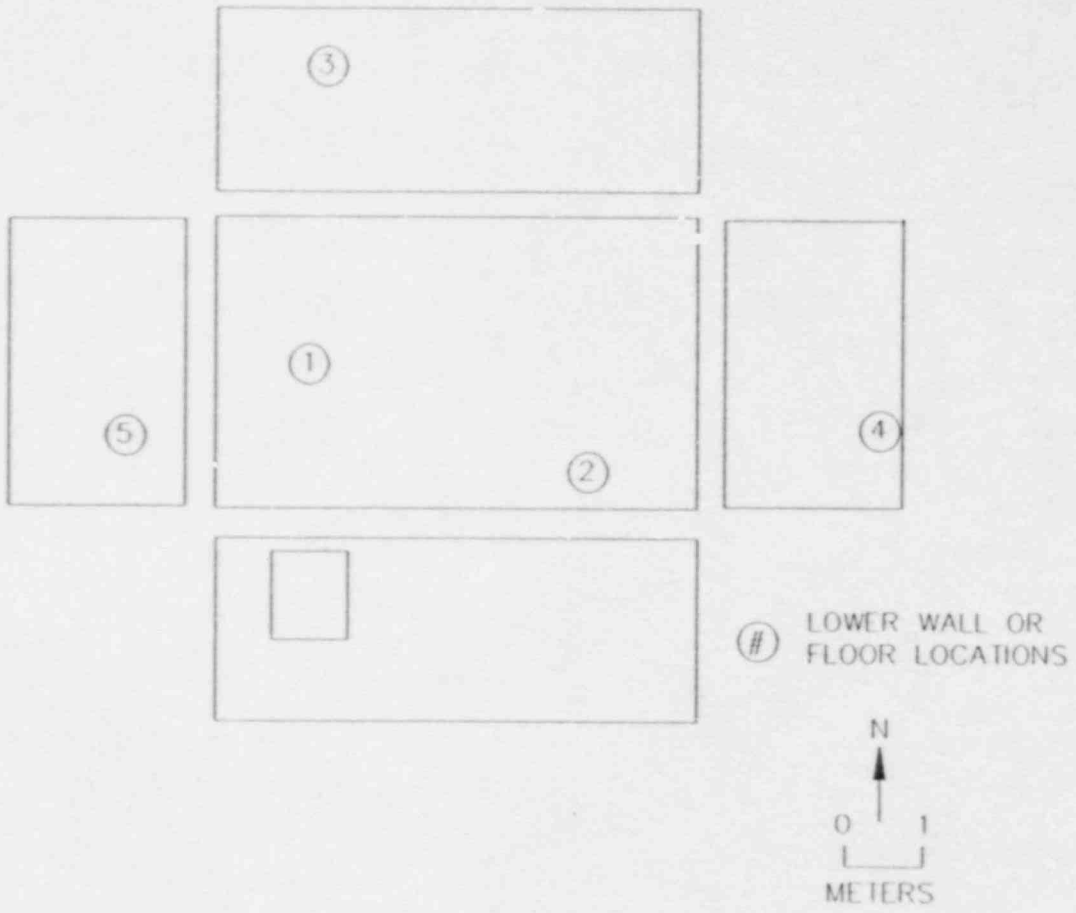


FIGURE 75: Penthouse (Above Vault) Showing Locations of Single-point Measurements

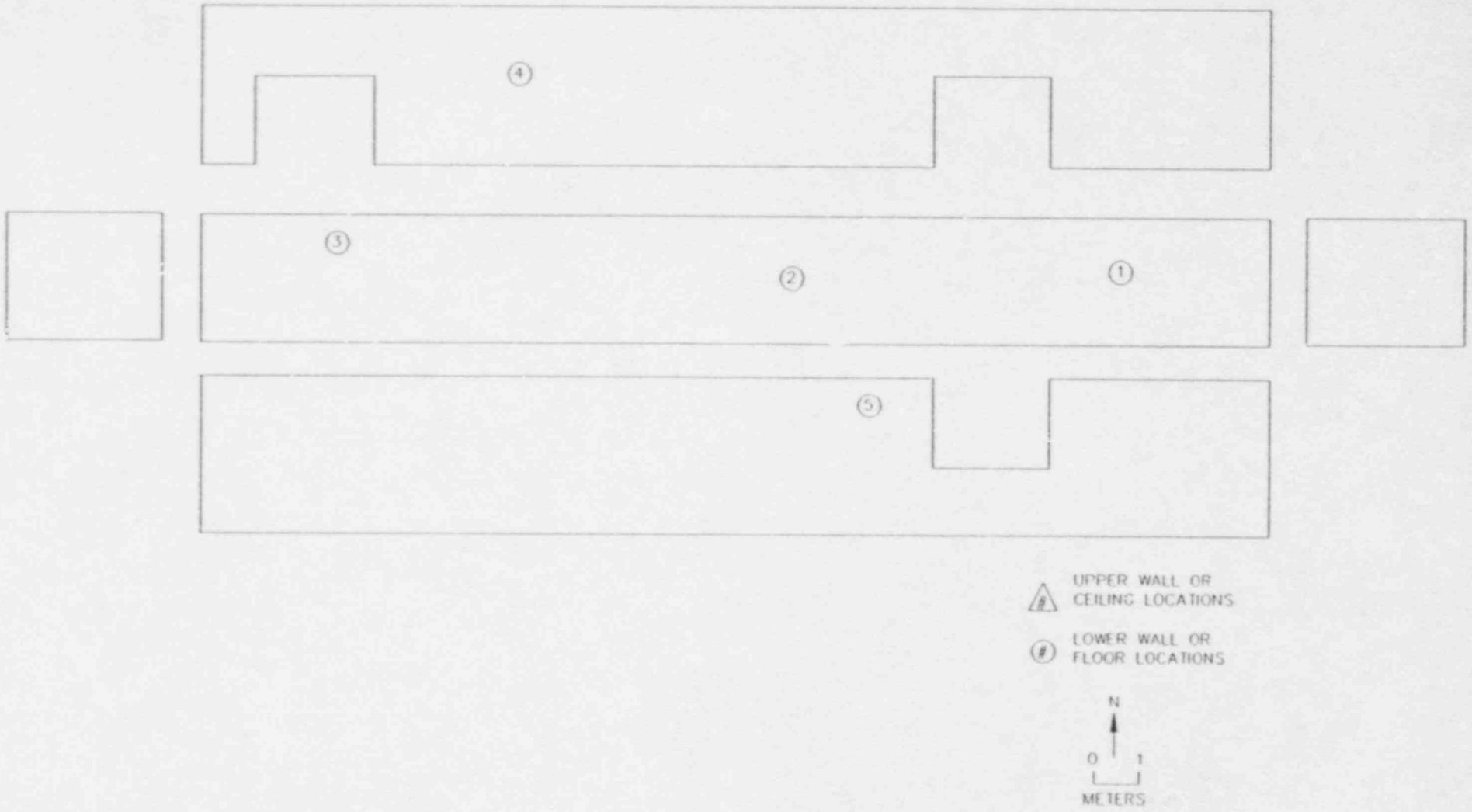


FIGURE 76: Storage Shed Showing Locations of Single-point Measurements

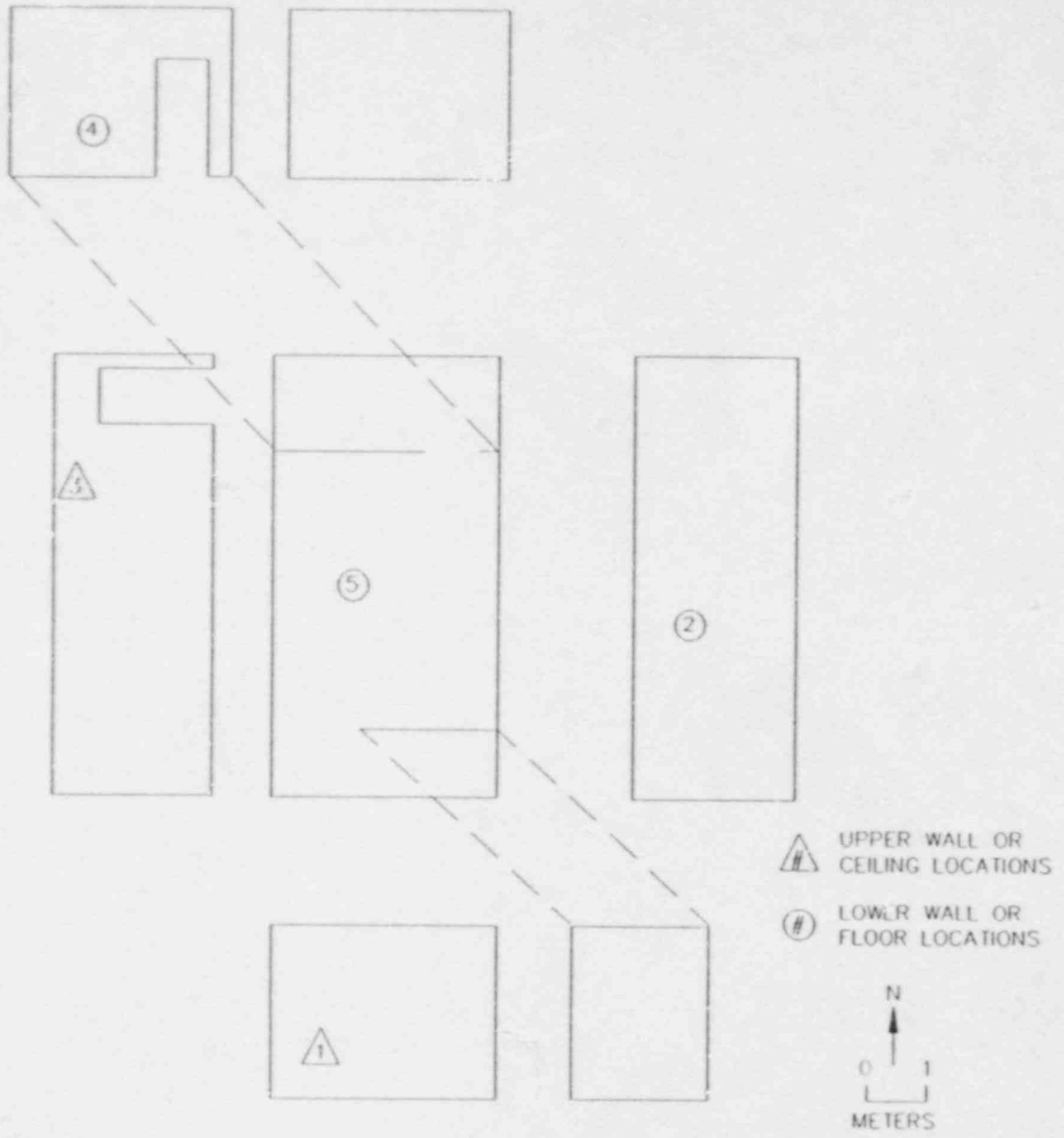


FIGURE 77: Vault Showing Locations of Single-point Measurements

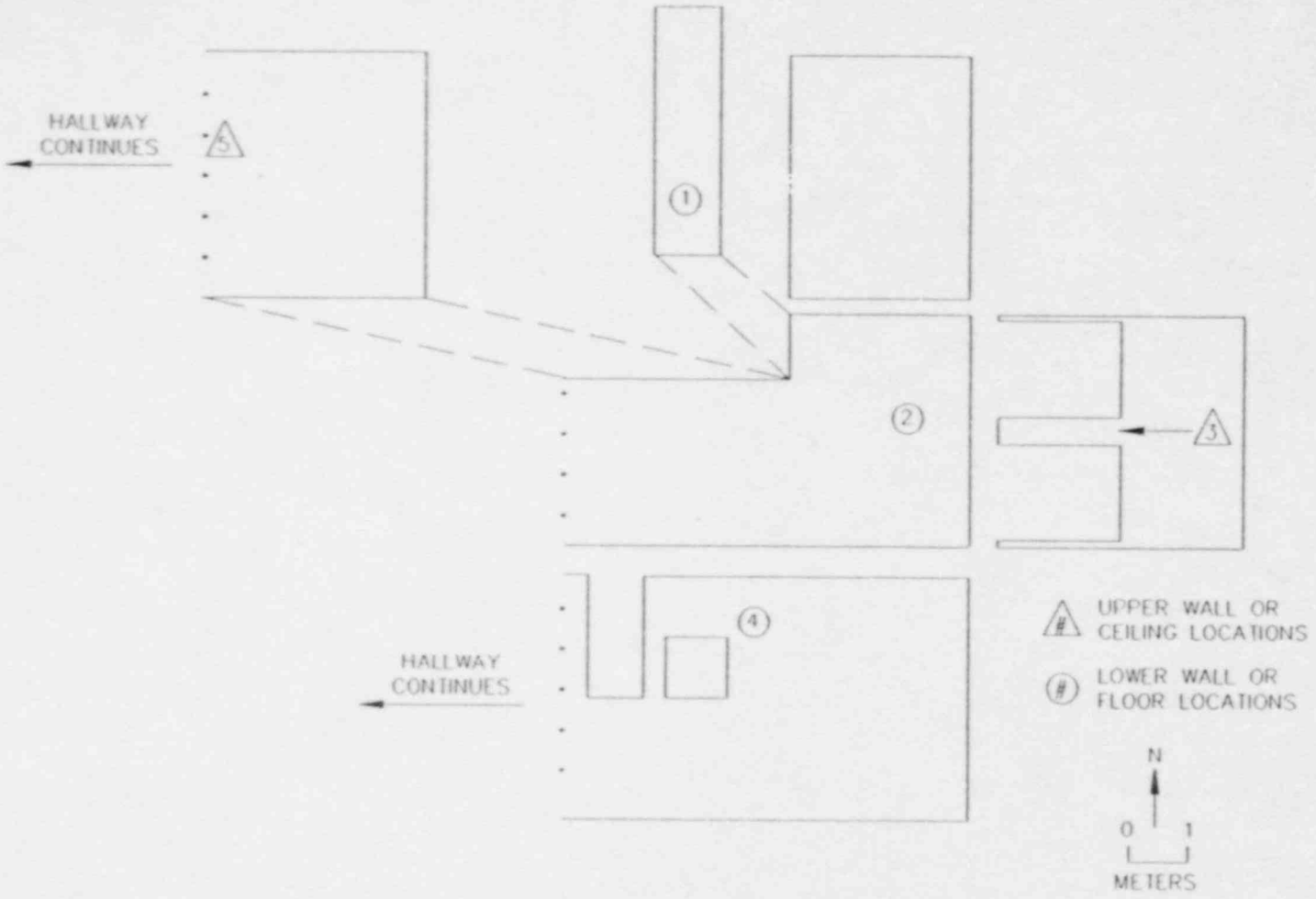


FIGURE 78: Hallway (Area 16N) Showing Locations of Single-point Measurements

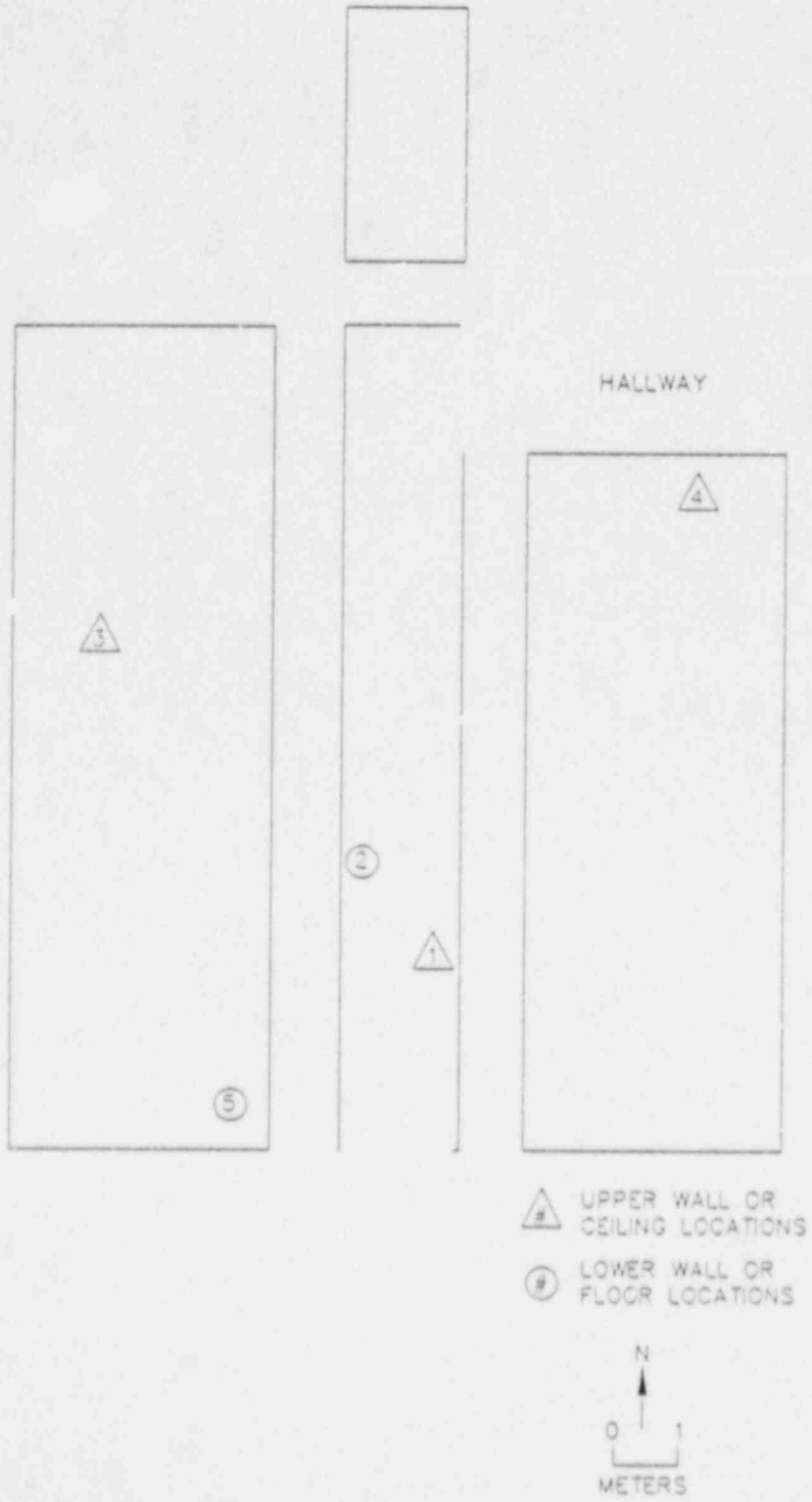


FIGURE 79: Hallway (Area 16W) Showing Locations of Single-point Measurements

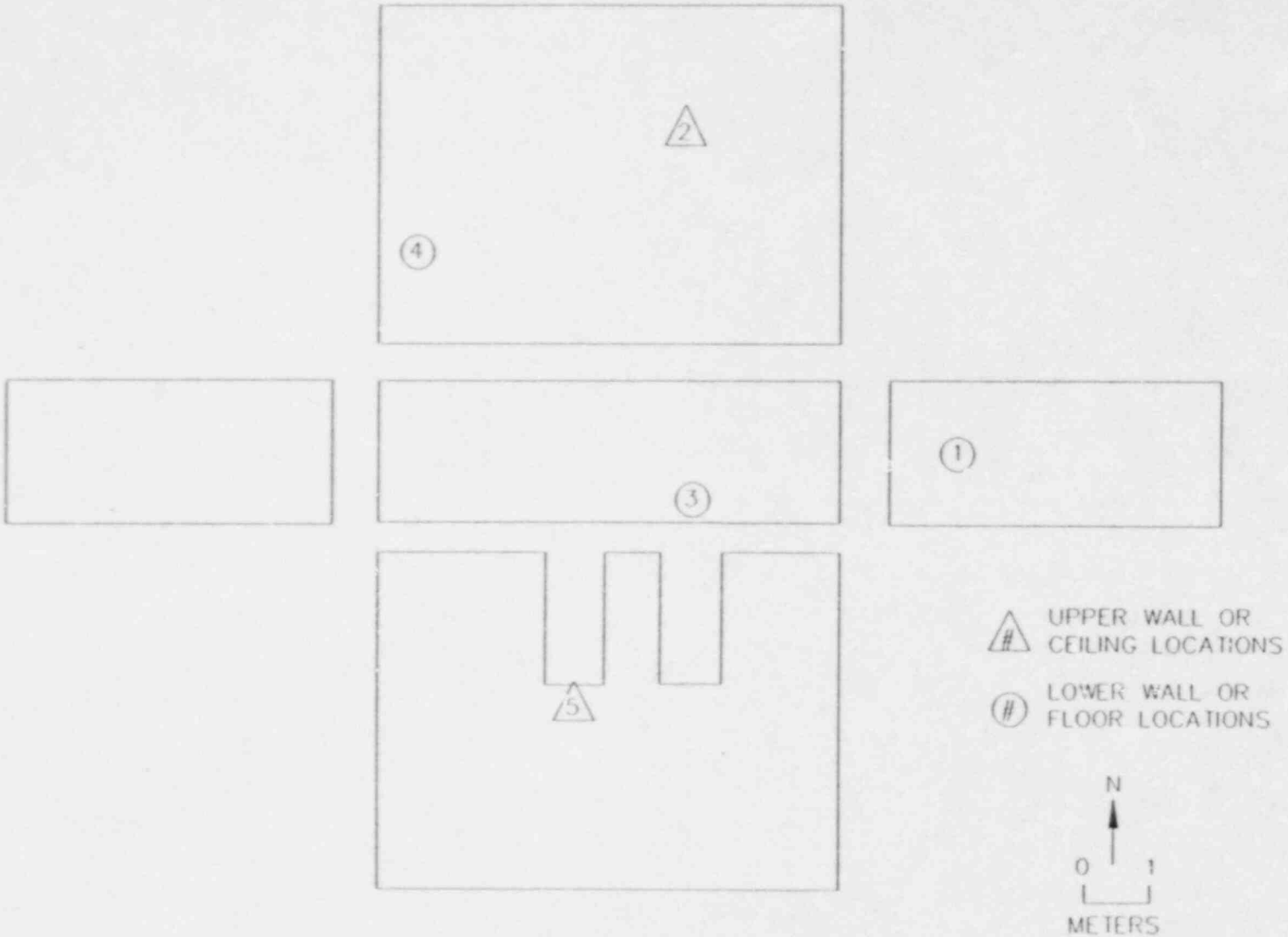


FIGURE 80: Hallway (Area 23) Showing Locations of Single-point Measurements

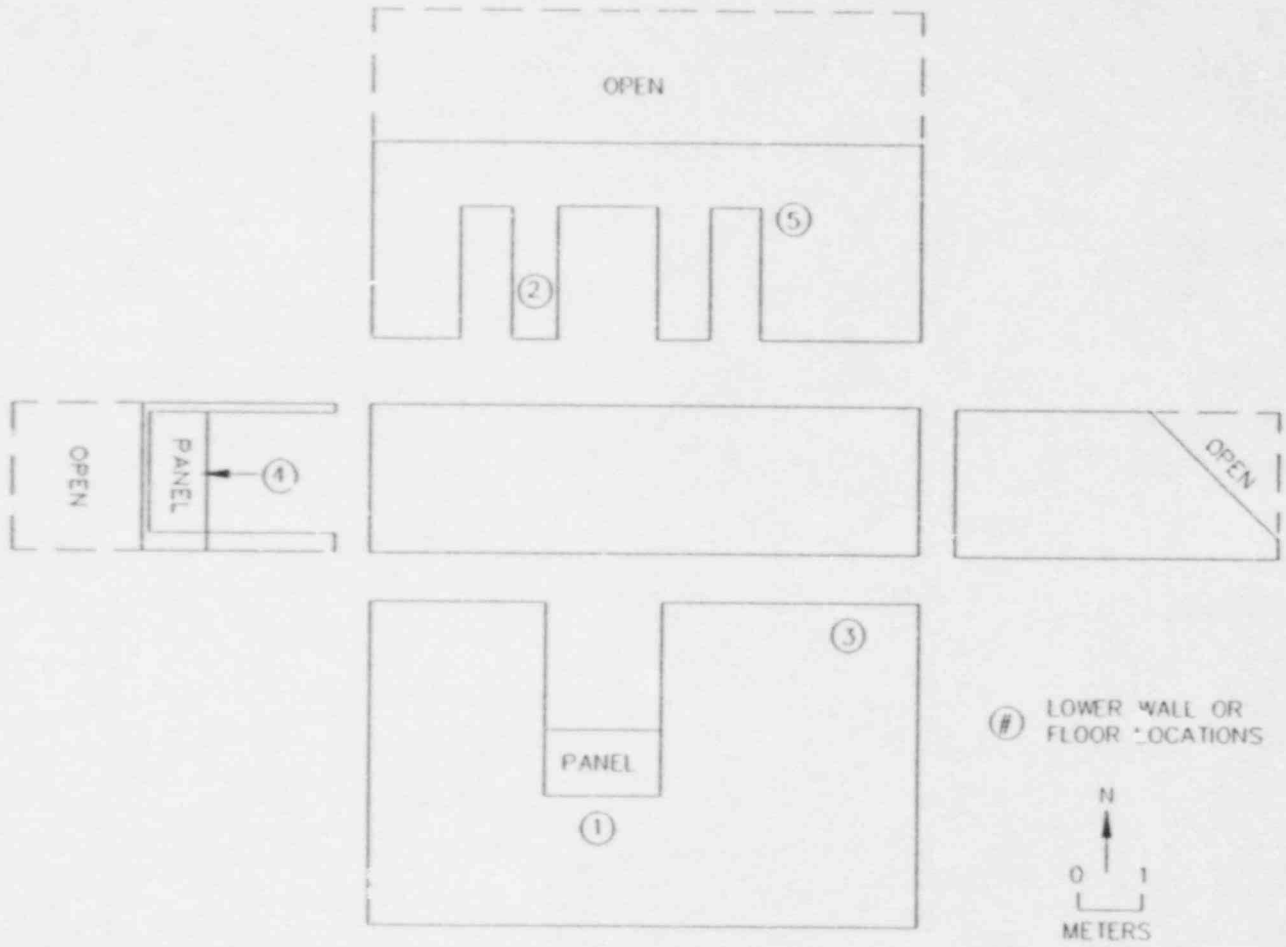


FIGURE 81: Hallway (Area 27E) Showing Locations of Single-point Measurements

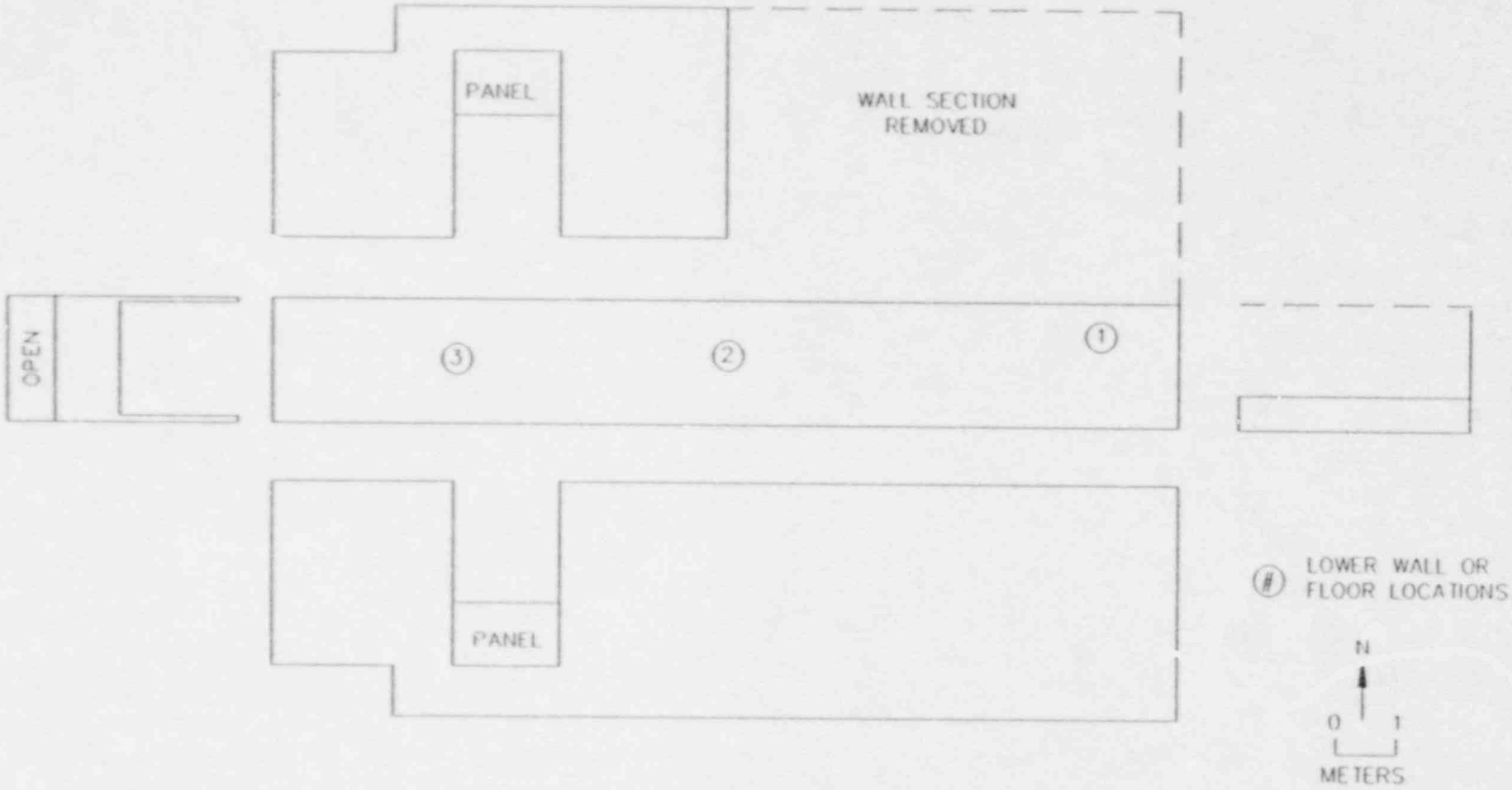


FIGURE 82: Hallway (Area 27W) Showing Locations of Single-point Measurements

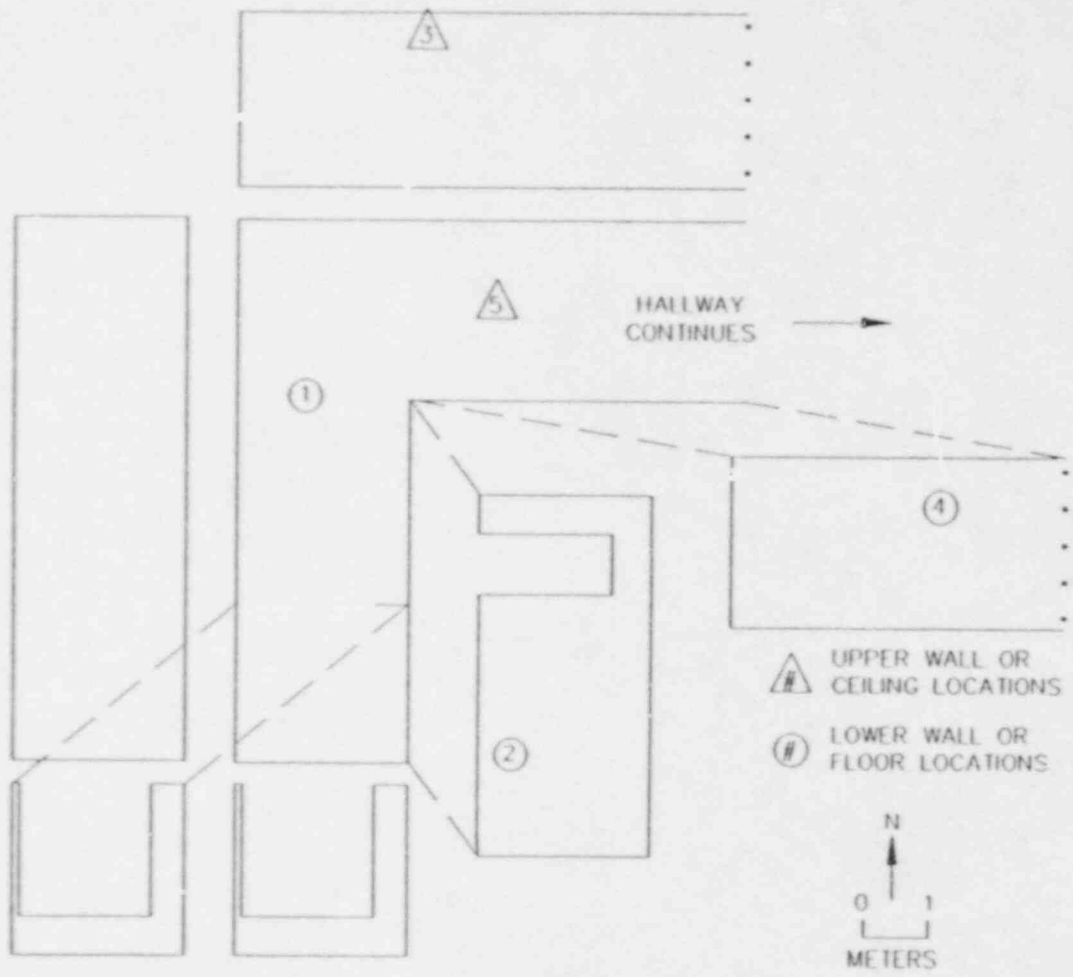


FIGURE 83: Hallway (Area 57) Showing Locations of Single-point Measurements

E/N77a

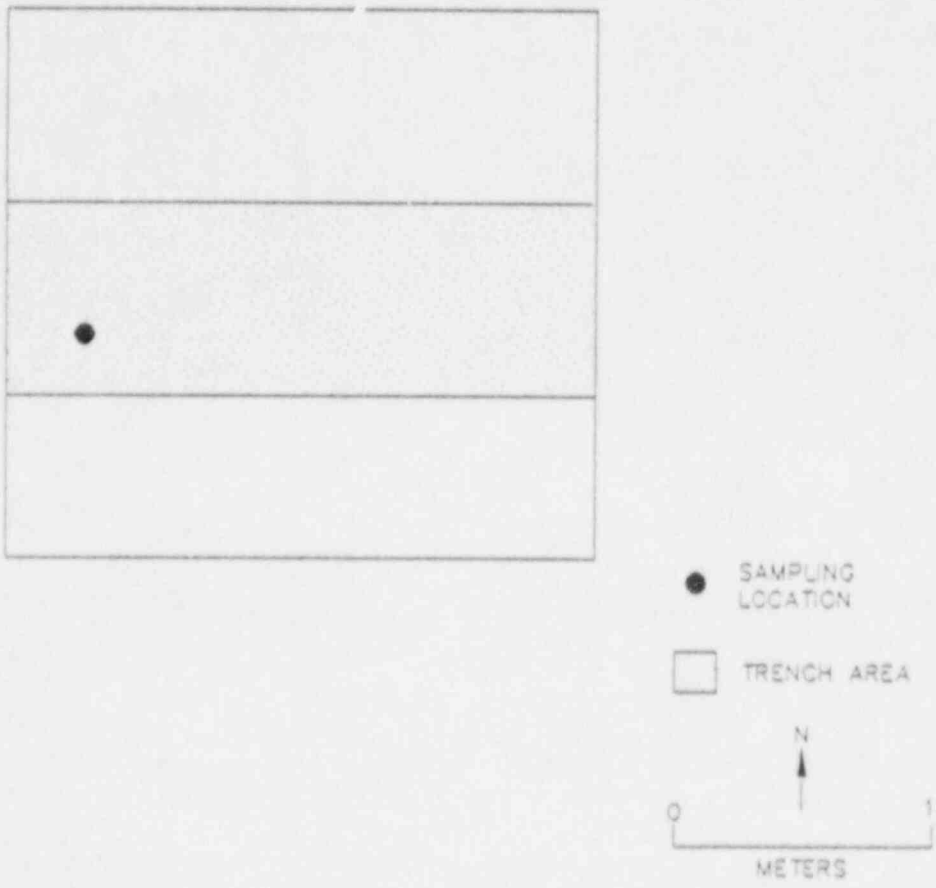


FIGURE 84: Room 1 Showing Trench Soil Sampling Location

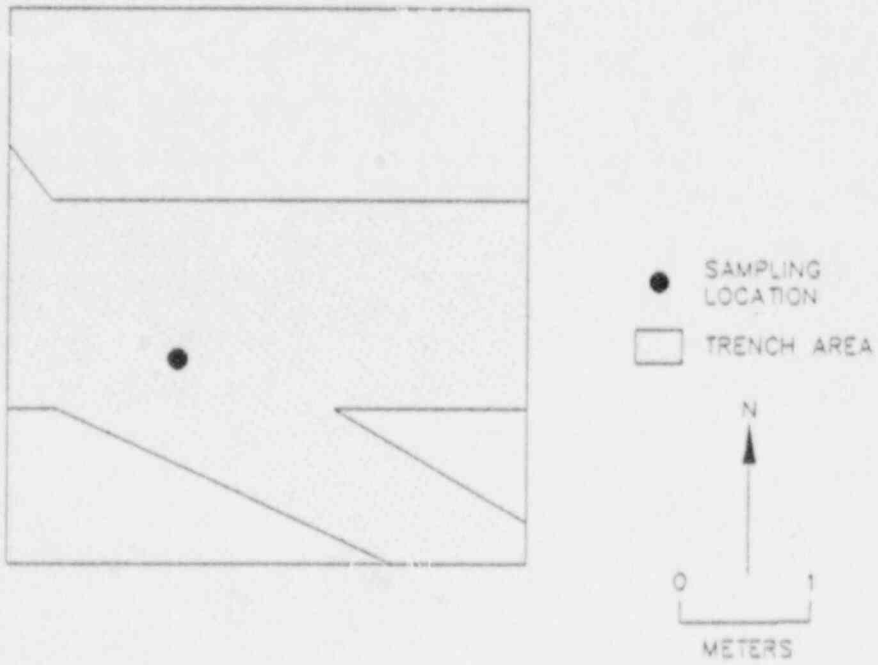


FIGURE 85: Room 3 Showing Trench Soil Sampling Location

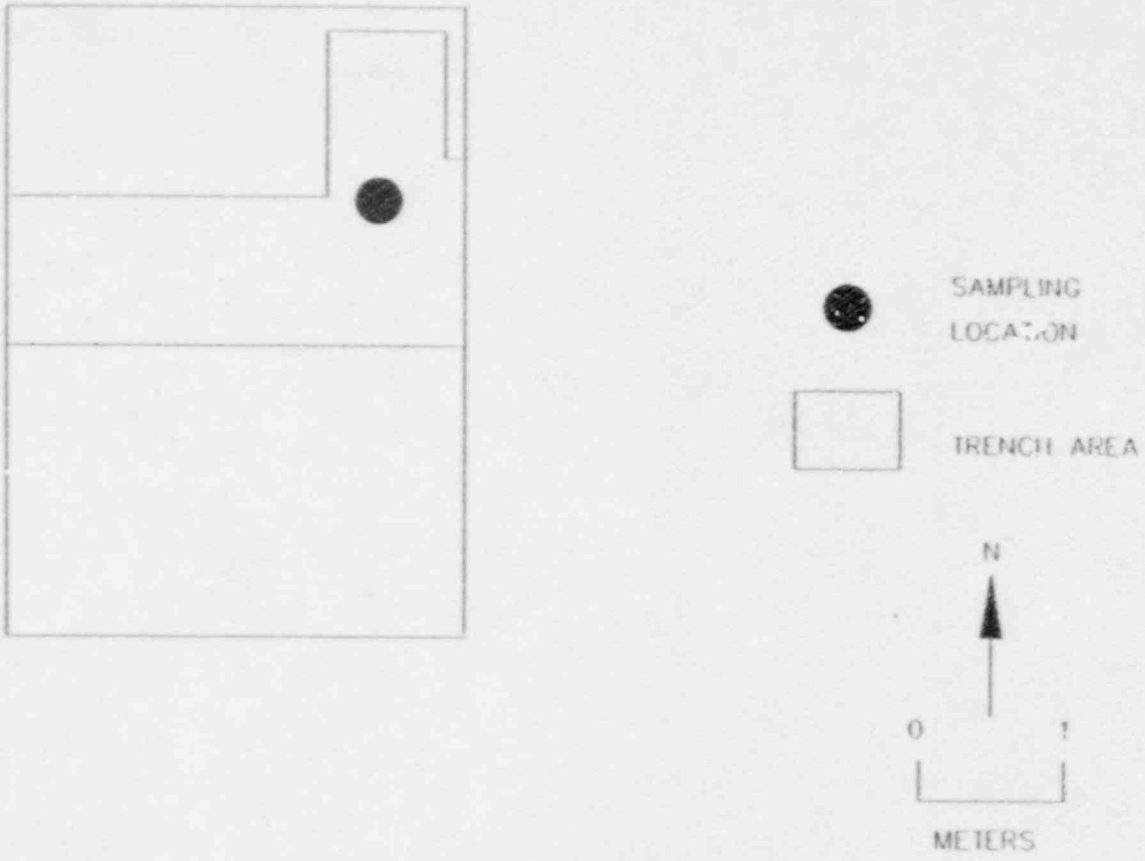
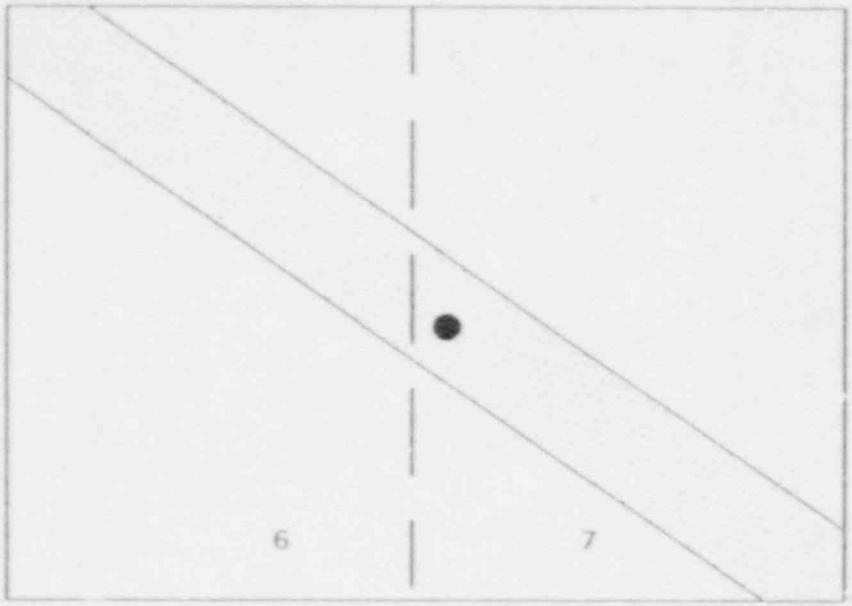


FIGURE 86: Room 5 Showing Trench Soil Sampling Location



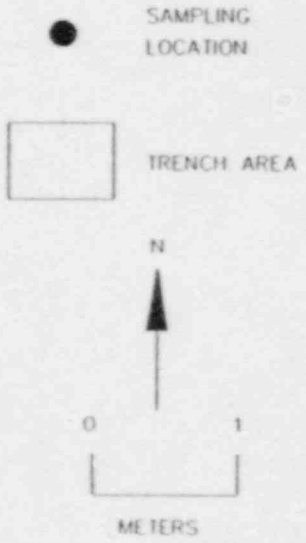


FIGURE 87: Rooms 6/7 Showing Trench Soil Sampling Location

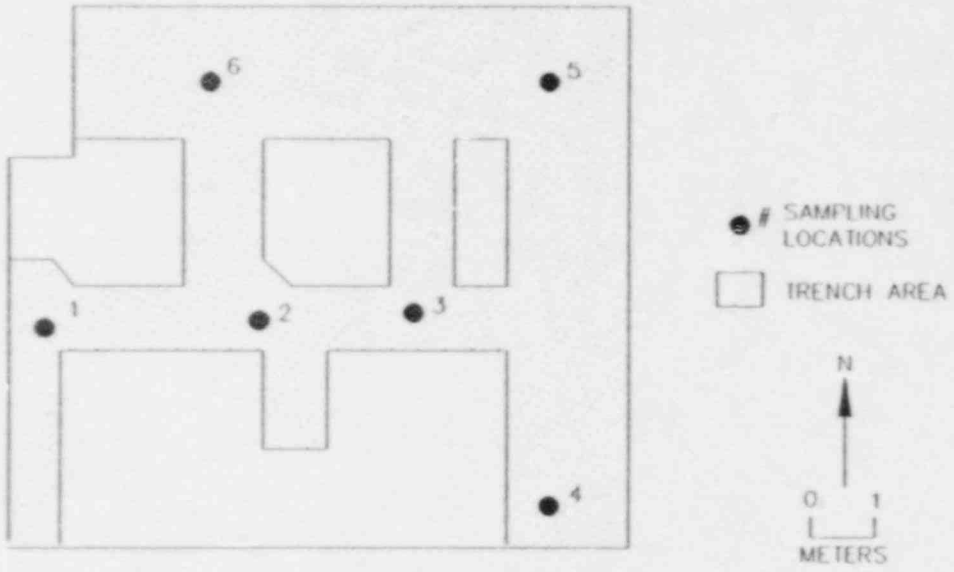


FIGURE 88: Room 15 Showing Trench Soil Sampling Locations

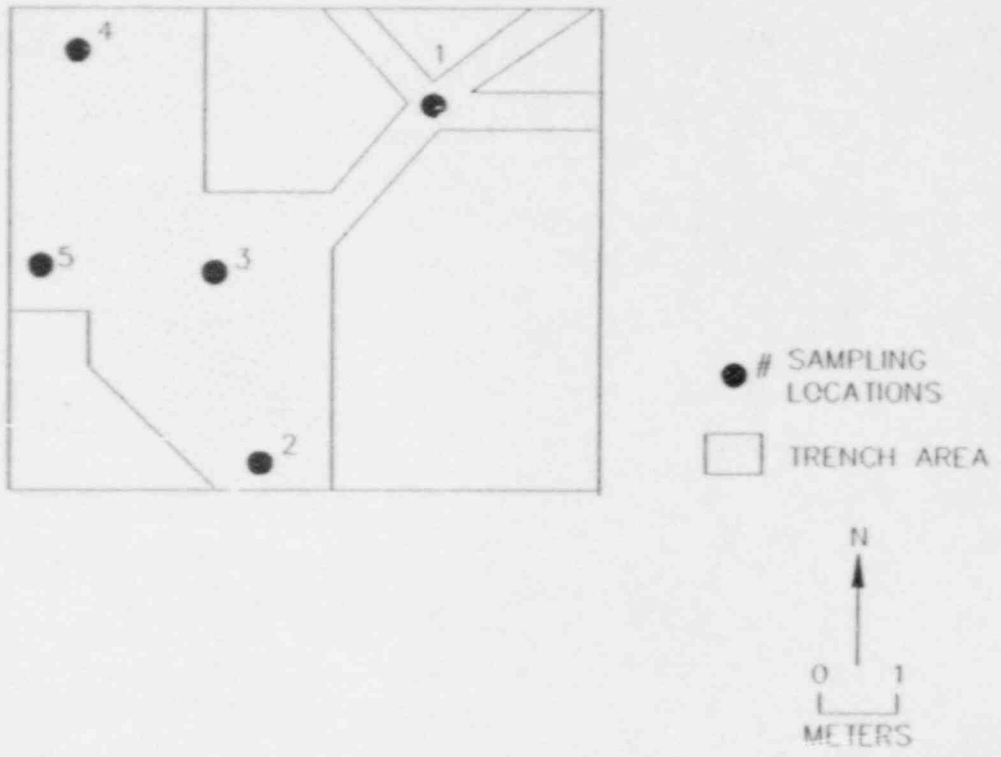


FIGURE 89: Room 16 Showing Trench Soil Sampling Locations

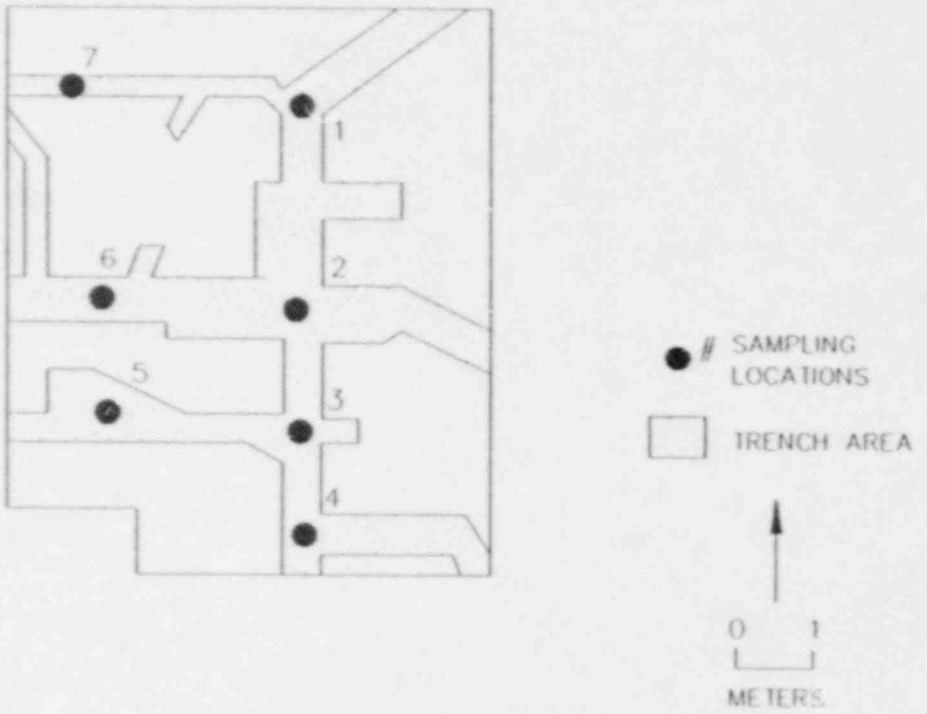


FIGURE 90: Room 17 Showing Trench Soil Sampling Locations

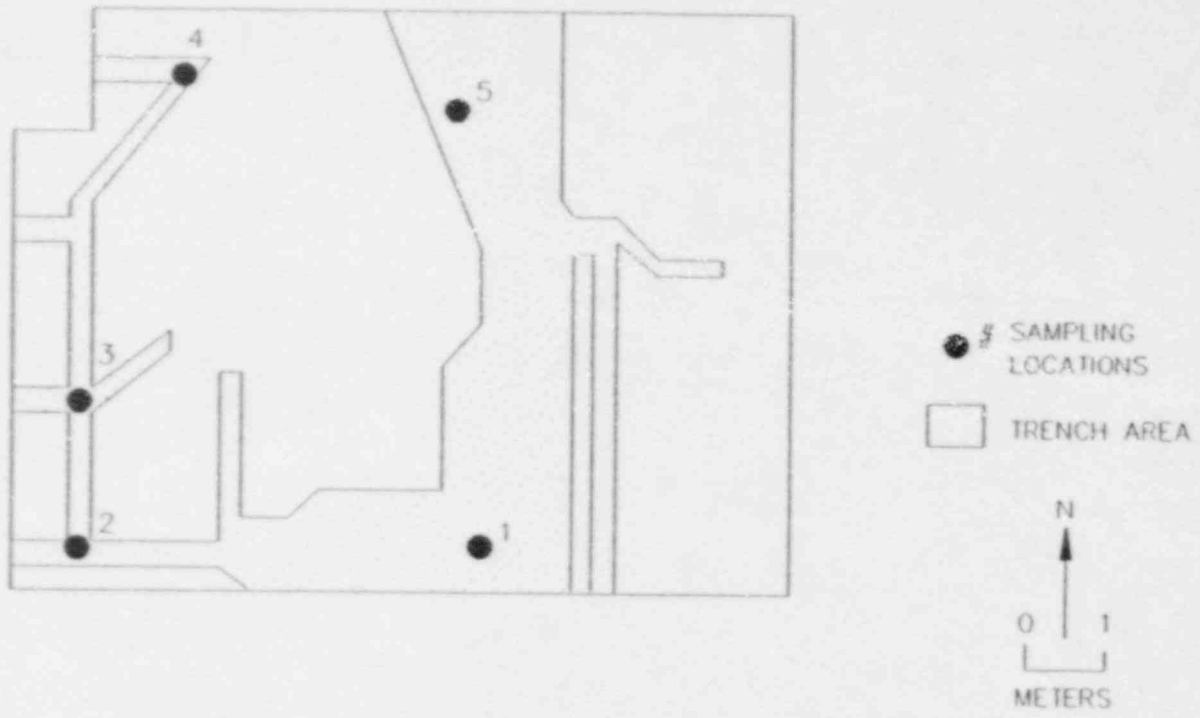


FIGURE 91: Room 19 Showing Trench Soil Sampling Locations

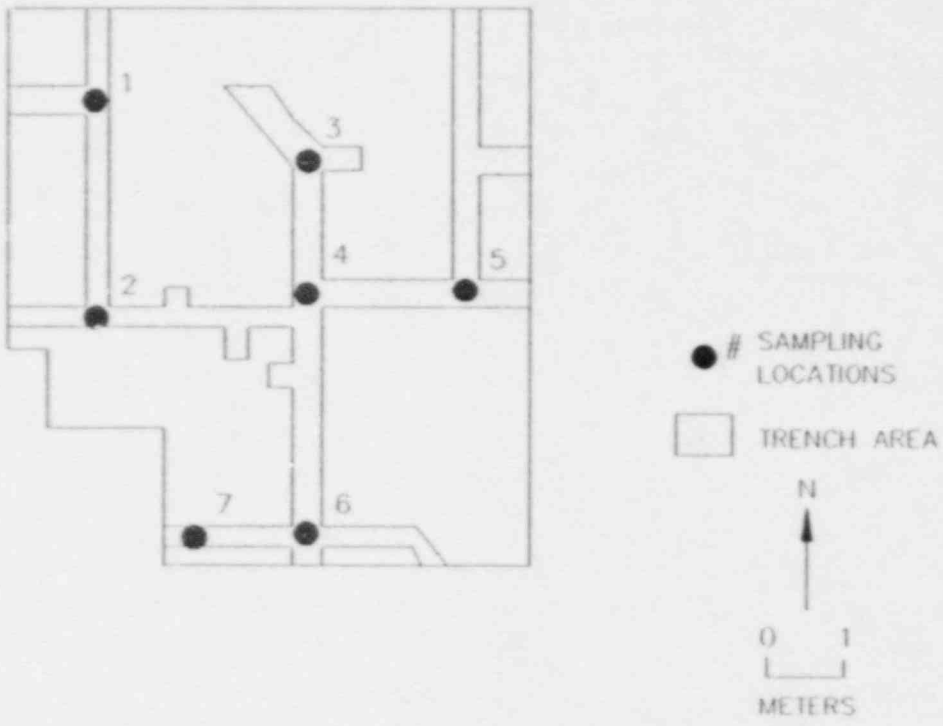


FIGURE 92: Room 20 Showing Trench Soil Sampling Locations

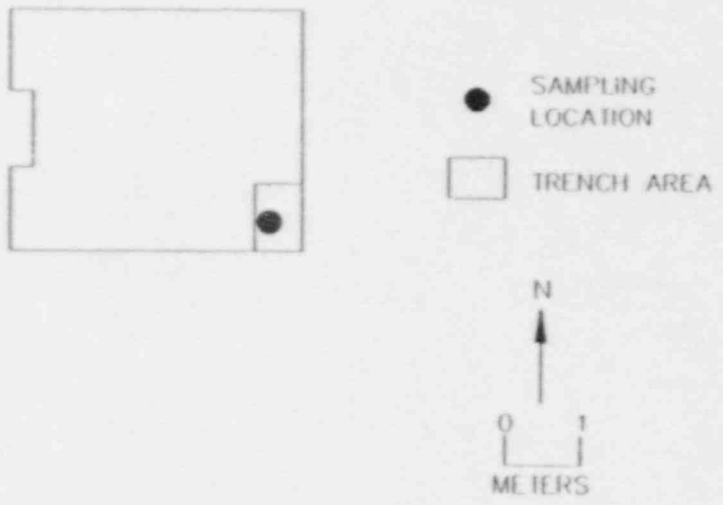


FIGURE 93: Room 22 Showing Trench Soil Sampling Location

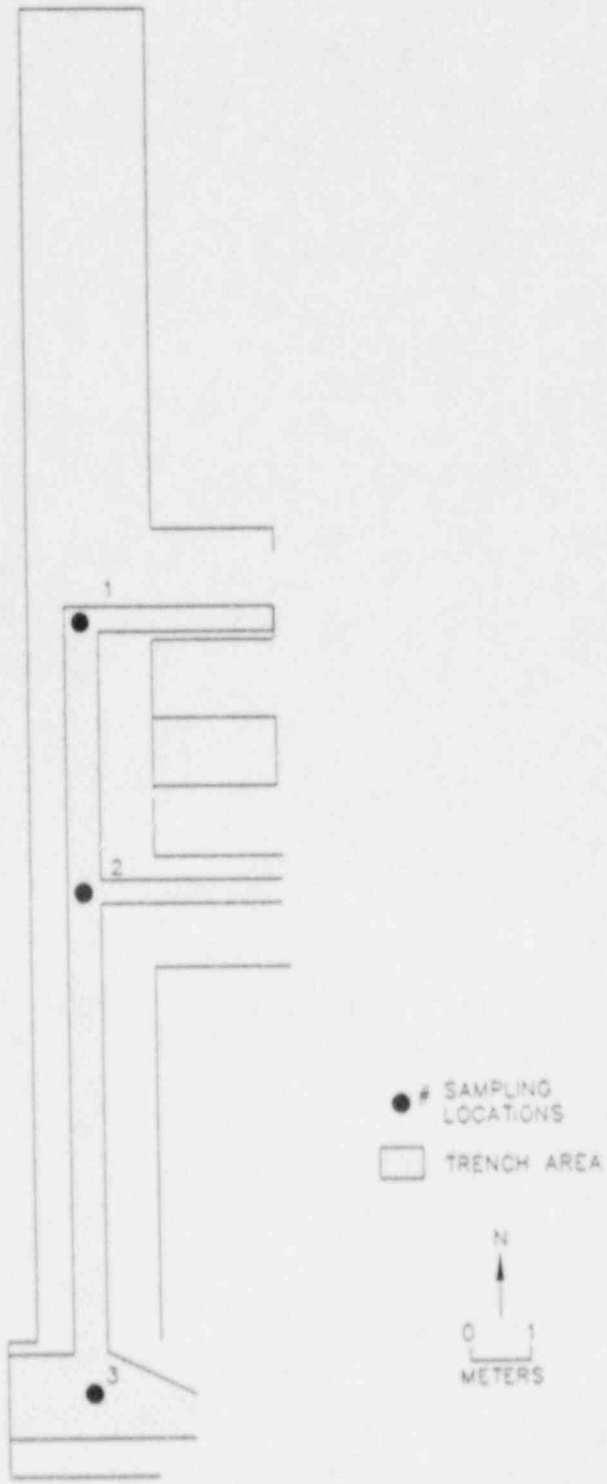


FIGURE 94: Hallway (Area 24) Showing Trench Soil Sampling Locations

BWV64o

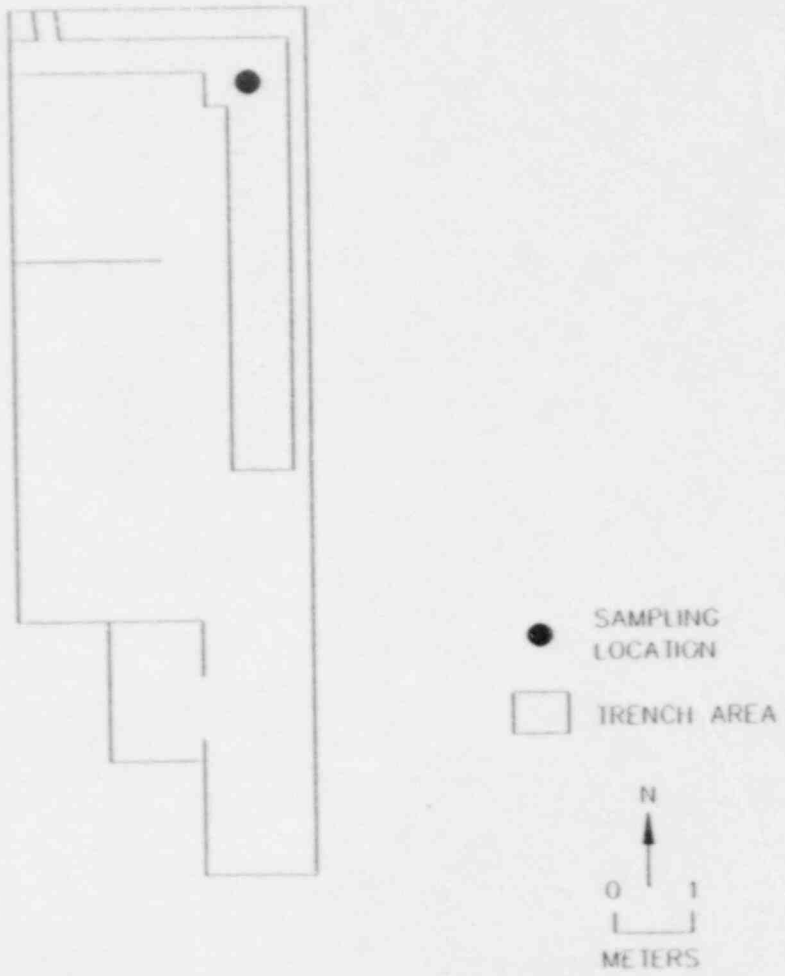


FIGURE 95: Ladies' Change Room Showing Trench Soil Sampling Location

BWV55a

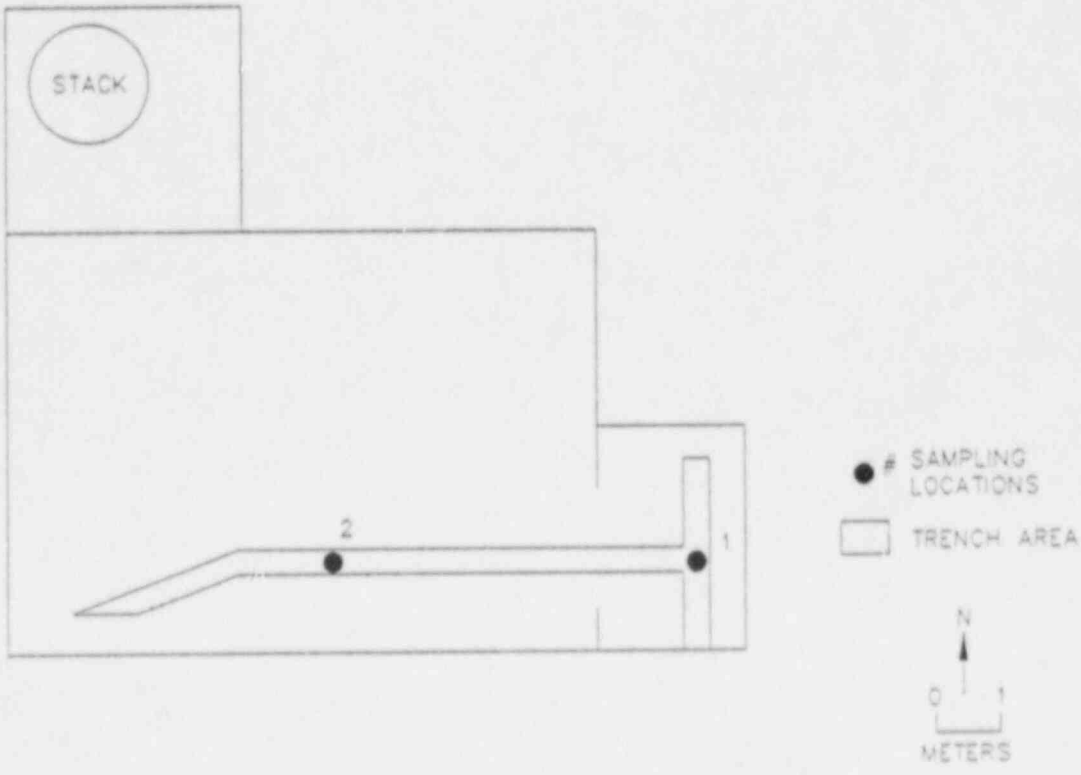


FIGURE 96: Laundry Room Showing Trench Soil Sampling Locations

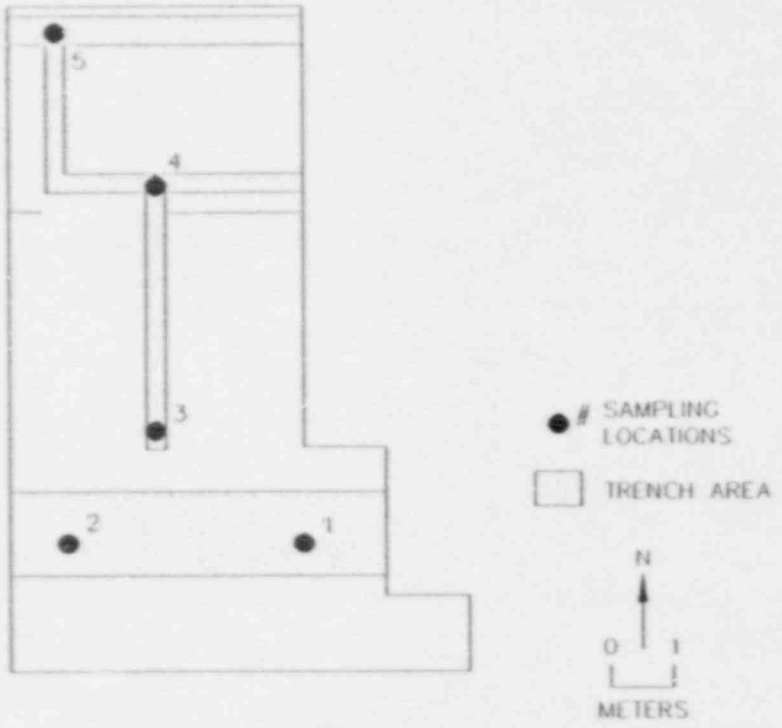


FIGURE 97: Men's Change Room Showing Trench Soil Sampling Locations

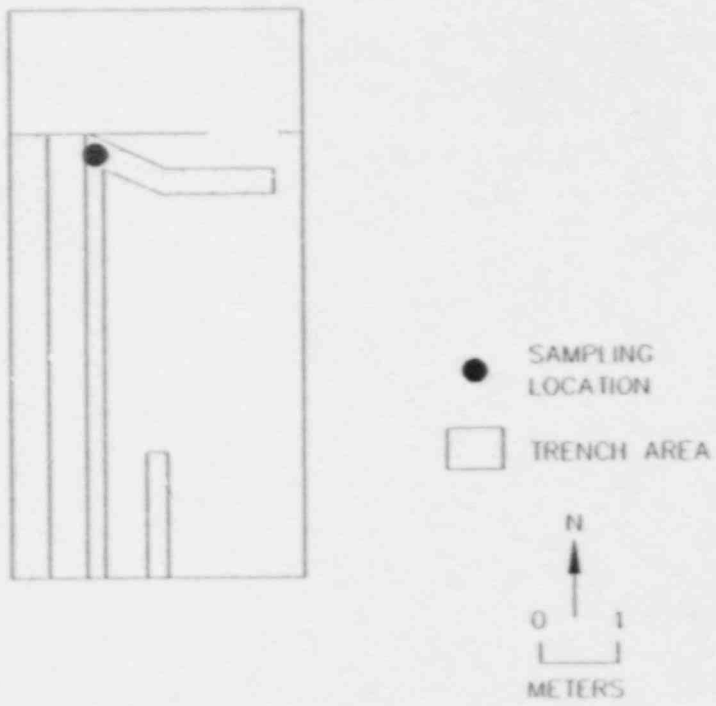


FIGURE 98: Vault Showing Trench Soil Sampling Location

E:\wv67b

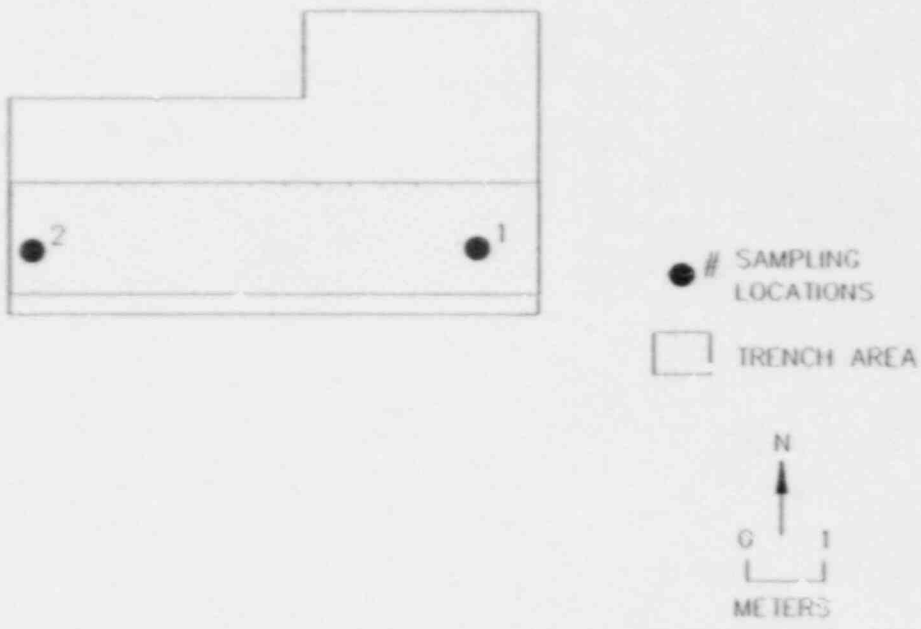


FIGURE 99: Hallway (Area 16N) Showing Trench Soil Sampling Locations

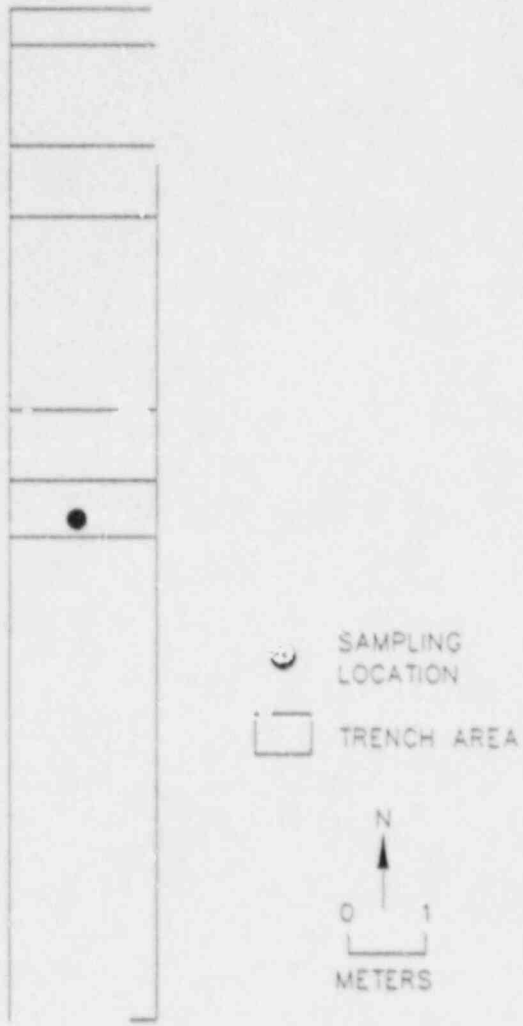


FIGURE 100: Hallway (Area 16W) Showing Trench Soil Sampling Location

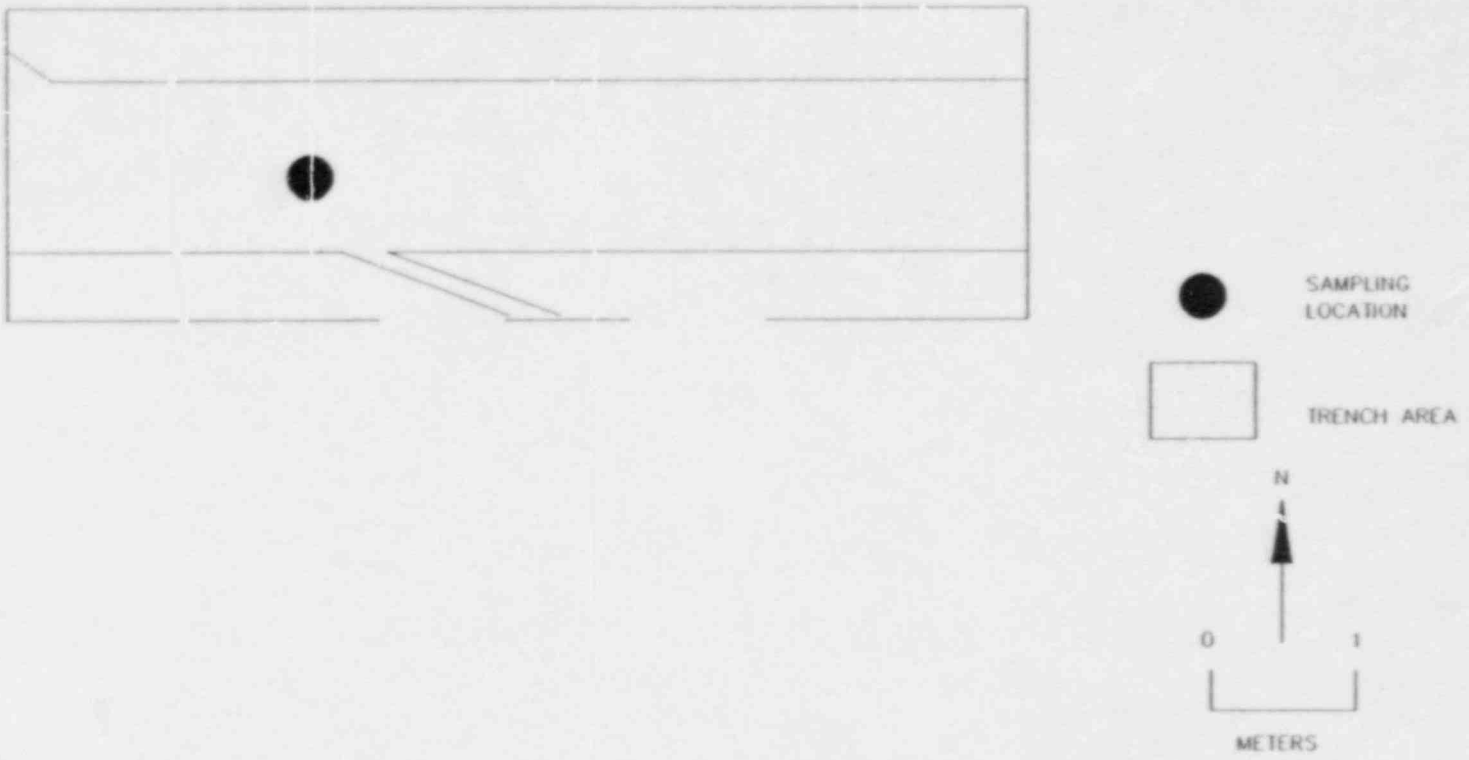


FIGURE 101: Hallway (Area 23) Showing Trench Soil Sampling Location

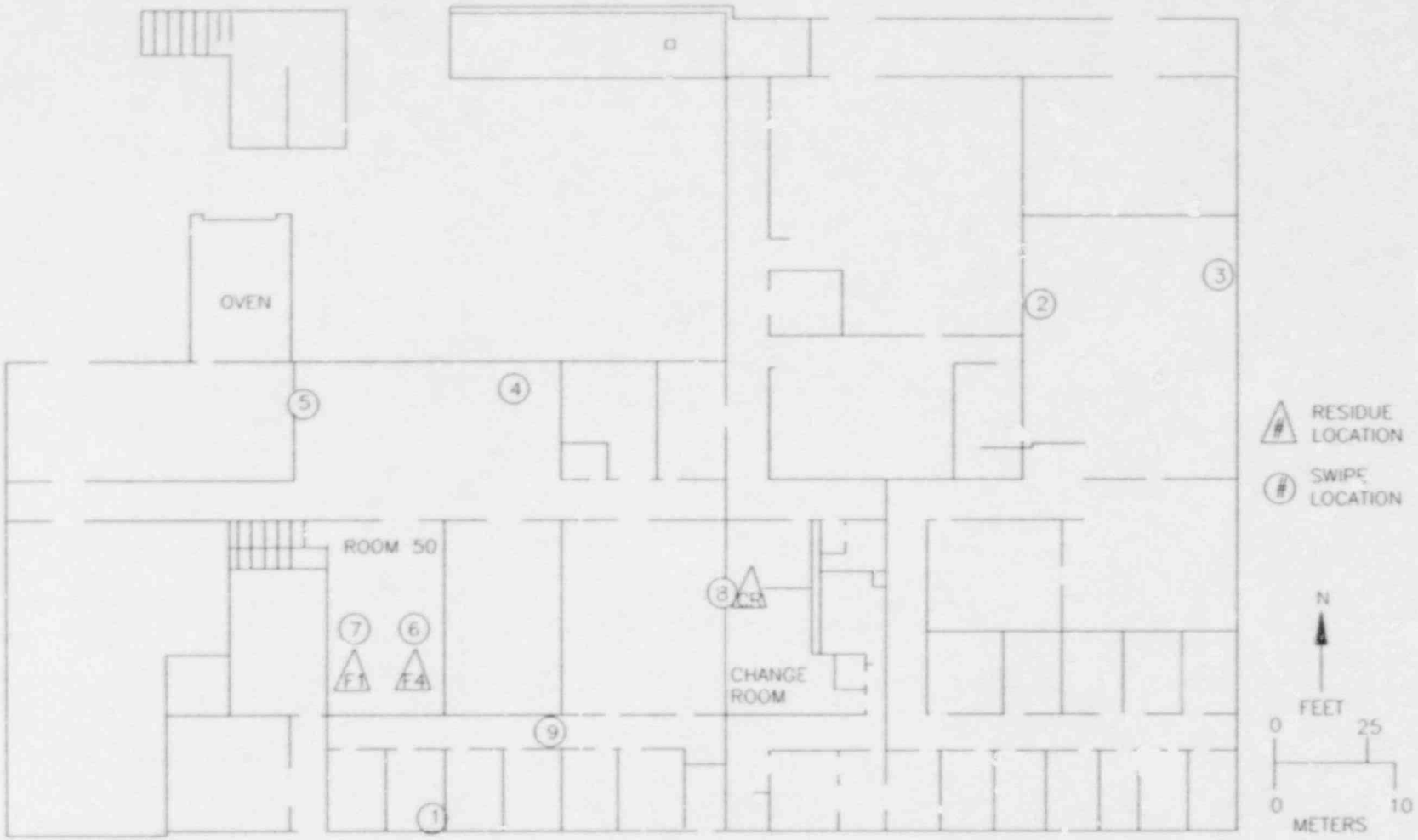


FIGURE 102: "Cold" Drain Residue and Swipe Sampling Locations

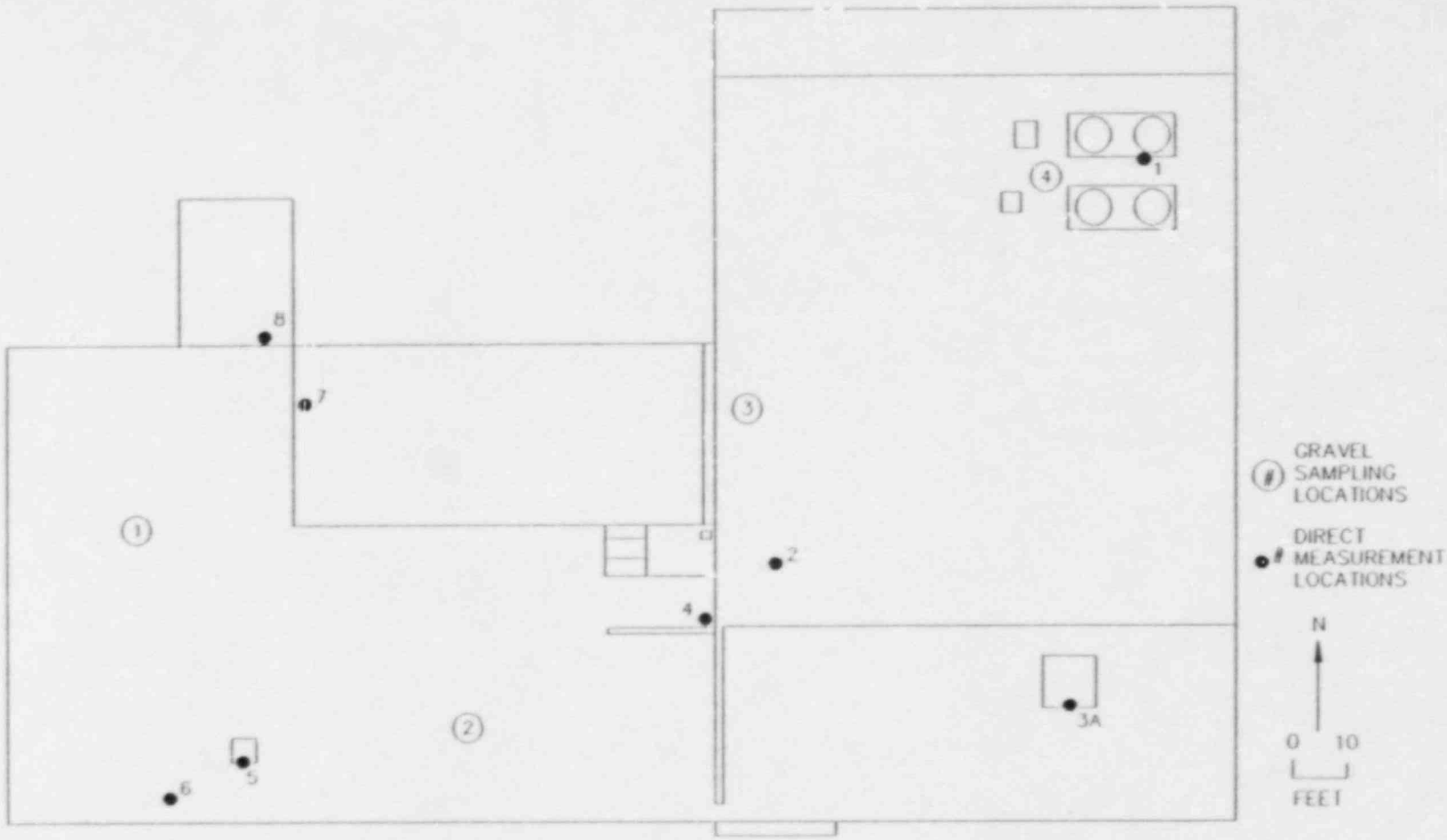


FIGURE 103: Roof Showing Locations of Direct Measurements and Gravel Sampling

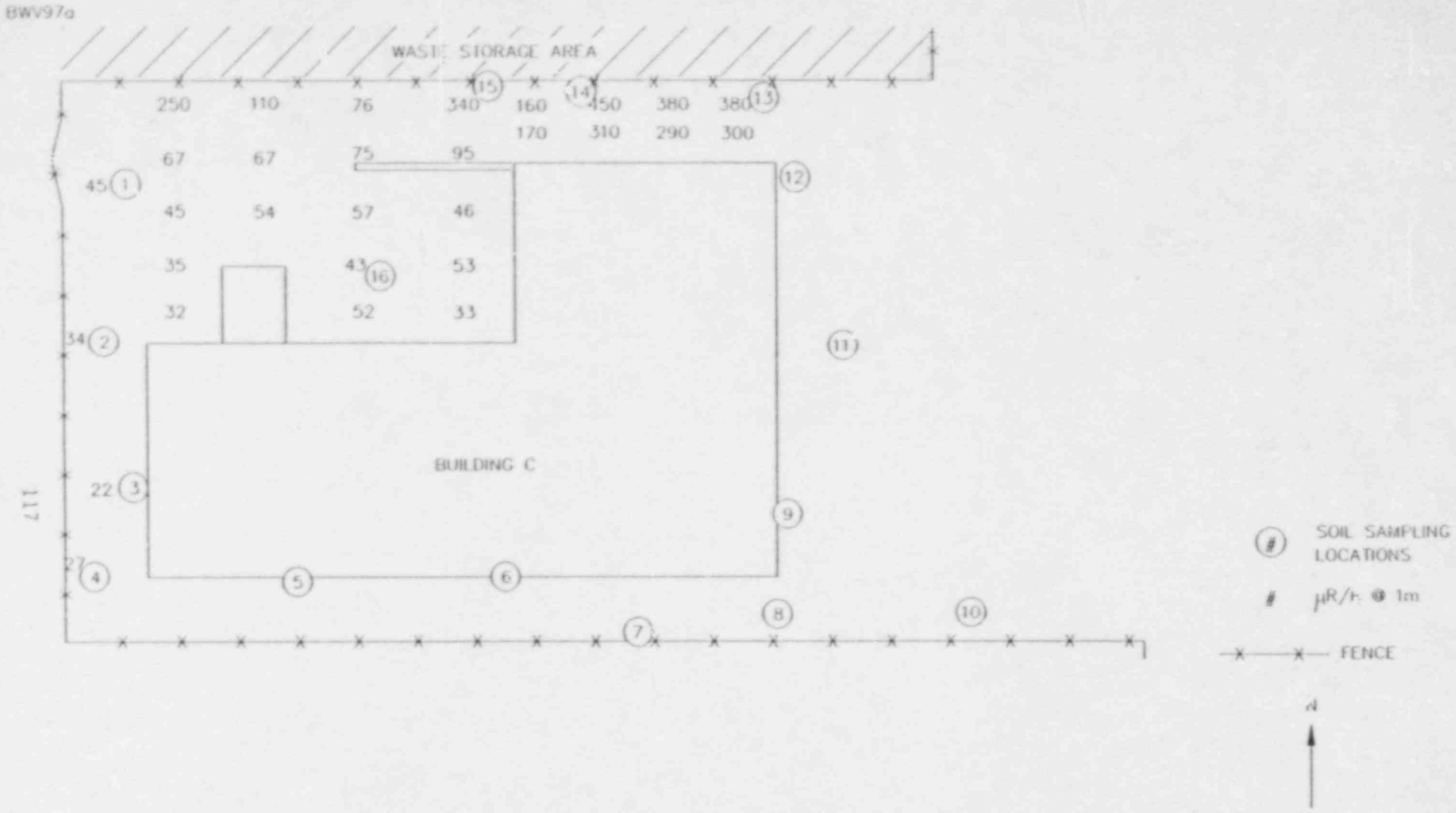


FIGURE 104: Surface Soil Sampling Locations and Direct Radiation Levels Measured Around Building C

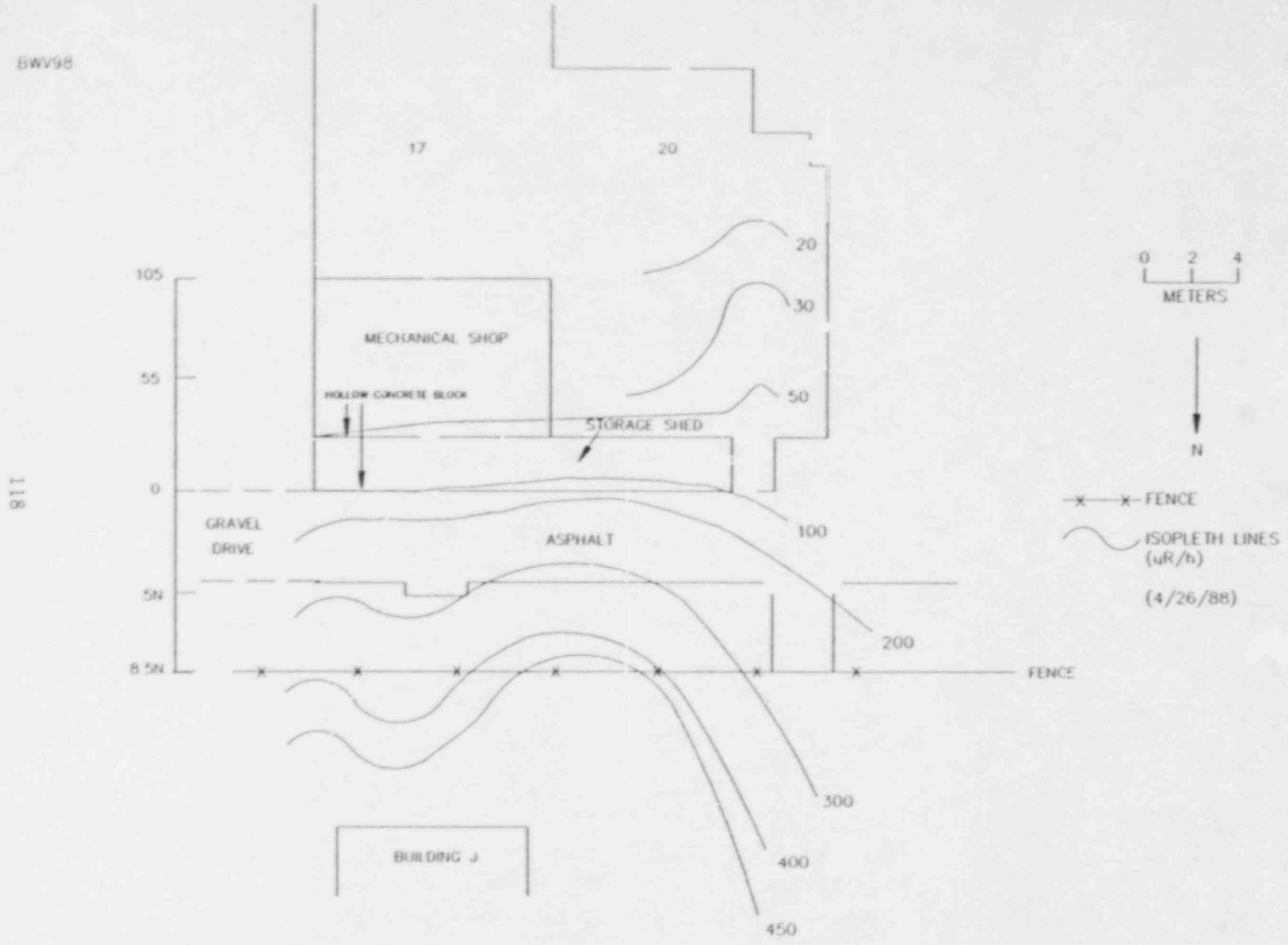


FIGURE 105: Isopleth Exposure Rate Levels Determined at Building C

FIGURE 106: Direct Radiation Levels North of Building C

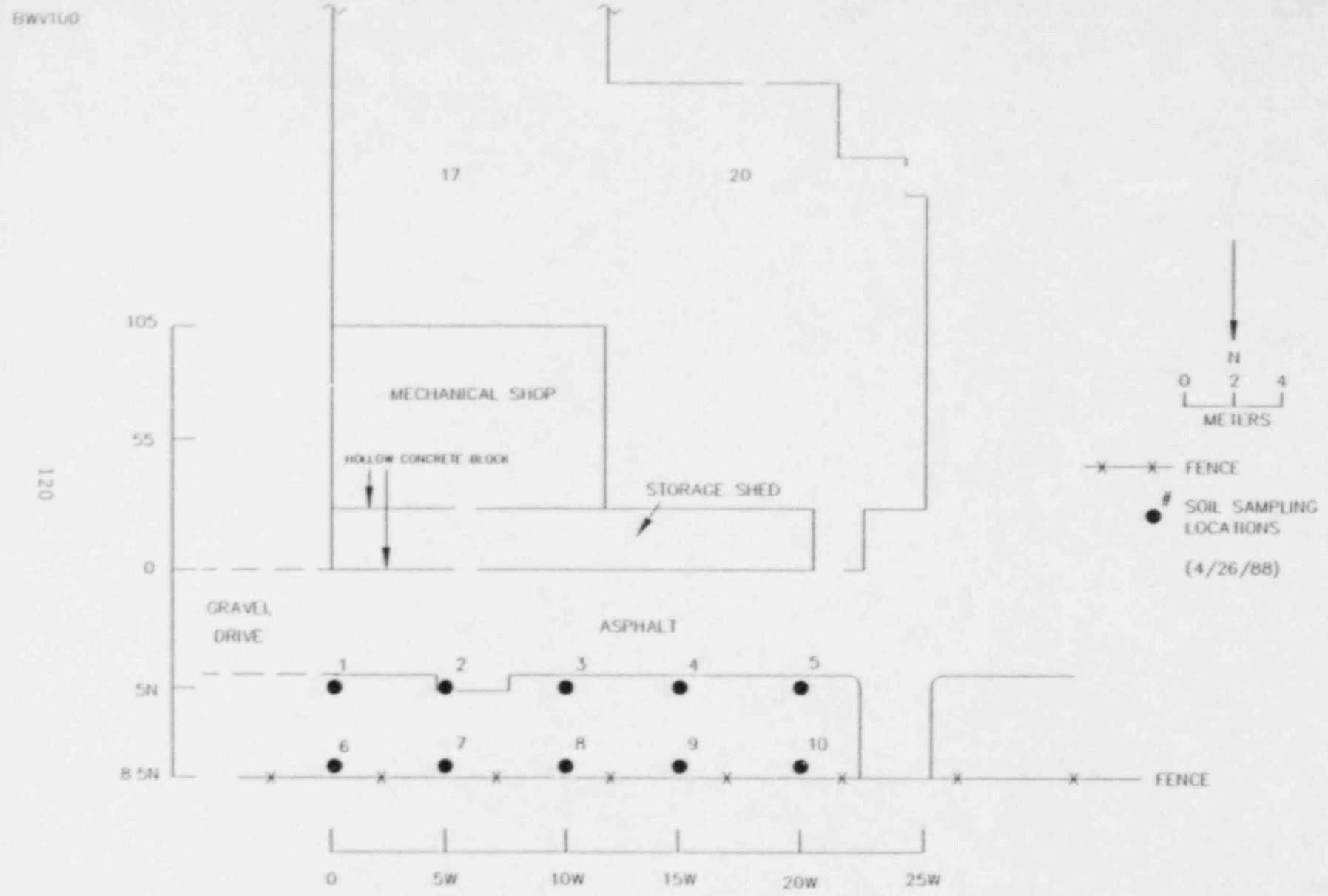


FIGURE 107: Surface Soil Sampling Locations

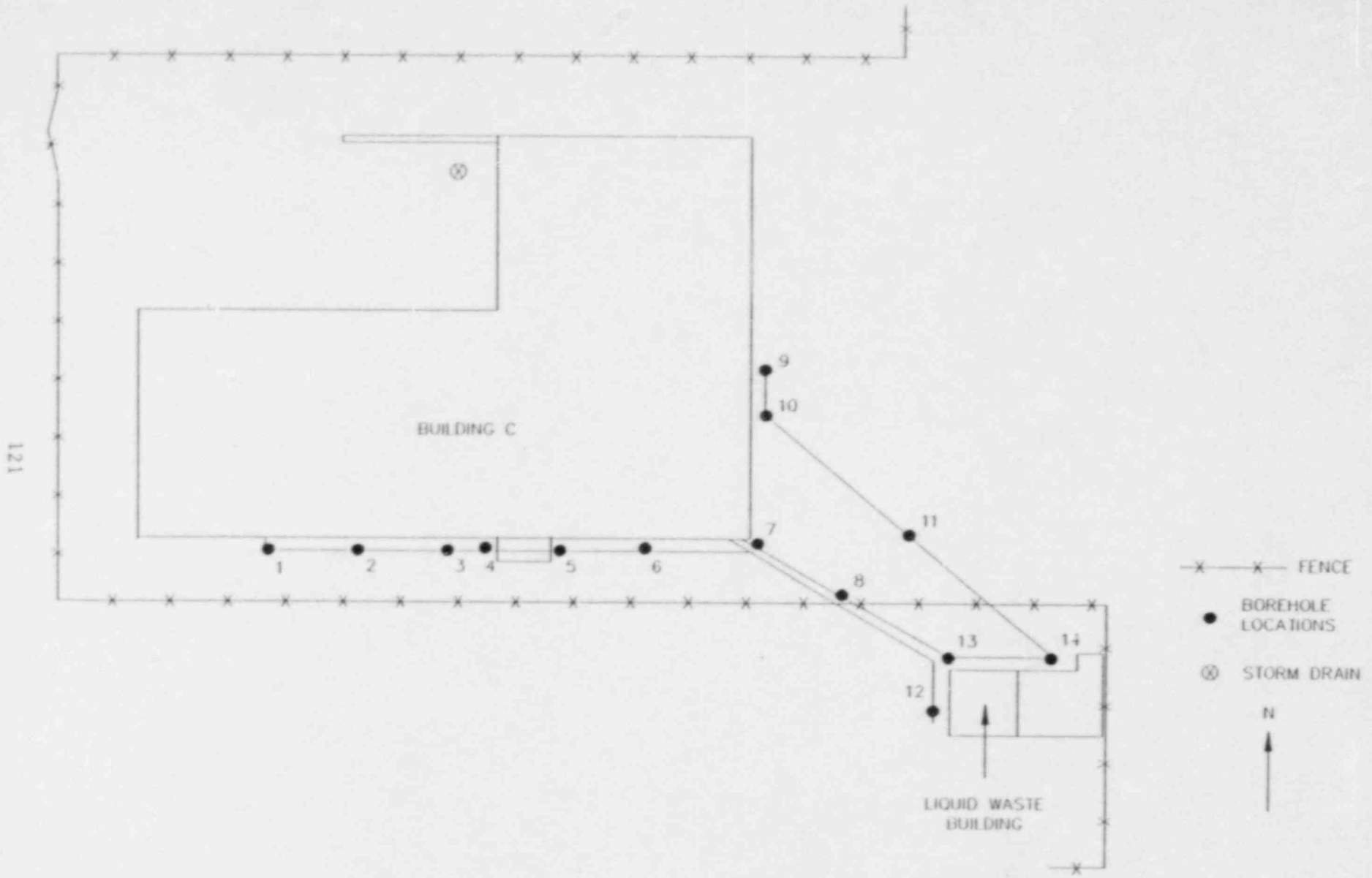


FIGURE 108: Outdoor Area Showing Storm Drain and Shallow Borehole Locations

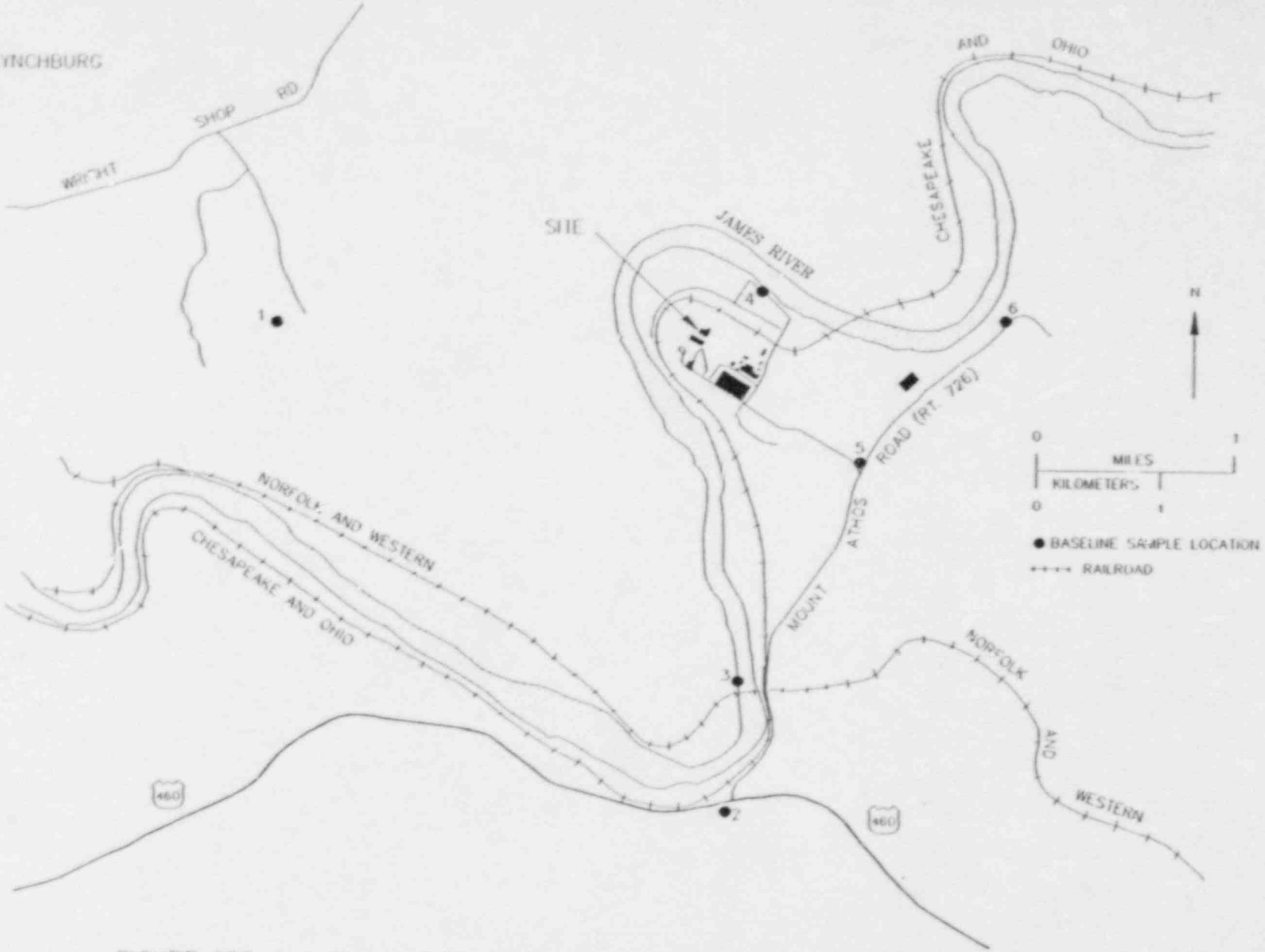


FIGURE 109: Locations of Background Measurements and Baseline Sampling

TABLE 1

DIRECT RADIATION LEVELS AND RADIONUCLIDE CONCENTRATIONS
MEASURED AT BASELINE SAMPLING LOCATIONS
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location[a]	Gamma Exposure Rates at 1 m Above the Surface (μR/h)	Radionuclide Concentrations (pCi/g)				
		Co-60	Cs-137	U-238	U-235	Th-232
1	11	<0.1	<0.1	2.1 ± 1.8[b]	<0.3	2.8 ± 0.7
2	8	<0.1	<0.1	0.3 ± 0.2	<0.2	0.4 ± 0.2
3	10	<0.1	<0.2	<2.4	<0.2	0.9 ± 0.4
4	10	<0.1	<0.1	<0.4	<0.1	0.5 ± 0.3
5	11	<0.1	<0.1	<1.4	<0.3	1.3 ± 0.5
6	10	<0.1	<0.2	<0.8	<0.2	1.2 ± 0.4

Reproduced from ORAU report dated June 1987.[2]

[a]Refer to Figure 109.

[b]Uncertainties represent the 95% confidence level, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 2

INDOOR GAMMA EXPOSURE RATE MEASUREMENTS
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location[a]	μR/h at 1 m Above Surface
1	17
2	29
3	17
4	17
5	17
6	15
7	14
8	19
9	19
10	13
11	14
12	18

[a]Refer to Figure 7.

TABLE 3

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS IN AREAS WITH A HIGH PROBABILITY OF CONTAMINATION (HPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Grid Blocks Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION		Number of Grid Blocks Exceeding Criteria
			Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)		Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
			Highest Grid Block Ave.	Range of Measurements	Highest Grid Block Ave.	Range of Measurements			
ROOM #3									
Floors/lower walls	8	2	37	<26 - 55	560	<430 - 740	<2	<5 - 12	0
Upper walls/ ceilings[a]	9	2	N/A	<26 - 55	N/A	<430 - 770	<2	<5 - 14	0
ROOM #15									
Floors/lower walls	10	15	70	<35 - 150	1600	<480 - 2200	<2 - 7	<5 - 21	0
Upper walls/ ceilings[a]	11	4	N/A	44 - 97	N/A	<470 - 1200	<2 - 3	<5 - 7	0
ROOM #16									
Floors/lower walls	12	8	49	<35 - 70	1100	<470 - 2200	<2 - 3	<5 - 6	0
Uppper walls/ ceilings[a]	13	4	N/A	<35 - 79	N/A	<470 - 1500	<2	<5 - 9	0

TABLE 3 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS IN AREAS WITH A HIGH PROBABILITY OF CONTAMINATION (HPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Grid Blocks Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION		Number of Grid Blocks Exceeding Criteria
			Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)				
			Highest Grid Block Ave.	Range of Measurements	Highest Grid Block Ave.	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
ROOM #17									
Floors/lower walls	14	28	41	<19 - 65	2000	<470 - 2500	<2 - 5	<5 - 15	0
Upper walls/ ceilings[a]	15	10	N/A	<35 - 70	N/A	<450 - 1500	<2	<5 - 9	0
ROOM #19									
Floors/lower walls	16	16	34	<19 - 65	1500	<470 - 2200	<2 - 10	<5 - 8	0
Upper walls/ ceilings[a]	17	7	N/A	<19 - 56	N/A	<470 - 2100	<2 - 3	<5 - 16	0
ROOM #19 (East Waste/ Sump Tank)									
Floors/lower walls	18	3	240	<19 - 610	2700	<440 - 13000	<2 - 3	<5	2
Floors/lower walls Resurvey[b]		2	96	<19 - 180	3300	<440 - 11000	<2	<5	0
ROOM #19 (West Waste/ Sump Tank)									
Floor/lower walls	19	3	40	<35 - 88	920	460 - 1200	<2	<5 - 7	0

TABLE 3 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS IN AREAS WITH A HIGH PROBABILITY OF CONTAMINATION (HPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Grid Blocks Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION		Number of Grid Blocks Exceeding Criteria
			Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)				
			Highest Grid Block Ave.	Range of Measurements	Highest Grid Block Ave.	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
ROOM #20									
Floors/lower walls	20	28	61	<20 - 120	2200	<450 - 3100	<2 - 3	<5 - 14	0
Upper walls/ ceilings[a]	21	12	N/A	<19 - 56	N/A	<430 - 3500	<2 - 3	<5 - 7	0
ROOM #22									
Floors/lower walls	22	4	45	<19 - 30	1100	<470 - 1900	<2	<5	0
Upper walls/ ceilings[a]	23	3	N/A	<19 - 37	N/A	<470 - 950	<2	<5	0
ROOM #26									
Floors/lower walls	24	7	<26	<19 - 65	1200	<430 - 1700	<2	<5 - 7	0
Upper walls/ ceilings[a]	25	3	N/A	<26 - 64	N/A	<470 - 1600	<2	<5	0

TABLE 3 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS IN AREAS WITH A HIGH PROBABILITY OF CONTAMINATION (HPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Grid Blocks Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION		Number of Grid Blocks Exceeding Criteria
			Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)				
			Highest Grid Block Ave.	Range of Measurements	Highest Grid Block Ave.	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
ROOM #27									
Floors/lower walls	26	20	38	<19 - 92	1100	<440 - 1500	<2 - 7	<5 - 13	0
Upper walls/ ceilings[a]	27	8	N/A	<19 - 46	N/A	<440 - 1700	<2 - 3	<5 - 6	0
ROOM #43									
Floor/lower walls	28	17	33	<19 - 56	<470	<430 - 980	<2 - 3	<5 - 7	0
Upper walls/ ceilings[a]	29	6	N/A	<19 - 28	N/A	<430 - 830	<2 - 3	<5 - 7	0
ROOM #50									
Floor/lower walls	30	12	29	<19 - 47	<470	<430 - 750	<2 - 7	<5 - 10	0
Upper walls/ ceilings[a]	31	6	N/A	<19 - 37	N/A	<430 - 520	<2 - 3	<5 - 6	0

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS IN AREAS WITH A HIGH PROBABILITY OF CONTAMINATION (HPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Grid Blocks Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION		Number of Grid Blocks Exceeding Criteria
			Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)				
			Highest Grid Block Ave.	Range of Measurements	Highest Grid Block Ave.	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
MEN'S CHANGE ROOM									
Floor/lower walls	32	14	30	<19 - 75	1400	<470 - 1900	<2 - 5	<5 - 8	0
Upper walls/ ceilings[a]	33	5	N/A	<19 - 400	N/A	<470 - 1600	<2 - 3	<5 - 7	1
Upper Walls/ ceilings[a,c]	35	4	N/A	<19 - 47	N/A	<470 - 1100	<2 - 3	<5	0
DRYING OVEN									
Floor/lower walls	34	10	44	<26 - 110	1600	<470 - 2000	<2 - 5	<5 - 12	0
Upper walls/ ceilings[a]	35	3	N/A	<26	N/A	<470 - 1500	<2 - 3	<5 - 7	0
HALLWAY (Area 24)									
Floor/lower walls	36	10	51	<26 - 73	1300	<430 - 1700	<2	<5 - 15	0
Upper walls/ ceilings[a]	37	5	N/A	<26 - 92	N/A	750 - 1900	<2 - 3	<5 - 7	0

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS IN AREAS WITH A HIGH PROBABILITY OF CONTAMINATION (HPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Grid Blocks Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION		Number of Grid Blocks Exceeding Criteria
			Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)		Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
			Highest Grid Block Ave.	Range of Measurements	Highest Grid Block Ave.	Range of Measurements			
HALLWAY (Area 55)									
Floor/lower walls	38	13	62	<19 - 100	940	<430 - 1500	<2 - 3	<5 - 6	0
Upper walls/ ceilings[a]	39	5	N/A	<19 - 28	N/A	<430 - 460	<2	<5 - 7	0
HALLWAY (Area 56)									
Floor/lower walls	40	11	42	<26 - 92	1100	<430 - 1500	<2	<5 - 6	0
Upper walls/ ceilings[a]	41	4	N/A	<26 - 64	N/A	<430 - 800	<2	<5	0
NRC Guideline			100	300	5000	15000	20	1000	

[a]Only single point measurements performed.
[b]Area cleaned by licensee; resurveyed by ORAU.
[c]Vent/grill removed by licensee.

TABLE 4

SUMMARY OF SINGLE POINT SURFACE CONTAMINATION MEASUREMENTS
FROM LOW PROBABILITY OF CONTAMINATION AREAS (LPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION		Number of Measurements Exceeding Criteria
			Alpha (dpm/100 cm^2) Range of Measurements	Beta-Gamma (dpm/100 cm^2) Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
ROOM 1	42	5	<19 - 47	<470 - 610	<2 - 3	<5	0
ROOM 2	43	5	<19 - 38	<470 - 920	<2 - 9	<5 - 7	0
ROOM 4	44	5	<19 - 28	<470 - 740	<2	<5 - 6	0
ROOM 5	45	5	<19 - 47	<470 - 1300	<2	<5 - 8	0
ROOM 6	46	5	<19 - 28	<470 - 740	<2	<5	0
ROOM 7	47	5	<26 - 64	<430 - 1100	<2 - 3	<5 - 7	0
ROOM 8	48	5	<19 - 38	<470 - 900	<2	<5 - 6	0
ROOM 9	49	5	<26 - 75	<430 - 660	<2 - 3	<5 - 6	0
ROOM 10	50	5	<19	<470 - 1600	<2	<5	0
ROOM 11	51	5	<19 - 38	<470 - 1200	<2	<5	0
ROOM 12	52	5	<19 - 19	<470 - 1200	<2	<5 - 7	0
ROOM 01	53	5	<19 - 38	<480 - 790	<2 - 3	<5 - 12	0
ROOM 02	54	5	<19 - 47	<480 - 1300	<2 - 3	<5 - 8	0
ROOM 03	55	5	<19	<480 - 1100	<2	<5 - 7	0
ROOM 04	56	5	<19 - 47	<480 - 880	<2	<5 - 7	0
ROOM 05	57	5	<19 - 19	<480 - 880	<2 - 3	<5 - 7	0
ROOM 06	58	5	<19 - 38	<480 - 620	<2	<5 - 7	0
ROOM 25	59	5	<19 - 66	750 - 1000	<2 - 7	<5 - 9	0
ROOM 44	60	7	<19 - 85	<470 - 1000	<2 - 3	<5 - 9	0
ROOM 52	61	5	<26 - 46	<470	<2 - 3	<5 - 12	0

TABLE 4 (Continued)

SUMMARY OF SINGLE POINT SURFACE CONTAMINATION MEASUREMENTS
FROM LOW PROBABILITY OF CONTAMINATION AREAS (LPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION		Number of Measurements Exceeding Criteria
			Alpha (dpm/100 cm^2) Range of Measurements	Beta-Gamma (dpm/100 cm^2) Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
ROOMS 53 & 54	62	5	<26 - 46	<470	<2 - 3	<5	0
CERAMIC LAB	63	8	<26 - 100	<430	<2 - 3	<5 - 6	0
FAN ROOM	64	5	<19	<470 - 720	<2	<5	0
FIRE EQUIPMENT ROOM	65	5	<19 - 19	<430	<2 - 7	<5 - 6	0
HP LAB	66	5	<26 - 37	<430 - 520	<2	<5 - 9	0
HP OFFICE	67	5	<26 - 120	<430 - 1200	<2 - 3	<5 - 8	0
LADIES CHANGE ROOM	68	5	<26 - 230	320 - 1100	<2 - 3	<5 - 6	0
LAUNDRY ROOM	69	5	<19 - 140	<470 - 620	<2	<5	0
MACHINE SHOP	70	12	<26 - 200	<430 - 950	<2	<5 - 6	0
MECHANICAL EQUIP. ROOM	71	5	<19 - 47	<430 - 1800	<2	<5 - 6	0
PIT (BASEMENT)	72	5	19 - 170	<470 - 1050	<2 - 3	<5 - 12	0
PENTHOUSE ABOVE ROOM 22	73	5	<19 - 38	<470 - 1800	<2 - 3	<5 - 9	0
PENTHOUSE ABOVE LADIES CHANGE ROOM	74	5	<26 - 37	<430 - 1300	<2	<5	0
PENTHOUSE ABOVE VAULT	75	5	<19 - 28	<430 - 1600	<2	<5 - 6	0
STORAGE SHED	76	5	<19 - 45	1200 - 13000	<2	<5 - 9	0
VAULT	77	5	19 - 85	<470 - 610	<2	<5	0
HALLWAY (AREA 16N)	78	5	<26 - 46	<430 - 1200	<2 - 3	<5 - 8	0
HALLWAY (AREA 16W)	79	5	<26 - 55	<430 - 1400	<2	<5	0

TABLE 4 (Continued)

SUMMARY OF SINGLE POINT SURFACE CONTAMINATION MEASUREMENTS
FROM LOW PROBABILITY OF CONTAMINATION AREAS (LPC)
BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION		Number of Measurements Exceeding Criteria
			Alpha (dpm/100 cm^2) Range of Measurements	Beta-Gamma (dpm/100 cm^2) Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)	
HALLWAY (AREA 23)	80	5	<26 - 82	<430 - 1400	<2 - 5	<5 - 10	0
HALLWAY (AREA 27E)	81	5	<19 - 28	<480 - 1200	<2 - 3	<5 - 15	0
HALLWAY (AREA 27W)	82	3	<26	<430	<2 - 3	<5 - 6	0
HALLWAY (AREA 57)	83	5	<19 - 28	<470 - 490	<2	<5 - 13	0
NRC Guideline			300	15000	20	1000	

TABLE 5

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES COLLECTED FROM EXPOSED TRENCHES
INSIDE BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Radionuclide Concentration (pCi/g)						
		Co-60	Cs-137	U-235	U-238	Th-232	Pu-238	Pu-239/240
ROOM 1	84	13.0 ± 0.7[a]	2.9 ± 0.3	0.2 ± 0.2	5.7 ± 1.2	0.7 ± 0.9	b	b
ROOM 3	85	0.5 ± 0.1	0.2 ± 0.1	0.4 ± 0.1	1.4 ± 0.7	2.6 ± 1.7	b	b
ROOM 5	86	<0.1	<0.1	0.2 ± 0.1	1.8 ± 0.9	1.3 ± 0.5	b	b
ROOM 6/7	87	<0.1	<0.1	0.1 ± 0.1	2.4 ± 1.1	1.0 ± 0.4	b	b
ROOM 15-1	88	<0.1	<0.1	0.1 ± 0.1	1.1 ± 0.4	0.4 ± 0.2		
ROOM 15-2		<0.1	<0.1	0.1 ± 0.1	3.6 ± 0.7	1.0 ± 0.4		
ROOM 15-3		<0.1	<0.1	0.1 ± 0.1	1.5 ± 0.8	1.3 ± 0.4		
ROOM 15-4		<0.1	<0.1	0.2 ± 0.1	3.6 ± 0.7	1.1 ± 0.3		
ROOM 15-5		<0.1	<0.1	0.2 ± 0.1	1.0 ± 0.6	0.9 ± 0.4		
ROOM 15-6		<0.1	<0.1	0.2 ± 0.1	1.2 ± 1.7	1.4 ± 0.4	<0.001[c]	0.013 ± 0.005[c]
ROOM 16-1	89	<0.1	<0.1	0.2 ± 0.1	1.3 ± 1.0	1.2 ± 0.3		
ROOM 16-2		0.1 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	4.0 ± 1.1	1.3 ± 0.4		
ROOM 16-3		<0.1	0.1 ± 0.1	0.4 ± 0.5	1.7 ± 0.8	1.2 ± 0.3		
ROOM 16-4		<0.1	<0.1	0.2 ± 0.1	1.6 ± 0.8	0.9 ± 0.4		
ROOM 16-5		<0.1	<0.1	0.2 ± 0.1	1.6 ± 0.8	1.4 ± 0.3		
ROOM 17-1	90	<0.1	<0.1	0.2 ± 0.1	1.6 ± 0.8	0.9 ± 0.5		
ROOM 17-2		<0.1	<0.1	0.1 ± 0.1	1.8 ± 0.8	1.4 ± 0.4		
ROOM 17-3		<0.1	0.1 ± 0.1	0.2 ± 0.1	3.2 ± 0.8	1.0 ± 0.4		
ROOM 17-4		<0.1	0.2 ± 0.1	0.2 ± 0.1	2.6 ± 0.7	1.0 ± 0.3	<0.001[d]	0.003 ± 0.002[d]
ROOM 17-5		<0.1	<0.1	0.2 ± 0.1	1.8 ± 0.5	1.3 ± 0.4		
ROOM 17-6		<0.1	0.1 ± 0.1	0.4 ± 0.4	3.4 ± 1.1	1.0 ± 0.4		

TABLE 5 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES COLLECTED FROM EXPOSED TRENCHES
INSIDE BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Radionuclide Concentration (pCi/g)						
		Co-60	Cs-137	U-235	U-238	Th-232	Pu-238	Pu-239/240
ROOM 17-7		<0.1	<0.1	0.3 ± 0.1	1.5 ± 0.8	1.3 ± 0.3		
ROOM 19-1	91	<0.1	<0.1	0.2 ± 0.1	2.2 ± 0.8	0.9 ± 0.4		
ROOM 19-2		<0.1	<0.1	0.2 ± 0.1	2.6 ± 0.7	1.7 ± 0.4		
ROOM 19-3		<0.1	0.1 ± 0.1	0.3 ± 0.1	4.5 ± 0.9	1.2 ± 0.5	<0.001[e]	0.004 ± 0.002[e]
ROOM 19-4		<0.1	<0.1	0.3 ± 0.1	3.1 ± 0.7	1.2 ± 0.3		
ROOM 19-5		<0.1	0.2 ± 0.1	0.2 ± 0.1	2.9 ± 0.6	1.4 ± 0.5		
ROOM 20-1	92	<0.1	0.1 ± 0.1	0.2 ± 0.1	0.5 ± 0.5	0.9 ± 0.4		
ROOM 20-2		<0.1	<0.1	0.2 ± 0.1	2.6 ± 0.8	1.1 ± 0.5		
ROOM 20-3		<0.1	<0.1	0.1 ± 0.1	2.1 ± 0.7	1.8 ± 0.5		
ROOM 20-4		<0.1	<0.1	0.2 ± 0.1	1.5 ± 0.8	1.2 ± 0.3	0.002 ± 0.002[f]	0.005 ± 0.003[f]
ROOM 20-5		<0.1	<0.1	0.2 ± 0.1	1.5 ± 0.8	1.3 ± 0.3		
ROOM 20-6		<0.1	<0.1	0.1 ± 0.1	1.6 ± 0.7	1.2 ± 0.7		
ROOM 20-7		<0.1	<0.1	0.2 ± 0.1	2.4 ± 0.9	1.0 ± 0.4		
ROOM 22	93	<0.1	<0.1	0.2 ± 0.1	2.0 ± 0.6	1.1 ± 0.4	b	b
ROOM 24-1	94	<0.1	<0.1	0.2 ± 0.1	1.4 ± 1.2	1.1 ± 0.5	b	b
ROOM 24-2		<0.1	0.4 ± 0.1	0.2 ± 0.1	1.5 ± 1.1	1.2 ± 0.6	b	b
ROOM 24-3		<0.1	<0.1	0.2 ± 0.1	2.9 ± 0.8	1.5 ± 0.4	b	b
LADIES CHANGE ROOM	95	<0.1	<0.1	0.2 ± 0.1	1.0 ± 1.4	1.2 ± 0.8	b	b

TABLE 5 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES COLLECTED FROM EXPOSED TRENCHES
INSIDE BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location	Figure	Radionuclide Concentration (pCi/g)						
		Co-60	Cs-137	U-235	U-238	Th-232	Pu-238	Pu-239/240
LAUNDRY ROOM 1	96	<0.1	<0.1	0.3 ± 0.1	1.8 ± 1.6	1.3 ± 0.5	b	b
LAUNDRY ROOM 2		<0.1	<0.1	0.2 ± 0.1	1.6 ± 1.1	1.1 ± 0.9	b	b
MEN'S CHANGE ROOM 1	97	<0.1	<0.1	0.2 ± 0.1	3.7 ± 0.7	1.2 ± 0.5		
MEN'S CHANGE ROOM 2		<0.1	<0.1	0.2 ± 0.1	1.2 ± 1.6	0.9 ± 0.3		
MEN'S CHANGE ROOM 3		<0.1	<0.1	0.2 ± 0.1	1.1 ± 0.7	0.9 ± 0.4	0.003 ± 0.002[g]	0.011 ± 0.004[g]
MEN'S CHANGE ROOM 4		<0.1	0.3 ± 0.1	0.2 ± 0.1	1.0 ± 1.5	1.5 ± 0.4		
MEN'S CHANGE ROOM 5		<0.1	0.1 ± 0.1	0.3 ± 0.1	2.3 ± 1.2	1.5 ± 0.4		
VAULT	98	<0.1	<0.1	0.2 ± 0.1	1.5 ± 0.7	0.9 ± 0.4	b	b
HALLWAY (16N) 1	99	<0.1	<0.1	0.1 ± 0.1	2.9 ± 2.3	1.1 ± 0.4	b	b
HALLWAY (16N) 2		<0.1	<0.1	0.2 ± 0.1	5.6 ± 1.8	2.8 ± 0.8	b	b
HALLWAY (17N)	100	<0.1	<0.1	2.3 ± 0.6	0.9 ± 0.5	1.6 ± 0.5	b	b
HALLWAY (23)	101	<0.1	<0.1	0.2 ± 0.1	1.4 ± 0.8	1.2 ± 0.4	b	b

[a]Uncertainties represent the 95% confidence level, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[b]Plutonium analyses were requested on random samples as indicators for the drain system.
[c]Composite all samples from Rooms 15 and 16.
[d]Composite all samples from Room 17.
[e]Composite all samples from Room 19.
[f]Composite all samples from Room 20.
[g]Composite all samples from Men's Change Room.

TABLE 6

RADIONUCLIDE CONCENTRATIONS IN RESIDUE COLLECTED FROM "COLD" DRAINS
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location[a]	Radionuclide Concentration (pCi/g)						
	Co-60	Cs-137	U-235	U-238	Th-232	Pu-238	Pu-239/240
CHANGE ROOM (CR)	<0.1	<0.2	<0.8	3.4 ± 2.9[b]	<0.6	<0.1	2.4 ± 0.3
ROOM 50 (F1)	0.4 ± 0.4	0.2 ± 0.5	0.9 ± 0.4	8.3 ± 3.7	1.3 ± 0.8	0.2 ± 0.1	4.5 ± 0.3
ROOM 50 (F4)	<0.2	0.3 ± 0.2	0.4 ± 0.4	5.6 ± 3.2	1.2 ± 1.0	<0.1	3.3 ± 0.4

[a]Refer to Figure 102.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 7

SUMMARY OF BETA-GAMMA SURFACE CONTAMINATION MEASUREMENTS
FROM THE ROOF OF BUILDING C
BABCOCK AND WILCOX
LYNCHBURG, VIRGINIA

Location[a]	Total Contamination (dpm/100 cm^2)	Removable Contamination (dpm/100 cm^2)
1	8200	<5
2	510	<5
3	<500	<5
4	<500	7
5	640	<5
6	<500	<5
7	2300	<5
8	1600	<5

[a]Refer to Figure 103.

TABLE 8

RADIONUCLIDE CONCENTRATIONS IN GRAVEL COLLECTED FROM THE
ROOF OF BUILDING C
BABCOCK AND WILCOX
LYNCHBURG, VIRGINIA

Location[a]	Radionuclide Concentration (pCi/g)						
	Co-60	Cs-137	U-235	U-238	Th-232	Pu-238	Pu-239/240
1	<0.2	<0.1	<0.1	<1.4	<0.2		
2	<0.1	1.0 ± 0.2[b]	<0.5	1.7 ± 1.3	<0.2		
3	<0.1	0.3 ± 0.2	<0.2	<1.4	<0.3	0.006 ± 0.001[c]	0.006 ± 0.001[c]
4	<0.1	0.6 ± 0.2	<0.3	2.8 ± 1.2	<0.3		

[a]Refer to Figure 103.
[b]Uncertainities represent the 95% confidence level, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[c]Composite of all samples (1-4).

TABLE 9

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL SAMPLES
COLLECTED AROUND BUILDING C
BABCOCK AND WILCOX
LYNCHBURG, VIRGINIA

Location[a]	Radionuclide Concentration (pCi/g)				
	Co-60	Cs-137	U-235	U-238	Th-232
1	<0.1	0.2 ± 0.1[b]	<0.4	0.8 ± 0.7	1.1 ± 0.3
2	<0.1	0.2 ± 0.1	0.2 ± 0.1	1.3 ± 1.1	1.1 ± 0.3
3	<0.1	0.3 ± 0.1	0.3 ± 0.2	1.3 ± 1.1	1.3 ± 0.4
4	<0.1	<0.1	<0.2	2.2 ± 0.6	1.1 ± 0.4
5	<0.1	<0.1	0.2 ± 0.1	1.0 ± 0.4	0.8 ± 0.3
6	<0.1	<0.1	<0.2	1.0 ± 0.7	0.5 ± 0.2
7	<0.1	0.4 ± 0.1	0.2 ± 0.1	2.1 ± 0.7	1.2 ± 0.4
8	0.2 ± 0.1	<0.1	0.2 ± 0.1	1.3 ± 0.9	1.1 ± 0.3
9	<0.1	<0.1	0.2 ± 0.1	3.5 ± 0.9	1.5 ± 0.4
10	<0.1	0.3 ± 0.1	0.3 ± 0.1	<0.1	1.3 ± 0.4
11	<0.1	<0.1	0.2 ± 0.1	3.0 ± 1.4	1.6 ± 0.4
12	<0.1	0.3 ± 0.1	0.2 ± 0.1	<1.8	1.4 ± 0.4
13	<0.1	0.3 ± 0.2	0.2 ± 0.1	2.8 ± 0.8	1.2 ± 0.3
14	<0.1	0.3 ± 0.1	<0.2	1.8 ± 0.7	1.5 ± 0.3
15	<0.1	0.2 ± 0.1	<0.5	2.5 ± 0.7	1.4 ± 0.4
16	<0.1	0.2 ± 0.1	0.5 ± 0.4	1.2 ± 1.1	0.9 ± 0.4

[a]Refer to Figure 104.
[b]Uncertainties represent the 95% confidence level, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 10

RADIONUCLIDE CONCENTRATIONS IN SURFACE SOIL
COLLECTED NORTH OF BUILDING C
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

Location[a]	Radionuclide Concentration (pCi/g)				
	Co-60	Cs-137	U-235	U-238	Th-232
1	<0.1	0.2 ± 0.1	<0.3	1.5 ± 0.7	1.5 ± 0.5
2	<0.1	<0.1	<0.3	<1.0	1.0 ± 0.5
3	<0.1	0.2 ± 0.1	<0.3	2.3 ± 0.7	1.6 ± 0.5
4	<0.1	0.3 ± 0.1	<0.3	<1.0	1.3 ± 0.4
5	<0.1	<0.1	<0.2	1.1 ± 0.9	0.9 ± 0.4
6	<0.1	0.2 ± 0.1	<0.3	<0.9	1.3 ± 0.4
7	<0.1	0.7 ± 0.2	<0.4	2.4 ± 1.9	1.4 ± 0.6
8	<0.1	<0.1	<0.3	<1.0	<0.4
9	<0.1	0.4 ± 0.1	<0.3	<1.0	1.7 ± 0.7
10	<0.1	0.4 ± 0.1	<0.3	<0.9	1.5 ± 0.4

[a]Refer to Figure 107

[b]Uncertainties represent the 5% confidence level, based only on counting statistics; additional laboratories uncertainties of ± 6 to 10% have not been propagated into these data.

TABLE 11

RADIONUCLIDE CONCENTRATIONS IN SOIL FROM STORM DRAIN AND SHALLOW BOREHOLES FROM FORMER LOCATIONS OF WASTE DRAIN LINES[a]
BUILDING C
BABCOCK AND WILCOX
LYNCHBURG, VIRGINIA

Location[b,c]	Radionuclide Concentration (pCi/g)						
	Co-60	Cs-137	U-235	U-238	Th-232	Pu-238	Pu-239/240
1 A	0.5 ± 0.1[d]	0.6 ± 0.2	0.2 ± 0.1	2.5 ± 0.[illegible]	0.5 ± 0.3		
2 A	<0.1	<0.1	<0.2	<4.8	1.1 ± 0.4		
3 A	<0.1	<0.1	<0.2	2.4 ± 0.7	1.1 ± 0.5		
4 A	<0.2	<0.1	0.3 ± 0.1	2.4 ± 0.7	0.9 ± 0.3		
5 A	1.9 ± 0.3	1.8 ± 0.3	0.5 ± 0.5	4.0 ± 2.0	1.2 ± 0.5		
6 A	<0.1	<0.1	0.2 ± 0.1	3.3 ± 0.8	1.3 ± 0.4		
6 B	<0.1	<0.1	0.2 ± 0.1	3.4 ± 2.3	1.3 ± 0.5		
7 A	<0.1	<0.1	0.2 ± 0.1	2.6 ± 0.8	1.0 ± 0.5		
7 B	<0.1	<0.1	0.2 ± 0.1	3.0 ± 1.6	1.5 ± 0.4		
8 A	<0.1	<0.1	0.6 ± 0.5	1.9 ± 0.8	1.1 ± 0.4		
8 B	<0.1	<0.1	0.2 ± 0.1	4.4 ± 0.8	1.4 ± 0.5		
9 A	<0.1	<0.1	<0.2	3.1 ± 1.5	1.1 ± 0.4		
9 B	<0.1	<0.1	0.2 ± 0.1	2.1 ± 1.5	1.1 ± 0.4	0.005 ± 0.003[e]	0.056 ± 0.010[e]
10 A	<0.2	<0.1	0.3 ± 0.1	1.7 ± 0.8	1.3 ± 0.4		
10 B	<0.1	<0.1	<0.2	3.1 ± 0.7	1.2 ± 0.6		
11 A	<0.1	<0.1	0.2 ± 0.1	1.6 ± 0.9	1.0 ± 0.6		
11 B	<0.1	<0.1	0.3 ± 0.1	1.3 ± 0.5	1.8 ± 0.4		
12 A	<0.1	<0.1	0.2 ± 0.1	1.7 ± 1.0	1.2 ± 0.4		
12 B	<0.1	<0.1	0.2 ± 0.1	<5.3	1.0 ± 0.4		
13 A	0.7 ± 0.2	11.5 ± 0.5	<0.4	<0.8	1.7 ± 0.4		
13 B	<0.1	4.4 ± 0.3	0.4 ± 0.2	2.2 ± 1.1	1.5 ± 0.5		

TABLE 11 (Continued)

RADIONUCLIDE CONCENTRATIONS IN SOIL FROM STORM DRAIN AND SHALLOW BOREHOLES
FROM FORMER LOCATIONS OF WASTE DRAIN LINES[a]
BUILDING C
BABCOCK AND WILCOX
LYNCHBURG, VIRGINIA

Location[b,c]	Radionuclide Concentration (pCi/g)						
	Co-60	Cs-137	U-235	U-238	Th-232	Pu-238	Pu-239/240
14 A	<0.1	<0.1	<0.2	1.5 ± 0.5	1.0 ± 0.4	e	e
14 B	<0.1	<0.1	0.3 ± 0.1	1.4 ± 0.9	0.9 ± 0.5	e	e
STORMDRAIN 0-15 cm	0.1 ± 0.1	0.3 ± 0.1	1.2 [illegible].5	0.2 ± 0.1	0.8 ± 0.2	f	f
STORMDRAIN 30-45 cm	0.2 ± 0.1	0.3 ± 0.1	0.[illegible]	0.1 ± 0.1	0.8 ± 0.3	f	f

[a]Waste drain lines had been excavated, removed and backfilled.
[b]Refer to Figure 108.
[c]Sample A collected from bottom of hole (N30 cm); Sample B collected from sidewall of hole (S 15 cm).
[d]Uncertainties represent the 95% confidence level, based only on counting statistics; additional laboratory uncertainties of ± 6 to 10% have not been propagated into these data.
[e]Composite of all samples location 1-14.
[f]Plutonium analyses were not requested on storm drain sediment.

APPENDIX A

PROPOSED CONFIRMATORY RADIOLOGICAL SURVEY PLAN
FOR BUILDING C
LYNCHBURG RESEARCH CENTER
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

DATED JULY 16, 1987

APPENDIX A

PROPOSED CONFIRMATORY RADIOLOGICAL SURVEY PLAN
FOR BUILDING C
LYNCHBURG RESEARCH CENTER
BABCOCK AND WILCOX COMPANY
LYNCHBURG, VIRGINIA

I. Site History and Description

The Lynchburg Research Center, located on the Babcock and Wilcox Company site, is located 16 kilometers east of Lynchburg, Virginia along the James River. The Lynchburg Research Center is a facility used to perform research and development studies of nuclear fuel cycles. Building C of the Lynchburg Research Center was formerly used as a research and development facility for uranium, thorium, and plutonium fuels. The existing structure is the result of several additions to an original laboratory constructed in 1962. The building consisted of approximately 952.2 m^2 (square meters) of laboratories for the handling and use of radioactive material. Building C also contains two vaults formerly used for the storage of special nuclear material and two waste tanks underneath one of the laboratories.

The decommissioning of Building C occurred in three phases. Phase I consisted of former laboratories 25 (health physics office), 26 (technician's office), 27 43, 44, 50, 51, 52, 53, and 54. Also included were offices associated with labs 43, 44, and 50; the western portion of hallway 23; and an area known as the Old Central Stores. Research conducted in these locations involved uranium. thorium, and plutonium solutions and powders.

Phase II included former laboratories 15, 16, and 17; offices and hallways along the front of the building; and offices adjacent to labs 15 and 16. The eastern portion of hallway 23 and a connecting hallway were also included. Projects in these locations utilized plutonium and uranium oxide powders.

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July 16, 1987

Phase III included former laboratories 19 and 20, two waste tanks, two special nuclear material vaults, hallway 24, part of hallway 23, the change rooms for men and women, ventilation equipment, penthouse, and adjacent areas in which very little or no radioactive materials use occurred. The primary use of these areas was for analytical chemistry on plutonium fuels.

The licensee has completed decontamination of Building C and has requested release of the facility for unrestricted use. Oak Ridge Associated Universities (ORAU), has been requested by the Nuclear Regulatory Commission (NRC), Region II, to conduct an independent confirmatory survey of Building C.

II. Purpose

The purpose of the survey is to verify the adequacy and accuracy of the licensee's final survey by providing data necessary to evaluate the radiological conditions of Building C, relative to NRC guidelines for release for unrestricted use.

III. Responsibility

Work described in this survey plan will be performed under the supervision of Mr. J.D. Berger, Manager, and Mr. G.L. Murphy, Assistant Manager, with the Radiological Site Assessment Program of ORAU.

Site activities will be coordinated through Mr. Arne F. Olsen, Senior License Administrator for Babcock & Wilcox's Lynchburg Research Center.

IV. Procedure

A. Document Review

1. ORAU will review and assess background documentation and the Babcock and Wilcox's decommissioning plans.

2. ORAU will review documentation of final survey procedures, survey instrumentation, instrument calibration procedures, and any other pertinent information supporting the decommissioning plan.

3. ORAU will review the close-out survey reports by Babcock and Wilcox. Information will be evaluated to assure that areas exceeding site guidelines were identified and have undergone decontamination.

B. Facility Survey

1. Gridding

Confirmatory measurements will be referenced to the initial grid system established by the licensee. ORAU will reestablish this grid where necessary. Measurements or samples collected from ungridded surfaces will be referenced to the floor and lower wall grid, or to prominent building features.

2. Surface Scanning

Accessible areas on the floors and lower walls (up to 2 m) will be surface scanned to identify and document locations of residual contamination using the NaI(Tl) scintillation detectors for elevated gamma radiation levels and for alpha and beta-gamma contamination utilizing ZnS scintillators, GM detectors, and gas proportional detectors.

Exposure rate measurements will be made 1 m above the surface and at representative locations throughout the building. A minimum of 12 locations will be selected for such measurements.

3. Surface Contamination Measurements

Measurements of total and removable alpha and beta-gamma contamination will be performed on approximately 10% of randomly selected floor and lower wall grid blocks. One set of five direct

measurements will be obtained from each surveyed grid block, and one smear will be taken for each set of five measurements, corresponding to the location of highest total (direct) measurement.

A minimum of 30 direct measurements and smears will be obtained on accessible areas of the upper walls and ceilings. Particular attention will be given to cracks, beams, piping, ledges, ducts, overhead crane, and other surfaces where material might settle or accumulate.

Direct measurements and smears will be obtained at locations of elevated contact radiation levels identified by the surface scans.

4. Additional Measurements and Sampling

   a. Drains, pipes, and ventilation ducts will be scanned, and direct measurements and smears will be obtained. Samples of scale or residue will be collected, where possible, using standard drain cleaning equipment.

   b. Residue samples and smears will be collected from the liquid waste retention tanks.

   c. Paint scrapings will be obtained, as required, from surfaces considered representative of the facility in general, and from surfaces having a high potential for surface contamination.

   d. The roof will be scanned and direct measurements, smears and/or samples will be obtained from locations of elevated contact radiation levels.

   e. Outdoor areas around the building will be scanned. Direct measurements and soil samples will be obtained from 10-15 random locations and from locations of elevated contact radiation levels.

f. Subsurface soil samples will be collected from the area immediately adjacent to external drain lines between Building C and the Liquid Waste Building.

V. Data and Sample Analysis

Samples and direct measurement data will be returned to Oak Ridge, Tennessee, for analysis and interpretation. Soil will be analyzed by solid state gamma spectrometry. Radionuclides of primary interest are Am-241, uranium, and thorium; however, spectra will be reviewed for other identifiable photopeaks. Selected and composited samples of soil, paint, and residues will be analyzed for Am-241, plutonium, uranium, and thorium by alpha spectroscopy and/or neutron activation techniques. Smears will be analyzed for gross alpha and beta. Results will be compared to the licensee's survey findings and the NRC guidelines for release for unrestricted use (see attachment).

VI. Tentative Schedule

Measurement and Sampling	August 17-28, 1987
Sample Analysis	August 31 - Sept. 14, 1987
Draft Report	October 30, 1987

APPENDIX B

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

APPENDIX B

MAJOR SAMPLING AND ANALYTICAL EQUIPMENT

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

A. Direct Radiation Measurements

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

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

Eberline Alpha Scintillation Detector
Model AC-3-7 or AC-3-8
(Eberline, Santa Fe, NM)

Eberline Beta-Gamma "Pancake" Detector
Model HP-260
(Eberline, Santa Fe, NM)

Transpec Portable Spectroscopy System
(Quantum Technology, Atlanta, GA)

EG&G ORTEC High Purity Germanium Detector
Model GEM-13180-S, 13% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

Ludlum Alpha-Beta Floor Monitor
Model 239-1
(Ludlum, Sweetwater, TX)

Ludlum Ratemeter-Scaler
Model 2220
(Ludlum, Sweetwater, TX)

Ludlum Ratemeter
Model 16
(Sweetwater, TX)

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

Victoreen NaI Scintillation Detector
Model 489-55
(Victoreen, Cleveland, OH)

B. Laboratory Analyses

Low Background Alpha-Beta Counter
Model LB-5110
(Tennelec, Oak Ridge, TN)

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

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

High Purity Germanium Coaxial Well Detector
Model GWL-1102010-PWS-S, 23% efficiency
(EG&G ORTEC, Oak Ridge, TN)

Used in conjunction with:
Lead Shield Model G-16
(Applied Physical Technology, Atlanta, GA)

High Purity Germanium Detector
Model IGC25, 25% efficiency
(Princeton Gamma-Tech, Princeton, NJ)

Used in conjunction with:
Lead Shield
(Nuclear Data, Schaumburg, IL)

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

Alpha Spectrometry System
Tennelec Electronics
(Tennelec, Oak Ridge, TN)

Multichannel Analyzer
Model ND-66
(Nuclear Data, Schaumburg, IL)

APPENDIX C

MEASUREMENT AND ANALYTICAL PROCEDURES

APPENDIX C

Measurement and Analytical Procedures

Surface Scans

Surface scans in the facility were performed by passing the probes slowly over the surface. The distance between the probes and the surface was maintained at a minimum - nominally about 1 cm. Identification of elevated levels was based on increases in the audible signal from the recording or indicating instrument. Alpha and beta-gamma scans of large surface areas on the floor of the facility were accomplished by use of a gas proportional floor monitor, with a 600 cm^2 sensitive area. The instrument was slowly moved in a systematic pattern to cover 100% of the accessible area. Combinations of detectors and instrument for the scans were:

Beta-Gamma	- Pancake G-M probe with PRM-6 ratemeter.
Beta-Gamma	- Pancake G-M probe with PRS-1 scaler/ratemeter.
Gamma	- NaI scintillation detector (3.2 cm x 3.8 cm crystal) with PRM-6 ratemeter.
Alpha	- ZnS probe with PRS-1 scaler/ratemeter.
Alpha/Beta	- Gas proportional floor monitor with Ludlum Model 16 ratemeter.

Alpha and Beta-gamma Surface Contamination Measurements

Measurements of total alpha radiation level were performed using Eberline Model PRS-1 portable scaler/ratemeters with Model AC-3-7 alpha scintillation probes. Measurements of total beta-gamma radiation levels were performed using Eberline Model PRS-1 portable scaler/ratemeters with Model HP-260 thin-window "pancake" G-M probes. Count rates (cpm) were converted to disintegration rates the active area of the detector. Effective window areas were converted to disintegration rates (dpm/100 cm^2) by dividing the net rate by the 4 efficiency and correcting for the active area of the detector. Effective window areas were 59 cm^2 for the G-M detectors. The background count rate for ZnS alpha probes averaged approximately 2 cpm; the average background count rate was approximately 44 cpm for the G-M detectors.

Removable Contamination Measurements

Smear measurements were performed on numbered filter paper disks, 47 mm in diameter. Smears were placed in labeled envelopes with the location and other pertinent information recorded. Smears were counted on a low background proportional counter at the Oak Ridge laboratory.

Exposure Rate Measurements

Measurements of gamma exposure rates were performed using an Eberline PRM-6 portable ratemeter with a Victoreen Model 489-55 gamma scintillation probe containing a 3.2 cm x 3.8 cm NaI(Tl) scintillation crystal. Count rates were converted to exposure rates (R/h) by cross-calibrating with a Reuter Stokes model RSS-111 pressurized ionization chamber at representative onsite locations.

Soil Sample Analysis

Soil samples were dried, mixed, and a portion sealed in 0.5-liter Marinelli beaker. The quantity placed in the beaker was chosen to reproduce the calibrated counting geometry and typically ranged from 600 to 800 g of soil. Net soil weights were determined and the samples counted using intrinsic germanium detectors coupled to a Nuclear Data Model ND-680 pulse height analyzer system. Background and Compton stripping, peak search, peak identification, and concentration calculations were performed using the computer capabilities inherent in the analyzer system. Spectra were reviewed for identifiable photopeaks which could be attributed to Babcock and Wilcox operations.

Water Sample Analysis

The water sample was rough-filtered through Whatman No. 2 filter paper. Remaining suspended solids were removed by filtration through 0.45 m membrane filter. The filtrate was acidified by the addition of 10 ml of concentrated nitric acid. A known volume of sample was evaporated to dryness counted for gross alpha and gross beta using a Tennelec Model LB-5100 low-background proportional counter.

Alpha Spectroscopy

Samples were dissolved by pyrosulfate fusion and precipitated with barium sulfate. The barium sulfate precipitate was redissolved and the plutonium separated by liquid - liquid extraction. The plutonium was then precipitated with a cerium fluoride carrier and counted using surface barrier detectors (ORTEC), alpha spectrometers (Tennelec), and an ND-66 Multichannel Analyzer (Nuclear Data).

Uncertainties and Detection Limits

The uncertainties associated with the analytical data presented in the tables of this report, represent the 95% confidence levels for that data. These uncertainties were calculated based on both the gross sample count levels and the associated background count levels. When the net sample count was less than the 95% statistical deviation of the background count, the sample concentration was reported as less than the detection limits of the procedure. Because of variations in background levels and Compton contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument. Additional uncertainties of $\pm$ 6 to 10%, associated with sampling and laboratory procedures, have not been propagated into the data presented in this report.

Calibration and Quality Assurance

Laboratory and field survey procedures are documented in manuals developed specifically for the Oak Ridge Associated Universities' Radiological Site Assessment Program.

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

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

APPENDIX D

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BY-PRODUCT, SOURCE OR SPECIAL NUCLEAR MATERIAL

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT, SOURCE, OR SPECIAL NUCLEAR MATERIAL

U.S. Nuclear Regulatory Commission
Divison of Fuel Cycle & Material Safety
Washington, D.C. 20555

July 1982

The instructions in this guide, in conjunction with Table 1, specify the radionuclides and radiation exposure rate limits which should be used in decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table 1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control is considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table 1 prior to the application of the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces or premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.

4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer of premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such requests must:

   a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

   b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table 1. A copy of

the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also the Administrator of the NRC Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223 Ra-224, U-232, I-126, I-131, I-133	1000 dpm/100 cm^2	3000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5000 dpm βγ/100 cm^2	15,000 dpm βγ/100 cm^2	1000 dpm βγ/100 cm^2

[a] Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides 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 observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[c] Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.

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

[e] The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

[f] The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.