CONFIRMATORY SURVEY ACTIVITIES
FOR THE
FORT ST. VRAIN NUCLEAR STATION
PUBLIC SERVICE COMPANY OF COLORADO
PLATTEVILLE, COLORADO

INTRODUCTION

Public Service Company of Colorado (PSC) operated a 330 MWe High Temperature Gas Cooled Reactor (HTGR) from July 1979 until August 1989. The plant, designated as the Fort St. Vrain Nuclear Station (FSV), was authorized for construction on September 17, 1968 when the U.S. Nuclear Regulatory Commission (NRC) issued a provisional construction permit. Construction was completed in December 1973 and a facility operating license, License No. DPR-34, Docket No. 50-267, was granted on December 21, 1973. Initial fuel loading commenced on December 26, 1973 and initial criticality was achieved January 31, 1974. After a prolonged period of startup testing, low-power operation and plant modifications, the plant was committed for commercial operation on July 1, 1979. Full power was achieved November 6, 1981 (PSC 1995a).

In the nuclear steam supply system for FSV, heat was produced by fission in the HTGR utilizing a uranium-thorium fuel cycle. Graphite was used for the moderator, core structure, and reflector. High temperature helium was used as the primary coolant to produce superheated and reheated steam at a temperature of 1,000 °F to match conventional thermal station conditions. The entire nuclear steam supply system, including the reactor core, graphite moderator and reflector, steam generators and helium circulators, was contained within a Prestressed Concrete Reactor Vessel (PCRV).

During the operational period, FSV operated for approximately 890 effective full-power days; FSV was shut down on August 18, 1989. The PSC Board of Directors reviewed and confirmed the Executive Management decision that FSV would not be restarted, and that PSC would pursue decommissioning of FSV. The decision to permanently shut down and decommission FSV was based on related technical and financial considerations. Problems were identified with the control rod drive assemblies and the steam generator steam ring headers that presented significant technical obstacles which could be overcome, but at a significant cost in dollars and time to PSC. In addition,

due to the uniqueness of the HTGR fuel cycle, the cost to purchase new fuel was prohibitive. This, in conjunction with low plant availability and correspondingly high operating costs, made continued operation of FSV impractical.

PSC's objective is the dismantlement and decommissioning of FSV to release all site areas for unrestricted use. To accomplish this, a portion of the PCRV structure and the radioactive balance-of-plant equipment that exceed the limits for unrestricted use will be decontaminated or removed as described in the Fort St. Vrain Decommissioning Plan. In May 1991, the NRC granted a 10 CFR 50 Possession Only License. On November 23, 1992, the NRC issued the Order to Authorize Decommissioning of Fort St. Vrain and Amendment No. 85 to Possession Only License No. DPR-34 (PSC 1995b).

The FSV facility will be largely left intact following decommissioning; dismantlement of structures will be confined to the PCRV, and portions of the Reactor Building, Turbine Building, and Liquid Waste System. Removal will be for purposes of removing contaminated structures and to provide paths for removal of contaminated piping and equipment.

Following defueling, the PCRV contained the majority of the remaining radioactive material inventory. Portions of the PCRV concrete are activated due to direct irradiation from the reactor core, and will be removed prior to final survey and disposed of as radioactive waste at a licensed radioactive waste disposal facility. Thus, the radioactive source term at FSV is primarily a result of neutron activation of both metallic and concrete components of the PCRV and neutron activation of impurities contained in graphite components of the PCRV. These activation products include beta-gamma emitters such as Co-60, Eu-152, and Eu-154, and low-energy beta and x-ray emitters such as H-3, C-14, and Fe-55. It should be noted that H-3 and Fe-55 are the largest contributors to the total radionuclide inventory (PSC 1995a).

FSV's final survey will include all pertinent structures, surfaces, systems and components, concentrating on those previously identified as contaminated or potentially contaminated during the dismantlement/decommissioning phases. The final survey will include:

- Sampling outside the restricted area of PSC property, soil, pavement, water, and liquid effluent ditch and pond sediment for radioisotopic analysis and measurement of gamma exposure rate,
- Sampling inside the restricted area of PSC property, soil, basin sediment, pavement and water for radioisotopic analysis and measurement of gamma exposure rate,
- Radiological surveys of the PCRV and Reactor Building, an
- Radiological surveys of the Turbine Building, Radwaste Compactor Building, New Fuel Storage Building, Radiochemistry Laboratory, Helium Transfer and Storage System, and Liquid Radwaste System.

At the request of the NRC's Division of Waste Management, the Environmental Survey and Site Assessment Program (ESSAP) of the Oak Ridge Institute for Science and Education (ORISE) performed independent confirmatory surveys activities at the Fort St. Vrain site in Platteville, Colorado. During the period January 22 through 25, 1996, ESSAP performed instrument comparison activities—including side-by-side surface activity measurements and surface scans—and reviews of the licensee's embedded piping program and planned use of *in situ* gamma spectrometry for determining the licensed material contribution to exposure rate.

SITE DESCRIPTION

The FSV facility is located approximately 56 kilometers (35 miles) north of Denver and 5.6 kilometers (3.5 miles) northwest of the town of Platteville, in Weld County, Colorado. The site is located in an agricultural area with gently rolling hills. Grade elevation at the plant is 1,460 meters (4,790 feet) above sea level. The site consists of 1130 hectares (2800 acres) owned by PSC, identified as the Owner-Controlled Area, of which approximately 260 hectares was designated as the exclusion area during plant operation.

The station is located approximately 3 kilometers south of the confluence of the South Platte River and the St. Vrain Creek. Neither of these two streams are considered navigable. Cooling for the plant is provided by mechanical draft cooling towers. Make-up water to the cooling towers is obtained from the two streams, and is supplemented by shallow well water. Nineteen shallow monitoring wells are located on the site. The licensee also owns surface water rights in four irrigation ditches which traverse portions of the site.

The major structures within the Restricted Area include the Reactor Building which contains the PCRV, Turbine Building, Radwaste Compactor Building, New Fuel Storage Building, Technical Support Building which contains the Radiochemistry Laboratory, Mechanical Draft Cooling Towers, Warehouse and Construction Workshops, Evaporation Ponds, and the Electrical Switchyard. The ground surface covering within the Restricted Area is composed primarily of gravel and vegetation, with smaller portions devoted to concrete or asphalt roadways and laydown areas.

OBJECTIVES

The objectives of the confirmatory survey activities were to provide NRC inspection support, including independent contractor reviews of decommissioning program elements and confirmatory survey data for use by the NRC in evaluating the adequacy and accuracy of the licensee's procedures and preliminary final status survey results.

PROCEDURES

During the period, January 22 through 25, 1996, ESSAP performed independent confirmatory survey activities at the Fort St. Vrain site in Platteville, Colorado. This technical assistance was provided to assist the NRC in their inspection of licensee decommissioning-related activities. Technical assistance activities included independent confirmatory surface scans, instrument comparison measurements, and a review of decommissioning program elements, and were performed in accordance with a survey plan dated January 17, 1996 (ORISE 1996a). This report summarizes the procedures and results of the technical assistance activities.

Embedded Piping Survey Procedures

Prior to the subject inspection, ESSAP reviewed the licensee's technical basis documents for piping survey instrumentation and provided comments to the NRC (Westinghouse 1995; ORISE 1996b). During the inspection, portions of the embedded piping survey program were reviewed—including a demonstration of the use of small-size GM detectors and thermoluminescent dosimeters (TLDs) on a string. The use of a cylindrical gas flow pipe detector to survey a 2.54 cm (1-inch) carbon steel pipe was also demonstrated. One concern that was sufficiently addressed during the on-site inspection was that the licensee employs an aggressive pipe decontamination procedure that minimizes the potential for crud/debris to remain in the pipe—initially the concern was that the buildup of debris in the pipe would absorb beta radiation and lower the actual efficiency of the pipe detectors.

Additional comments were generated following the on-site inspection and are included as Attachment A of this report.

Use of *In Situ* Gamma Spectrometry for Exposure Rate Compliance

As part of the technical assistance activities, ESSAP evaluated—through discussions with the licensee's contractor—the licensee's plans for incorporating the use of *in situ* gamma spectrometry to determine the licensed material contribution to exposure rate. This measure is necessary because of the significantly varying background exposure rate levels due to both altitude and the composition of building materials, i.e., large masses of concrete that form the PCRV. Two primary uses of *in situ* gamma spectrometry are planned for exposure rate compliance. First, the *in situ* gamma spectrometer will be set up in background reference areas to ensure that the exposure rate in these background areas is not influenced by licensed material. Secondly, the *in situ* gamma spectrometer will be used in conjunction with a NaI detector—that has been cross-calibrated to a pressurized ionization chamber (PIC) to measure exposure rate—to assess the fraction of the total exposure rate at a survey location due to licensed material (i.e., Co-60). Generally, the planned procedure will consist of estimating the peak-to-total count ratio for each of the licensed material photopeaks so that

the contribution of licensed material to exposure rate can be calculated. The licensee stated that the work to develop this procedure is on-going and is anticipated to be completed in approximately 6 weeks.

Surface Scans and Comparison to Licensee Scan Results

Confirmatory surface scans for beta activity were performed over accessible floor and lower wall surfaces in survey units C031, C046, F044, F045, and C005 (refer to Figures 1 through 5). Scans were performed using gas proportional detectors coupled to ratemeter-scalers with audible indicators; both a floor monitor with a 573 cm^2 detector and a hand-held 126 cm^2 detector were used for scanning. Surface activity levels were determined from any locations of elevated direct radiation as identified by scans.

C031 is an affected area located on the Level 7 of the Turbine Building with a floor area of approximately 254 m^2. The floor surface was covered with a red tile that is not located in any other area of the plant, which eliminated the possibility of establishing a material-specific background (the licensee used outdoor concrete as an equivalent surface for a red tile background). The wall surfaces were comprised of steel and concrete. One hundred percent of both floor and lower wall surfaces were scanned, with the exception of the wall area over the portion of the floor that was open to Level 6. An elevated area (3000 to 4000 cpm) extending over a few square meters was identified, while the remainder of the floor area had a scan range of 2000 to 2700 cpm—consistent with background levels. No elevated direct radiation was detected on any of the wall surfaces. A direct measurement within the elevated floor area resulted in an activity of 2000 dpm/100 cm^2.

C046, located within Building 10, is an unaffected area with an approximate floor space of 184 m^2. This survey unit includes four lower level rooms and a second level loft area. No areas of elevated direct radiation were detected on the floors or lower walls. Scan ranges were consistent with background levels—1700 to 2600 cpm and 400 to 800 cpm for the floors and lower walls, respectively.

Located on Level 5 of the Turbine Building is the unaffected 322 m^2 survey unit, C005. The floors and walls are constructed with concrete and the area is congested due to plant systems and stored equipment. Therefore, scans were limited to approximately 40 to 50% of the floor area. Due to the small amount of wall space, some equipment was scanned. No locations of elevated direct radiation were detected throughout the survey unit and the scan ranges were 1300 to 2000 cpm and 300 to 500 cpm for the floor and walls, respectively.

F044 is an affected area located on Level 3 of the Reactor Building with 177 m^2 of floor space. Floors were of concrete and steel grate construction, while walls consisted of concrete blocks. Three locations, each less than one square meter in size, ranging from 3100 to 5100 cpm were identified on the floor. Surface activity measurements on two of the floor areas were 6300 to 8700 dpm/100 cm^2. Subsequent to the ESSAP scan of this survey unit it was recognized that the licensee had not completed this survey package and that comparisons to licensee data were not appropriate.

Survey unit F045, adjacent to F044, is also an affected area with a floor area of 214 m^2. Due to the presence of plants systems, approximately 40% of the floor area was accessible to scans. No scans of the lower walls were completed. No areas elevated direct radiation were detected on the concrete and steel grate floor. The scan range was 1800 to 2600 cpm. As with F044, the licensee had not completed this survey package and comparisons to licensee data were not appropriate.

Comparisons of the ESSAP scan results to the licensee scan results documented in their survey packages were performed for survey units C005, C031, and C046. In general, the scan results were consistent between ESSAP and the licensee. For survey units C005 and C046, both ESSAP and the licensee concluded that surface scans identified no locations of elevated direct radiation. In survey unit C031, ESSAP identified one location in excess of background levels—measuring 2,000 dpm/100 cm^2 —while the licensee identified a different location of elevated direct radiation

measuring 3,600 dpm/100 cm^2. Thus, both ESSAP and the licensee identified one location of above background activity that the other had not detected—the two locations were separated by about 4 m and were both located on the floor.

One recommendation that would facilitate review of the licensee's scan results would be for the licensee to clearly state in the survey package when the scan did not identify any locations of elevated direct radiation. Presently, an indirect method exists for determining if the licensee identified any elevated areas, namely to determine if the licensee collected more direct measurements than specified in the survey package plan.

Side-By-Side Surface Activity Measurements

Field comparisons of ESSAP and licensee (two FSV teams were used) surface activity measurements were performed at NRC-selected locations within building surface and structure survey units. The locations were selected to yield surface activity in an unaffected area at near background levels—at levels of 2,000 dpm/100 cm^2, and at levels of 4,000 dpm/100 cm^2. Specific locations included the Turbine Lube Oil Room (Level 5 of the Turbine Building) for backr nd levels of surface activity, and two locations in the Barrel Evaporator Room (Level 9 of the Reactor Building) for surface activity levels of 2,000 and 4,000 dpm/100 cm^2. The objective was to determine comparability of ESSAP's and the licensee's surface activity measurements.

Both ESSAP and FSV performed beta measurements using Ludlum Model 43-68 gas proportional detectors (126 cm^2) coupled to ratemeter-scalers. ESSAP determined background surface activity measurements on concrete in the Battery Room on Level 5 of the Turbine Building. The background surface activity was used to correct the surface activity measurements at selected side-by-side locations as described above. FSV employed a different technique to evaluate the background level to subtract, as described below.

FSV evaluates background surface activity for a given material by dividing the background into two components: natural material (e.g., concrete) background and the local area exposure rate background. FSV initially collects a series of shielded counts (using a 300 mg/cm^2 Lucite beta shield) at the selected background location that represents the local area exposure rate contribution to the detector response, followed by unshielded measurements that include the contribution from both the local area exposure rate and the natural material background. The difference of these two values yields the natural material background for a specific material (i.e., concrete, steel, wood, etc.)—for concrete, FSV applies a value of 767 dpm/100 cm^2. This natural material background, plus the specific local area exposure rate contribution to the detector response determined for the survey unit being evaluated, are subtracted from the gross surface activity measurements.

Because ESSAP does not account for a changing local area exposure rate contribution to the detector response from where the initial material background levels were established, the material backgrounds subtracted by ESSAP and FSV will typically be different. Therefore, to allow better comparison of ESSAP and FSV surface activities, ESSAP collected shielded measurements at each location using an FSV-provided Lucite shield to determine the detector response from the local area background exposure rate. ESSAP also collected shielded and unshielded surface activity measurements on the concrete in the Battery Room on Level 5 of the Turbine Building. The net material background for concrete was determined by subtracting the shielded response from the unshielded response, resulting in a concrete material background of 162 ± 7.9 cpm (reported 1σ error propagated from counting errors).

Ten repetitive gross counts were performed at each survey location—ESSAP's count time was 1 minute, while FSV collected counts for 15 seconds. Gross (unshielded) count rates were converted to surface activity levels (dpm/100 cm^2) by subtracting both the shielded background and concrete material background, and then dividing the net rate by the 4π efficiency and correcting for the probe area of the detector (Table 1). Both ESSAP and FSV calibrated the gas proportional detectors to Tc-99. ESSAP obtained an efficiency value of 0.25, while the FSV efficiencies were 0.22 and 0.25 for the two FSV teams. Uncertainties in the surface activities represent 1σ errors based on propagating the counting errors in each measurement.

TABLE 1

RESULTS OF SIDE-BY-SIDE SURFACE ACTIVITY MEASUREMENTS

Location	Surface Activity (dpm/100 cm^2)		
	ESSAP	FSV-1	FSV-2
Lube Oil Room	-19 ± 41[a]	-134 ± 180	-83 ± 157
Barrel Evap. Room # 1	1911 ± 49	2199 ± 135	2476 ± 312
Barrel Evap. Room #2	3505 ± 42	4335 ± 346	4213 ± 220

[a]Uncertainties represent 1σ error, based only on counting statistics.

The Student's t-test was used to perform a comparison of the means of ESSAP and each of the two FSV populations, assuming unequal variances. The null hypothesis was stated as the ESSAP mean equals the FSV mean, with a level of significance (α) of 0.05. For the comparison of means at the near background levels in the Lube Oil Room, the null hypothesis was accepted—indicating that there is no statistical difference between the calculated ESSAP and FSV surface activity means. However, for the comparison of means at both surface activity levels in the Barrel Evaporator Room, the null hypothesis was rejected—indicating that there appears to be a statistical difference between the mean surface activities. The raw data from ESSAP and FSV was further evaluated to identify reasons for these differences.

The first finding was that the ESSAP gas proportional detector exhibited a lower detector response than either of the FSV detectors due to specific detector characteristics. Detector characteristics responsible for this difference may include voltage and threshold settings, dimensions of the corona wire, and grounding of the corona wire. The higher FSV detector response should have been resolved through calibration; that is, obtaining ESSAP and FSV detector efficiencies with the same calibration source and at the same source-to-detector spacing. The lower response of the ESSAP detector would then be compensated by having a lower detector efficiency compared to the FSV instruments. However, ESSAP and FSV used different source-to-detector spacings during calibration—ESSAP calibrates in contact with the source (about 0.10 cm), while FSV calibrates at

a spacing of 0.27 cm. This difference may increase the ESSAP efficiency relative to the FSV efficiency by a couple of percent—the increased efficiency results in lower calculated surface activities, relative to FSV.

Another issue identified upon review of the raw data was that the shielded background varied between the two FSV teams in the Barrel Evaporator Room. ESSAP also experienced an increase in the shielded background when the detector was moved from the 2,000 to 4,000 dpm/100 cm^2 surface activity location—from location #1 to #2 in the Barrel Evaporator Room (Table 2). The initial concern is that the Lucite shield is allowing the licensed gamma activity (e.g., Co-60, Cs-137) to interact in the plastic, producing Compton electrons that interact and produce counts in the detector. This increased detector response is then treated as the local area exposure rate and subtracted from the unshielded gross count. It is recommended that further work be performed with the Lucite shield at varying levels of activity to determine if the shield is enhancing detector response through Compton interactions.

SUMMARY

During the period January 22 through 25, 1996, the Environmental Survey and Site Assessment Program of ORISE performed confirmatory survey activities at the Fort St. Vrain site in Platteville, Colorado. Survey activities included technical reviews of the embedded piping survey program and the use of *in situ* gamma spectrometry for exposure rate measurement corrections, surface scans, and surface activity measurements.

Review of the embedded piping program resulted in the resolution of one concern, but generated a couple of new concerns (see Attachment A). Because the licensee is continuing to develop the use of *in situ* gamma spectrometry for exposure rate measurement corrections, additional review of this decommissioning program element will be performed at a later date.

The difference between the ESSAP and FSV total surface activities from the side-by-side comparisons does appear to be statistically significant—FSV's surface activity results appear to be consistently higher. A possible reason for this difference may be that ESSAP and FSV calibrate at different geometries—FSV calibrates at a greater source-to-detector spacing than does ESSAP. In addition, the FSV correction for the variable local area background exposure rate contribution to detector response may be problematic if the Lucite shield produces additional detector response due to licensed gamma activity which is treated as background.

Comparison of scan results from the three survey units evaluated indicated that the licensee performed thorough scan surveys with adequate detection sensitivities.

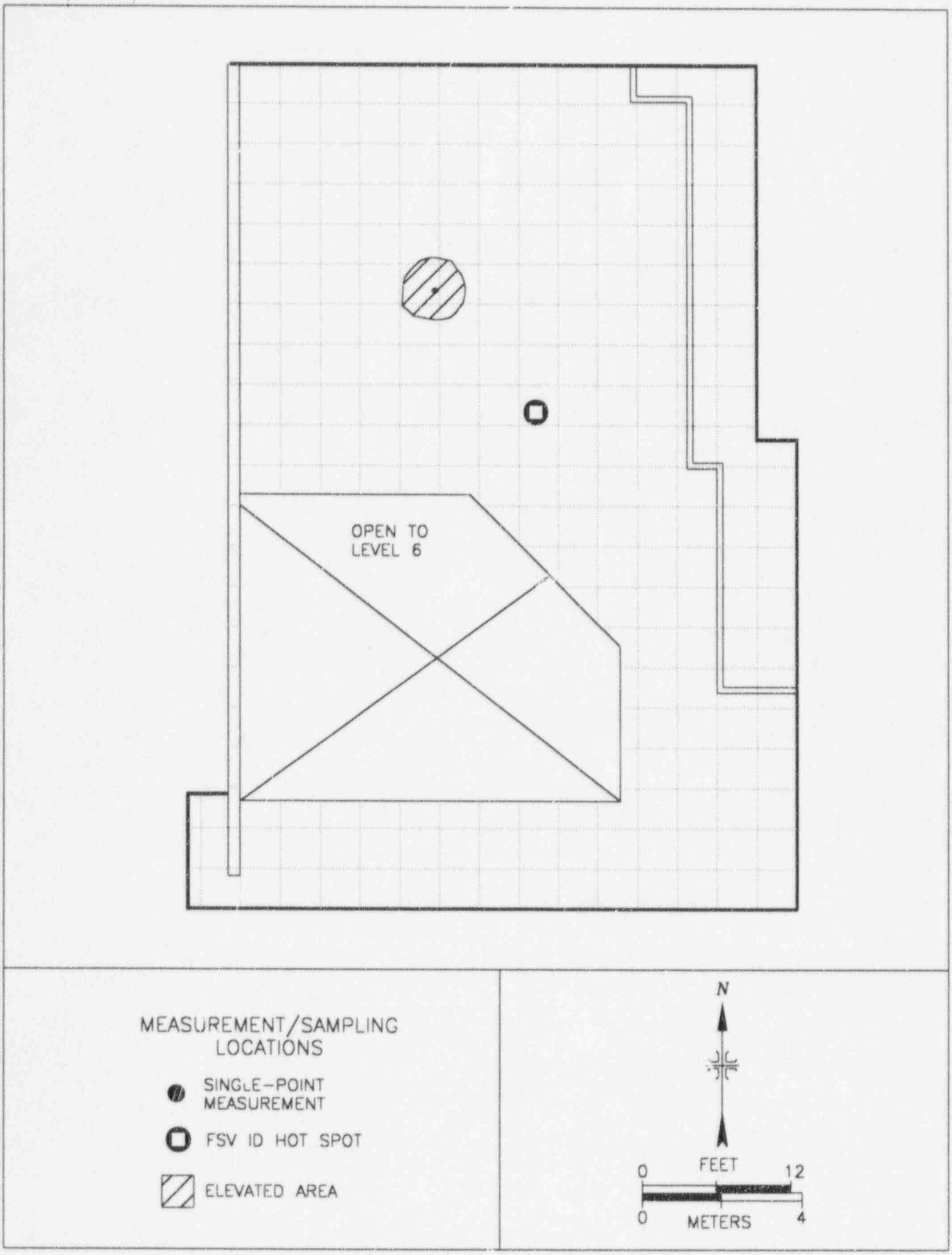

FIGURE 1: Turbine Building Level 7, Deck Southwest General Area, Survey Unit C031

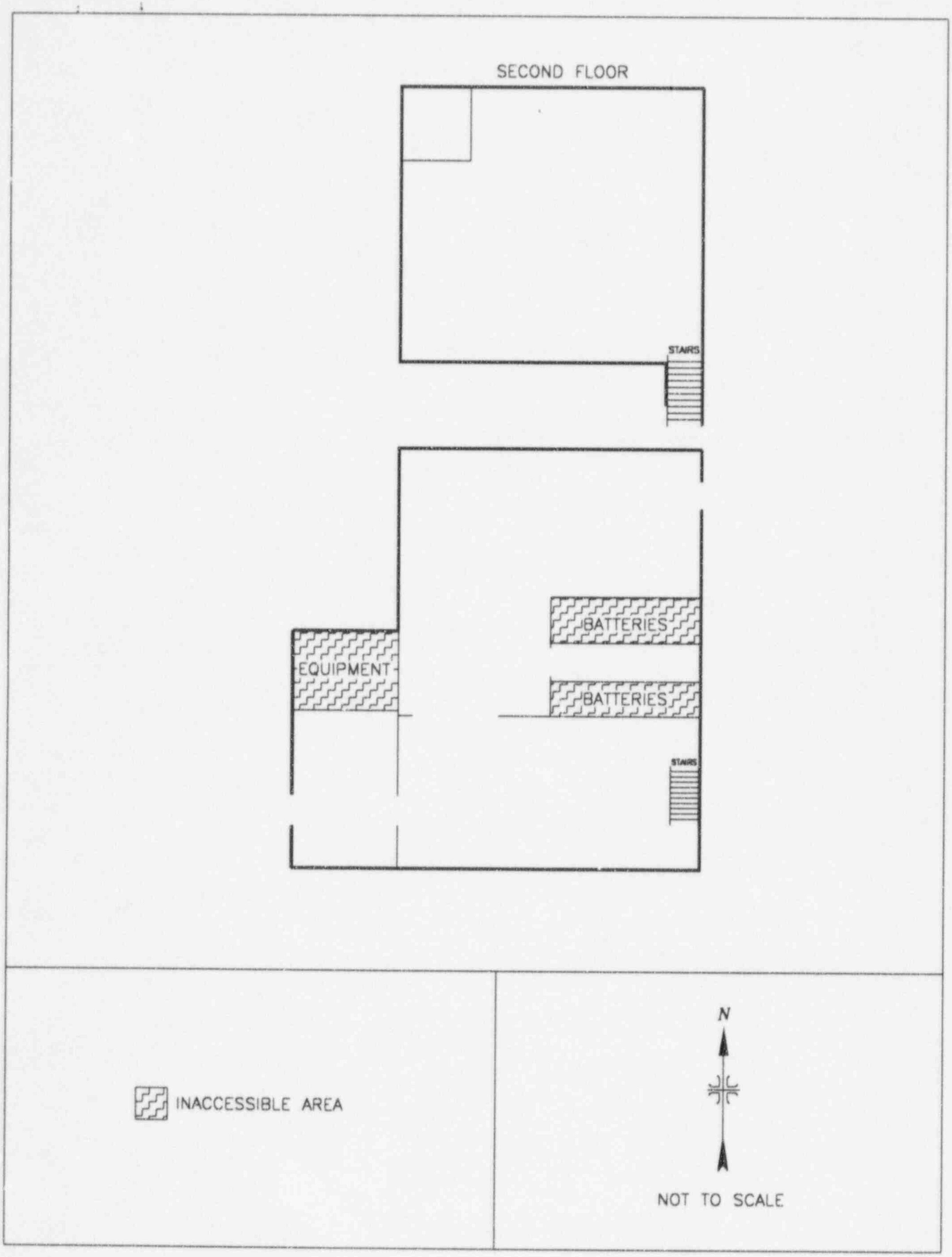

FIGURE 2: Building 10, Survey Unit C046

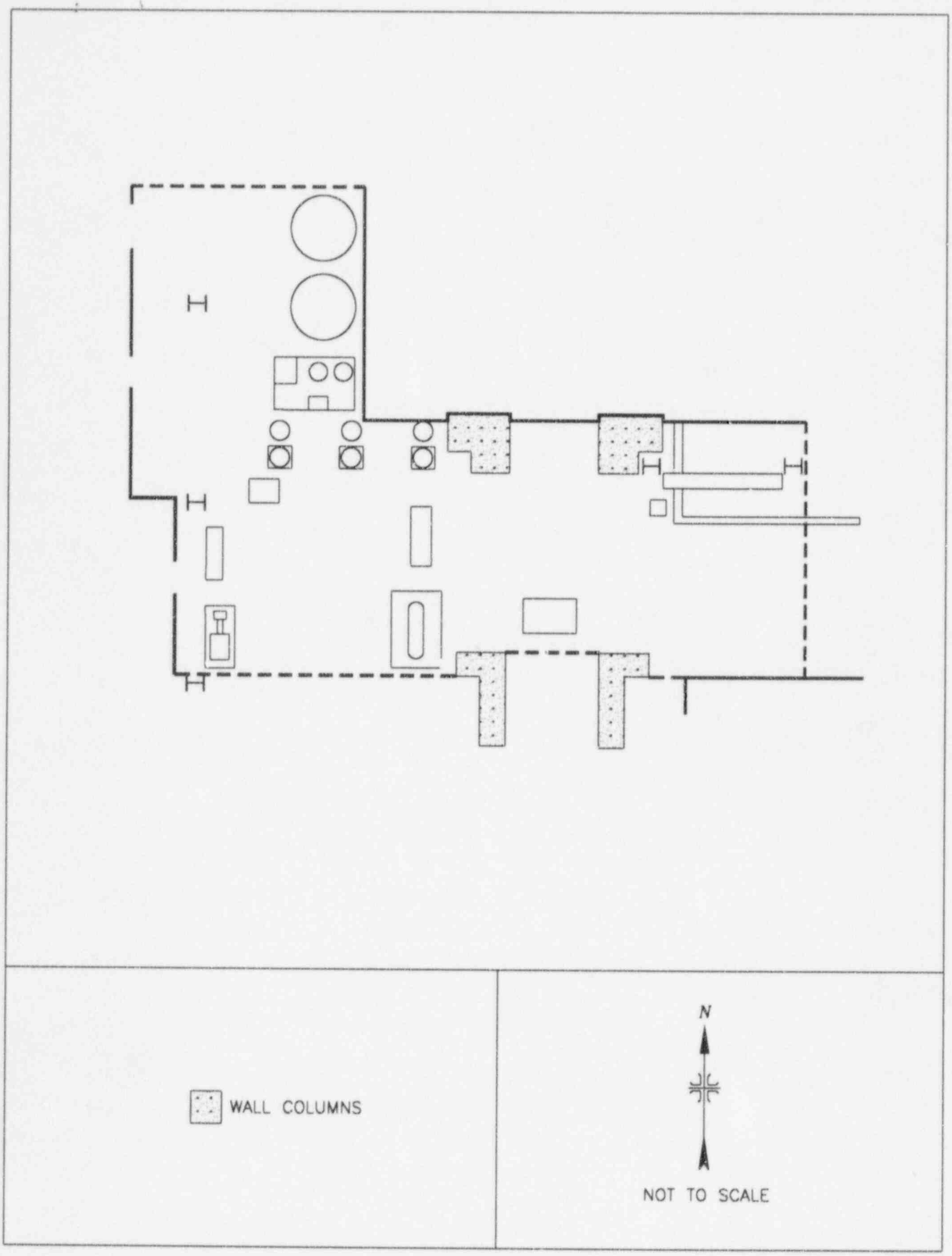

FIGURE Turbine Building, Level 5, South General Area, Survey Unit C005

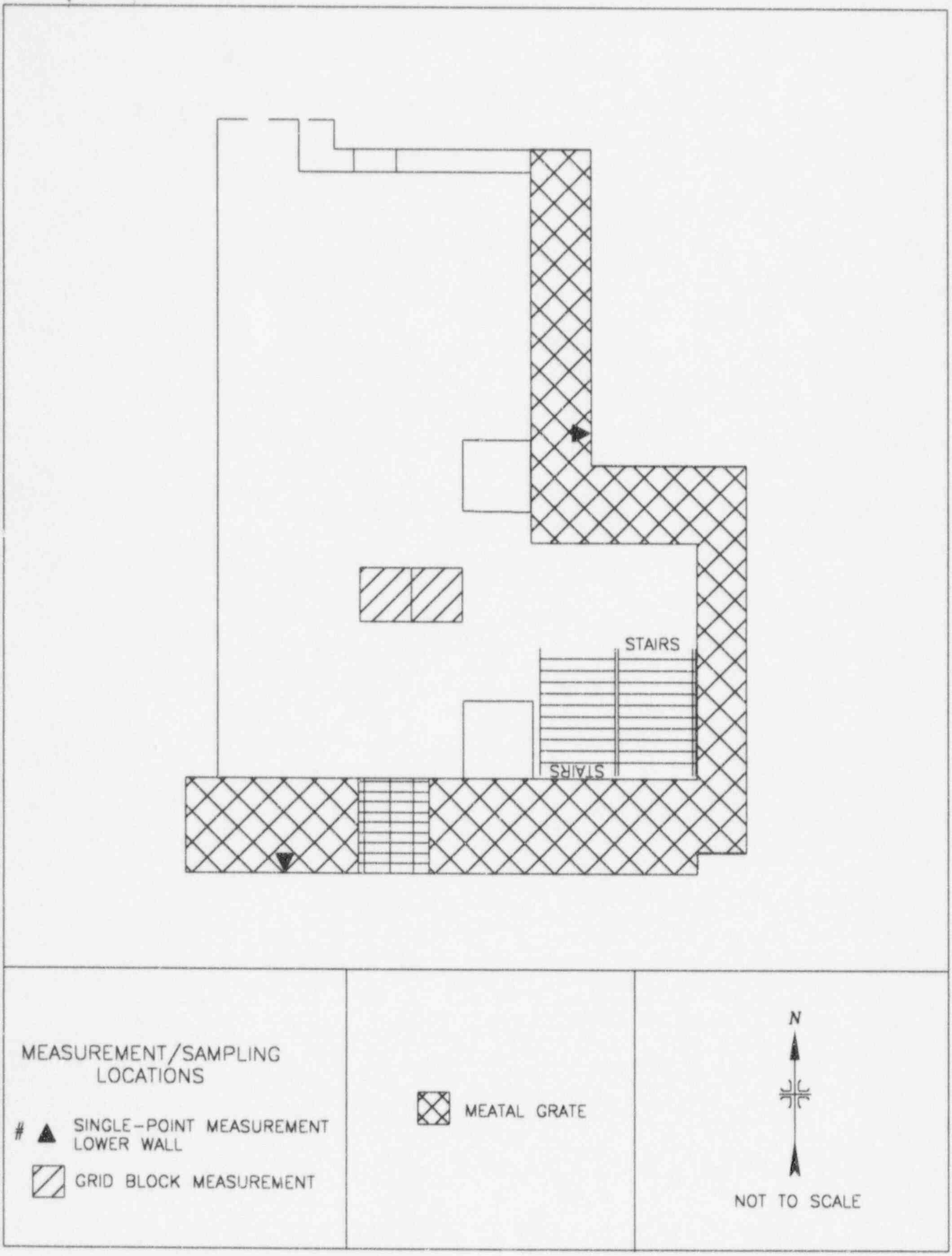

FIGURE 4: Reactor Building, Level 3, East, Northeast General Area, Survey Unit F044

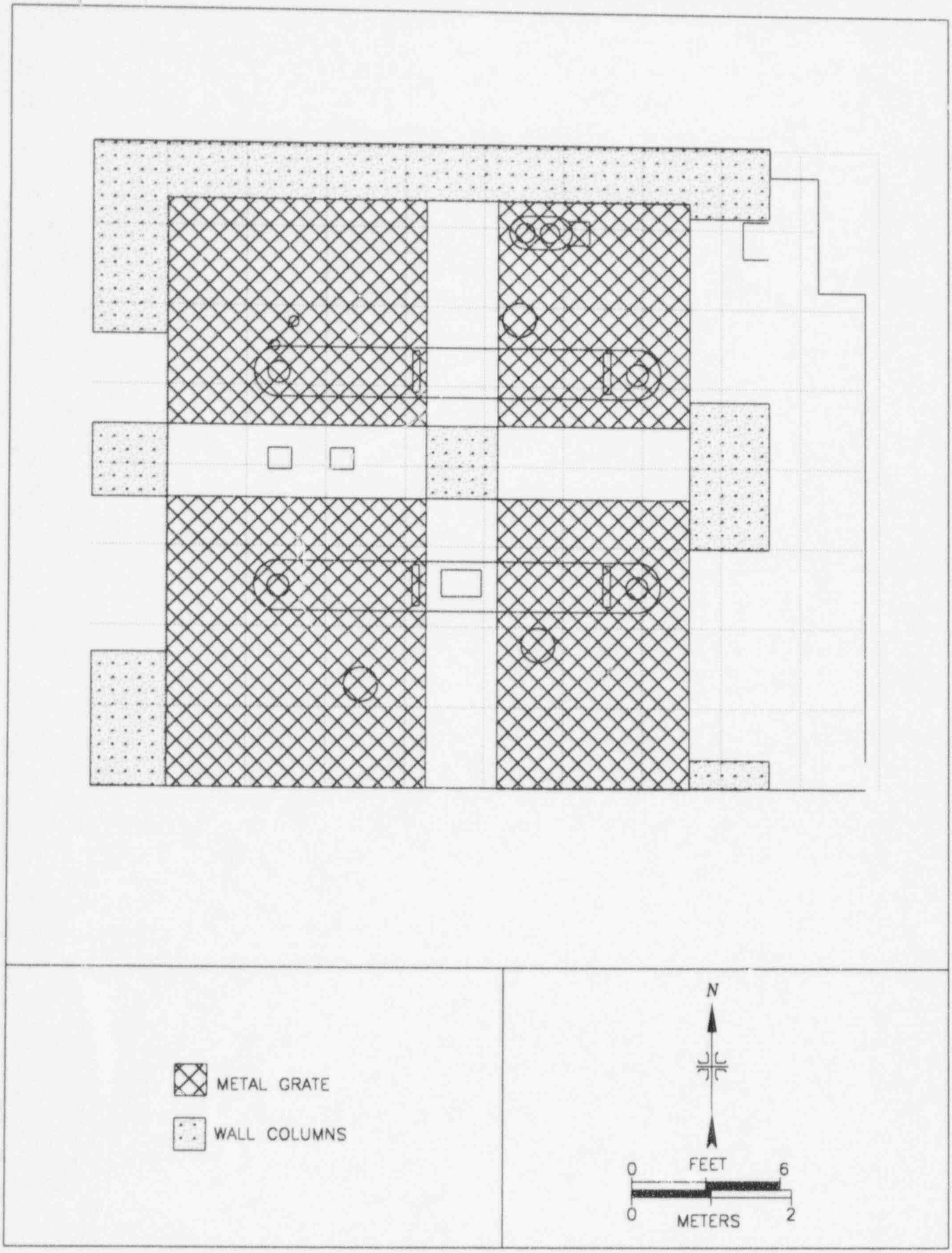

FIGURE 5: Reactor Building, Level 3, East, 1B/ID Cooling Water HTX Room, Survey Unit F045

TABLE 2

SIDE-BY-SIDE MEASUREMENT DATA

Location	Detector Response (cpm/125 cm^2)					
	ESSAP		FSV-1		FSV-2	
	Unshielded	Shielded	Unshielded	Shielded	Unshielded	Shielded
Battery Room	511 (20)[a]	349 (14)	627.6 (58.1)	426.0 (39.7)	712.0 (75.4)	457.3 (41.5)
Lube Oil Room	507 (28)	351 (17)	569.6 (49.8)	391.3 (59.3)	656.8 (48.1)	442.7 (56.4)
Barrel Evap. Room #1	1176 (36)	412 (22)	1316.8 (37.3)	494.0 (56.7)	1498.4 (95.9)	497.3 (31.3)
Barrel Evap. Room #2	1733 (31)	467 (12)	1908.0 (95.4)	495.3 (29.0)	2099.6 (67.7)	564.7 (69.3)

[a]The value in parentheses is the standard deviation of the detector response based on repetitive measurements.

REFERENCES

Oak Ridge Institute for Science and Education (ORISE 1996a). Confirmatory Survey Activities Plan for the Fort St. Vrain Nuclear Station, Public Service company of Colorado, Platteville, Colorado (Docket No. 50-267, RFTA 96-5). Oak Ridge, TN; January 17, 1996.

Oak Ridge Institute for Science and Education (ORISE 1996b). Comments on Fort St. Vrain Technical Basis Documents for Piping Survey Instrumentation. Oak Ridge, TN; January 1996.

Public Service Company of Colorado (PSC 1995a). Final Survey Plan for Site Release (revision 1). Fort St. Vrain Nuclear Station Decommissioning Project. May 25, 1995.

Public Service Company of Colorado (PSC 1995b). Final Survey Report for Release of Repower Area. Fort St. Vrain Nuclear Station Decommissioning Project. March 2, 1995.

Westinghouse Electric Corporation (Westinghouse 1995). Fort St. Vrain Technical Basis Documents for Piping Survey Instrumentation. Pittsburgh, PA; November 1995.

ATTACHMENT A

ADDITIONAL COMMENTS FOR FSV EMBEDDED PIPING SURVEY PROCEDURE BASED ON OBSERVATIONS DURING SITE VISIT

1. It is understood that additional work is being performed to evaluate the TLD response due to small, localized areas of surface contamination on interior pipe surfaces. The results of this work should be considered in the determination of the TLD spacing, so that the largest hot spot that could go undetected is acceptable. Furthermore, upon review of the TLD string results, pipe surface activities that exceed a pre-determined action level—calculated from the additional work discussed above—should receive additional survey evaluation, which may include deploying supplementary TLDs at a higher density to better characterize the potential hot spot or using the small-size detectors to scan and assess the surface activity at these locations.

2. It is recommended that the up-facing and down-facing TLD for 1-inch pipes not be combined when their results are significantly different, e.g., greater than 25% relative difference. These differences should be investigated to determine if additional survey effort is required to evaluate potential hot spots.