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Certification Docket for the Remedial Action Performed at the National Guard Armory in Chicago, Illinois from April 1987 to June 1987

Department of Energy
Technical Services Division
Oak Ridge Operations Office

February 1989

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CERTIFICATION DOCKET FOR THE REMEDIAL ACTION PERFORMED AT THE NATIONAL GUARD ARMORY IN CHICAGO, ILLINOIS FROM APRIL 1987 TO JUNE 1987

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INTRODUCTION TO THE CERTIFICATION DOCKET FOR THE REMEDIAL ACTION PERFORMED AT THE NATIONAL GUARD ARMORY IN CHICAGO, ILLINOIS FROM APRIL 1987 TO JUNE 1987

Description of the Formerly Utilized Sites Remedial Action Program at the National Guard Armory in Chicago, Illinois

The U.S. Department of Energy (DOE), Office of Nuclear Energy, Office of Remedial Action and Waste Technology, Division of Facility and Site Decommissioning Projects (and/or the predecessor agency, offices, and divisions) has conducted a remedial action project at the National Guard Armory in Chicago, Illinois. The work is being administered by the Formerly Utilized Sites Remedial Action Program (FUSRAP), one of two remedial action programs under the direction of the DOE Division of Facility and Site Decommissioning Projects. The United States Government initiated FUSRAP in 1974 to identify, clean up, or otherwise control sites where residual radioactive material (exceeding current guidelines) remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has mandated DOE to remedy (Ref. 1). The objectives of FUSRAP are to:

- Identify and assess sites formerly utilized to support early Manhattan Engineer District/Atomic Energy Commission (MED/AEC) nuclear work to determine whether further decontamination and/or control is needed
- Decontaminate and/or apply controls to these sites to permit conformance with currently applicable guidelines
- Dispose of and/or stabilize all generated residues in a radiologically and environmentally acceptable manner
- Accomplish all work in accordance with appropriate landowner agreements; local and state environmental and land use requirements to the extent permitted by Federal law; and applicable DOE orders, regulations, standards, policies, and procedures
- Certify, at the completion of remedial action, that the

radiological conditions of sites comply with guidelines and are appropriate for future use.

FUSRAP is currently being managed by the DOE Oak Ridge Operations Office (ORO). As the Project Management Contractor (PMC) for FUSRAP, Bechtel National, Inc. (BNI) is the DOE representative for planning, managing, and implementing FUSRAP.

To support remedial action planning and to define the locations and boundaries of contamination, DOE directed that radiological surveys be performed at the National Guard Armory (NGA) by Argonne National Laboratory (ANL) in 1977 and 1978 and by BNI in 1987 (Refs. 2, 3). It was determined based on these surveys that numerous isolated areas on building surfaces were contaminated. Remedial action was conducted at the NGA from April to June 1987.

Executive Order 11991 empowered the Council on Environmental Quality (CEQ) to issue regulations to federal agencies for implementing those procedural provisions of the National Environmental Policy Act (NEPA) that are mandatory under law (Ref. 4). The CEQ issued the regulations containing guidance and specific requirements in June 1979 (Ref. 5). The DOE guidelines for implementing the NEPA process and satisfying the CEQ regulations were made effective on March 28, 1980 (Ref. 6).

The NEPA process requires FUSRAP decision-makers to identify and assess the environmental consequences of proposed actions prior to beginning remedial activities, developing disposal sites, or transporting and emplacing radioactive wastes. Documentation required by NEPA in support of remedial action is prepared by ANL. Supporting documentation is provided by the FUSRAP PMC through the preparation of a series of engineering studies and environmental reports to evaluate remedial action alternatives for the site under consideration. The action deemed appropriate by DOE based on the NEPA process evaluations is then implemented with consideration for public safety and in compliance with applicable federal, state, and local requirements.

For the site discussed in this report, the NEPA requirements were satisfied by the preparation of an Action Description Memorandum, which led to issuance of a Memorandum to File (MTF) documenting that the project had no significant impact on the environment (Refs. 7, 8).

Work performed under FUSRAP is governed by the provisions of the DOE quality assurance program plan for FUSRAP, which complies with DOE Order 5700.6 (Ref. 9). Work performed under FUSRAP by the PMC or by architect-engineers, construction and service subcontractors, and other project subcontractors is governed by the quality assurance program plan as specified in the FUSRAP Project Quality Assurance Manual (Ref. 10). Effectiveness of implementation is appraised by the BNI quality assurance organization, and by DOE-ORO on a regular basis.

Remedial action was completed at the NGA in June 1987. On January 31, 1989, DOE certified that the property is in compliance with DOE decontamination criteria and standards developed to protect health, safety, and the environment. The notice of certification for publication in the Federal Register was signed by DOE on February 17, 1989.

Purpose

This docket has been assembled to document the successful decontamination of the NGA in Chicago, Illinois. The material in this docket consists of documents supporting certification by DOE that radiological conditions at the NGA are in compliance with radiological guidelines and standards determined to apply to the site and that use of this property will not result in any measurable radiological hazard to the general public derived from the activities of the Department of Energy predecessor agencies.

The certification docket contains only the material deemed most pertinent to the certification of this property; the comprehensive package of records is available and will be archived by DOE through the Assistant Secretary for Management and Administration after certification. Copies of this docket will be available for public review between 9:00 a.m. and 4:00 p.m., Monday through Friday (except Federal holidays) at the DOE Public Reading Room located in Room 1E-190 of the Forrestal Building, 1000 Independence Avenue, SW, Washington, D.C.

Property Identification

The NGA site is located at East 52nd Street and Cottage Grove Avenue in Chicago, Illinois, approximately 6 miles south of the downtown business district. It is an active facility, presently occupied by the Illinois National Guard (1st Battalion, 178th Infantry, and 2nd Battalion, 122nd Field Artillery).

Docket Contents

Exhibit I is a summary of remedial action activities performed at the subject property. It provides a brief history of the origin of the contamination at the NGA, and summarizes the radiological characterizations conducted, the remedial action performed, and post-remedial action/verification activities.

The following documents contain the guidelines that determine the need for remedial action. The subject site has been decontaminated to comply with these guidelines. The first document listed is included as Appendix A to Exhibit I of this docket; the second and third documents are included in Exhibit II (1).

> U.S. Department of Energy. U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Rev. 2, March 1987.

U.S. Department of Energy. Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP), 14501-00-DC-01, Rev. 2, Oak Ridge, TN, February 1986.

Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987.

The following document authorized or designated the remedial action at the NGA. A copy of the document is included in Exhibit II (2).

Memorandum, William R. Voigt, Jr., Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters, to Joe LaGrone, Manager, Oak Ridge Operations Office. "Designation of Sites for Remedial Action - Metal Hydrides, Beverly, MA; Bridgeport Brass; Adrian, MI and Seymour, CT; National Guard Armory, Chicago, IL," NE-20, Washington, D.C., December 17, 1985.

The following documents describe radiological conditions at the subject property before remedial action. They are referenced in Exhibit II (3) of this docket.

Argonne National Laboratory. Radiological Survey of the National Guard Armory at Washington Park, 52nd Street, and Cottage Grove Avenue, Chicago, Illinois, DOE/EV-0005/22, (ANL-OHS/HP-83-100), Chicago, Illinois, January 1983.

Bechtel National, Inc. Radiological and Limited Chemical Characterization Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-179, Oak Ridge, TN, January 1988.

The documents listed below were prepared to fulfill NEPA requirements for the subject site. The second of these documents includes the FONSI. These documents are included in Exhibit II (4).

Argonne National Laboratory. Action Description Memorandum, Proposed Decontamination of the NGA in Chicago, Illinois, Argonne, IL, March 1987.

Memorandum, J.E. Baublitz for W.R. Voigt, Jr., Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters, to J. LaGrone, Manager, Oak Ridge Operations Office. "Review of Remedial Actions at the National Guard Armory, Chicago, Illinois," Washington, D.C., July 27, 1987.

Exhibit II (5) includes the access agreement signed by the property owner and DOE before remedial action was initiated. The affected property owner is listed below.

The Illinois Military and Naval Department

The following report describes the extent of the remedial action and documents the successful decontamination of the subject site. This report is included in Exhibit II (6).

Bechtel National, Inc. Post-Remedial Action Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-184, Revision 1, Oak Ridge, TN, November 1988.

The following materials document activities to verify the successful decontamination of the subject site and are included in Exhibit II (7):

Letter, J.D. Berger, Oak Ridge Associated Universities, to J.J. Fiore, Director, Division of Facility and Site Decommissioning, Office of Nuclear Energy, Department of Energy

Headquarters. "Verification of Remedial Actions at the National Guard Armory, Chicago, Illinois," June 30, 1987.

Oak Ridge Associated Universities. Verification of Remedial Action, Illinois National Guard Armory, Chicago, Illinois, ORAU 88/A-20, Oak Ridge, TN, February 1988.

The information in Exhibit II (8) states that the State of Illinois was kept fully informed of all DOE activities in connection with the remedial action performed at the NGA.

The information in Exhibit II (9) states that there are no restrictions on use of the NGA site following verification that remedial action at the property was successful.

The Federal Register notice informs the public of DOE's intent to certify that the subject site is in compliance with applicable radiological criteria and guidelines. The text of the Federal Register notice is included in Exhibit II (10).

J.E. Baublitz, Acting Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters. Federal Register Notice: Department of Energy, Office of Nuclear Energy, "Certification of the Radiological Condition of the National Guard Armory in Chicago, Illinois," February 17, 1989.

The documents listed below validate the final certification of the NGA site and are included in Exhibit II (11).

Memorandum, J.J. Fiore, Director, Division of Facility and Site Decommissioning, Office of Nuclear Energy, Department of Energy Headquarters, to J.E. Baublitz, Acting Director, Office of Remedial Action and Waste Technology, Office of

Nuclear Energy, Department of Energy Headquarters. "Recommendation for Certification of Remedial Action at the National Guard Armory site in Chicago, Illinois," February 16, 1989.

P.J. Gross, Director, Technical Services Division, Oak Ridge Operations Office, Department of Energy. "Statement of Certification: National Guard Armory Site in Chicago, Illinois," January 31, 1989.

Cost data and waste volumes associated with remedial action performed at the NGA site are included in Exhibit I of this docket.

Exhibit I *Summary of Remedial Action Activities*

EXHIBIT I

SUMMARY OF REMEDIAL ACTION ACTIVITIES

FEBRUARY 1989

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

Bechtel National, Inc.

Oak Ridge, Tennessee

Bechtel Job No. 14501

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ABBREVIATIONS

cm	centimeter
cm^2	square centimeter
dpm	disintegrations per minute
ft	foot
ft^2	square foot
gal	gallons
m	meter
m^2	square meter
uR/h	microroentgens per hour
uCi/ml	microcuries per milliliter
MeV	million electron volts
mrad/h	millirad per hour
mrem	millirem
mrem/yr	millirem per year
pCi/g	picocuries per gram
WL	working level

ACRONYMS

AEC	Atomic Energy Commission
ANL	Argonne National Laboratory
BNI	Bechtel National, Inc.
CEQ	Council on Environmental Quality
DOE	Department of Energy
EPA	Environmental Protection Agency
ERDA	Energy and Research Development Agency
FONSI	Finding of No Significant Impact
FUSRAP	Formerly Utilized Sites Remedial Action Program
IVC	Independent Verification Contractor
MED	Manhattan Engineer District
NEPA	National Environmental Policy Act
NGA	National Guard Armory
ORAU	Oak Ridge Associated Universities
ORNL	Oak Ridge National Laboratory
ORO	Oak Ridge Operations
PMC	Project Management Contractor

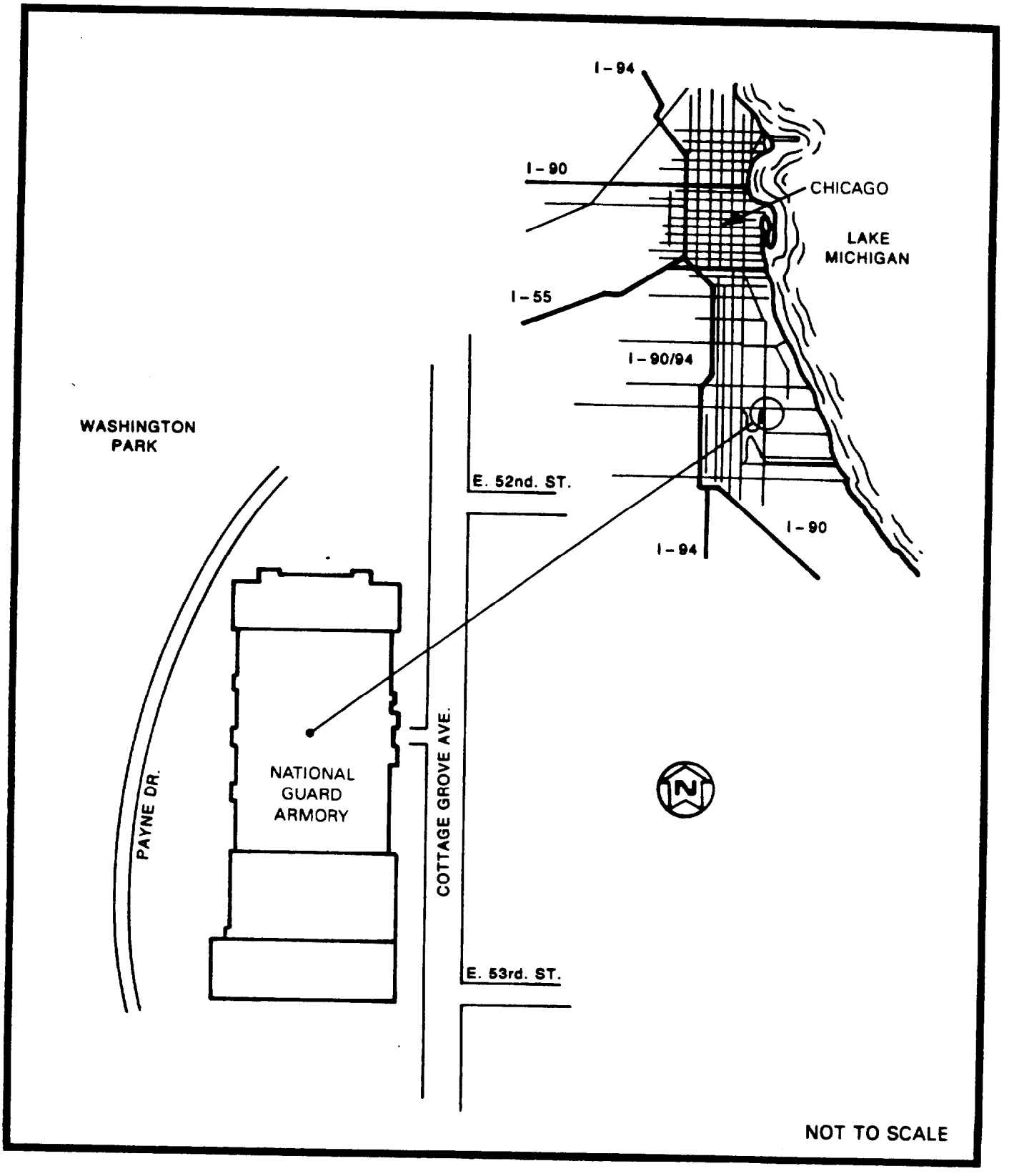

FIGURE 1-1 LOCATION OF THE NATIONAL GUARD ARMORY

2.0 SITE HISTORY

In 1942, the Manhattan Engineer District (MED) leased the National Guard Armory to alleviate space shortages at the nearby University of Chicago, where research was being conducted jointly by the university and the MED Metallurgical Laboratory. Records indicate that the NGA was used primarily for the storage and processing of uranium metal, and served as the central procurement and shipping location for the Metallurgical Laboratory (Ref. 11).

It is suspected that most of the MED activities were carried out in the arena and the south headhouse (which adjoins the arena). It is believed that the armory storeroom was used to store uranium shavings and grinding wastes, because at least one of several uranium fires in the armory was reported to have occurred in the northeast corner of this storeroom. One fire contaminated both the receiving area and the storeroom. These two areas have not been positively identified in the historical records; however, based on current radiological findings, they may have been in the western half of the south headhouse ground floor.

In 1951 the Atomic Energy Commission (AEC), which succeeded the MED, terminated use of the NGA, and the property was returned to the State of Illinois. When operations ceased at the National Guard Armory, some effort was apparently made to decontaminate the facility. After the MED ceased using the facility, contaminated soil from the arena was removed and disposed of; however, no records indicating where this dirt was taken could be located. Later, more soil was removed, and a concrete pad was installed.

1.0 INTRODUCTION

Exhibit I summarizes the activities culminating in the certification that radiological conditions at the property discussed in this docket are in compliance with applicable guidelines and that use of the property will result in no radiological exposure above DOE criteria and standards established to protect members of the general public and occupants of the site. These activities were conducted under the Formerly Utilized Sites Remedial Action Program (FUSRAP) (Ref. 1). This summary includes a discussion of the remedial action process at this property: characterization of its radiological status, designation of the property as requiring remedial action, performance of the remedial action, and verification that the radioactivity has been removed. Further detail on each activity can be found in the referenced documents, most of which are included in the docket.

The property addressed in this docket is the National Guard Armory (NGA) in Chicago, Illinois. The location of the NGA is shown in Figure 1-1.

3.0 SITE DESCRIPTION

The NGA site is located at East 52nd Street and Cottage Grove Avenue, Chicago, Illinois, approximately 6 miles south of the downtown business district. The facility is a four-story concrete building with outer walls of stone. Its total area is approximately 290,000 ft^2. An arena occupies the center of the building; offices, classrooms, storage areas, and garages are located at the north and south ends of the building. The 230-ft arena has a ceiling more than 100 ft high, with stadium bleachers located on the east and west sides. Figure 3-1 is a plan view of the NGA.

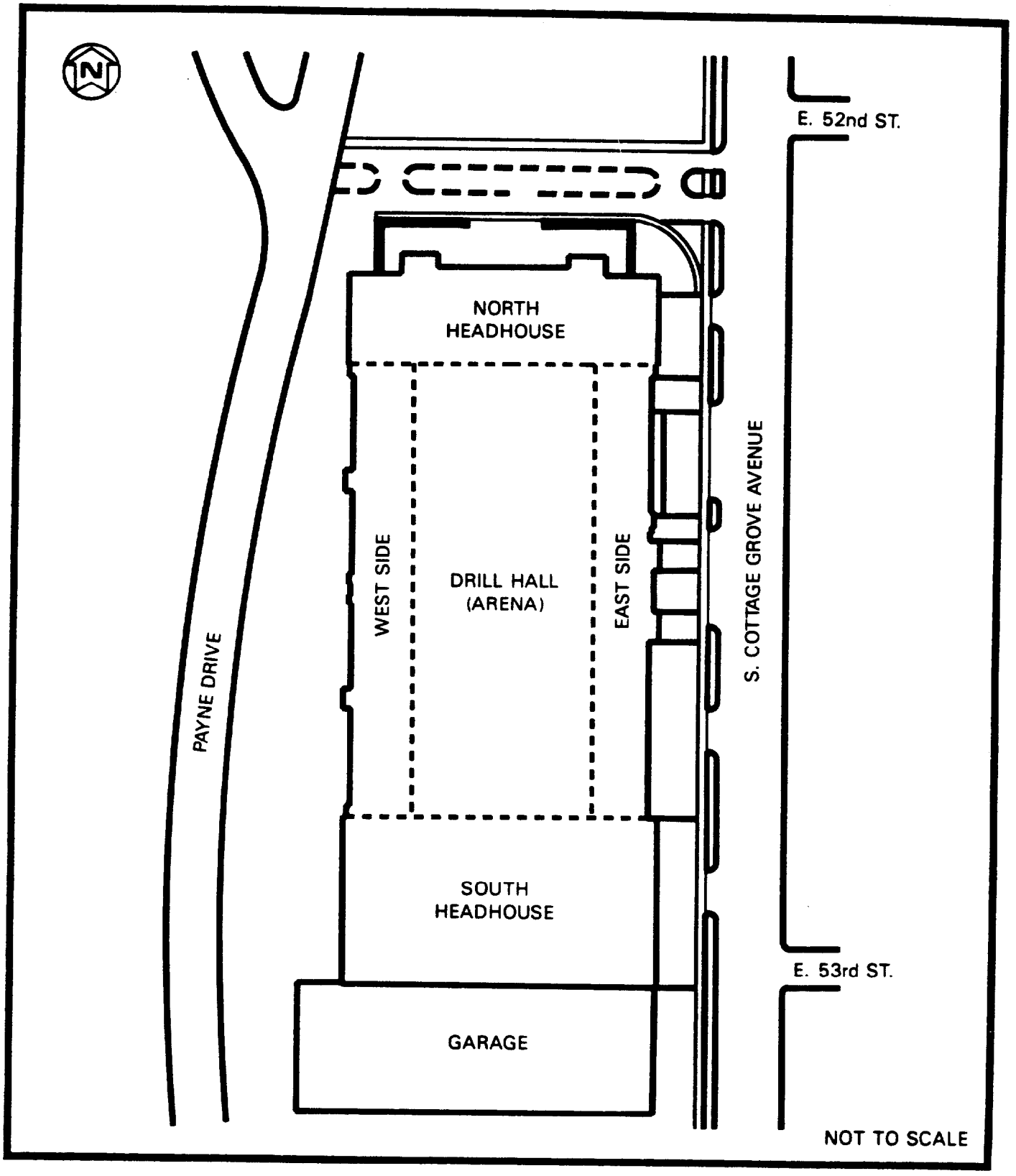

FIGURE 3-1 PLAN VIEW OF THE NATIONAL GUARD ARMORY

4.0 RADIOLOGICAL HISTORY AND STATUS

Conversations with personnel who worked at the NGA during the MED/AEC era revealed that an effort had been made to decontaminate some bleachers in the arena; however, no records of radiological surveys or decontamination efforts conducted at the facility upon termination of MED/AEC activities could be found (Ref. 12). Therefore, the Energy Research and Development Agency (ERDA), predecessor of DOE, requested that a comprehensive radiological survey of the NGA be performed to determine if any detectable radioactive contamination remained as a result of the MED/AEC operations. The survey was performed between September 19, 1977 and October 11, 1978 (Ref. 12).

Results of this survey indicated that residual contamination was present at the NGA in excess of the limits suggested by the remedial action guidance in effect at that time. Relatively extensive contamination was found in Room 1 and in the drainage systems for the floors of Rooms 1 and 5. Small (less than 300 cm^2), isolated areas of contamination were found on floor surfaces in other locations (Ref. 12).

Based on the results of this survey, DOE designated the NGA for remedial action under FUSRAP (Ref. 13).

4.1 REMEDIAL ACTION GUIDELINES

The principal radionuclide of concern at the NGA was uranium. A site-specific uranium guideline was derived on the basis of very conservative scenarios for future use of the site. A guideline of 150 pCi/g was derived for uranium-238 in soil with uranium-234 and uranium-235 present in naturally occurring concentrations, on the basis of a scenario in which a person would live in the armory, drink water from a shallow on-site well, and raise 10 percent of his plant-food diet in an on-site garden (Ref. 14). DOE residual contamination guidelines governing the release of the property for

future use are listed in Table 4-1 (Ref. 15). The DOE guidelines are compatible with those of the Environmental Protection Agency (EPA). The guidelines presented in Table 4-1 were applied primarily to surfaces, such as walls, ceilings, floors, and columns. On surfaces where contamination exceeded the applicable criteria, remedial action was performed until measurements indicated that guidelines were met. The design criteria document for FUSRAP contains additional information regarding applicable federal regulations (Ref. 16).

4.2 POST-REMEDIAL ACTION STATUS

As shown in the post-remedial action report for the NGA, there is no area where radioactive contamination exceeds DOE guidelines (Ref. 17). An independent review of the remedial action performed on the property discussed in this report was conducted by an independent verification contractor (IVC), the Radiological Site Assessment Group of Oak Ridge Associated Universities. The purpose of the IVC assessment was to verify the data supporting the adequacy of the remedial action and to confirm that the site was in compliance with existing remedial action guidelines upon completion of remedial action.

Based on all data collected, this property is in conformance with all applicable DOE radiological guidelines established for release for future use (Refs. 18, 19).

TABLE 4-1

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES FOR THE NATIONAL GUARD ARMORY

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES

Radionuclide	Soil Concentration (pCi/g) above background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Uranium-238	150 pCi/g*
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that has no radiological restrictions on its use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[d] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site that has no radiological restrictions on its use shall not exceed the background level by more than 20 μR/h.

Indoor/Outdoor Structure Surface Contamination

Radionuclide[f]	Allowable Residual Surface Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
Transuranics, Ra-226, Ra-228, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224 U-232, I-126, I-131, I-133	1,000	3,000	200

*Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987.

TABLE 4-1

(continued)

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[f]	Allowable Residual Surface Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β - γ	15,000 β - γ	1,000 β - γ

[a]These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit.

[b]These guidelines represent allowable residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100-m^2 surface area.

[c]Localized concentrations in excess of these limits are allowable provided that the average concentration over a 100-m^2 area does not exceed these limits.

[d]A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

[e]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.

[f]Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[g]Measurements of average contamination should not be averaged over more than 1 m^2. For objects of less surface area, the average shall be derived for each such object.

[h]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

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

[j]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 measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

5.0 SUMMARY OF REMEDIAL ACTION

The following subsections briefly describe the remedial action process and measures taken to protect the public and the environment.

5.1 PRE-REMEDIAL ACTION ACTIVITIES

After it was determined that the National Guard Armory was contaminated, DOE designated the building for remedial action under FUSRAP. A radiological characterization of the NGA was performed to define the areas of contamination in preparation for remedial action (Ref. 11). Surface contamination was found in 12 rooms, and contaminated sludges were found in the catch basin system in Rooms 1, 1D, and 5. The soil in one area outside the west wall of Room 1 was found to be contaminated, with uranium concentrations in excess of 150 pCi/g.

The Illinois National Guard was notified when DOE designated the armory for remedial action, and engineering design and related activities were initiated in preparation for remedial action. These activities included preparation of an engineering work plan (Ref. 20).

5.2 DECONTAMINATION ACTIVITIES

During remedial action operations, measures were taken to prevent the spread of contamination and to keep exposure rates as low as possible for the building occupants, including remedial action workers. Measures were also taken to monitor airborne radioactivity resulting primarily from dust and to limit personnel exposure to organic vapors emanating from the sludges (Ref. 17).

Remedial action consisted of the removal of radioactive contamination from the contaminated areas. A total of 20 yd^3 of waste was generated during remedial action. This material was disposed of as low specific activity waste at the DOE Hanford Reservation. Figures showing the areas in which remedial action was

performed are provided in Exhibit III of this certification docket.

Four types of remedial action were performed at the NGA. One procedure involved the decontamination of surfaces containing removable contamination by vacuuming the surface with a high-efficiency filtered exhaust or by cleaning the area with a cloth. This procedure was used to decontaminate the ceiling in Room 1.

The second type of remedial action was the removal of fixed surface contamination by sanding, grinding, or scabbling the contaminated area as appropriate. These activities were conducted in Rooms 1, 1A, 1E, 5, 5B, S201, S202, S212, S213, S215, and S234.

The third type of remedial action involved the removal of contaminated sludges that contained both radioactive and nonradioactive wastes and had a low flash point (70°F). The decontamination process required several steps. First, the sludges were removed from the six catch basins using a non-sparking shovel. Then the catch basin walls were sandblasted to remove all contamination adhering to the walls. Finally, a high-pressure, low-volume water pipe cleaning system was used to decontaminate all pipes extending from each catch basin. A portion of the main pipe between Catch Basins 3 and 4 could not be decontaminated with the pipe cleaning system; this segment was removed and disposed of.

The fourth type of remedial action conducted at the site was the removal of contaminated soil from the area outside the armory building and the area between Catch Basins 3 and 4 (where the main pipe was removed).

Wastes removed from the NGA during remedial action were placed in 55-gal steel drums for disposal. The sludges from the catch basins contained mixed wastes which were treated to elevate the flash point and were solidified for disposal off-site. All wastewater generated from remedial action activities was placed in drums and temporarily stored on-site.

5.3 POST-REMEDIAL ACTION MEASUREMENTS

After the soil containing the radioactive contaminants was removed and remedial action was complete, a post-remedial action survey was conducted to determine whether the remedial action was successful in removing radioactive contamination that exceeded existing DOE guidelines. Detailed post-remedial action data are contained in the post-remedial action report (Ref. 17). The post-remedial action survey was performed using the procedures described below.

5.3.1 Outdoor Areas

The primary method of ensuring that the outdoor area was cleaned up in compliance with DOE cleanup guidelines was to take soil samples. These samples were analyzed in a laboratory to determine the concentrations of radium-226, thorium-232, and uranium-238.

5.3.2 Interior Surfaces

Methods for determining the effectiveness of remedial action performed on interior surfaces of the building included measuring direct alpha and beta-gamma activity, and scanning for both alpha and beta-gamma activity to ensure that no isolated areas of contamination remained.

5.3.3 Catch Basins

Direct alpha and beta-gamma readings were taken inside all catch basins except Catch Basin 3, which was removed and replaced.

5.4 VERIFICATION ACTIVITIES

The IVC is responsible for preparing a generic plan outlining the procedures to be used during verification activities. The IVC conducted two types of verification reviews for NGA. Type A reviews were performed by reviewing post-remedial action data and radiological contractor data, as well as the analysis of some

samples. Type B verification reviews consisted of a site visit and survey that included direct measurements and sampling.

5.5 PUBLIC AND OCCUPATIONAL EXPOSURES

5.5.1 Public Exposure

Measurements taken following the completion of remedial action at the NGA indicate that radiological exposure to the public is less than 100 mrem/yr above the background level. This total dose includes exposures from all pathways.

5.5.2 Occupational Exposure

A health physics program was conducted during remedial action; it consisted of contamination control, management of occupational exposures, and radiological monitoring of construction activities (Ref. 17).

Exposure to External Gamma Radiation

Personnel were monitored for external gamma exposure during the remedial action work at the NGA. Exposure levels for all individuals working at NGA were below the limit of detectability.

Internal Exposure

During the remedial action at the NGA, 94 bioanalyses were performed to monitor the potential exposure of personnel to airborne radionuclides such as radium-226, natural uranium, polonium-239, thorium-232, and thorium-230. None of the samples exhibited radionuclide concentrations exceeding the minimum action level to warrant re-sampling. With a total of 225 measurements, post-remedial action air particulate concentrations ranged from 1.0×10^{-14} to 9.8×10^{-14} uCi/ml. The average concentration

was 3.7×10^{-14} uCi/ml. The most restrictive standard for uranium-238, the principal contaminant of concern, is 1×10^{-13} uCi/ml (Ref. 21).

5.6 COSTS

Costs associated with the remedial action performed at the NGA are given in Table 5-1.

TABLE 5-1

REMEDIAL ACTION COSTS

FOR THE NATIONAL GUARD ARMORY

Activity	Fiscal Year ($) 1987	1988	1989
Site Characterization	438,000	47,000	-0-
Preliminary Engineering	-0-	-0-	-0-
NEPA	47,000	-0-	-0-
Design Engineering	-0-	-0-	-0-
Site Access	500	-0-	-0-
Remedial Action	616,000	180,000	-0-
Transportation	2,000	-0-	50,000*
Surveillance/ Maintenance	37,000	-0-	-0-
Final Report	-0-	135,000	38,000
TOTAL FOR FISCAL YEAR	1,140,500	362,000	68,000*

TOTAL COST INCURRED (Estimated):

$1,570,500

*Estimated 1989 cost

REFERENCES

1. U.S. Department of Energy. Description of the Formerly Utilized Sites Remedial Action Program, ORO-777, Oak Ridge, TN, September 1980.

2. Argonne National Laboratory. Radiological Survey of the National Guard Armory at Washington Park, 52nd Street, and Cottage Grove Avenue, Chicago, Illinois, DOE/EV-0005/22, (ANL-OHS/HP-83-100), Chicago, Illinois, January 1983.

3. Bechtel National, Inc. Radiological and Limited Chemical Characterization Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-179, Oak Ridge, TN, January 1988.

4. Executive Order 11991. "Relating to Protection and Enhancement of Environmental Quality," May 24, 1977.

5. U.S. Code of Federal Regulations. 40 CFR 1500-1508, "Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act," Washington, DC, November 29, 1978.

6. U.S. Department of Energy. Federal Register, "Compliance with the National Environmental Policy Act," Vol. 45, No. 62., Washington, DC, March 28, 1980.

7. Argonne National Laboratory. Action Description Memorandum, Proposed Decontamination of the National Guard Armory in Chicago, Illinois, Argonne, IL, March 1987.

8. Memorandum, J.E. Baublitz for W.R. Voigt, Jr., Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters, to J. LaGrone, Manager, Oak Ridge Operations Office. "Review of Remedial Actions at the National Guard Armory, Chicago, Illinois," Washington, D.C., July 27, 1987.

9. U.S. Department of Energy. Order 5700.6, " Quality Assurance - ORO Site Implementation Plan," Washington, DC, March 1982.

10. Bechtel National, Inc. Formerly Utilized Sites Remedial Action Program, Project Quality Assurance Manual, Revision B. Oak Ridge, TN, April 16, 1986.

11. Bechtel National, Inc. Radiological and Limited Chemical Characterization Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-179, Oak Ridge, TN, January 1988.

12. Argonne National Laboratory. Radiological Survey of the National Guard Armory at Washington Park, 52nd Street, and Cottage Grove Avenue, DOE/EV-0005-22 (ANL-OHS/HP-83-100), Chicago, IL, January 1983.

13. Memorandum, W.R. Voigt, Jr., Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, U.S. Department of Energy, to J. LaGrone, Manager, Oak Ridge Operations Office. "Designation of Sites for Remedial Action - Metal Hydrides, Beverly, MA; Bridgeport Brass; Adrian, MI and Seymour, CT; National Guard Armory, Chicago, IL," NE-20, Washington, D.C., December 17, 1985.

14. Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987.

15. U.S. Department of Energy. U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Revision 2, March 1987.

16. U.S. Department of Energy. Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP), 14501-00-DC-01, Rev. 3, Oak Ridge, TN, March 1986.

17. Bechtel National, Inc. Post-Remedial Action Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-184, Revision 1, Oak Ridge, TN, November 1988.

18. Letter, J.D. Berger, Oak Ridge Associated Universities, to J.J. Fiore, Director, Division of Facility and Site Decommissioning, Office of Nuclear Energy, Department of Energy Headquarters. "Verification of Remedial Actions at the National Guard Armory, Chicago, Illinois," June 30, 1987.

19. Oak Ridge Associated Universities. Verification of Remedial Action, Illinois National Guard Armory, Chicago, Illinois, ORAU 88/A-20, Oak Ridge, TN, February 1988.

20. Bechtel National, Inc. Work Plan for Remedial Action at National Guard Armory, Chicago, Illinois, 119-00-IG-02, Revision 1, Oak Ridge, TN, September 1987.

21. Memorandum, R.J. Stern, Department of Energy, to Distribution. "Preparation of Annual Site Environmental Reports for Calendar Year 1985" (Attachment: "DOE-Derived Concentration Guides for Drinking Water and Breathing Air Contaminated With Radionuclides by Members of the Public"), February 26, 1986.

Alpha-emitting - See radiation.

Background Radiation - Background radiation refers to naturally occurring radiation emitted from either cosmic (e.g., from the sun) or terrestrial (e.g., from the earth) sources. Exposure to this type of radiation is unavoidable and its level varies greatly depending on geographic location; e.g., New Jersey typically receives 100 mrem/yr, Colorado receives about 300 mrem/yr, and some areas in South America receive up to 7000 mrem/yr. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, thorium, etc. (see definition of **radionuclide** below). These dose levels do not include the concentrations of naturally occurring radon inside buildings.

Beta-gamma-emitting - See radiation.

Centimeter - A centimeter (cm) is a metric unit of measurement for length; 1 inch is equal to 2.54 cm; 1 foot is equal to approximately 30 cm.

Contamination - Contamination is used generally to mean a concentration of radioactive materials in the soil exceeding naturally occurring levels. Contamination may or may not exceed the DOE cleanup guidelines.

Counts per minute - A count is the unit of measurement registered by a radiation detection instrument when radiation imparts its energy within the sensitive range of the detector probe. The number of counts registered per minute can be related to the number of disintegrations per minute occurring from a radioactive material. See the definition of **disintegrations per minute**.

Disintegrations per minute - Disintegrations per minute (dpm) is the measurement indicating the amount of radiation being released from a substance per minute. See the definition of **picocurie**.

Dose - Dose as used in this report is actually dose equivalent and is used to relate absorbed dose (mrad) to an effect on the body. Dose is measured in mrem. For the purpose of comparison, a dose of 500,000 mrem to the whole body within a short time causes death in 50 percent of the people who receive it; a dose of 5,000,000 mrem may be delivered to a cancerous tumor during radiation treatment; normal background radiation results in an annual dose of about 100 mrem; DOE radiation protection standards limit the dose to members of the general public to 100 mrem/yr above background levels; living in a brick house results in a dose of about 75 mrem/yr above the background level.

Exposure rate - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (uR), and exposure rate is typically expressed as uR/h. The dose to the whole body can be approximated by multiplying the exposure rate by the number of hours of exposure. For example, if an individual were exposed to gamma radiation at a rate of 20 uR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole-body dose would be 170 mrem.

Gamma Radiation - See radiation.

Gram - A gram (g) is a metric unit of weight. There are 454 g in 1 pound, and 28 g in 1 ounce.

Meter - A meter (m) is a metric unit of length; 1 m is equal to approximately 39 inches.

Microcurie - A microcurie (uCi) is 1,000,000 picocuries (see definition of picocurie for additional explanation).

Microroentgen - A microroentgen (uR) is a unit used to measure radiation exposure. For further information, see the definition of exposure rate.

Milliliter - A milliliter (ml) is a unit of measure for volume. There are 3785 ml in 1 gallon.

Millirad - The millirad (mrad) is used to indicate the amount of energy imparted by radiation to a unit of mass. An absorbed dose rate is expressed in terms of mrad per hour (mrad/h).

Millirem - The millirem (mrem) is the unit used to measure radiation dose to man. The DOE dose limit is 100 mrem above background radiation levels within any one-year period for members of the general public. Naturally occurring radioactive substances in the ground result in a yearly exposure of about 100 mrem to each member of the population. To date, no difference can be detected in the health of population groups exposed to 100 mrem/yr above background and in the health of groups who are not exposed.

Picocurie - A picocurie (pCi) is the unit of measure for radioactivity, just as an ounce is a unit to measure weight. A measurement of 1 pCi means that one radioactive particle is released on the average of every 27 seconds.

Radium-226 - Radium-226 is a naturally occurring radioactive material that spontaneously emits alpha radiation.

Radiation - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops. Alpha radiation cannot penetrate the outer layer of skin on the body. Beta radiation can penetrate the outer layers of skin, but cannot reach the internal organs of the body. Gamma radiation is the most penetrating type and can usually reach the internal organs.

Radionuclide - Radioactive elements are also referred to as radionuclides. For example, uranium-235 is a radionuclide, uranium-238 is another, thorium-232 another, and so on.

Remedial Action - Remedial action is a general term used to mean "cleanup of contamination that exceeds DOE guidelines." It refers to any action required to bring a property into compliance with applicable DOE criteria and standards established to protect members of the general public and occupants of the property. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc. Remedial action also includes restoring remediated properties to their original conditions, to the extent that this is possible.

Uranium - Uranium is a naturally occurring, radioactive element. The principal use of uranium when refined is for the production of fuel for nuclear reactors. Uranium in its natural form is not suitable for use as a fuel source.

Working Level - Working level (WL) is a unit of measurement for the amount energy expended in air by radon or its radioactive decay products. The term was derived to measure radon progeny concentrations to which uranium miners were exposed.

Exhibit II *Documents Supporting the Certification of the Remedial Action at the National Guard Armory in Chicago, Illinois*

EXHIBIT II

DOCUMENTS SUPPORTING THE CERTIFICATION OF THE

REMEDIAL ACTION PERFORMED AT THE

NATIONAL GUARD ARMORY

IN CHICAGO, ILLINOIS

FROM APRIL 1987 TO JUNE 1987

PREFACE

For the convenience of the reader, Exhibit II is paginated continuously. Each page number begins with the designator "II-" to distinguish the numbering system used for Exhibit II from the individual numbering systems used in the documents comprising Exhibit II. The Exhibit II page numbers on which the individual documents begin are given on pages ii and II-iii of this docket. These page numbers are also listed on the title page introducing each subpart of Exhibit II.

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Exhibit II (1) - Decontamination or Stabilization Criteria

The following documents contain the guidelines that determine the need for remedial action. The subject property has been decontaminated to comply with these guidelines. The first document listed is included as Appendix A to Exhibit I. The second and third documents are included in this exhibit.

Page

U.S. Department of Energy. U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Rev. 2, March 1987.

U.S. Department of Energy. Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP), 14501-00-DC-01, Rev. 2, Oak Ridge, TN, March 1986. II-2

Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987. II-45

ADVANCED TECHNOLOGY
DIVISION

35271

REVISION
NOTICE NO. 3

DESIGN CRITERIA

PAGE 1 OF 1

DEPARTMENT OF ENERGY
FORMERLY UTILIZED SITES
REMEDIAL ACTION PROGRAM
BECHTEL JOB 14501 (FUSRAP)

ISSUE DATE: 03/07/86

TO: Tech Writer MANUAL NUMBER 15

Please replace Table of Contents, Rev. 2 in your Design Criteria for Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP) which has a typographical error and format change, with the attached corrected Table of Contents, Rev. 2.

Please sign this revision notice in duplicate, retaining one copy for the front of your folder, returning one copy to the address indicated below:

PLEASE NOTE: As indicated on Table of Contents, Appendicies A, B, and D are still at Rev. 0.

PLEASE SIGN, DATE, AND RETURN THIS ENTIRE SHEET TO:

Bechtel National, Inc.
800 Oak Ridge Turnpike
Oak Ridge, TN 37830 ATTN: B. WOOD

ACKNOWLEDGEMENT:

MY COPY HAS BEEN BROUGHT TO CURRENT STATUS AND SUPERSEDED MATERIAL HAS BEEN REMOVED AND DESTROYED

☒ MY ADDRESS IS THE SAME

☐ MY ADDRESS IS AS FOLLOWS

SIGNATURE Jeannette M. Hoffman DATE 4/3/86 MANUAL NO. 15
VERIFY

14501-00-DC-01
REV. 1

DESIGN CRITERIA FOR FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM [FUSRAP] AND SURPLUS FACILITIES MANAGEMENT PROGRAM [SFMP]

FEBRUARY 1986

Prepared by
U.S. DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE

14501-00-DC-01-15

Rev. 1

DESIGN CRITERIA
FOR
FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM (FUSRAP)
AND
SURPLUS FACILITIES MANAGEMENT PROGRAM (SFMP)



(ISSUED FOR CLIENT APPROVAL)

FEBRUARY 1986

Approved by: E. L. Keller — 2-24-86
E. L. Keller, Director — Date
Technical Services Division
Oak Ridge Operations Office

Approved by: John T. Milloway — 2-24-86
John T. Milloway — Date
Assistant Manager for
Construction and Engineering
Oak Ridge Operations Office

PREFACE TO DESIGN CRITERIA

These design criteria have been written in a generic form that summarizes criteria applicable for remedial action and long-term management activities associated with the radioactive wastes at the FUSRAP and SFMP sites. Site-specific information is provided in the appendices to this generic document. As a specific scope of work for a site is determined, design bases and work plans for each of the sites will be developed.

Appendix A contains definitions of terms used in these design criteria and referenced documents. Appendix B provides a listing of FUSPAP and SFMP sites by WBS number and contains estimated waste quantities at the sites. Appendix C contains the residual contamination and waste control criteria. Appendix D lists site information for specific sites which will be required as a remedial action for the specific site is developed. This information will be included in the work plan for each site.

The design criteria will be referenced by the designation 14501-00-DC-01.

These design criteria will be periodically revised, as appropriate, to reflect new practices, additional information, revisions of applicable regulations, and standard revisions.

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1.0 INTRODUCTION

1.1 SCOPE

This document defines the design criteria for the identification of materials, evaluation of remedial action alternatives, selection of design parameters for site cleanup remedial actions and interim storage, and long-term management methods for handling FUSRAP and SFMP radioactive wastes.

1.2 OBJECTIVE

The primary objective of the Formerly Utilized Sites Remedial Action Program (FUSRAP) and Surplus Facilities Management Program (SFMP) projects is to stabilize, decontaminate, and/or dispose of FUSRAP and SFMP derived wastes in such a manner as to minimize the radiological risks posed by these wastes and to enable certification of the cleaned up FUSRAP and SFMP sites for unrestricted future use. At some sites, remedial action may be in situ long-term management with monitoring as necessary to detect any contaminant migration from the site in excess of radiological design criteria. At other sites, an interim storage program may be established until a decision for final disposition is made.

1.3 DEFINITIONS

Appendix A contains definitions of terms that are used in these design criteria as well as in the referenced documents.

1.4 CHANGES TO CRITERIA

The criteria for FUSRAP and SFMP remedial actions set forth in this document are based on elements of various federal orders, regulations, and standards that may be subject to change. This document will be revised to reflect changed criteria as authorized and approved by DOE.

2.0 APPLICAELE DOCUMENTS

2.1 GENERAL

The intent of these design criteria is to use DOE Orders where applicable. Applicable orders, regulations and standards, and sections thereof, as well as industry standards, will be investigated on a site-specific basis to formulate the design bases for the specific site.

2.2 FEDERAL ORDERS, REGULATIONS, AND STANDARDS

The following federal orders, regulations, and standards contain elements that are generally applicable to the FUSRAP and SFMP projects, and are summarized for these criteria.

2.2.1 Quality Assurance

DOE Order 5700.6A--Quality Assurance and DOE/OR-FUSRAP-82-001 Plan for Quality Assurance. The Project Quality Assurance Program complies with DOE Order 5700.6A, and the FUSRAP Plan for Quality Assurance (DOE/OR-FUSRAP-82-001).

For each remedial action site, and interconnecting activities (such as transportation), a formal evaluation (Quality Assurance Assessment) will be made of the consequences of failure of equipment and facilities to perform satisfactorily in service. This Assessment, which will be an adjunct to design engineering with subsequent modifications as may be required, will give full consideration to safety, environment, costs, schedule delays, programmatic goals, public reaction, or any other factor important to achieving project objectives.

When the formal evaluation indicates that consequences of failure may be unacceptable, significant, or unknown and the probability of failure is high or unknown, additional deliberate actions to find

and prevent quality problems are mandatory. The additional actions to assure quality of design and engineering, and particularly to assure implementation of that design and engineering, will be documented using a Quality Action Plan.

2.2.2 Radiation Protection

DOE Order 5480.1A. This order establishes control over the environmental protection, safety, and health protection programs. Chapter XI, Requirements for Radiation Protection, Attachment XI-1, defines radiation protection guides for concentration in air and water above natural background which will be used as criteria for releases from DOE's FUSRAP and SFMP operations. Chapter XII, Prevention, Control, and Abatement of Environmental Pollution, provides requirements for the control of sources of environmental pollution in accordance with the substantive and procedural aspects of all applicable federal, state, and local pollution control standards.

DOE Order 5480.2--Hazardous and Radioactive Mixed Waste Management. This order establishes hazardous waste management procedures for facilities operated under authority of the Atomic Energy Act of 1954, as amended (AEA). The procedures will follow, to the extent practicable, regulations issued by the Environmental Protection Agency (EPA) pursuant to the Resource Conservation and Recovery Act of 1976 (RCRA).

DOE Order 5481.1--Safety Analysis and Review System. This DOE Order establishes requirements for the preparation and review of safety analyses for each DOE operation, including: identification of hazards and their elimination or control; assessment of risk; documented management authorization of operation; and transportation of hazardous materials.

2.2.3 Land Disposal of Radioactive Wastes

Elements of the DOE Orders and federal regulations mentioned in the following sections provide technical guidelines for long-term, near-surface land burial facilities and ancillary facilities.

DOE Order 6430.1--General Design Criteria Manual. This order contains basic architectural and engineering design requirements for new DOE facilities; provides technical specification requirements; and outlines planning and design requirements for new facilities, facility additions, facility alterations, and building acquisitions to achieve economy of construction, operation, and maintenance.

40 CFR 192--Standards for Remedial Action at Inactive Uranium Processing Sites. This regulation defines remedial action criteria for inactive uranium processing sites. Some elements of these standards are applicable to the FUSRAP and SFMP programs. Service life of a mill tailings disposal site is defined in this regulation and has been adopted for FUSRAP and SFMP projects. Specific service life and release control requirements for interim storage sites and long-term management sites are noted in Section 3.2 of these Design Criteria.

2.2.4 Handling, Transportation, and Storage

DOE Order 1540.1--Materials Transportation and Traffic Management. Hazardous materials at FUSRAP and SFMP sites shall be shipped in accordance with DOE Order 1540.1. This document outlines DOE's policies and procedures for the management of materials transportation to ensure that it is accomplished in a manner commensurate with:

(1) Operational requirements for transportation services

(2) Established practices and procedures for transportation safety, economy, efficiency, and cargo security

(3) The National Transportation Policy as established by Congress and cognizant federal agencies

(4) Applicable federal, state, local, and international transportation regulations.

Intra-building and intra-site transfers are excluded from the provisions of this order.

DOE Order 5480.1A--Environmental Protection, Safety, and Health Protection Program for DOE Operations. Chapter 3 of this Order contains safety requirements for packaging of fissile and radioactive material. It also defines the requirements for design, evaluation, and testing of containers used for the transport of DOE's fissile and radioactive materials.

49 CFR 171-179--Transportation of Hazardous Materials. These regulations specify requirements for bulk shipments of uranium or thorium ores and physical or chemical concentrations of those ores and uranium metal or natural thorium metal, or alloys of these materials.

2.2.5 Health and Safety

Occupational Safety and Health Administration (OSHA) 29 CFR 1910. This section contains the health and safety regulations for general industry.

Occupational Safety and Health Administration (OSHA) 29 CFR 1926. This section establishes the general health and safety regulations for construction.

2.2.6 Surveys

Surveys for characterization and remedial action will be performed in accordance with the following specifications.

National Oceanic and Atmospheric Administration (NOAA).

- "Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys"
- "Specification to Support Classification, Standards of Accuracy, and General Specifications of Geodetic Control Surveys"
- "Manual of Geodetic Triangulation," "Specification Publication No. 247

U.S. Department of Interior (USDI) "Manual of Instructions for the Survey of Public Lands of the United States," 1973, Bulletin 6.

2.2.7 Weather

National Oceanic and Atmospheric Administration. "Comparative Climatic Data for the United States through 1982," 1983.

2.3 STATE AND LOCAL REGULATIONS

State and local regulations governing handling, transportation, and storage of radioactive materials generally follow federal orders and regulations, but may vary depending on whether the particular state is an "Agreement State" under the Atomic Energy Act of 1954, as amended. DOE regulations will be followed, and state and local regulations will be reviewed on a site-specific basis.

2.4 DESIGN CODES, GUIDES, AND STANDARDS

The following industry and national codes, standards, and guides, as applicable, will also serve as guidelines for the Design Criteria for FUSRAP and SFMP:

- American Association of State Highway and Transportation Officials (AASHTO)
- American Concrete Institute (ACI)

- American Conference of Government Industrial Hygienists (ACGIH)
- American Institute of Steel Construction (AISC)
- American National Standards Institute (ANSI)
- American Nuclear Society (ANS)
- American Petroleum Institute (API)
- American Railway Engineering Association (AREA)
- American Society for Testing and Materials (ASTM)
- American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE)
- American Society of Mechanical Engineers (ASME)
- American Water Works Association (AWWA)
- American Welding Society (AWS)
- Institute of Electrical and Electronic Engineers (IEEE)
- Interstate Commerce Commission (ICC)
- Illuminating Engineering Society (IES)
- National Electrical Code (NEC)
- National Electrical Manufacturers' Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA) "National Fire Code"
- National Geodetic Survey (NGS)
- National Standard Plumbing Code (NSPC)
- Occupational Safety and Health Standards (OSHA)
- Underwriters' Laboratory (UL)
- Uniform Building Code (UBC)
- U.S. Army Corps of Engineers Dredging Documents
- U.S. Geological Survey (USGS)

3.0 DESIGN REQUIREMENTS

3.1 GENERAL

FUSRAP work may involve remedial action at a number of sites. The currently designated FUSRAP and SFMP sites are listed in Appendix B; waste characteristics and estimated volumes at each site are also given.

Additional sites may be added or deleted with passage of federal legislation; therefore, the list of sites may be subject to revision. The specific type and quantity of contaminated material at each site, as well as geologic, meteorologic, and other site conditions affecting the design and design approach, differ from site to site.

3.2 RADIOLOGICAL DESIGN CRITERIA

The proposed DOE Interim Residual Contamination and Waste Control Guidelines for FUSRAP and SFMP sites are summarized in Appendix C. This criteria should be followed in defining cleanup requirements, developing remedial action plans, and performing and verifying field remedial actions.

3.3 SPECIFIC SITE CONDITIONS

The following information is required for each site and will be completed before or during detailed design and engineering of disposal facilities.

3.3.1 Scope of Work

The Scope of Work for the needed remedial actions must be clearly defined. This may be initiated with the preparation of the Preliminary Engineering Evaluation Report for each site with a

Design Basis, or as a separate document. It will be in accordance with the waste management plan outlined in Section 3.3.4 of these Design Criteria.

3.3.2 State and Local Regulations

In consultation with appropriate DOE-ORO personnel, applicable state and local regulations and ordinances will be reviewed to determine requirements to achieve compliance with health, safety, and environmental regulations. Construction permits and local property access agreements will be obtained as required. Any permits, licenses, or other authorization required by federal, state, or local environmental protection statutes, or any other legal authorizations required by DOE, will be obtained by DOE, Oak Ridge Operations.

3.3.3 Site Information

Define the site conditions for each site as necessary for design decisions. Parameters that may be needed include the following (see Appendix D for detailed requirements):

- Property surveys, easements, and datum
- Water levels
- Precipitation
- Humidity
- Groundwater table
- Frost penetration
- Ice conditions
- Air temperature
- Noise levels
- Winds
- Seismology

- o Soil and foundation conditions
- o Site historical information (including past and current use; as-built design drawings of buried utilities, structures, and systems; and existing monitoring systems).

3.3.4 Waste Characterization

Complete information on the type, quantity, and existing disposition of the radioactive wastes at any given site will usually be required prior to initiation of the Preliminary Engineering Evaluation Report or detailed design. If data and information in existing reports is not complete, or possibly out of date, additional characterization survey work may be required. Examples of additional characterization, to be planned by Bechtel and approved by DOE on a site specific basis and according to a predetermined need, include the following:

- o Location and depth of buried wastes.
- o Radiological, physical, and chemical characteristics of wastes in ponds, under surface water, and/or in groundwater.
- o Extent of radiological migration, groundwater flow patterns, and seasonal variations.
- o Wastes/contamination in building structures that may be scheduled for dismantlement or demolition.

3.3.5 Support Facilities

The identification of the needed temporary and/or permanent support facilities will be made and may include the following:

- o Security
- o Contamination control
- o Structures
- o Equipment
- o Water treatment and control

- o Utilities
- o Access routes
- o Monitoring system
- o Document control
- o Administration

3.3.6 Waste Transportation

The following facets for transporting the waste materials will be investigated as applicable:

- o Waste form and quantity to be transported
- o Mode of transportation
- o Packaging and control
- o Transportation routes
- o Local traffic patterns and impact on community.

APPENDIX A

DEFINITIONS

Abbreviations/Terms	Definitions
AEC	Atomic Energy Commission
alpha particle	A positively charged particle emitted from certain radioactive material. It consists of two protons and two neutrons, hence is identical with the nucleus of the helium atom. It is the least penetrating of common radiation, hence is not dangerous unless alpha-emitting substances have entered the body.
background radiation	Naturally occurring low-level radiation to which all life is exposed. Background radiation levels vary from place to place on the earth.
beta particle	A particle emitted from some atoms undergoing radioactive decay. A negatively charged beta particle is identical to an electron. A positively charged beta particle is called a position. Beta radiation can cause skin damage, and beta emitters are harmful if they enter the body.
BNI	Bechtel National, Inc.

buffer zone	A portion of the land disposal site that is controlled by the licensee and that lies between the disposal unit and the boundary of the site.
CFR	Code of Federal Regulations
Ci	Curie (the unit of radioactivity of any nuclide, which decays at a rate of 3.7×10^{10} disintegrations/second)
contamination	The radioactive substance which is not a portion of the material into and onto which it is now dispersed.
daughter product	The nuclide remaining after a radioactive atom (parent) has undergone radioactive decay. A daughter atom also may be radioactive, producing further daughter products.
decontamination	The removal of radioactive material by chemical or mechanical means from an undesirable location and placement of the removed radioactive material in an acceptable form and location.
dismantlement	The organized manner by which a system or structure is segmented into component pieces which can be managed.

disposal	Isolation of waste from the biosphere with no intent of retrieval in a manner which does not permit easy access to the waste after its emplacement, and does not require perpetual maintenance and monitoring.
disposal site	A portion of a land disposal facility which is used for disposal of waste. It consists of disposal units and a buffer zone.
disposal unit	For near-surface disposal, a "disposal unit" means a discrete portion of the disposal site into which waste is placed for disposal.
DOE	Department of Energy
dpm	Disintegrations per minute
egr	External gamma radiation (gamma radiation emitted from a source(s) external to the body, as opposed to internal gamma radiation emitted from ingested or inhaled sources)
engineered barrier	Man-made structures or devices that are intended to prevent an intruder from inadvertent exposure to radiation from certain waste or to prevent escape of radionuclides to the environment.
EPA	Environmental Protection Agency
exposure	Magnitude of radiation. It is defined and measured in terms of electrical charge produced per unit mass of air.

FUSRAP	Formerly Utilized (MED/AEC) Sites Remedial Action Program
gamma background	Natural gamma ray activity everywhere present, originating from two sources: (1) cosmic radiation bombarding the earth's atmosphere continually, and (2) terrestrial radiation. Whole body absorbed dose equivalent in the U.S. due to natural gamma background ranges from about 60 to 125 mrem/yr.
gamma ray	High energy electromagnetic radiation emitted from the nucleus of a radioactive atom, with specific energies for the atoms of different elements and having high penetrating power.
ground water	Subsurface water in the zone of full saturation.
half-life	The period of time required for one-half of the original amount of a radioisotope to decay into a daughter product.
health effect	An adverse physiological response to environmental pollutants. While physiological responses include sickness, genetic defects, and death, for FUSRAP/SFMP one health effect is defined as one death resulting from cancer caused by exposure to radiation.

hydrogeologic unit	Any soil or rock unit or zone which, by virtue of its porosity or permeability or lack thereof, has a distinct influence on the storage or movement of ground water.
inadvertent intruder	A person who might occupy the disposal site unknowingly after closure and engage in normal activities, such as agriculture, dwelling construction, and other pursuits in which the person might be exposed to radiation from the waste.
interim storage	A short-term disposal having control and stabilization features designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years at which time ultimate disposal will be made.
intruder barrier	A sufficient depth of cover over the waste that exposure to radiation by an inadvertent intruder will meet the standards for protection against radiation specified in DOE Manual 5820.1 and in 10 CFR 61, or engineered structures that provide equivalent protection to the inadvertent intruder.
land disposal facility	The land, buildings, and equipment which are intended to be used for the disposal of radioactive wastes beneath the surface of the land.

long-term management	A form of ultimate disposal and storage involving near-surface burial of FUSRAP and SFMP radioactive wastes. Includes monitoring and corrective action, as necessary, to ensure that contaminants are not migrating from the site in excess of design criteria, and an institutional control period not less than that specified in 40 CFR 192. Control and stabilization features are designed to ensure to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.
LSA	Low Specific Activity - A class of radioactive material as defined in 49 CFR 173.389(c).
umhos/cm	Micromhos per centimeter (10^{-6} mho/cm)
uR/hr	Microroentgens per hour (10^{-6} R/hr)
mR/hr	Milliroentgens per hour (10^{-3} R/hr)
mrad/hr	Millirads per hour (10^{-3} rad/hr)
MED	Manhattan Engineer District
mho	A unit of electrical conductance, the reciprocal of electrical resistance.
MPC	Maximum permissible concentration as defined per 10 CFR 20.103.

near-surface disposal facility	A land disposal facility in which radioactive waste is disposed within the upper 15-20 meters of the earth's surface.
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
nuclide	A general term applicable to all atomic forms of the elements; nuclides comprise all the isotopic forms of all the elements. Nuclides are distinguished by their atomic number, atomic mass, and energy state.
pCi/l	Picocurie per liter (10^{-12} Ci/l)
R	Roentgen (a unit of exposure to ionizing radiation). It is that amount of gamma or x-rays required to produce an electrical charge that is numerically equal to 2.58 x 10^{-4} coulombs/kg.
rad	The basic unit of absorbed dose of ionizing radiation. A dose of one rad means the absorption of 100 ergs of radiation energy per gram of absorbing material.
radioactivity	The spontaneous decay or disintegration of an unstable atomic nucleus, usually accompanied by the emission of ionizing radiation.

radioactive decay chain	A succession of nuclides, each of which transforms by radioactive disintegration into the next, until a stable nuclide results. The first member is called the parent, the intermediate members are called daughters, and the final stable member is called the end product.
radon	A radioactive, chemically inert gas having a half-life of 3.8 days (radium-222); formed as a daughter product of radium (radium-226).
radon background	Low levels of radon gas found in an area due to the presence of uranium or radium in soil and building materials.
radon daughter	One of the several short-lived radioactive daughter products of radon. (Several of the daughters emit alpha particles.)
remedial action	Steps and processes that are undertaken to physically identify, decontaminate, stabilize, or otherwise provide long-term management of radioactive materials to permit certification for unrestricted public use of the area or site.
rdc	Radon daughter concentration (the concentration in air of short-lived radon daughters, usually expressed in pCi/l; also measured in terms of working level (WL).

rem	Roentgen equivalent man. The unit of dose equivalence for all types of ionizing radiation which expresses the effectiveness of the absorbed dose on a common scale. The rem is the basic unit used to record the accumulated dose equivalent to personnel.
site closure and stabilization	Those actions that are taken upon completion of operations that prepare the disposal site for custodial care and that assure that the disposal site will remain stable and will not need ongoing, active maintenance.
SFMP	Surplus Facilities Management Program
surveillance	Observation of the disposal site for purposes of visual detection of need for maintenance, custodial care, evidence of intrusion, and compliance with other license and regulatory requirements.
WL	Working level. A unit of radon daughter exposure, equal to any combination of short-lived radon daughters in 1 liter of air, that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. This level is equivalent to the energy produced in the decay of the daughter products that are present under equilibrium conditions in a liter of air containing 100 pCi of radium-222. It does not include decay of lead-210 (22-year half-life) and subsequent daughter products.

WLM	Working Level Month - An exposure to a one-WL concentration for 170 hours per month.
WBS NO.	Work Breakdown Structure identification sequence number designated by DOE. (See Appendix B for list of identification numbers for the specific sites.)

APPENDIX B

LIST OF FUSRAP AND SFMP SITES

AND

ESTIMATED WASTE QUANTITIES(7/82)

FUSRAP SITES

WBS No.	Site Name	State	Radioisotope	Estimated Volume (yd^3)	Concentration (pCi/g)	Radioactivity (Ci)	References	Remarks
101	Acid/Pueblo	NM	Plutonium-239	390*	110	4.8×10^{-2}	Remedial Action Completed	Soils
102	Albany Research	OR	Natural Uranium Uranium-238 Natural Uranium Radium-226	3,000[b]	a	a	b	Radiological characterization not complete
104	Bayo Canyon	NM	Strontium-90	1,520*	-	-	FB&DU 409-317	No Excavation Required - Marker Placed
105	Chupadera	NM	-	N/A	-	-	Remedial Action Not Required	
108	E. I. duPont	NJ	Uranium-238 Uranium-238 Uranium-238	7,000	1,400 1,100 6,600	2.7 0.5 0.9	DOE/EV-0005/8	Contam. Soils & Drainage Ditch
114	Kellex	NJ	-	175*	-	-		Completed
115	Niagara Falls Vicinity Properties	NY	Radium-226	48,000	a	a	BMI-2045, 2061, 2074	
117	Middlesex Landfill	NJ	Radium-226	33,000	11	1.4	DOE/EV-0005/20	
118	Middlesex Sampling Plant	NJ	Radium-226 Radium-226	- 57,000	- -	3.5 10.5 -	DOE/EV-0005/1	
121	Palos Park	IL	Hydrogen-3	4,030	-	3.0×10^3	DOE/EV-0005/7	
153	St. Louis Airport	MO	Radium-226	86,000	30	3.8	DOE/EV-0005/16	

APPENDIX B (Cont'd)

FUSRAP SITES

WBS No.	Site Name	State	Radioisotope	Estimated Volume (yd^3)	Concentration (pCi/g)	Radioactivity (Ci)	References	Remarks
125	Shpack	MA	Radium-226 Uranium-238	400	109 125	5.5 6.3	ORNL-5799 DOE/EV-0005/31	
126	Universal Cylops	PA	-	30	-	-	ORO-777	
129	Linde Air Products	NY	Radium-226 Uranium-238 Actinium-227	26,000	9.3 349 2.3	8.0×10^{-2} 2.88 2.0×10^{-2}	DOE/EV-0005/5 PB&DU 409-323	
130	Univ. of Calif.	CA	-	30*	-	-	Completed 9/82	
131	Univ. of Chicago	IL	-	75*	-	-		
134	SLAPSS (Vic. Prop)	MO	-	13,000	-	-		
137	Wayne/Pequannock	NJ	Uranium-238 Thorium-232 Thorium-228 Radium-226	50,000	a	a		
138	Maywood	NJ	Uranium-238 Uranium-235 Uranium-234 Thorium-230 Thorium-232 Thorium-228 Radium-226	218,000	a	a		
139	Colonie	NY	Uranium-238	30,000	a	a		Radiological Characterization Not Complete
140	Hazelwood	MO	Thorium-230 Radium-226 Uranium-238 Uranium-235 Uranium-234	61,000	a	a		Radiological Survey Not Available
			Total Volume FUSRAP	638,650				

APPENDIX B (Cont'd)

SFMP SITES

WBS No.	Site Name	State	Radioisotope	Estimated Volume (yd^3)	Concentration (pCi/g)	Radioactivity (Ci)	References	Remarks
201	Weldon Spring Storage Site	MO						
	o Raffinate Pits		Natural Uranium and Thorium, Radium-226	220,500	-	824	DOE/OR/20722-5	Sludge volume
	o Quarry		Natural Uranium and Thorium, Radium-226	130,800	-	-	-	
	o Vicinity Properties		Natural Uranium Radium-226	102,00	-	-	-	
202	Niagara Falls Storage Site	NY	Radium-226 Uranium-238	218,000	-	940	DOE/OR/20722-1	(Includes contaminated residues, soils and rubble)
		Total Volumes SFMP		671,300				

[a]Actual waste volume

[b]Volumes are from Project Plan

[c]Information is unknown at this time.

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APPENDIX C

U.S. DEPARTMENT OF ENERGY GUIDELINES FOR RESIDUAL RADIOACTIVITY AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Rev. 1, July 1985)

A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactivity, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Dept. Energy 1984). More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactivity from basic dose limits, is contained in a supplementary document--referred to herein as the "supplement" (U.S. Dept. Energy 1985).

"Residual radioactivity" includes: (1) residual concentrations of radionuclides in soil material,** (2) concentrations of airborne radon decay products, (3) external gamma radiation level, and (4) surface contamination. A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). Basic dose limits are used explicitly for deriving guidelines for residual concentrations of radionuclides in soil material, except for thorium and radium. Guidelines for

*A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

**The term "soil material" refers to all material below grade level after remedial action is completed.

residual concentrations of thorium and radium and for the other three quantities (airborne radon decay products, external gamma radiation level, and surface contamination) are based on existing radiological protection standards (U.S. Environ. Prot. Agency 1983; U.S. Nucl. Reg. Comm. 1982). These standards are assumed to be consistent with basic dose limits within the uncertainty of derivations of levels of residual radioactivity from basic limits.

A "guideline" for residual radioactivity is a level of residual radioactivity that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactivity presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement.

An "authorized limit" is a level of residual radioactivity that must not be exceeded if the remedial action is to be considered completed. Under normal circumstances, expected to occur at most sites, authorized limits for residual radioactivity are set equal to guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in Sections D and F. A site may be released for unrestricted use only if the residual radioactivity does not exceed guideline values at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if the residual radioactivity exceeds guideline values. The applicable controls and restrictions are specified in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). Implementation of ALARA policy is specified as procedures to be applied after authorized limits have been set. For sites to be released for unrestricted use, the intent is to reduce residual radioactivity to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual radioactivity is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as is reasonably achievable. Procedures for implementing ALARA policy are described in the supplement. ALARA policies, procedures, and actions must be documented and filed as a permanent record upon completion of remedial action at a site.

B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 500 mrem/yr for a period of exposure not to exceed 5 years and an average of 100 mrem/yr over a lifetime. The committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), shall be used for determining the dose.

C. GUIDELINES FOR RESIDUAL RADIOACTIVITY

C.1 Residual Radionuclides in Soil Material

Residual concentrations of radionuclides in soil material shall be specified as above-background concentrations averaged over an area of 100 m^2. If the concentration in any area is found to exceed the average by a factor greater than 3, guidelines for local concentrations shall also be applicable. These "hot spot" guidelines depend on the extent of the elevated local concentrations and are given in the supplement.

The generic guidelines for residual concentrations of Th-232, Th-230, Ra-228, and Ra-226 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit. Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

The guidelines for residual concentrations in soil material of all other radionuclides shall be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. Procedures for deriving these guidelines are given in the supplement.

C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

C.4 Surface Contamination

The following generic guidelines, adapted from standards of the U.S. Nuclear Regulatory Commission (1982), are applicable only to existing structures and equipment that will not be demolished and buried. They apply to both interior and exterior surfaces. If a building is demolished and buried, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

Radionuclides†[2]	Allowable Total Residual Surface Contamination (dpm/100 cm²)†[1]		
	Average†[3],†[4]	Maximum†[4],†[5]	Removable†[4],†[6]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000β-γ	15,000β-γ	1,000β-γ

†[1] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

†[2] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

†[3] Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

†[4] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

†[5] The maximum contamination level applies to an area of not more than 100 cm².

†[6] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVITY

The remedial action shall not be considered complete unless the residual radioactivity is below authorized limits. Authorized limits shall be set equal to guidelines for residual radioactivity unless: (1) exceptions specified in Section F of this document are applicable, in which case an authorized limit may be set above the guideline value for the specific location or condition to which the exception is applicable; or (2) on the basis of site-specific data not used in establishing the guidelines, it can be clearly established that limits below the guidelines are reasonable and can be achieved without appreciable increase in cost of the remedial action. Authorized limits that differ from guidelines must be justified and established on a site-specific basis, with documentation that must be filed as a permanent record upon completion of remedial action at a site. Authorized limits differing from the guidelines must be approved by the Director, Oak Ridge Technical Services Division, for FUSRAP and by the Director, Richland Surplus Facilities Management Program Office, for remote SFMP--with concurrence by the Director of Remedial Action Projects for both programs.

E. CONTROL OF RESIDUAL RADIOACTIVITY AT FUSRAP AND REMOTE SFMP SITES

Residual radioactivity above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A requires compliance with applicable federal, state, and local environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

a. 5440.1B, Implementation of the National Environmental Policy Act

b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations

c. 5480.2, Hazardous and Radioactive Mixed Waste Management

d. 5480.4, Environmental Protection, Safety, and Health Protection Standards

e. 5482.1A, Environmental, Safety, and Health Appraisal Program

f. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

h. 5484.2, Unusual Occurrence Reporting System

i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-Background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing federal, state, or local standards.

d. Access to a site shall be controlled and misuse of onsite material contaminated by residual radioactivity shall be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The federal government shall have title to the property.

E.2 Interim Management

a. A site may be released under interim management when the residual radioactivity exceeds guideline values if the residual radioactivity is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.

b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactivity or cause it to migrate.

c. The owner of the site or appropriate federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

Uranium, Thorium, and Their Decay Products

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 pCi/m^2/s, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b of this section (E.3) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a of this section (E.3).

d. Groundwater shall be protected in accordance with 40 CFR 192.20(a)(2) and 192.20(a)(3), as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The federal government shall have title to the property.

Other Radionuclides

f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

F. EXCEPTIONS

Exceptions to the requirement that authorized limits be set equal to the guidelines may be made on the basis of an analysis of site-specific aspects of a designated site that were not taken into account in deriving the guidelines. Exceptions require approvals as stated in Section D. Specific situations that warrant exceptions are:

a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

c. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not

be necessary where only minor quantities of residual radioactive materials are involved or where residual radioactive materials occur in an inaccessible location at which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. In order to invoke this exception, a site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactivity must be included in the appropriate state and local records.

d. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be effected by remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of remedial actions that would be less costly than removal of the residual radioactive materials. A statement specifying the residual radioactivity must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

G. SOURCES

Limit or Guideline	Source
Basic Dose Limits	
Dosimetry Model and Dose Limits	International Commission on Radiological Protection (1977, 1978)
Generic Guidelines for Residual Radioactivity	
Residual Concentrations of Radium and Thorium in Soil Material	40 CFR 192
Airborne Radon Decay Products	40 CFR 192
External Gamma Radiation	40 CFR 192
Surface Contamination	Adapted from U.S. Nuclear Regulatory Commission (1982)
Control of Radioactive Wastes and Residues	
Interim Storage	DOE Order 5480.1A
Long-Term Management	DOE Order 5480.1A; 40 CFR 192

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APPENDIX D

SITE INFORMATION FOR SPECIFIC SITES
(See Design Criteria, Section 3.3.3)

1.0 GENERAL

This appendix is a general outline of the information that will be obtained for a FUSRAP/SFMP site through historical research and/or field investigation activities during site characterization. This information will be used as a starting point for preparation of Design Bases for the sites. The data unique to a particular site are enclosed between single asterisks (*..*).

2.0 SURVEYS AND DATUM

Information on site description, surveys, plant coordinates, plant datum, plant grade, horizontal and vertical survey control points, plant grid north, site boundary, access roads, railroads, etc., will be obtained.

3.0 WATER LEVELS

For sites located on rivers, lakes, or at the ocean, the probable maximum and minimum water levels and their fluctuations will be obtained. The design maximum flood elevations, as noted below, will be investigated and recorded for the site:

	Elevation Above Mean Sea Level (MSL) (*..*)
Maximum recorded high water	ft
100-year projected flood	ft
Probable maximum flood	ft
Maximum projected water level for plant safety	ft
Design high water	ft
Design low water	ft

(In general, the 100-year flood shall be used for design.)

4.0 PRECIPITATION (*..*)

Rainfall

Average annual	in.
Daily maximum	in.
Design hourly maximum (100-year storm)	in.
Probable maximum precipitation (PMP) per hour	in.

Flash floods caused by thunderstorm may occur and are to be considered in the design. (Note value to be used in flood design as *..* in. per hour.)

SNOWFALL (*..*)

Average annual	in.
Season maximum	in.
Maximum for month of *..*	in.
Daily maximum	in.
Design snow load	lb/sq. ft.

5.0 GROUNDWATER TABLE

The high water table to be used in design will be stated.

For the design of all underground structures, the high water table will be assumed as elevation *..* ft.

Average groundwater level is approximately at *..* ft.

6.0 FROST PENETRATION

Depth below grade *..* in.

7.0 ICE

If applicable, ice pack formation will be described giving appropriate design loads.

8.0 AIR TEMPERATURE (*..*)

Maximum design	°F
Minimum design	°F
Average annual	°F
Average wet bulb	°F
Average dry bulb	°F

9.0 NOISE LEVELS

Noise level measurement and monitoring during construction will be maintained for sites as required by local authorities.

10.0 WINDS

Based on 100-year recurrence interval, the design wind velocity shall be *..* mph at *..* feet above grade in accordance with the Uniform Building Code (UBC). The prevailing wind is in *..* direction. Wind velocity will be adjusted as appropriate for structure height and gust factors. The effects of tornadoes will be investigated as required by site conditions.

11.0 SEISMOLOGY

The site is in UBC Zone *..*. Seismic loads shall be considered in accordance with Section 2312 of UBC criteria.

Verification of whether a higher zoning than that required by UBC may be more appropriate for the particular site will be made.

12.0 GEOTECHNICAL INVESTIGATIONS

Subsurface investigations will provide a description of the soil and geological and hydrological conditions and other data for the preparation of "Soil and Geological Investigation Report". The design basis will list from the report the hydraulic gradient of ground water, soil profile, location of bedrock, determination of confined and unconfined aquifers, establishment of monitoring wells, test results of soil and rock properties, allowable bearing and/or pile capacities (as applicable) for foundation design, active and passive lateral earth pressure, etc. Compaction criteria and maximum slopes for excavation will also be specified.

13.0 GUIDELINES FOR RESIDUAL RADIOACTIVITY

To be developed for each site. Refer to Appendix C.

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

DERIVATION OF A URANIUM RESIDUAL RADIOACTIVITY GUIDELINE FOR THE NATIONAL GUARD ARMORY IN CHICAGO, ILLINOIS

prepared by

Charley Yu and John M. Peterson

Energy and Environmental Systems Division

May 1987

work sponsored by

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations Office

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DERIVATION OF A URANIUM RESIDUAL RADIOACTIVITY GUIDELINE FOR THE NATIONAL GUARD ARMORY IN CHICAGO, ILLINOIS

by

Charley Yu and John M. Peterson

ABSTRACT

A uranium residual radioactivity guideline for the National Guard Armory in Chicago, Illinois, was derived using data from radiological surveys carried out in 1977 and 1978 by Argonne National Laboratory and in 1987 by Bechtel National, Inc. The derived guideline is based on the requirement that the 50-year committed effective dose equivalent to an individual who lives in the Armory should not exceed a dose of 100 mrem/yr following decontamination of the Armory. Procedures specified in the U.S. Department of Energy manual for implementing residual radioactivity guidelines were used in this evaluation. The results of the evaluation indicate that the basic dose limit of 100 mrem/yr will not be exceeded in the foreseeable future, provided that the concentration of uranium-238 within the Armory does not exceed 150 pCi/g following decontamination. This guideline applies to the activity concentration of uranium-238, with uranium-234 and uranium-235 present in the same activity ratio as in natural uranium (the activity ratio of uranium-238, uranium-234, and uranium-235 in natural uranium is 1:1:0.046).

1 HISTORY AND SUMMARY OF EXISTING CONDITIONS

The National Guard Armory is located in the northeast section of Washington Park at 52nd Street and Cottage Grove Avenue in Chicago, Illinois (Fig. 1). The Armory building, constructed in 1924, is a 71-m (230-ft) by 200-m (650-ft) concrete building with a facade of Indiana limestone. An arena occupies the center of the building, and offices are located on four floors at the north and south ends. The arena is 68 m (220 ft) by 100 m (350 ft) and has a ceiling over 30 m (100 ft) high of clear span (steel truss) construction. Stadium bleachers are located on the east and west sides of the arena. The arena was formerly used by a horse calvary and later for horse polo games played on a dirt floor (U.S. Dept. Energy 1983; Jones 1986).

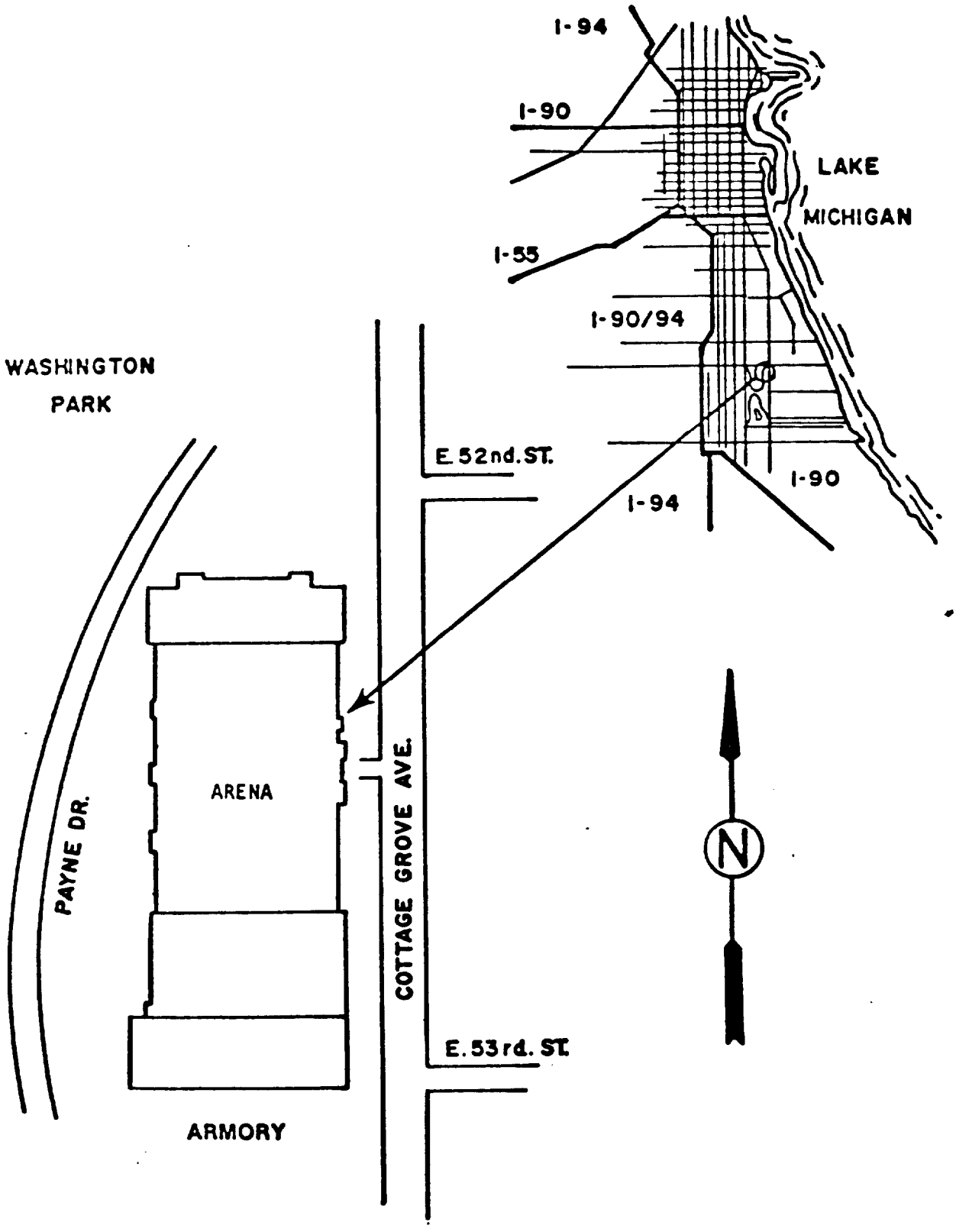

FIGURE 1 Location of the Illinois National Guard Armory, Chicago, Illinois (Source: Modified from U.S. Department of Energy 1983)

The Armory was leased from the state of Illinois 124th Field Artillery by the Manhattan Engineer District (MED) during World War II to support activities associated with development of the atomic bomb. Beginning in 1942, the building was used jointly by the MED Metallurgical Laboratory and the University of Chicago in support of federal programs involving nuclear materials. When use of this facility in support of nuclear programs was terminated in 1951, the property was returned to the state of Illinois for use by the National Guard (U.S. Dept. Energy 1980a, 1980b).

Various types of uranium processing activities were conducted in the Armory in support of nuclear activities. The arena was probably used for chemical processing and metal casting of uranium; the bleachers surrounding the arena were used for storage of radioactive materials. After MED stopped using the Armory, contaminated sediment from the arena dirt floor was removed and efforts were made to decontaminate some of the bleachers around the arena. A concrete slab was later poured over the dirt floor to facilitate use of the arena for maintenance of military vehicles (U.S. Dept. Energy 1983).

The principal radioactive contaminant in the Armory is processed natural uranium. The contamination is generally limited to relatively small areas (less than 300 cm^2), and the radiation level resulting from the contamination is quite low. In a radiological survey conducted in 1977 and 1978 (U.S. Dept. Energy 1983), no exposure rates in excess of background levels were detected at 1 m from the surface. The maximum contact exposure rate measured was 3 mR/h on a catch basin manhole cover in Room 1. The concentrations of radon-222 and its decay products in air in the building were within the range of values normally expected for background concentrations. The concentrations of long-lived radionuclides in air samples and the concentrations of radionuclides in soil samples collected around the facility were also essentially at background levels. These results indicate that the primary radioactive contaminant in the Armory is processed natural uranium, with minimal amounts of any decay products (i.e., thorium-230 and radium-226). A radiological survey was carried out by Bechtel National, Inc., in 1987 to more accurately delineate the extent of the contamination. TMA Eberline (1987) data from that survey are in general agreement with the results of the previous radiological survey conducted by Argonne National Laboratory in 1977 and 1978 (U.S. Dept. Energy 1983); the results from both surveys were used in this analysis.

A site-specific pathway analysis was carried out to establish the residual radioactivity guideline for the Armory, i.e., the residual radionuclide concentration that must not be exceeded if the Armory is to be released for unrestricted use. In this analysis, it was assumed that the three long-lived uranium isotopes -- uranium-238, uranium-234, and uranium-235 -- are in equilibrium, with an activity ratio of 1:1:0.046 (as in natural uranium). The derivation of the uranium guideline is based on procedures described in the U.S. Department of Energy (DOE) manual for implementing residual radioactivity guidelines (Gilbert et al. 1985 -- hereafter referred to as "the Manual"); the guidelines are presented in App. A. The derivation is limited to uranium-238, with uranium-234 and uranium-235 in equilibrium, because these are the only radionuclides that were detected in elevated concentrations in the areas surveyed.

2 SCENARIO DEFINITIONS

The potential exposure scenario considered in this evaluation assumes unrestricted use of the site at some time in the future. A hypothetical person is assumed to take up residence in the Armory building, drink water from a well adjacent to the Armory, and ingest plant foods grown in a garden adjacent to the Armory. The four pathways analyzed in this scenario are (1) external radiation from the contaminated materials, (2) internal radiation from inhalation of dust, (3) internal radiation from ingestion of plant foods grown in the uncontaminated soil outside the Armory but irrigated with potentially contaminated water, and (4) internal radiation from drinking water from a hypothetical shallow well adjacent to the Armory on the downgradient side. The livestock (meat and milk) and aquatic food (fish) pathways described in the Manual were eliminated from consideration based on the relatively small size of the Armory site.

The radiation dose to this potential future resident was calculated according to the method described in the Manual, based on the following specific assumptions:

- The individual lives in the most extensively contaminated room of the Armory building.
- Ten percent (10%) of the plant-food diet consumed by the individual is raised in the garden outside the Armory and is irrigated with potentially contaminated water.
- Wastewater collected in catch basins and sewer line eventually reaches the groundwater.
- The hydrogeologic and geochemical parameters for the Armory site are similar to those for the city of West Chicago, for which data are available. West Chicago is located about 40 km (25 mi) from the Armory site.

3 DOSE-TO-SOURCE RATIOS

The dose-to-source (D/S) ratios were calculated using the method described in the Manual. The summation of D_{ip}/S_i for each radionuclide i over the pathway p is the total D/S ratio that will be used to determine the allowable residual radioactivity for the Armory site, i.e.,

$$\text{Total } D/S = \sum_p \sum_i D_{ip}/S_i$$

The derivation of D_{ip}/S_i for uranium-238 for the four pathways applicable to the Armory site is presented in Sections 3.1-3.4. The various parameters used for this analysis are defined in App. B.

3.1 EXTERNAL GAMMA RADIATION PATHWAY

The formula for the D/S ratio for the external radiation pathway (p = 1) is:

$$D_{i1}/S_i = (D/E)_{i1} \times \rho_b \times FO_1 \times FA_1 \times FD_{i1}$$

Substituting the parameter values listed in Table B.1, App. B, one obtains:*

$$D_1/S = \sum_{i=1}^{2} D_{i1}/S_i = 0.087 \times 1.5 \times 1.0 \times 0.61 \times 0.45$$

$$+ 9.5 \times 10^{-4} \times 1.5 \times 1.0 \times 0.61 \times 0.63$$

$$= 3.6 \times 10^{-2} \text{ (mrem/yr)/(pCi/g)}$$

3.2 DUST INHALATION PATHWAY

The D/S ratio for internal exposure from inhalation of dust (p = 2) was calculated using the following equation:

$$D_{i2}/S_i = (D/E)_{i2} \times (E/A)_2 \times FO_2 \times FS_2 \times (A/S)_2$$

*The summation is carried out for uranium-238 and uranium-234 (uranium-234 is assumed to be present in secular equilibrium with uranium-238). The dose contribution from uranium-235 is not included in this evaluation because it will be much lower than that for either uranium-238 or uranium-234, due to the much lower activity concentration of uranium-235.

The mass loading factor $(A/S)_2$, i.e., the mass of airborne dust per unit volume of air, was assumed to be 2.0×10^{-4} g/m^3. This value is conservative for normal indoor activities, i.e., it results in a higher inhalation dose (Gilbert et al. 1983). Because horse polo games were previously played in the arena of the Armory (Argonne Natl. Lab 1987), such an indoor mass loading factor at the Armory could occur in the future. Using the parameters listed in Table B.1, App. B, one obtains:

$$D_2/S = \sum_{i=1}^{2} D_{i2}/S_i = 0.12 \times 8400 \times 1.0 \times 1.0 \times 2.0 \times 10^{-4}$$
$$+ 0.13 \times 8400 \times 1.0 \times 1.0 \times 2.0 \times 10^{-4}$$
$$= 4.2 \times 10^{-1} \text{ (mrem/yr)/(pCi/g)}$$

3.3 PLANT-FOOD INGESTION PATHWAY

For the plant-food ingestion pathway (p = 3), the plant food was assumed to be raised in a garden adjacent to the Armory in an uncontaminated area. Thus, the root uptake and foliar deposition pathways were not considered in this analysis. However, the irrigation pathway, assuming use of potentially contaminated water, was evaluated. The D/S ratio for internal exposure from ingestion of the hypothetical plant-food diet was calculated using the following equation:

$$D_{i3}/S_i = (D/E)_{i3} \times (E_{i3}/S_i) \times FA_3 \times FD_3$$

The environmental transport factors in the above equation, E_{i3}/S_i, was calculated as

$$E_{i3}/S_i = (E_{i3}/W_i) \times (W_i/S_i)$$

using the conversion factors, E_{i3}/W_i, listed in Table 4.5 of the Manual. The water-to-source concentration ratios, W_i/S_i, were obtained from the drinking water pathway discussed in Section 3.4.

Using parameter values listed in Table B.1, App. B, and the W_i/S_i value calculated in Section 3.4, one obtains:

$$D_3/S = \sum_{i=1}^{2} (D_{i3}/S_i) = 2.6 \times 10^{-4} \times 7.7 \times 10^{2} \times 0.76 \times 0.10 \times 1.0$$
$$+ 2.8 \times 10^{-4} \times 7.7 \times 10^{2} \times 0.76 \times 0.10 \times 1.0$$
$$= 3.2 \times 10^{-2} \text{ (mrem/yr)/(pCi/g)}$$

3.4 DRINKING WATER PATHWAY

The D/S ratio for internal exposure from drinking water (p = 4) was calculated using the equation:

$$D_{i4}/S_i = (D/E)_{i4} \times (E_{i4}/W_i) \times (W_i/S_i)$$

The water-to-source concentration factor, W_i/S_i, was calculated as

$$W_i/S_i = \left(1000/K_{d_i}^{cz}\right) \times F_{uz_i} \times F_{sz_i}$$

where $K_{d_i}^{cz}$ is the ith radionuclide distribution coefficient in the contaminated (source) materials. The F_{uz_i} and F_{sz_i} factors were calculated using the method described in the Manual, except the retardation factor, R_d, was modified so that the radionuclide migration velocity is more conservatively estimated. The retardation factor defined in the Manual (p. 4-70) reads:

$$R_d = 1 + \rho_b K_d/\theta_e$$

where θ_e is the effective water content. It was modified to read:

$$R_d = 1 + \rho_b K_d/\theta_t$$

where θ_t is the total water content. The rationale for this modification can be found in reports of the U.S. Department of Energy (1987) and Yu (1987).

Using the parameters listed in Table B.1, App. B, it was calculated that:

$$F_{uz_i} = 1.0$$

and

$$F_{sz_i} = 3.8 \times 10^{-2}$$

Hence,

$$W_i/S_i = (1000/50) \times 1.0 \times 3.8 \times 10^{-2} = 0.76 \text{ (pCi/L)/(pCi/g)}$$

Therefore,

$$D_4/S = \sum_{i=1}^{2} D_{i4}/S_i = 2.6 \times 10^{-4} \times 410 \times 0.76 + 2.8 \times 10^{-4} \times 410 \times 0.76 = 1.7 \times 10^{-1} \text{ (mrem/yr)/(pCi/g)}$$

4 RESIDUAL RADIOACTIVITY GUIDELINE

Based on the dose-to-source ratios derived in the previous section for each pathway applicable to the Armory site, the total D/S ratio was calculated as follows:

$$\text{Total } D/S = \sum_{i=1}^{2} \sum_{p=1}^{4} D_{ip}/S_i$$

$$= \sum_{p=1}^{4} (D_p/S)$$

$$= 3.6 \times 10^{-2} + 4.2 \times 10^{-1} + 3.2 \times 10^{-2} + 1.7 \times 10^{-1}$$

$$= 6.6 \times 10^{-1} \text{ (mrem/yr)/(pCi/g)}$$

The residual radioactivity guideline is defined as the concentration of residual radioactivity that can remain in the Armory and still allow for unrestricted use of the site. Using the annual radiation dose limit of 100 mrem/yr (App. A), the residual radioactivity guideline for the Armory site is 150 pCi/g (i.e., 100 ÷ 0.66 = 150) for uranium-238, with uranium-234 and uranium-235 present in naturally occurring concentrations.

5 REFERENCES

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APPENDIX A. DOE GUIDELINES FOR RESIDUAL RADIOACTIVITY

U.S. DEPARTMENT OF ENERGY GUIDELINES FOR RESIDUAL RADIOACTIVITY AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Rev. 1, July 1985)

A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactivity, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Dept. Energy 1984). More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactivity from basic dose limits, is contained in a supplementary document--referred to herein as the "supplement" (U.S. Dept. Energy 1985).

"Residual radioactivity" includes: (1) residual concentrations of radionuclides in soil material,** (2) concentrations of airborne radon decay products, (3) external gamma radiation level, and (4) surface contamination. A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). Basic dose limits are used explicitly for deriving guidelines for residual concentrations of radionuclides in soil material, except for thorium and radium. Guidelines for

*A remote SFMP site is one that is excess to DOE programmatic needs and is located outside a major operating DOE research and development or production area.

**The term "soil material" refers to all material below grade level after remedial action is completed.

residual concentrations of thorium and radium and for the other three quantities (airborne radon decay products, external gamma radiation level, and surface contamination) are based on existing radiological protection standards (U.S. Environ. Prot. Agency 1983; U.S. Nucl. Reg. Comm. 1982). These standards are assumed to be consistent with basic dose limits within the uncertainty of derivations of levels of residual radioactivity from basic limits.

A "guideline" for residual radioactivity is a level of residual radioactivity that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactivity presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement.

An "authorized limit" is a level of residual radioactivity that must not be exceeded if the remedial action is to be considered completed. Under normal circumstances, expected to occur at most sites, authorized limits for residual radioactivity are set equal to guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in Sections D and F. A site may be released for unrestricted use only if the residual radioactivity does not exceed guideline values at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if the residual radioactivity exceeds guideline values. The applicable controls and restrictions are specified in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). Implementation of ALARA policy is specified as procedures to be applied after authorized limits have been set. For sites to be released for unrestricted use, the intent is to reduce residual radioactivity to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual radioactivity is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as is reasonably achievable. Procedures for implementing ALARA policy are described in the supplement. ALARA policies, procedures, and actions must be documented and filed as a permanent record upon completion of remedial action at a site.

B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 500 mrem/yr for a period of exposure not to exceed 5 years and an average of 100 mrem/yr over a lifetime. The committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), shall be used for determining the dose.

C. GUIDELINES FOR RESIDUAL RADIOACTIVITY

C.1 Residual Radionuclides in Soil Material

Residual concentrations of radionuclides in soil material shall be specified as above-background concentrations averaged over an area of 100 m^2. If the concentration in any area is found to exceed the average by a factor greater than 3, guidelines for local concentrations shall also be applicable. These "hot spot" guidelines depend on the extent of the elevated local concentrations and are given in the supplement.

The generic guidelines for residual concentrations of Th-232, Th-230, Ra-228, and Ra-226 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit. Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

The guidelines for residual concentrations in soil material of all other radionuclides shall be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. Procedures for deriving these guidelines are given in the supplement.

C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

---

*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

C.4 Surface Contamination

The following generic guidelines, adapted from standards of the U.S. Nuclear Regulatory Commission (1982), are applicable only to existing structures and equipment that will not be demolished and buried. They apply to both interior and exterior surfaces. If a building is demolished and buried, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

Radionuclides[b]	Allowable Total Residual Surface Contamination (dpm/100 cm²)[a]		
	Average[c,d]	Maximum[d,e]	Removable[d,f]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000β-γ	15,000β-γ	1,000β-γ

[a] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[b] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[c] Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 cm².

[f] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVITY

The remedial action shall not be considered complete unless the residual radioactivity is below authorized limits. Authorized limits shall be set equal to guidelines for residual radioactivity unless: (1) exceptions specified in Section F of this document are applicable, in which case an authorized limit may be set above the guideline value for the specific location or condition to which the exception is applicable; or (2) on the basis of site-specific data not used in establishing the guidelines, it can be clearly established that limits below the guidelines are reasonable and can be achieved without appreciable increase in cost of the remedial action. Authorized limits that differ from guidelines must be justified and established on a site-specific basis, with documentation that must be filed as a permanent record upon completion of remedial action at a site. Authorized limits differing from the guidelines must be approved by the Director, Oak Ridge Technical Services Division, for FUSRAP and by the Director, Richland Surplus Facilities Management Program Office, for remote SFMP--with concurrence by the Director of Remedial Action Projects for both programs.

E. CONTROL OF RESIDUAL RADIOACTIVITY AT FUSRAP AND REMOTE SFMP SITES

Residual radioactivity above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A requires compliance with applicable federal, state, and local environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

a. 5440.1B, Implementation of the National Environmental Policy Act

b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations

c. 5480.2, Hazardous and Radioactive Mixed Waste Management

d. 5480.4, Environmental Protection, Safety, and Health Protection Standards

e. 5482.1A, Environmental, Safety, and Health Appraisal Program

f. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

h. 5484.2, Unusual Occurrence Reporting System

i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing federal, state, or local standards.

d. Access to a site shall be controlled and misuse of onsite material contaminated by residual radioactivity shall be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The federal government shall have title to the property.

E.2 Interim Management

a. A site may be released under interim management when the residual radioactivity exceeds guideline values if the residual radioactivity is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.

b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactivity or cause it to migrate.

c. The owner of the site or appropriate federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

Uranium, Thorium, and Their Decay Products

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 $pCi/m^2/s$, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b of this section (E.3) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a of this section (E.3).

d. Groundwater shall be protected in accordance with 40 CFR 192.20(a)(2) and 192.20(a)(3), as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The federal government shall have title to the property.

Other Radionuclides

f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

F. EXCEPTIONS

Exceptions to the requirement that authorized limits be set equal to the guidelines may be made on the basis of an analysis of site-specific aspects of a designated site that were not taken into account in deriving the guidelines. Exceptions require approvals as stated in Section D. Specific situations that warrant exceptions are:

a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

c. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not be necessary where only minor quantities of residual radioactive materials are involved or where residual radioactive materials occur in an inaccessible location at

which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. In order to invoke this exception, a site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactivity must be included in the appropriate state and local records.

d. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be effected by remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of remedial actions that would be less costly than removal of the residual radioactive materials. A statement specifying the residual radioactivity must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

G. SOURCES

Limit or Guideline	Source
Basic Dose Limits	
Dosimetry Model and Dose Limits	International Commission on Radiological Protection (1977, 1978)
Generic Guidelines for Residual Radioactivity	
Residual Concentrations of Radium and Thorium in Soil Material	40 CFR 192
Airborne Radon Decay Products	40 CFR 192
External Gamma Radiation	40 CFR 192
Surface Contamination	Adapted from U.S. Nuclear Regulatory Commission (1982)
Control of Radioactive Wastes and Residues	
Interim Storage	DOE Order 5480.1A
Long-Term Management	DOE Order 5480.1A; 40 CFR 192

H. REFERENCES

International Commission on Radiological Protection. 1977. Recommendations of the International Commission on Radiological Protection (Adopted January 17, 1977). ICRP Publication 26. Pergamon Press, Oxford. [As modified by "Statement from the 1978 Stockholm Meeting of the ICRP." Annals of the ICRP, Vol. 2, No. 1, 1978.]

International Commission on Radiological Protection. 1978. Limits for Intakes of Radionuclides by Workers. A Report of Committee 2 of the International Commission on Radiological Protection. Adopted by the Commission in July 1978. ICRP Publication 30. Part 1 (and Supplement), Part 2 (and Supplement), Part 3 (and Supplements A and B), and Index. Pergamon Press, Oxford.

U.S. Environmental Protection Agency. 1983. Standards for Remedial Actions at Inactive Uranium Processing Sites; Final Rule (40 CFR Part 192). Fed. Regist. 48(3):590-604 (January 5, 1983).

U.S. Department of Energy. 1984. Formerly Utilized Sites Remedial Action Program. Summary Protocol: Identification - Characterization - Designation - Remedial Action - Certification. Office of Nuclear Energy, Office of Terminal Waste Disposal and Remedial Action, Division of Remedial Action Projects. April 1984.

U.S. Department of Energy. 1985. Supplement to U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites. A Manual for Implementing Residual Radioactivity Guidelines. Prepared by Argonne National Laboratory, Los Alamos National Laboratory, Oak Ridge National Laboratory, and Pacific Northwest Laboratory for the U.S. Department of Energy. (In preparation.)

U.S. Nuclear Regulatory Commission. 1982. Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material. Division of Fuel Cycle and Material Safety, Washington, DC. July 1982.

APPENDIX B. PARAMETERS USED IN THE PATHWAY ANALYSIS

The parameter values used in the pathways analysis and their sources are listed in Table B.1. All parameter values are reported to two significant digits.

TABLE B.1 Parameters Used in the Pathway Analysis for the Armory Site

Parameter	Unit	Value	Reference
External Radiation Pathway (p = 1)			
$(D/E)_{U-238,1}$	$(mrem/yr)/(pCi/cm^3)$	0.087	Gilbert et al. (1985)
$(D/E)_{U-234,1}$	$(mrem/yr)/(pCi/cm^3)$	9.5×10^{-4}	Gilbert et al. (1985)
FA_1	-[a]	0.61	Gilbert et al. (1985)
FO_1	-[a]	1.0	-[b]
$FD_{U-238,1}$	-[a]	0.45	Gilbert et al. (1985)
$FD_{U-234,1}$	-[a]	0.63	Gilbert et al. (1985)
A	m^2	200	Argonne Natl. Lab (1987)
T	m	0.05	Argonne Natl. Lab (1987)
ρ_b	g/cm^3	1.5	-[b]
Dust Inhalation Pathway (p = 2)			
$(E/A)_2$	m^3/yr	8400	Gilbert et al. (1985)
FO_2	-[a]	1.0	-[b]
FS_2	-[a]	1.0	Gilbert et al. (1985)
$(A/S)_2$	g/m^3	2.0×10^{-4}	-[b]
$(D/E)_{U-238,2}$	mrem/pCi	0.12	Gilbert et al. (1985)
$(D/E)_{U-234,2}$	mrem/pCi	0.13	Gilbert et al. (1985)

TABLE B.1 Continued

Parameter	Unit	Value	Reference
Ingestion Pathway (p = 3 and 4)			
FA_3	-[a]	0.10	-[b]
FD_3	-[a]	1.0	Gilbert et al. (1985)
$(D/E)_{U\text{-}238,3\&4}$	mrem/pCi	2.6×10^{-4}	Gilbert et al. (1985)
$(D/E)_{U\text{-}234,3\&4}$	mrem/pCi	2.8×10^{-4}	Gilbert et al. (1985)
$(E/W)_3$	L/yr	770	Gilbert et al. (1985)
$(E/W)_4$	L/yr	410	Gilbert et al. (1985)
l	m	10	-[b]
d	m	5	Gilbert et al. (1985)
$K_{d_U}^{cz}$	mL/g	50	-[b]
$K_{d_U}^{uz}$	mL/g	50	U.S. Nucl. Reg. Comm. (1987)
$K_{d_U}^{sz}$	mL/g	4	U.S. Nucl. Reg. Comm. (1987)
θ_e^{uz}	-[a]	0.03	U.S. Nucl. Reg. Comm. (1987)
θ_t^{uz}	-[a]	0.21	U.S. Nucl. Reg. Comm. (1987)
θ_e^{sz}	-[a]	0.25	U.S. Nucl. Reg. Comm. (1987)
θ_t^{sz}	-[a]	0.40	U.S. Nucl. Reg. Comm. (1987)

TABLE B.1 Continued

Parameter	Unit	Value	Reference
K_h^{sz}	m/yr	2.1×10^4	U.S. Nucl. Reg. Comm. (1987)
ρ_b^{uz}	g/cm^3	1.8	U.S. Nucl. Reg. Comm. (1987)
ρ_b^{sz}	g/cm^3	1.5	U.S. Nucl. Reg. Comm. (1987)
J	-[a]	0.01	U.S. Nucl. Reg. Comm. (1987)
h	m	1.0	U.S. Nucl. Reg. Comm. (1987)
R	m/yr	1.0	-[b]

[a] A hyphen means the parameter is dimensionless.

[b] No data are available; conservative values are used in this analysis.

REFERENCES

Argonne National Laboratory, 1987, *Action Description Memorandum, Proposed Decontamination of the National Guard Armory in Chicago, Illinois*, prepared for U.S. Department of Energy, Oak Ridge Operations Office (March).

Gilbert, T.L., et al., 1985, *A Manual for Implementing Residual Radioactivity Guidelines: A Supplement to U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites*, prepared by Argonne National Laboratory, Oak Ridge National Laboratory, Los Alamos National Laboratory, and Battelle Pacific Northwest Laboratory for U.S. Department of Energy (Sept.).

U.S. Nuclear Regulatory Commission, 1987, *Draft Supplemental Environmental Statement Related to the Decommissioning of the Rare Earths Facility, West Chicago, Illinois*, prepared by Energy and Environmental Systems Division, Argonne National Laboratory, Argonne, Ill.

Exhibit II (2) - Designation or Authorization Documentation

The following document authorized or designated the subject site for remedial action. A copy of this document follows.

Page

Memorandum, William R. Voigt, Jr., Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters, to Joe LaGrone, Manager, Oak Ridge Operations Office. "Designation of Sites for Remedial Action - Metal Hydrides, Beverly, MA; Bridgeport Brass; Adrian, MI and Seymour, CT; National Guard Armory, Chicago, IL," NE-20, Washington, D.C., December 17, 1985. II-69

Memorandum

054358

DATE: DEC 17 1985

REPLY TO ATTN OF: NE-20

SUBJECT: Designation of Sites for Remedial Action - Metal Hydrides, Beverly, MA; Bridgeport Brass, Adrian, MI and Seymour, CT; National Guard Armory, Chicago, IL

TO: Joe LaGrone, Manager
Oak Ridge Operations Office

Based on the attached radiological survey data (Attachments 1 through 3) and an appropriate authority review, the following properties are being authorized for remedial action. It should be noted that the attached survey data are for designation purposes only and that Bechtel National, Inc. (BNI) should conduct appropriate comprehensive characterization studies to determine the extent and magnitude of contamination on these properties.

Site	Location	Priority
Former Bridgeport Brass Co. (General Motors)	Adrian, MI	Low
Former Bridgeport Brass Co. (Seymour Wire Specialty)	Seymour, CT	Low
National Guard Armory	Chicago, IL	Low
Former Metal Hydrides, Inc. (Ventron Div., Thiokol Corp.)	Beverly, MA	Med/Low

At the Bridgeport Brass Sites in Adrian, Michigan, and Seymour, Connecticut, the radioactive material is inaccessible, and if not disturbed, poses no threat to anyone, i.e., in drains, sewers, in concrete covered pits, etc. This being the case, OR/BNI should give serious consideration to leaving the radioactive material in place and arranging for institutional control until modification of the facilities occurs for other reasons. This approach was used for some of the contamination at Gilman Hall, Berkeley, California, and the University of Chicago, Chicago, Illinois. However, there may be other areas of contamination due to Manhattan Engineer District/Atomic Energy Commission activities below the floor at the General Motors plant in Adrian, Michigan, that have not been discovered because there are no as-built drawings or other drawings that show "underground" drains, pits, etc. This possibility should be considered by the BNI staff in planning the characterization survey.

A summary of the Ventron Corporation radiological survey report is attached (Attachment 4). The full report will be sent to you when it is finalized by ORNL. The data in the summary is the radiological basis for conducting remedial action at this facility.

904/2
3.2.3.2

If there are any questions, please call me on FTS 233-4716 or call Arthur Whitman of my staff on FTS 233-5439.

/s/ VOIGT

William R. Voigt, Jr.
Director
Office of Remedial Action
and Waste Technology
Office of Nuclear Energy

Attachments
1. Radiological Survey of the National Guard Armory, Chicago, IL
2. Radiological Survey of the Former Bridgeport Brass Co., Adrian, MI
3. Follow-up Survey of Bridgeport Brass Co., Seymour, CT
4. Preliminary Report of Ventron Site, Beverly, MA

bcc:
E. Keller, OR, w/attach.
B. Berven, ORNL, w/o attach.
J. Berger, ORAU, w/o attach.
A. Whitman, NE-23, w/o attach.
Aerospace, w/o attach.

Baublitz RF
Whitman RF
NEG (4)

NE-23:AWhitman:ph:353-5439:12/16/85:IBM:346/62:3.21.3
3.22
3.7
3.13.4

NE-23 Whitman 12/16/85
NE-23 DeLaney 12/16/85
NE-20 Baublitz 12/16/85
NE-20 Voigt 12/16/85

904/3

Exhibit II (3) - Radiological Characterization Reports

The documents listed below address the pre-remedial action status of the subject site; they are included in this exhibit by reference.

	Page
Argonne National Laboratory. Radiological Survey of the National Guard Armory at Washington Park, 52nd Street and Cottage Grove Avenue, DOE/EV-0005/22 (ANL-OHS/HP-83-100), Chicago, IL, January 1983.	II-72
Bechtel National, Inc. Radiological and Limited Chemical Characterization Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-179, Oak Ridge, TN, January 1988.	II-209

DOE/EV-0005/22

ANL-OHS/HP-83-100

FORMERLY UTILIZED MED/AEC SITES REMEDIAL ACTION PROGRAM

RADIOLOGICAL SURVEY OF THE NATIONAL GUARD ARMORY AT WASHINGTON PARK, 52ND STREET AND COTTAGE GROVE AVENUE, CHICAGO, ILLINOIS

September 19, 1977 - October 11, 1978

OCCUPATIONAL HEALTH AND SAFETY DIVISION
Health Physics Section
ARGONNE NATIONAL LABORATORY, ARGONNE, ILLINOIS

Prepared for the U. S. DEPARTMENT OF ENERGY
under Contract W-31-109-Eng-38

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9700 South Cass Avenue
Argonne, Illinois 60439

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September 19, 1977 - October 11, 1978

Prepared by

R. A. Wynveen	Health Physics Manager
W. H. Smith	Senior Health Physicist
C. Boggs Mayes*	Health Physicist
A. L. Justus	Health Physicist

Radiological Survey Group
Health Physics Section
Occupational Health and Safety Division

January 1983

Work Performed under

Budget Activity ERDA RK-01-05-02-3
and ANL 73706

*Now at Exxon Nuclear Idaho, Inc.

PREFACE AND EXECUTIVE SUMMARY

This is one in a series of reports resulting from a program initiated in 1974 by the Atomic Energy Commission (AEC) to determine the conditions of sites formerly used by the Manhattan Engineer District (MED) and the AEC for work involving the handling of radioactive material.* Since the early 1940s, the control of over 100 sites that were no longer required for nuclear programs has been returned to private industry or to the public for unrestricted use. A search of MED and AEC records indicated that for some of these sites, existing documentation was insufficient to determine whether the decontamination work done at the time nuclear activities ceased is adequate by current guidelines. The Illinois National Guard Armory at Washington Park, in Chicago, Illinois, is one such site. This facility, once used for uranium processing during the MED/AEC era, is now used as offices, classrooms, and storage and garage areas.

To determine if any contamination remains as a result of the MED/AEC activities, a comprehensive radiological assessment of the armory was conducted during the period from September 19, 1977, to October 11, 1978. Direct instrument surveys and smear surveys indicated that some contamination and radioactive materials were still present. Contamination or radioactive material was found at 82 locations in 18 rooms or areas throughout the National Guard Armory. However, some of this radioactivity was judged to be a result of later use, not MED/AEC operations. Contamination possibly resulting from MED/AEC activities was found at 73 locations in 11 rooms or areas throughout the Armory. Except for Rooms 1 and 260 (messhall) and the drainage system for the floors of Rooms 1 and 5, where contamination was widespread, most of the contamination consisted of small localized spots (less than 300 cm^2), mainly on floors. The contamination in Room 1 was extensive and involved about 30% of the ceiling and floor and 200 m^2 of concrete. The contamination in Room 260 (messhall) involved about 3 m^2 of the concrete floor. The contamination on the floors was not easily removable, but most of the contamination on the ceiling was easily removable when smeared. The

*The various types and sources of radiation mentioned in this report are discussed in more detail in Appendix 8.

contamination in the floor-drainage system for Rooms 1 and 5 consisted of about 2 m^2 of contaminated brick and sludge in catch basins 3 and 4.

Beta-gamma readings taken with a gas-flow proportional survey meter on the contaminated areas in Room 1 ranged from background to 3.4×10^5 dis/min-100 cm^2. The alpha readings taken in Room 1 with the same instrument ranged from background to 5.8×10^4 dis/min-100 cm^2. The highest Geiger-Mueller (GM) End-Window contact exposure-rate reading from contamination in Room 1 was 3.0 mR/h; no GM End-Window exposure-rate readings taken at 1 m were distinguishable from the instrument background of 0.03-0.05 mR/h.

The beta-gamma contamination levels detected in the rest of the National Guard Armory with the gas-flow proportional survey meter ranged from 1.7×10^3 to 3.1×10^5 dis/min-100 cm^2. The alpha readings at those locations ranged from background to 5.8×10^2 dis/min-100 cm^2. The highest GM End-Window contact exposure-rate reading in the rest of the National Guard Armory was 0.5 mR/h, with no GM End-Window exposure-rate readings taken at 1 m distinguishable from the instrument background.

Contamination was detected on 50 of the smears collected during the survey; 48 of them were from Room 1. The beta-gamma readings of smears ranged from background to 2.5×10^3 dis/min-100 cm^2, and the alpha readings ranged from background to 1.7×10^3 dis/min-100 cm^2.

The readings obtained from the instrument and smear surveys were compared with the standards and guidelines in the American National Standard N13.12, "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use," and the Nuclear Regulatory Commission "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."

It is known that uranium processing took place at the National Guard Armory during the MED/AEC era. Additionally, through gamma-spectral analysis of a sludge/dirt sample from a catch basin, the contaminant was identified as predominately normal uranium. Hence, the limits for uranium have been used for comparative purposes. The limits for uranium as given in the ANSI Standard N13.12 are 5000 dis/min-100 cm^2 total, of which only 1000 dis/min-100 cm^2 can be removable. Contamination possibly due to MED/AEC occupancy was found to exceed these limits at 42 locations in 9 rooms or areas throughout the National Guard Armory. Four of these locations also exceeded "the maximum radiation

level of 1.0 mrad/h at 1 cm or the average radiation level of 0.2 mrad/h at 1 cm" as given in the NRC Guidelines for surface contamination resulting from beta-gamma emitters. Room 1 contained 30 of the 42 locations of contamination that exceeded the ANSI limits. Nine of these were on the floor, one on a pillar, and 20 on overhead structures. Two of the Room 1 locations also exceeded the NRC Guidelines for maximum radiation levels associated with surface contamination. One of these was on the floor (2.0 mR/h) and the other on a catch basin manhole cover (3.0 mR/h). The contamination was in most instances found to be removable and available for transfer to other locations, but under current use conditions, the potential for significant radiation exposure to occupants of the armory from these sources of contamination is believed to be small.

Radon daughter concentrations determined by indoor air samples ranged from 0.0003 to 0.0193 Working Levels (WL), including background. Grab-sampling techniques were used to collect the samples at selected locations, including the areas where contamination had been found during the direct surveys. Under the Surgeon General's Guidelines in 10 CFR 712, no need for remedial action is indicated when concentrations of radon daughters are less than 0.01 WL above background concentrations. The concentrations measured in the National Guard Armory air samples indicated normally expected background fluctuations. Radon concentrations, as determined from the radon-daughter measurements, ranged from 0.03 to 1.93 pCi/ℓ, well below the concentration guide of 3 pCi/ℓ for an uncontrolled area as given in the Department of Energy's "Requirements for Radiation Protection". No long-lived radionuclides were detected on any air sample.

Soil samples taken about the grounds and within the drainage system of the National Guard Armory to determine the presence of any radionuclides that could have been spilled or released during MED/AEC activities contained uranium concentrations ranging from less than 0.1 to 3.6 pCi/g. Background samples taken from the Chicago area indicated concentrations of natural uranium ranging from 0.6 to 2.2 pCi/g. Even though some of the samples collected about the armory exceeded the 2.2 pCi/g maximum measured in the background samples, the armory readings are most probably not a result of contamination. Since fertilization of the soil with inorganic compounds can increase the levels of uranium and thorium, these slightly elevated readings could have been a result of fertilization rather than residual contamination.

Analysis of the sludge/dirt sample taken from the drainage system for the floors of Rooms 1 and 5 indicated elevated levels of uranium (1.1×10^4 pCi/g, normal uranium). There now are no standards specifying a limit for uranium in soil, but, the measured uranium concentration in the sludge/dirt sample does exceed the proposed interim soil limit of 40 pCi/g for decommissioning and decontamination projects. (Ref. 1 and Appendix 6).

Potential radiation doses resulting from exposure to the radioactivity remaining from MED/AEC use of the armory were calculated for a pathway that could result in the presumed maximum 50-year dose commitments from inhalation/ingestion of contaminants. The internal radiation 50-year dose commitments from potential inhalation/ingestion of contamination remaining from MED/AEC activities were calculated to be 2.5 mrem to the lung, 0.51 mrem to the bone, 0.12 mrem to the kidney, and 0.031 mrem whole-body. Each of these is less than 0.5% of the appropriate standards for an individual in an uncontrolled area.

In order to reduce the potential for radiation exposure, remedial measures such as stabilization of the contamination in place would be applicable as a short-term measure. In order to reduce the risk in the event that building modifications take place in the future, health physics procedures and coverage are recommended. The long-term solution would involve decontamination by removal of the radioactive residues from the 11 rooms or areas in the facility.

This survey was performed by the following Health Physics personnel of the Occupational Health and Safety Division, Argonne National Laboratory, Argonne, Illinois: R. A. Wynveen, W. H. Smith, C. Boggs Mayes, P. C. Gray, and D. W. Reilly

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RADIOLOGICAL SURVEY OF NATIONAL GUARD ARMORY AT WASHINGTON PARK, 52nd STREET AND COTTAGE GROVE AVENUE, CHICAGO, ILLINOIS

ABSTRACT

A comprehensive radiological survey was conducted at the Illinois National Guard Armory at Washington Park in Chicago. This facility, used for uranium processing during the MED/AEC era, is now used as offices, classrooms, and storage and garage areas.

The survey was undertaken to determine the location and quantities of any radioactive materials remaining from the MED/AEC operations. Survey measurements included alpha and beta-gamma contamination determinations, both fixed and removable; beta-gamma exposure readings at contact and at 1 m; concentration estimates of radon daughters; and concentration determinations for ^{137}Cs, the ^{232}Th decay chain, the ^{226}Ra decay chain, and uranium in the soil on the site.

Forty-two spots of contamination in nine rooms or areas exceeded the allowable limits for uranium as given in the ANSI Standard N13.12. In most instances, the contamination was found to be removable and available for transfer to other locations. However, under current use conditions, the potential for radiation exposure to occupants of this building from these sources of contamination is small.

Concentrations of radon daughters in the air in the building, as measured by grab-sampling techniques, were less than the limit of 0.01 WL above background as given in the Surgeon General's Guidelines in 10 CFR 712. No long-lived radionuclides were detected in any air sample. Concentrations of radionuclides in soil samples collected around the facility indicated essentially background levels.

The presumed maximum 50-year dose commitments from potential inhalation/ingestion of residual contamination were calculated to be 2.5 mrem to the lung, 0.51 mrem to the bone, 0.12 mrem to the kidney, and 0.031 mrem whole-body; each of these is less than 0.5% of the appropriate standards for an individual in an uncontrolled area.

In order to reduce the potential for radiation exposure, remedial measures such as stabilization of the contamination in place would be applicable as a short-term measure. In order to reduce the risk in the event that building modifications take place in the future, health physics procedures and coverage are recommended. The long-term solution would involve decontamination by removal of the radioactive residues from the 11 rooms or areas in the facility.

INTRODUCTION

To resolve a critical space problem suffered by the Manhattan Engineer District, the United States Government leased from the State of Illinois the 124th Field Artillery Armory (presently the Illinois National Guard Armory at Washington Park) at 52nd Street and Cottage Grove Avenue in Chicago, Illinois, for work involving radioactive material. Beginning in March 1942, the building was used jointly by the MED Metallurgical Laboratory and the University of Chicago. The AEC terminated use of this facility in 1951, and the property was returned to the State of Illinois.

Personnel involved with the armory during the MED/AEC era recalled that some type of uranium processing was conducted there and that the grandstands surrounding the armory arena were used for storage of radioactive materials.* The use of the arena could have involved both the chemical processing and metal casting of uranium. After MED use of the armory ceased, contaminated dirt from the arena was removed. No record could be found of where the dirt was taken. Later, more dirt was removed from the arena and replaced with a concrete pad. Conversations with personnel involved with the facility also revealed that there was an effort to decontaminate some of the bleachers in the arena. However, no reports of radiation surveys or decontamination efforts conducted at the facility upon termination of MED/AEC activities could be found. It was, therefore, requested by the Energy Research and Development Administration, Chicago Operations Office, that a comprehensive radiological survey of the armory should be undertaken to determine if any detectable radioactive contamination remains as a result of the MED/AEC operations.

*See Appendix B for a detailed discussion and definitions of the various terms and concepts mentioned in this report relative to types of radiation, exposures, doses, and similar topics.

The survey was performed on an intermittent basis between September 19, 1977 and October 11, 1978.

The Illinois National Guard Armory is presently occupied by the Illinois National Guard and houses the 1st Battalion, 178th Infantry and the 2nd Battalion, 122nd Field Artillery. It is currently used for offices, classrooms, and storage and garage areas.

SURVEY AND ANALYTICAL TECHNIQUES

General

A radiological survey of the armory was performed on all accessible floors and original walls to a height of 2 m (7 ft).* A representative selection of accessible overhead structures, such as ceilings, pipes, vents, and light fixtures, were also surveyed. In many areas, the floors and walls had been retiled or painted after the MED/AEC era. Even though these were not the original surfaces, these areas were surveyed with instruments that have some capability to detect potential beta-gamma activity on the underlying surfaces. Locations of accessible areas surveyed are indicated in Table 1 and Figures 2 through 26. (Rooms 1 through 199 are on the first floor, Rooms 200 through 299 on the second floor, Rooms 300 through 317 on the third floor, and Room 401 is on the fourth floor.)

Instrumentation Used for Direct Survey

Five types of survey instruments were used in the direct surveys. An Eberline gas-flow proportional probe (FM-4G) with a detection area of 325 cm^2 and using the Eberline PAC-4G-3 electronics was used to survey the floors. A PAC-4G-3 with a hand-held gas-flow proportional probe and with a detection area of 51 cm^2 was used to survey the walls and other areas inaccessible with the floor monitor. An Eberline Model 530 Geiger-Mueller (GM) detector with an

*When metric units are followed (in parentheses) by English units, the measurements were originally made in English units and then converted into metric. In cases where only metric units are given, the values were either originally given in metric, or resulted from calculations involving numbers previously converted from English into metric.

Eberline HP-190 end-window probe was used to measure the contact exposure rate (mR/h) of the contaminated areas. This instrument also was held 1 m (3 ft) above the floor to determine general ambient background radiation levels throughout the surveyed area.

Two other instruments were introduced toward the completion of the survey and also were used to detect the presence of any contamination in the catch basins in the armory. One, an Eberline Pulse Rate Meter Model PRM-5-3 with a Model PG-2 Low Energy Gamma Scintillation Detector, was used to detect low-energy x and gamma radiation. The other, an Eberline Micro R/h Scintillation Meter Model PRM-7, was used to detect higher energy gamma-rays.

All five instruments are described in more detail in Appendix 1.

Although ^{239}Pu and ^{90}Sr-^{90}Y standards were used to calibrate the gas-flow instruments, it should be noted that the numerous isotopes that could be encountered exhibit emission energies differing from those of the standards used in the calibration. When detecting known isotopes that emit alpha and beta energies differing from those of the standards, such as normal uranium, a conversion factor for those particular radionuclides was developed to determine the appropriate yield. (The methods used to determine the conversion factors are described in Appendix 2.) All readings of disintegrations per minute per 100 cm^2 (dis/min-100 cm^2), as reported in Table 1, are equated to normal uranium, unless otherwise stated. It should also be noted that since calibrations are to infinitely-thin flat-plate standards, all reported readings should be regarded as minimal values; no corrections were made for absorption by surface media within the armory.

When possible, the isotopes of contamination were identified by performing a gamma-spectral analysis (using a multichannel analyzer described in Appendix 1), on the contaminated item or on a sample of material taken from the contaminated area.* This instrument, along with all other survey and sampling devices, was housed in a mobile laboratory, a converted motor home.

*Such analysis was performed on one sample collected during the survey.

Smear Surveys

Dry smears were taken at selected locations throughout the National Guard Armory facility. Smears were taken on original structures and components such as walls, floors, pipes and vents. All standard smears were taken with Whatman No. 1 filter paper, 4.25 cm in diameter. A standard smear is performed by applying moderate pressure by the tips of the first two fingers to the back of the filter paper and rubbing the paper over the surface. Smears of about 930 cm^2 (1 ft^2) were normally taken. A smear of 100 cm^2 was taken if an area or object had an instrument reading higher than normal background, or if there was excessive dirt or dust in an area.

Two different instruments were used to measure (count) the contamination on the smears. They were first counted in groups of ten using a 10-wire flat-plate gas-flow proportional detector developed by ANL. The instrument detects alpha and beta particles and x- and gamma-rays. Additionally, at least one smear of each group was removed and counted in the more sensitive Nuclear Measurements Corp. 2π Internal Gas-Flow Proportional Counter (PC counter) using an aluminized Mylar cover (Mylar spun top) over the smear. All smears from areas or objects with elevated direct readings and, smears in groups indicating readings above the instrument background levels in the 10-wire assembly were individually counted in the PC counter. Smears were counted in each detector for both alpha and beta-gamma activity. These instruments are described in detail in Appendix 1.

In addition to collection of standard smears, a 100-g helium weather balloon (see Figure 29) was used in the arena to obtain smears of overhead structures (beams) that were about 27 m high. A small wooden cross frame was attached to the base of the balloon, and at one end of the cross frame was a small wooden block (covered with a foam pad) used to hold the smear paper. The smear paper used for the balloon smears was Whatman No. 1 paper, 15 cm in diameter. Control strings were attached to the wooden cross-frame to maneuver the balloon so smears could be obtained. The control strings were maneuvered to apply pressure while the smear was being taken. A 5-cm diameter portion of the filter paper was then cut and counted in the PC counter for both alpha and beta-gamma activity.

The smear-count conversion factors used to convert instrument counts to disintegrations of a particular isotope for all the smears are given in Appendix 2. Unless otherwise indicated, all contamination on the smears reported in Table 1 is equated to normal uranium, as described in Appendix 2.

The results of the instrument surveys and smears are given in Table 1, and the locations of elevated instrument readings and smear locations are shown in Figures 2 through 26. Since the contamination was widespread in Room 1, Figure 2 includes only the locations where elevated direct instrument readings and/or smear contamination was found.

Air Samples

Air samples were collected with a commercial vacuum cleaner modified at ANL for use as a particulate air-sampling device. A flow rate of 40 cubic meters per hour (m^3/h) was used. A 10% portion (5 cm in diameter) was removed from the filter media after collection and counted for both alpha and beta-gamma activity in the PC counter, using a Mylar spun top. The counting results were used to determine radon and radon daughter concentrations and the presence of any long-lived radionuclides. Information and assumptions used to determine the radon daughter concentrations are presented in Appendix 3; the results are given in Table 2, and the locations where air samples were collected are shown in Figures 2 through 24.

Soil Samples

Environmental soil corings were collected at selected undisturbed locations outside the National Guard Armory to detect any deposition of radioactive material that could have been spilled or released during MED/AEC activity. Nine environmental soil samples were taken from the grounds adjacent to the armory; the locations are shown in Figure 28. Uranium-fluorometric and gamma-spectral analyses were conducted on these soil samples. The corings were taken with a 10 cm (4 in.) diameter, 15 cm (6 in.) long, right-circular cylinder cutting tool commonly used to cut golf-green holes. Each core was 30 cm long, and each was divided into four segments. Starting from the surface, three separate 5 cm segments were cut, bagged, and marked A, B, and C, respectively; the final segment of 15 cm was marked D (see Figure 31).

The segmented coring technique was used to determine if any contaminant migration had occurred, to reduce the dilution of upper-level soil with the lower-level segments with respect to the surface deposition of the contaminants (or vice versa), and to reveal if any overburden or backfill material had been added over the years.

The soil samples were prepared at Argonne National Laboratory and shipped to a commercial laboratory (LFE Environmental Analysis Laboratories) for radiochemical (fluorometric) and gamma-spectral analyses. Their analysis procedures are described in Appendix 4. As shown in Figure 31, sample preparation consisted of weighing the samples and then drying them for about 24 hours at 80°C. All samples were then reweighed, placed into mill jars (8.7 ℓ), and milled until a sufficient amount of the soil sample would pass a No. 30 standard (600-micron mesh) stainless steel sieve. At no point were the rocks and solid material ground or pulverized, since this material would act as a diluent and, hence, lower the reported concentration of deposited radioactive material. The rocks and dross and the sieved material were segregated, bagged, and weighed separately (weights are given in Table 3).

Aliquots of the sieved material were loaded into screwtop plastic containers. The amount placed in the containers varied according to the type of analysis to be performed--100 g for gamma-spectral and radiochemical (fluorometric) analysis and 10 g for radiochemical (fluorometric) only.

Every effort was made throughout the sample preparation operations to eliminate cross-contamination. Soil samples suspected of containing elevated amounts of radioactivity were processed in separate equipment from that used to process the soil samples considered to contain background levels. Additionally, all items of equipment were thoroughly scrubbed and air dried before introduction of the next sample.

In addition to the nine environmental soil samples, a dirt/sludge sample (3-S10) was taken from the drainage system for the floors of Rooms 1 and 5. This sample was taken from the sediments at the bottom of Catch Basin 3 (see Figure 27 for location). The sample was collected with a 1.9 cm diameter pipe section driven about 5 cm into the residual sludge that had accumulated in the catch basin over the years. When the pipe was extracted from the deposits, the core sample remained in the pipe until shaken into a plastic bag. The preparation of this sample was similar to that described above for the environmental soil samples. However, because of its relatively small mass, the

sample was milled with a mortar and pestle prior to sieving. Aliquots of the sieved material were loaded into screwtop plastic containers and sent to the Analytical Chemistry Laboratory at ANL for analysis. Eight grams were sent for gamma-spectral analysis and 2 g for radiochemical (uranium-fluorometric and uranium mass spectrometry) analysis.

Results of the analyses of the soil samples and of the sludge/dirt sample are shown in Table 4. Background data for comparison with the soil sample analyses were obtained from a number of soil samples collected in the Chicago area (see Table 5). This information was obtained from the Environmental Monitoring Section of the Occupational Health and Safety (OHS) Division of Argonne National Laboratory.

SURVEY RESULTS

General

The results of the radiological survey are discussed in this section. The PAC-4G-3 instrument readings and smear results have been normalized to units of disintegrations per minute per 100 square centimeters (dis/min-100 cm^2) using the factors derived in Appendix 2 and are equated to normal uranium, unless otherwise stated. The PAC-4G-3 readings and smear data are reported in net count rates; i.e., the background count rates have been subtracted from the gross count rates prior to conversion to dis/min-100 cm^2. Any alpha contributions have been subtracted from the readings taken in the beta mode so that the corrected values reflect only the beta-gamma readings. The GM exposure rates given in Table 1 include the instrument background of 0.03-0.05 mR/h.

Room background levels varied somewhat, due in part to differences in the construction materials used. The average background readings for all modes of operation of the instruments used are given in Appendix 1.

The fraction of surface areas accessible for survey varied from room to room. The percentages of the areas accessible for survey are indicated in Table 1. The average percentage of the total area that was accessible was 80% for the floors and 70% for the walls.

Instrument and Smear Surveys

Radioactivity, i.e., measurements indicating above background levels, was found at 82 locations in 18 rooms or areas throughout the National Guard Armory. (See Table 1 and Figures 2 through 26 for the maximum instrument readings at these locations.) Some of this radioactivity was determined to have resulted from later use, not MED/AEC operations. For example, radioactive sources and other items (including a radium dial, radioluminescent radio knobs, a gas mantle containing thorium, and radioluminescent compass dials) not related to MED/AEC operations were found in Rooms 3D, 101A, 121, 141, 144, 147, and 150.

Contamination possibly present as a result of the MED/AEC occupancy was found at 73 locations in 11 rooms or areas throughout the National Guard Armory. With the exception of Rooms 1 and 260 (messhall), and the drainage system for the floors of Rooms 1 and 5, the contamination consisted of small localized spots ($\leq$ 300 cm^2), found mainly on the floors. The contamination in Room 1 was extensive (see Figures 2a and 2b). Much of the ceiling and floor of this room was found to be contaminated, especially toward the southeastern side of the room, where most of the contamination was located. About 30% of the concrete floor and ceiling areas were involved, representing about 200 m^2 of concrete. The areas of contamination on floors were, for the most part, spots of contamination, but the ceiling areas were more widespread. Most of the ceiling in the southeastern corner was contaminated. The PAC beta-gamma contamination levels in Room 1 ranged from background to 3.4×10^5 dis/min-100 cm^2. The maximum beta-gamma reading, 3.4×10^5 dis/min-100 cm^2, was at location 104 on a catch basin manhole cover. The highest GM contact exposure rate reading of 3.0 mR/h was also on this manhole cover. The PAC alpha contamination levels in Room 1 ranged from background to 5.8×10^4 dis/min-100 cm^2. The maximum alpha reading, 5.8×10^4 dis/min-100 cm^2, was at location 121 on the ceiling. No GM exposure-rate readings taken at 1 m were distinguishable from the instrument background of 0.03-0.05 mR/h.

The PAC beta-gamma contamination levels detected in the rest of the National Guard Armory ranged from 1.7×10^3 to 3.1×10^5 dis/min-100 cm^2. The maximum beta-gamma reading outside Room 1, 3.1×10^5 dis/min-100 cm^2, was at location 821 on the floor of Room 260 (see Figure 16). The highest GM contact exposure rate reading of 0.5 mR/h was also found at this location. The PAC

alpha contamination levels detected in the rest of the armory ranged from background to 5.8 x 10^2 dis/min-100 cm^2. The maximum alpha reading, 5.8 x 10^2 dis/min-100 cm^2, was at location 1081 on the floor of the 2nd-floor corridor (see Figure 19). No GM exposure rate readings taken at 1 m were distinguishable from the instrument background.

In addition to the room surveys, all accessible areas of the drainage system for the floors of Rooms 1 and 5 were surveyed (see Figure 27). Catch Basins 3, 4, and 6 were opened and surveyed with the PAC-4G-3 and PRM 5-3 instruments. As indicated in Table 1, contamination was detected in Catch Basins 3 and 4. The maximum beta-gamma contamination levels were 5.1 x 10^3 dis/min-100 cm^2 at locations 1199 and 1201 on the walls inside Catch Basins 4 and 3, respectively. Each location involved about 1 m^2 of contaminated brick and sludge. A gamma-spectral analysis was performed on a sample taken from inside Catch Basin 3. Results of the analysis indicated that the contaminant was predominantly normal uranium.* (See Figure 30 for the gamma spectrum.) Catch Basins 1, 2 and 5, were sealed shut and could not be opened. Micro R meter (PRM-7) readings, taken with the instrument in contact with the catch basin manhole covers, were not distinguishable from the instrument background readings of 5-7 μR/h. These catch basins are apparently connected to the Chicago sanitary sewer system.

Results of the smear survey indicated that 50 smears in the following rooms showed loose contamination:

- Room 1 (see Figs. 2a & 2b) — 48 smears of the floor and ceiling were contaminated. Location 121 of the ceiling had the highest level of contamination, 2.5 x 10^3 dis/min-100 cm^2 beta-gamma and 1.7 x 10^3 dis/min-100 cm^2 alpha. (See Table 1 for readings of other contaminated smears.)

*The term "normal uranium" refers to uranium which has been separated from its radioactive decay daughter products and other impurities, and which has the normal isotopic percent abundance as found in nature. The normal percent abundances are 0.0057% ^{234}U, 0.7196% ^{235}U, and 99.276% ^{238}U (Ref. 2). The less precise definition of normal uranium as 0.7% ^{235}U, 99.3% ^{238}U, and a trace of ^{234}U is sometimes used for brevity in discussions. The term natural uranium denotes uranium and all daughter products as found in its natural state in the earth, and is sometimes incorrectly referred to as normal uranium. Appendix 5 contains the detailed calculation of the specific activity of normal U.

• Room 1E (see Fig. 2)	Location 174 of the floor was background beta-gamma and 11 dis/min-100 cm^2 alpha.
• Room 5 (see Fig. 6)	Location 497 of the floor was 14 dis/min-100 cm^2 beta-gamma and background alpha.

No contamination statistically greater than the instrument background of the gas-flow proportional counters, as given in Appendix 1, was detected on any other smears. In Room 1, only locations of contaminated smears are shown in Figures 2a and 2b. In other rooms, all smear locations are shown in Figures 3 through 26.

Results of the instrument and smear surveys were compared with both the American National Standards Institute (ANSI) Standard N13.12, "Control of Radioactive Surface Contamination on Materials, Equipment, and Facilities to be Released for Uncontrolled Use," and the NRC's "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" (see Appendix 6). Since normal uranium was identified in the building, the surface contamination limits for uranium were used for comparative purposes. The allowable limit in the ANSI Standard for uranium activity is 5000 dis/min-100 cm^2 total, of which only 1000 dis/min-100 cm^2 can be removable. These levels may be averaged over 1.0 m^2, provided the maximum activity in any area of 100 cm^2 is less than three times the limit value. The NRC Guidelines for uranium are stated as follows: the average is 5000 dis/min-100 cm^2 alpha, the maximum is 15,000 dis/min-100 cm^2 alpha, and the removable is 1000 dis/min-100 cm^2 alpha. The measurements used for the average may not be averaged over more than 1 m^2, and the maximum level applies to an area of not more than 100 cm^2. Also, 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 mg/cm^2 of total absorber. The ANSI Standard is identical to the NRC Guidelines for uranium; however, the ANSI limits do not exclude the determination of uranium by beta-gamma activity, whereas the NRC Guidelines are stated in terms of alpha activity only.

The 42 locations in which contamination possibly due to MED/AEC activities were found to be greater than the acceptable limits are listed in Table 6.

Air Samples

Results of the analyses of air samples collected at 34 selected locations are presented in Table 2. Techniques detailed in Appendix 3 were used to determine the radon-222 concentration and daughter working levels (WL) at each location. The results ranged from 0.0003 to 0.0193 WL and were within the range of values normally expected for background concentrations. Under the U.S. Surgeon General's Guidelines in 10 CFR 712 (see Appendix 6), concentrations of radon daughters of less than 0.01 WL above background do not indicate a need for remedial action. Radon concentrations, as determined from the radon-daughter measurements, ranged from 0.03 to 1.93 pCi/ℓ, well below the concentration guide of 3 pCi/ℓ for an uncontrolled area, as given in the Department of Energy's "Requirements for Radiation Protection." No long-lived radionuclides were detected on any air sample.

Soil Samples

Results of the gamma-spectral and uranium-fluorometric analyses performed on the samples by LFE Environmental Analysis Laboratories and ANL Analytical Chemistry Laboratory are listed in Table 4. The analyses indicated concentrations of uranium in environmental soil samples ranging from < 0.1 to 3.6 pCi/g. As indicated in Table 5, levels of natural uranium in background samples collected in the Chicago area ranged from 0.6 to 2.2 pCi/g. Even though the concentrations in some of the samples collected around the armory exceeded 2.2 pCi/g, the elevated concentrations were likely not a result of contamination resulting from MED/AEC activities. Since fertilization of the soil with inorganic compounds can result in increased levels of uranium and thorium, the slightly elevated concentrations detected in some of the armory samples could have been a result of fertilization rather than residual contamination. Results of the analyses of the sludge/dirt sample taken from the drainage system for the floors of Rooms 1 and 5 indicated a concentration of normal uranium of 1.1×10^4 pCi/g, far in excess of the proposed interim soil limit of 40 pCi/g (Ref. 1).

ESTIMATED EXTENT OF CONTAMINATION

Any estimate of the total mass and volume of radioactively contaminated material that would be generated by remedial action at the National Guard Armory is subject to many uncertainties. For example, one can only surmise as to the actual depth of contamination within concrete and brick. For the purposes of this report, it will be assumed that contamination on concrete or brick will require removal to a depth of 5 cm (2 in); contamination on the iron manhole cover to Catch Basin 3 will require the removal of the entire cover, estimated to have a mass of 68 kg (150 lb). These assumptions are believed to be conservative.

Estimates of the total activity of contaminated material are likewise subject to some uncertainties because of survey limitations. Unless otherwise stated, all readings of dis/min-100 cm^2 (as reported in Table 1) are equated to thin flat-plate standards. No corrections are made for absorption by surface media since any correction factors would, in themselves, only be rough estimates. Hence, estimates of activity in surface media could be underestimated.

Despite these uncertainties and limitations, estimates of volume, mass and activity have been made for the several types of material present and are presented in Table 7. The total would consist of an estimated 10.5 m^3 of material with a mass of 25,000 kg and an activity of 30 μCi.

DOSE AND POTENTIAL HAZARD EVALUATION

The survey data on surface contamination, external penetrating radiation, radioactivity on airborne particulates, and radioactivity in soil samples at the National Guard Armory may be evaluated in terms of the doses that potentially exposed persons could receive. The doses can then be compared to the appropriate standards and/or natural background radiation doses or used to estimate risks of health effects.

The appropriate radiation protection standards for external and internal exposure of individuals and population groups in uncontrolled areas are given in the Department of Energy's publication "Requirements for Radiation Protection" (see Appendix 6) and are expressed as the permissible dose or dose commitment annually (in mrem) beyond that received from background radiation and medical exposures.

Natural background radiation doses consist of an external penetrating dose from cosmic and terrestrial sources and an internal dose from the inhalation/ingestion of radioactivity from cosmogenic and terrestrial sources. The average annual natural background doses for the U.S. population are 54 mrem external and 28 mrem internal to the whole-body (soft tissue), 54 mrem external and 125 mrem internal to the lung, and 54 mrem external and 117 mrem internal to the bone (osteocytes) (Ref. 3). The total whole-body, lung, and bone doses are thus 82 mrem, 179 mrem, and 171 mrem per year, respectively. Background radiation is discussed in more detail in Appendix 8.

Estimates of radiological risks resulting from specific doses are usually based on risk factors as provided in reports by the International Commission on Radiological Protection (ICRP) (Ref. 4), National Research Council Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR) (Refs. 5, 6), or United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (Ref. 7). By multiplying the estimated dose by the appropriate risk factor, one can obtain an estimate of the risk or probability of the occurrence of health effects such as cancers and hereditary effects to an individual or his descendants as a result of that exposure. The evaluation of risk factors is presently subject to large uncertainties and continual revision, and is the subject of considerable controversy. For these reasons, it will not be considered further.

Potential doses resulting from exposure to the radioactivity remaining from MED/AEC use of the armory were calculated for a pathway or scenario that could result in the presumed maximum internal radiation dose from inhalation/ingestion of radioactive material. Since no GM End-Window exposure readings at 1 m were greater than the instrument background, no external radiological hazard is envisioned from the contaminated items and areas. Additionally, since the radioactivity on airborne particulates and the radioactivity in environmental soil samples indicated natural background only, no pathways are considered here for those two sources. Therefore, only surface contamination is considered. Details of the dose calculations are discussed in Appendix 7; results are summarized below.

The presumed internal radiation dose commitments from potential inhalation/ingestion of contamination possibly due to the MED/AEC occupancy were calculated to be 2.5 mrem to the lung, 0.51 mrem to the bone, 0.12 mrem to the kidney, and 0.031 mrem to the whole-body. These are 50-year dose commitments

and represent the total dose that would be accumulated in the body or specific critical organs over a 50-year period from inhalation/ingestion in the first year. Fifty-year dose commitments are always as large or larger than first-year annual doses; hence, all comparisons to annual dose standards are of a conservative nature. For the lung, bone, and kidney, these doses represent additions of 1.4%, 0.3%, and 0.15% to the 179-mrem, 171-mrem, and 82-mrem annual natural background lung, bone, and kidney doses, respectively, and 0.2%, 0.03%, and 0.008% of the 1500-mrem standard for an individual in an uncontrolled area. For the whole body, the calculated dose represents an increase of 0.04% to the 82-mrem annual natural background whole-body dose and 0.006% of the 500-mrem standard for an individual in an uncontrolled area.

In order to reduce the potential for radiation exposure, remedial measures such as stabilization of the contamination in place would be applicable as a short-term measure. To reduce the risk in the event that building modifications take place in the future, health physics procedures and coverage are recommended. The long-term solution would involve decontamination by removal of the radioactive residues from the 11 rooms or areas in the facility where contamination possibly resulting from MED/AEC activities was detected.

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FIGURE 1

SITE LOCATION OF ILLINOIS NATIONAL GUARD ARMORY

ANL-HP DWG.NO. 79-5

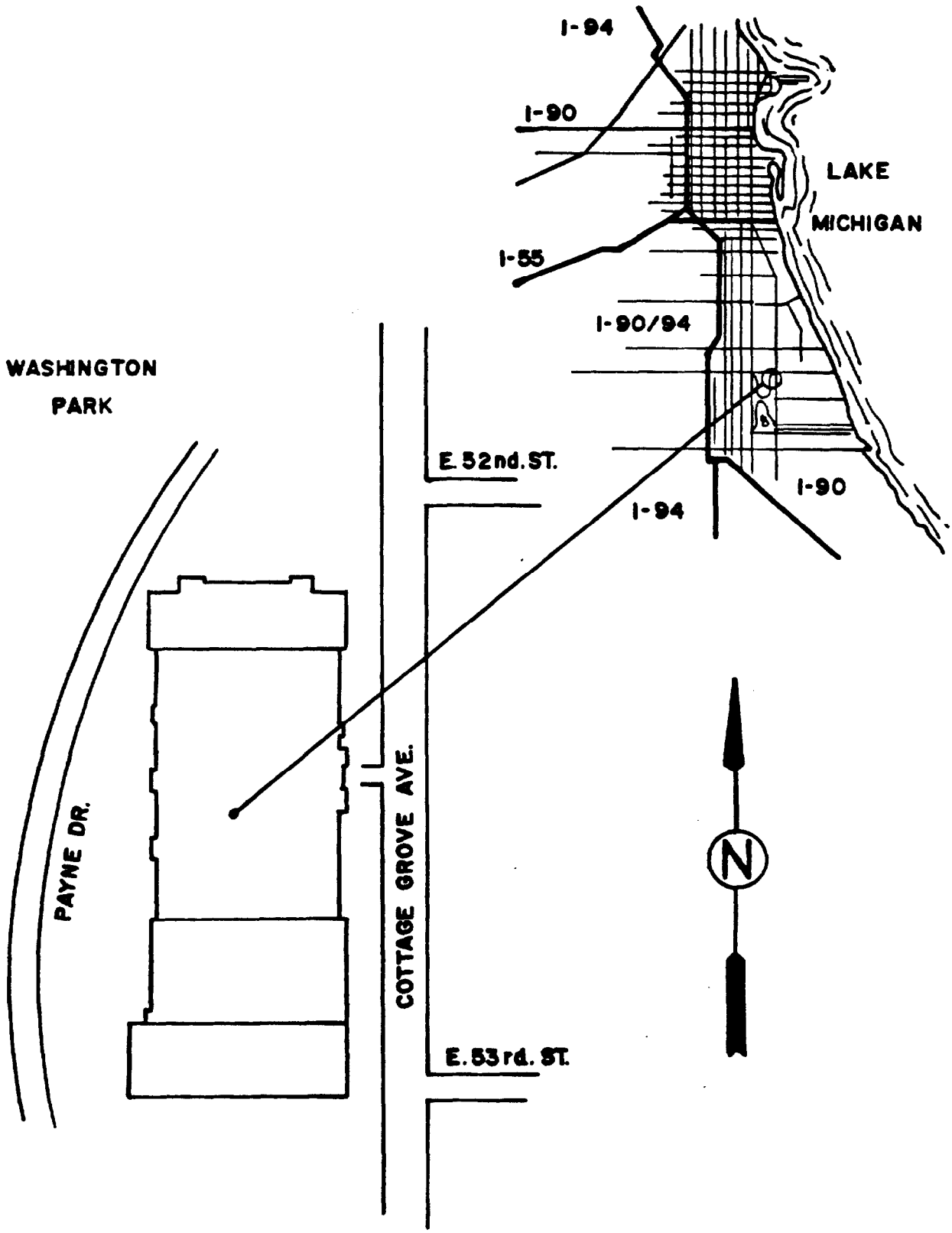


FIGURE 2A

AIR SAMPLE AND FLOOR SURVEY LOCATIONS IN ROOMS 1, 1A, 1B, 1C, 1D, 1E, 1F and 6

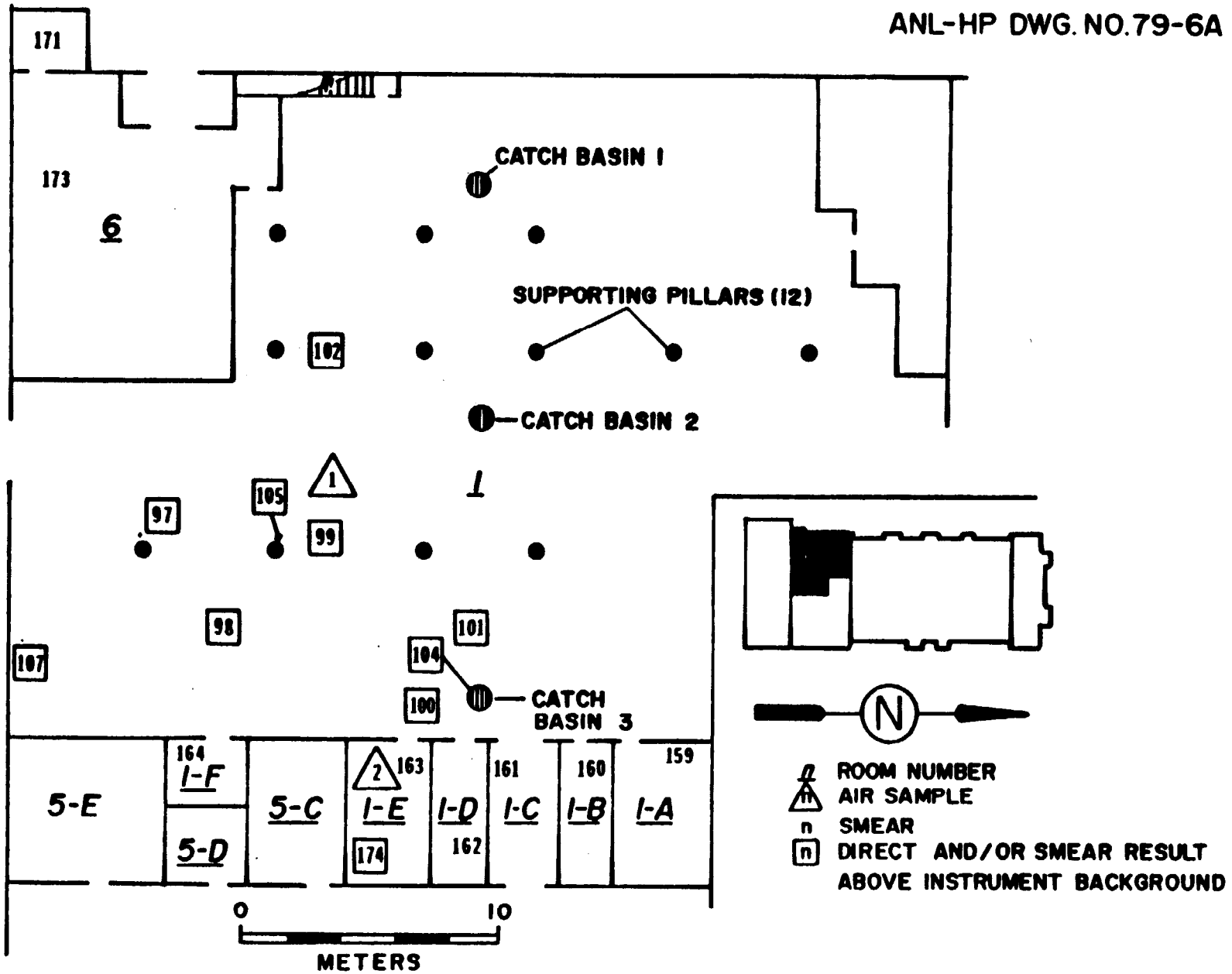


FIGURE 2B

OVERHEAD SURVEY LOCATIONS IN ROOMS 1, 1A, 1B, 1C, 1D, 1E, 1F and 6

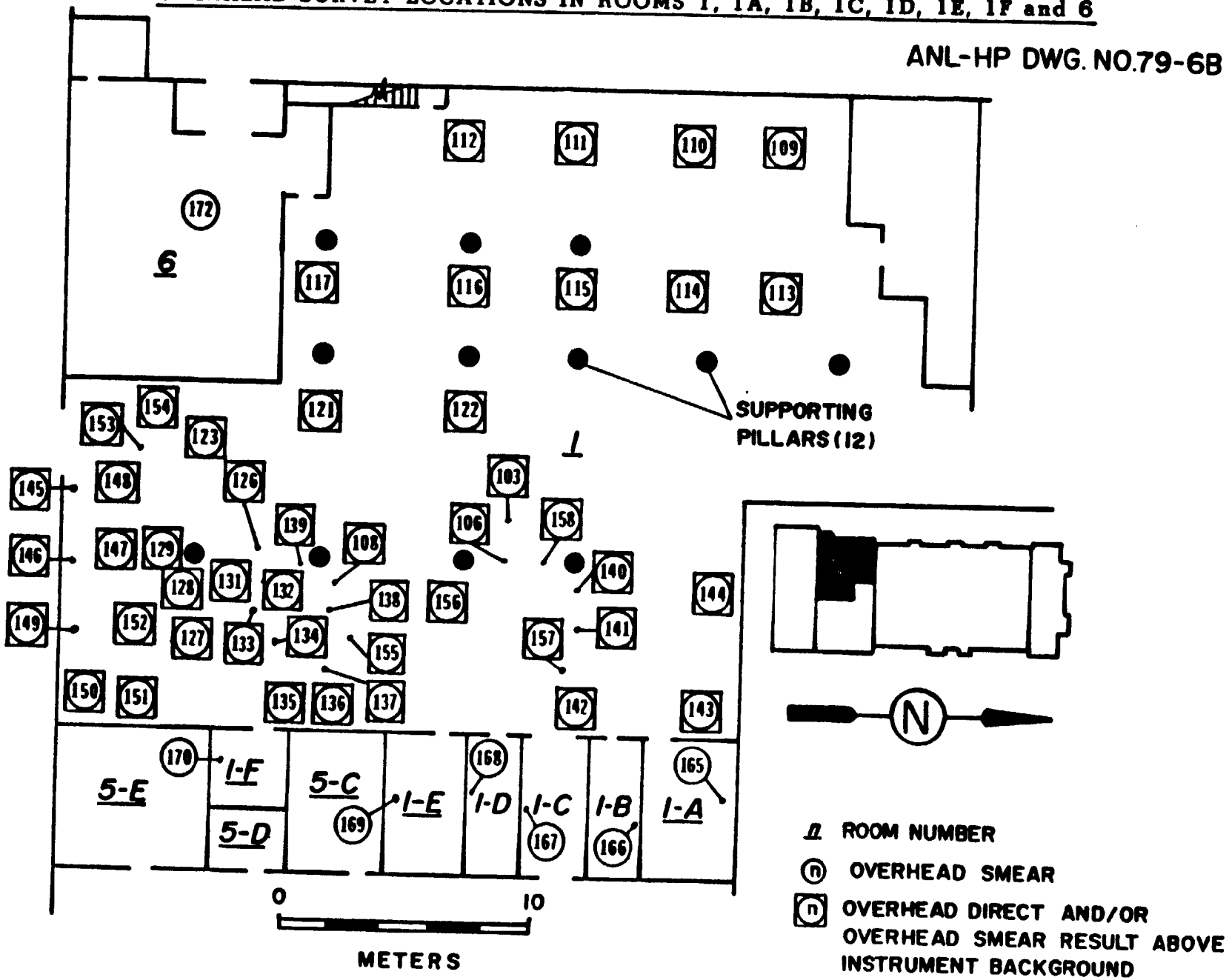


FIGURE 3

AIR SAMPLE AND SURVEY LOCATIONS IN ROOM 2

ANL-HP DWG. NO. 79-13

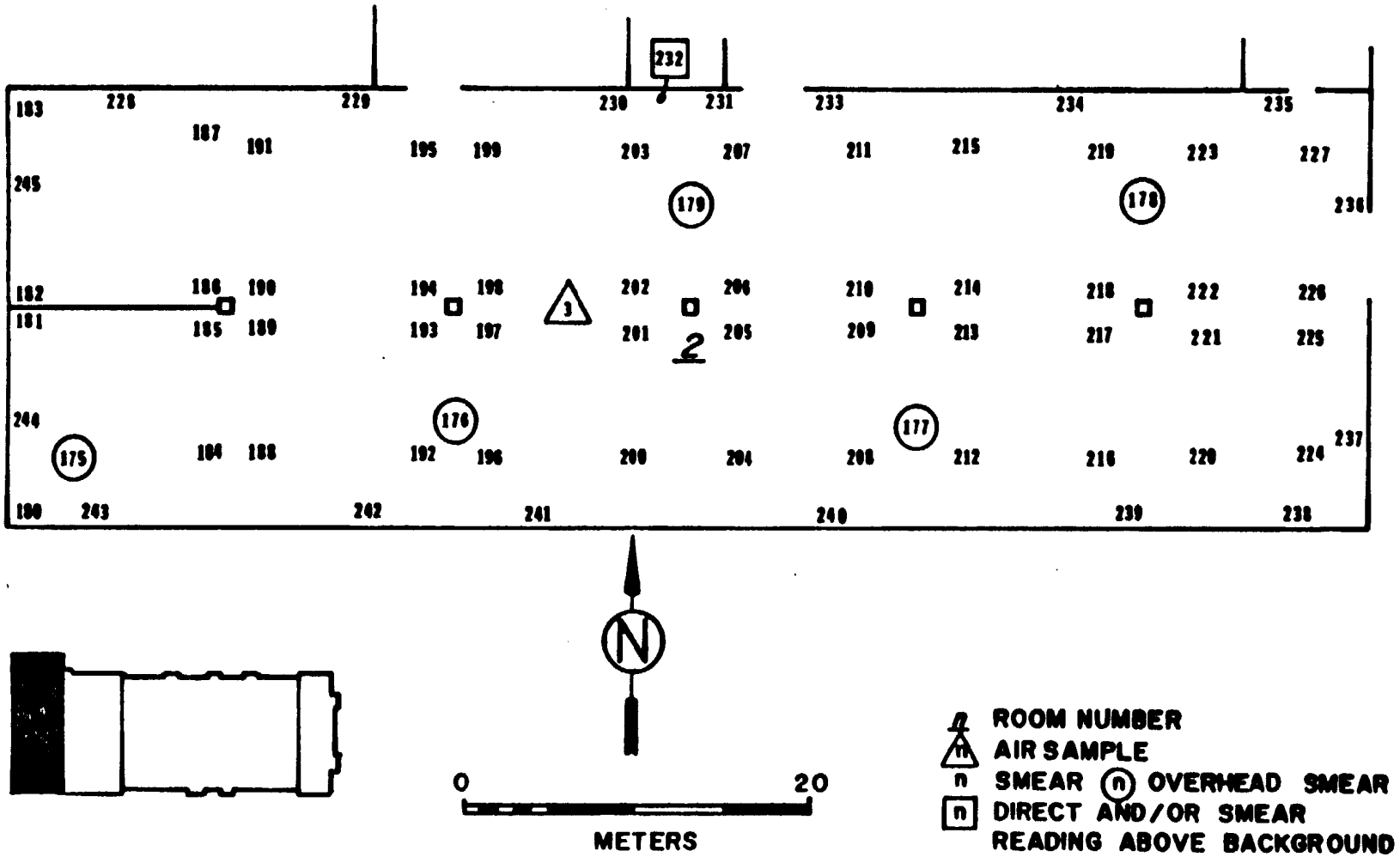


FIGURE 4

AIR SAMPLE AND SURVEY LOCATIONS IN ROOM 3 (ARENA)

ANL-HP DWG. NO. 79-12

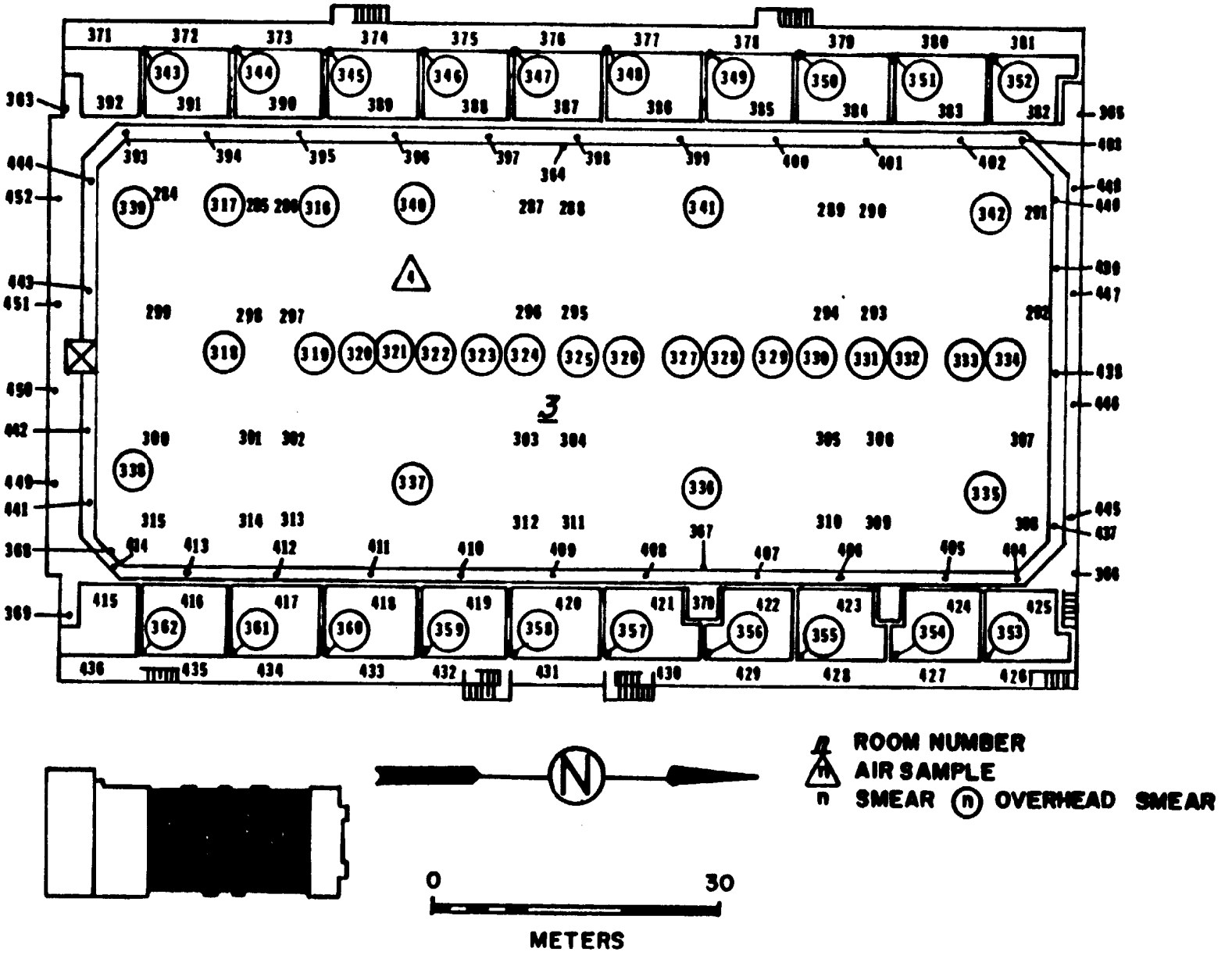


FIGURE 5

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 3A, 3B, 3C, 3D, 3E, and 3F

ANL-HP DWG. NO. 79-14

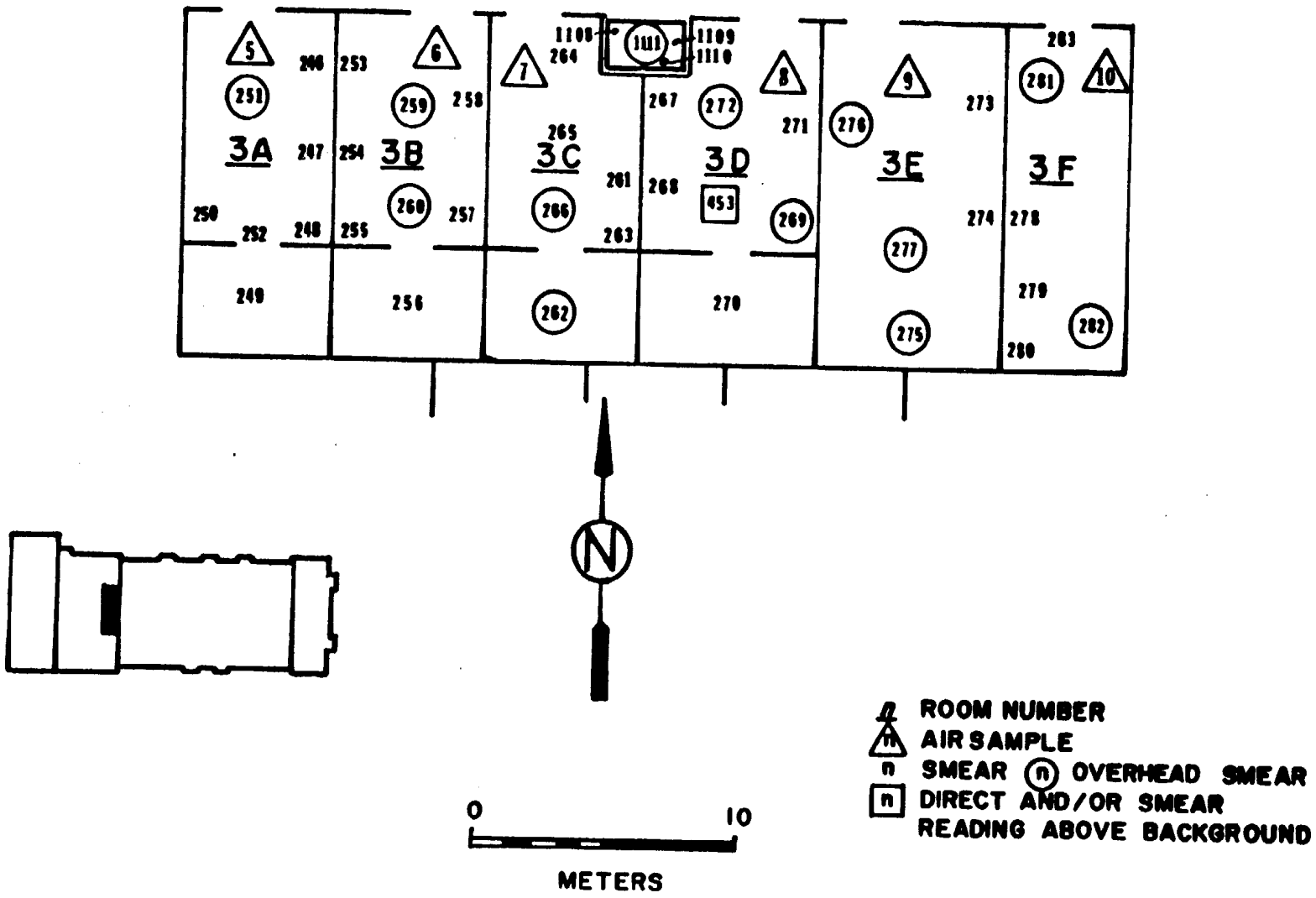


FIGURE 6

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 5, 5A, 5B, 5C, 5D and 5E

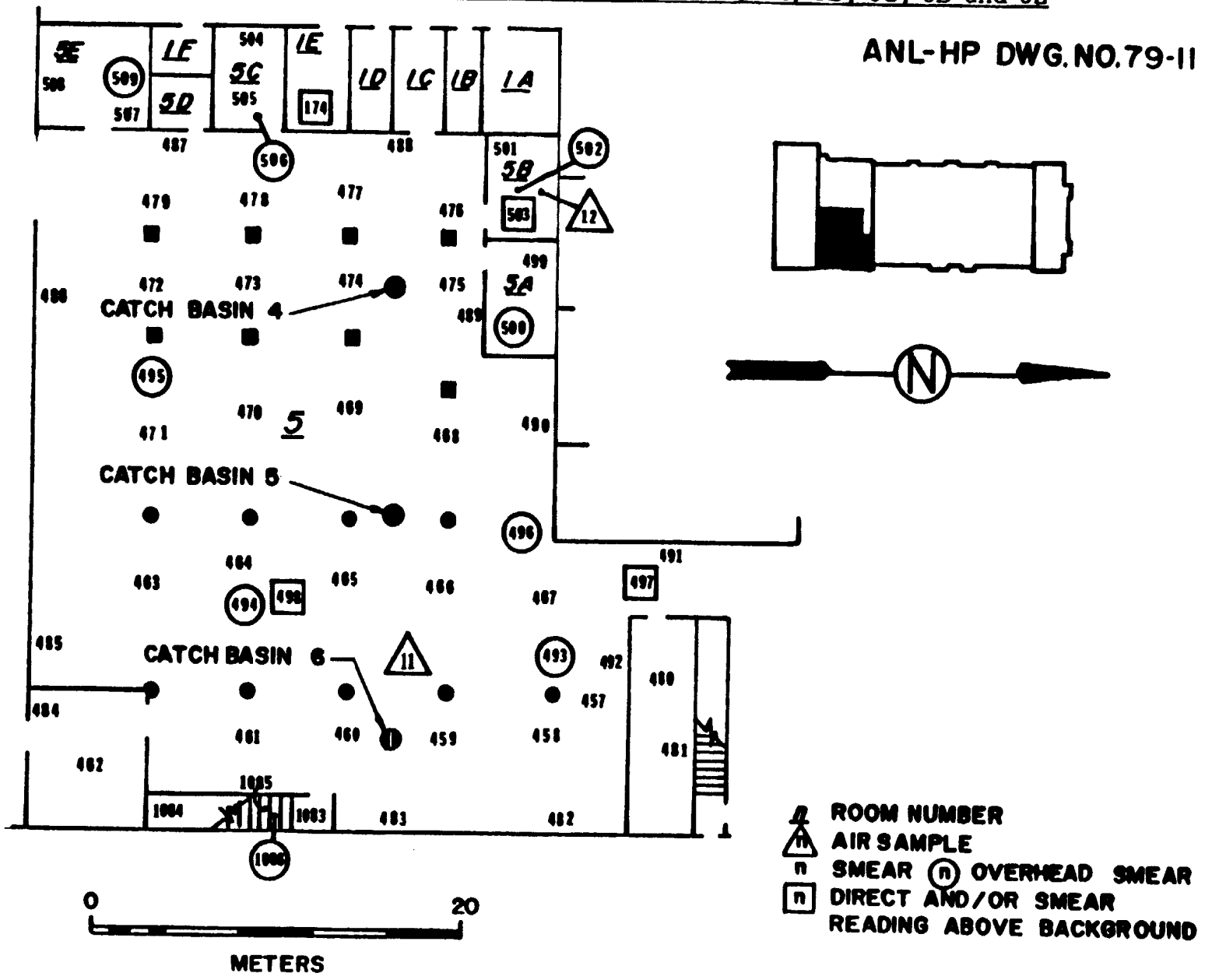


FIGURE 7

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 101, 101A, 102, 103, 104, 105
146A, 147, 147A, 147B, 148, 149 and NORTH EAST LOBBY

ANL-HP DWG. NO. 79-15

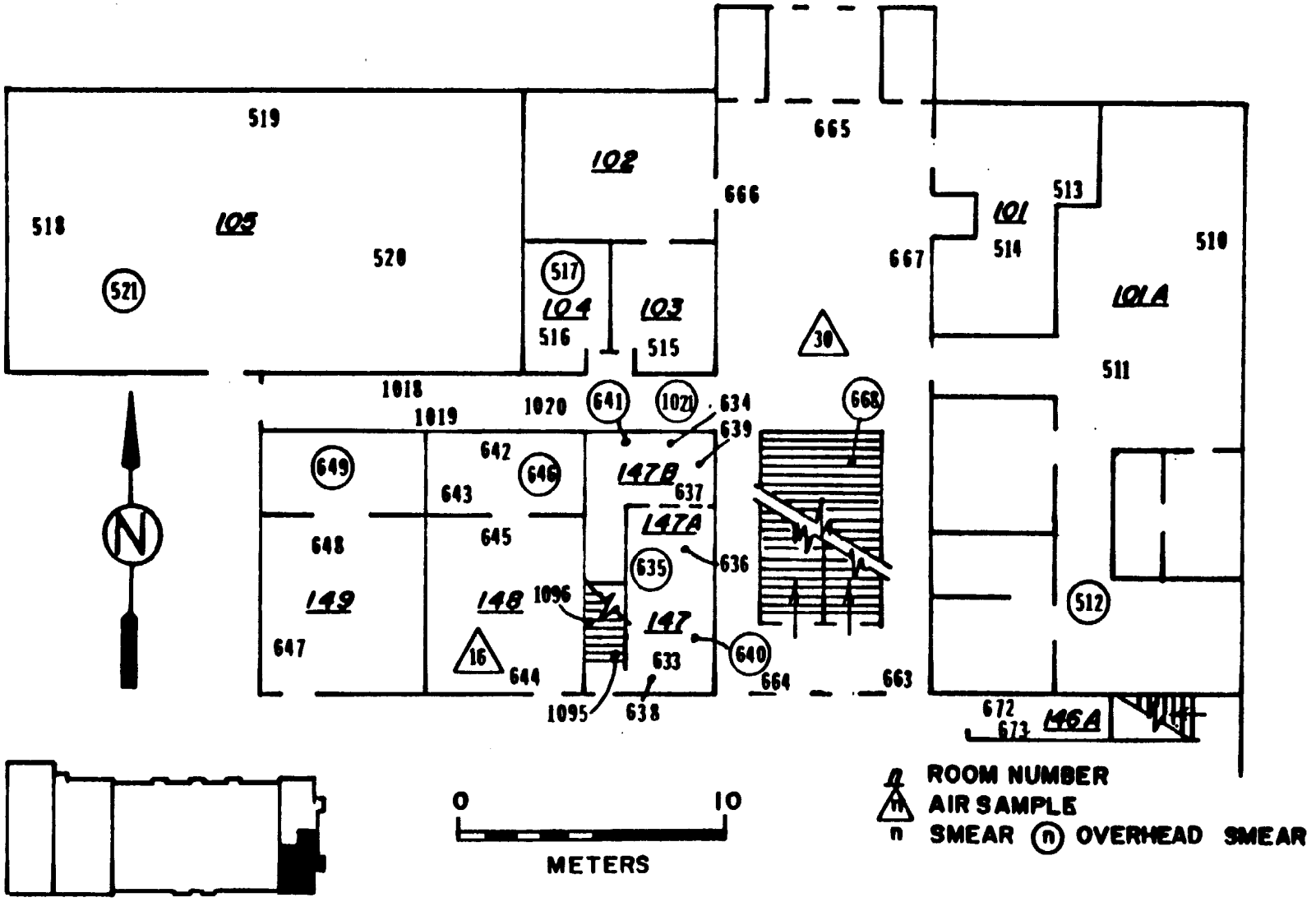


FIGURE 8

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 106, 107, 108, 108A, 109, 150, 151, 152 and NORTH WEST LOBBY

ANL-HP DWG.NO.79-16

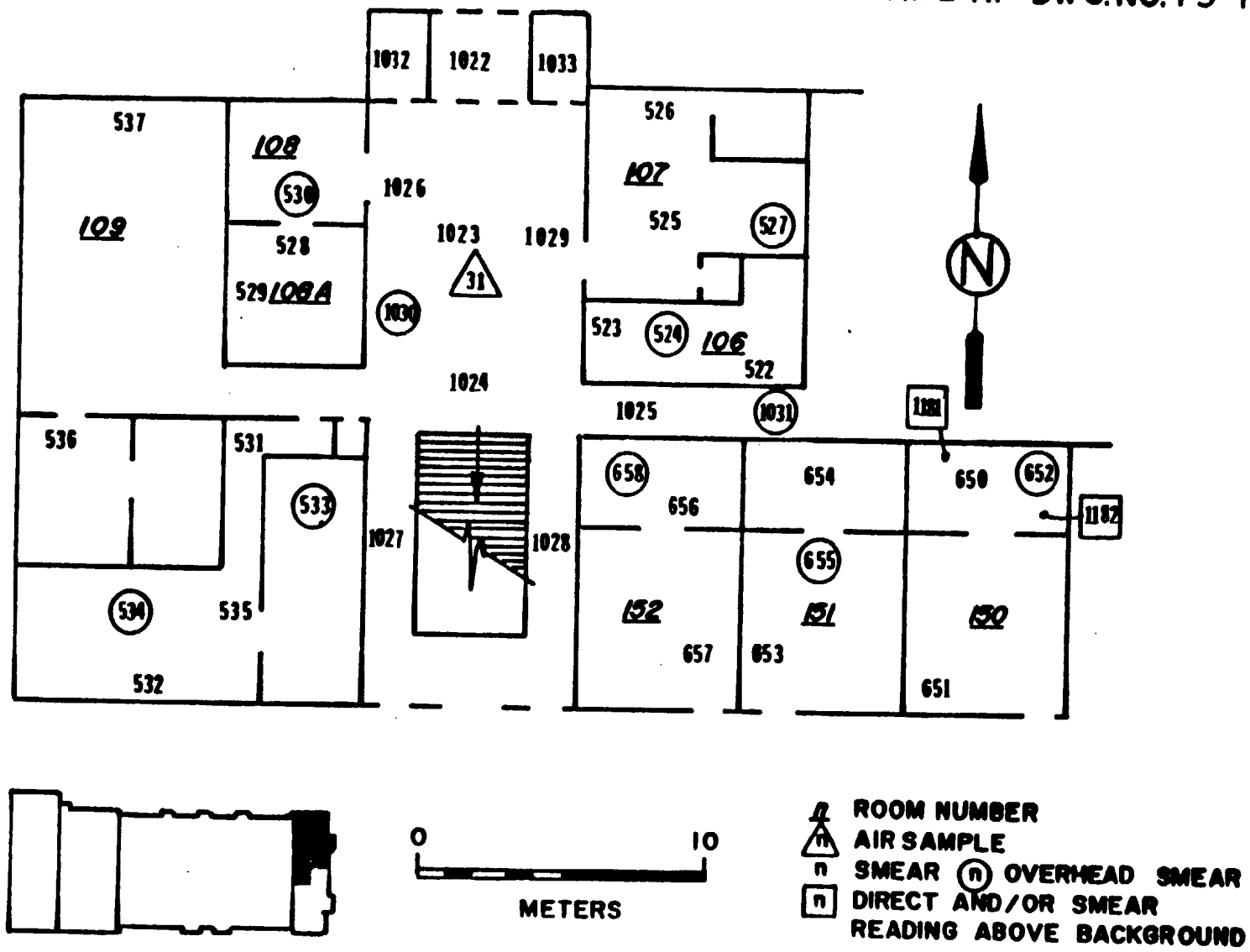


FIGURE 9

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 110, 111, 112, 113, 114, 115, 116 and 117

ANL-HP DWG. NO. 79-23

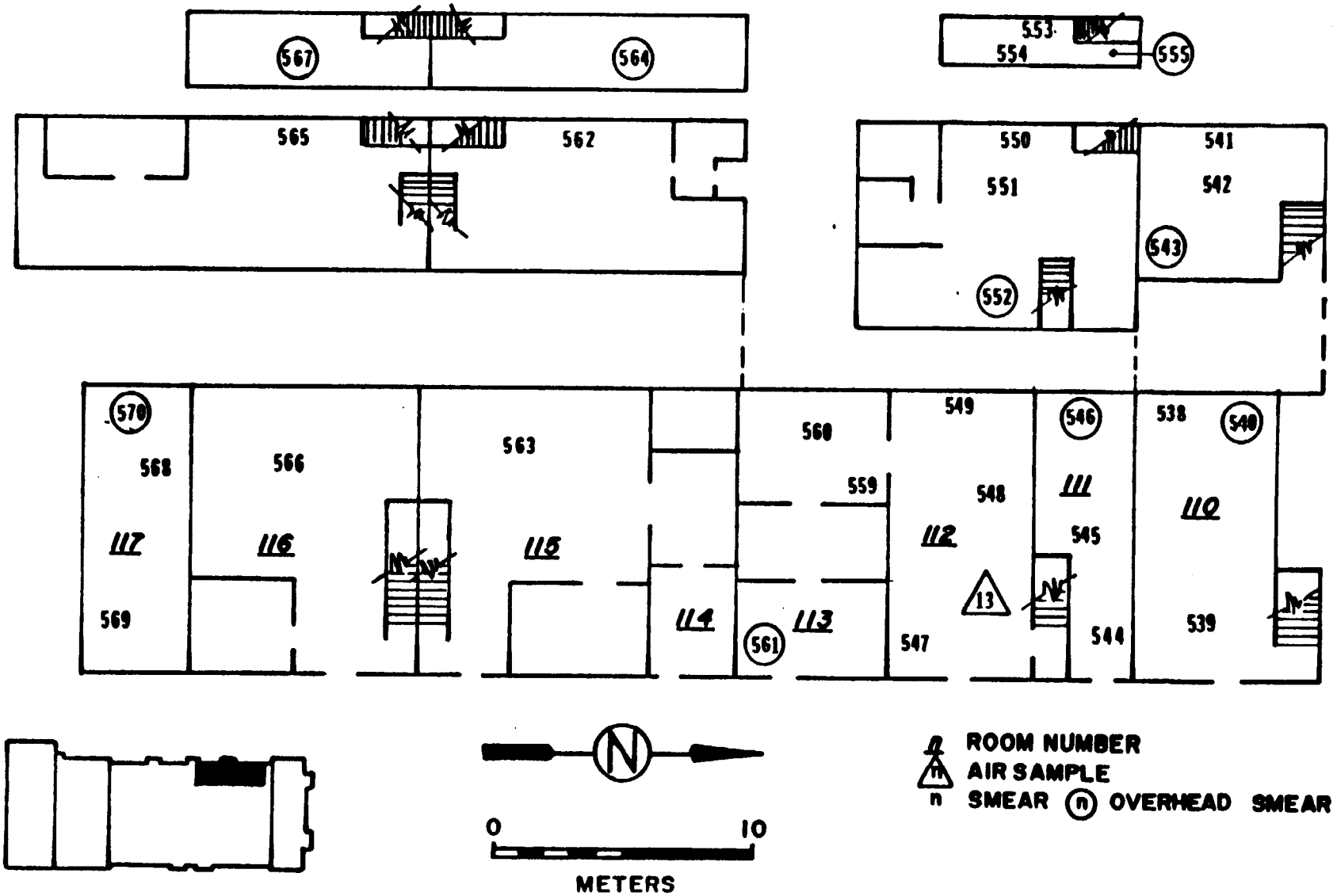


FIGURE 10

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 118, 118A, 119, 120, 121, 122, 123 and 125

ANL-HP DWG. NO. 79-24

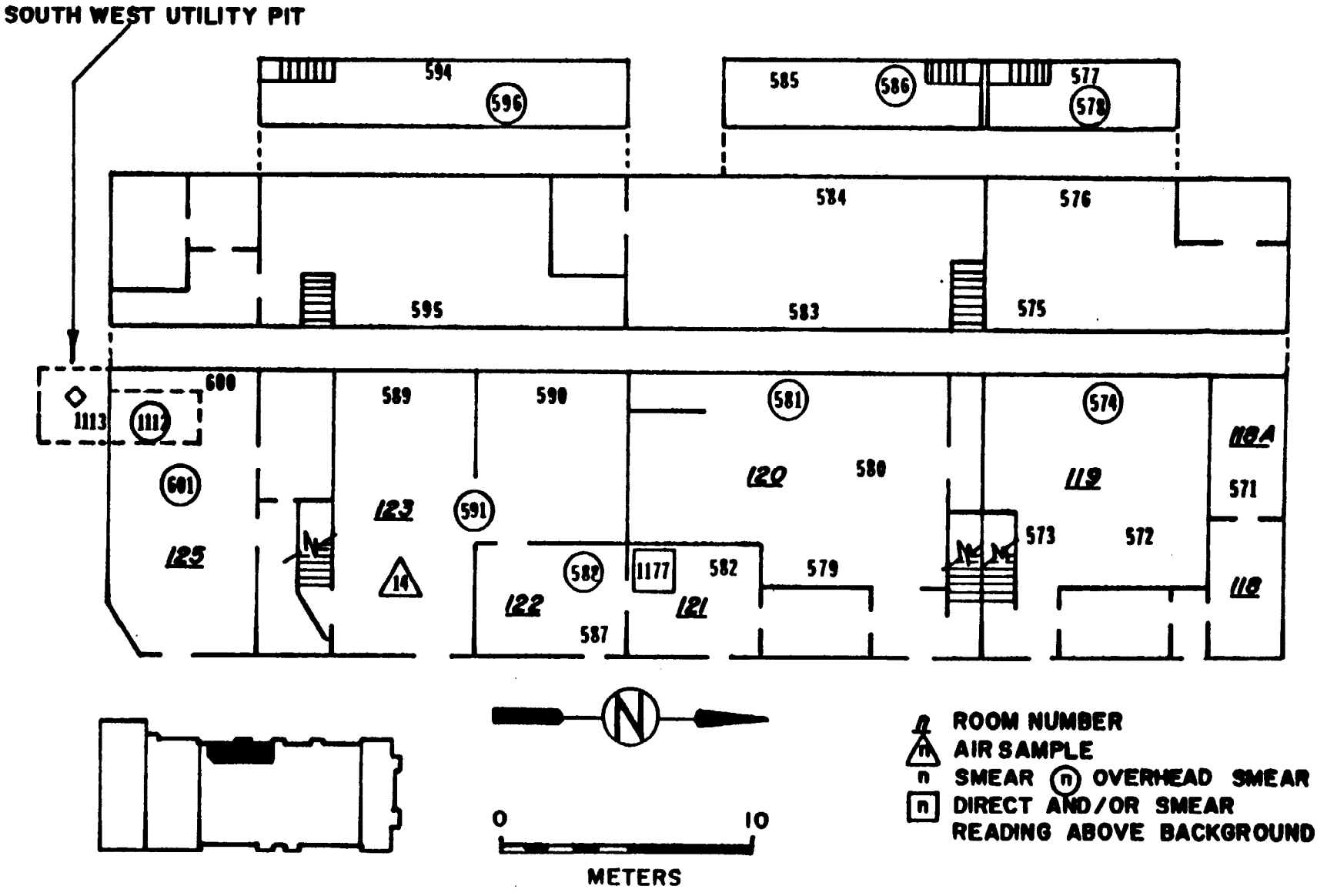


FIGURE 11

SURVEY LOCATIONS IN ROOMS 136, 136A, 136B, 137, 139, 140, 141 and 240

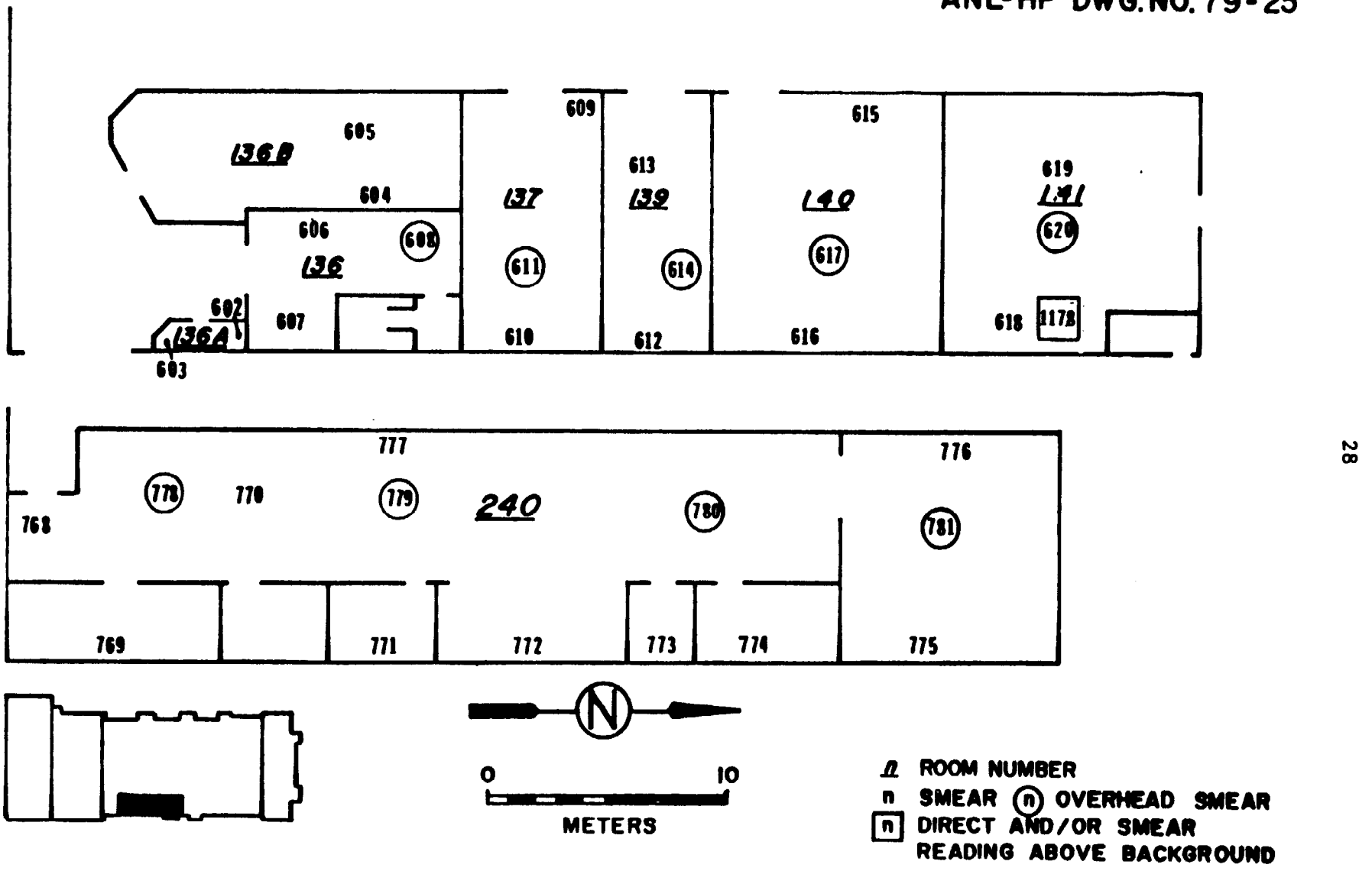


FIGURE 12

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 142, 143, 144, 145, 146, 176, 178, 180 and 273

ANL-HP DWG. NO. 79-26

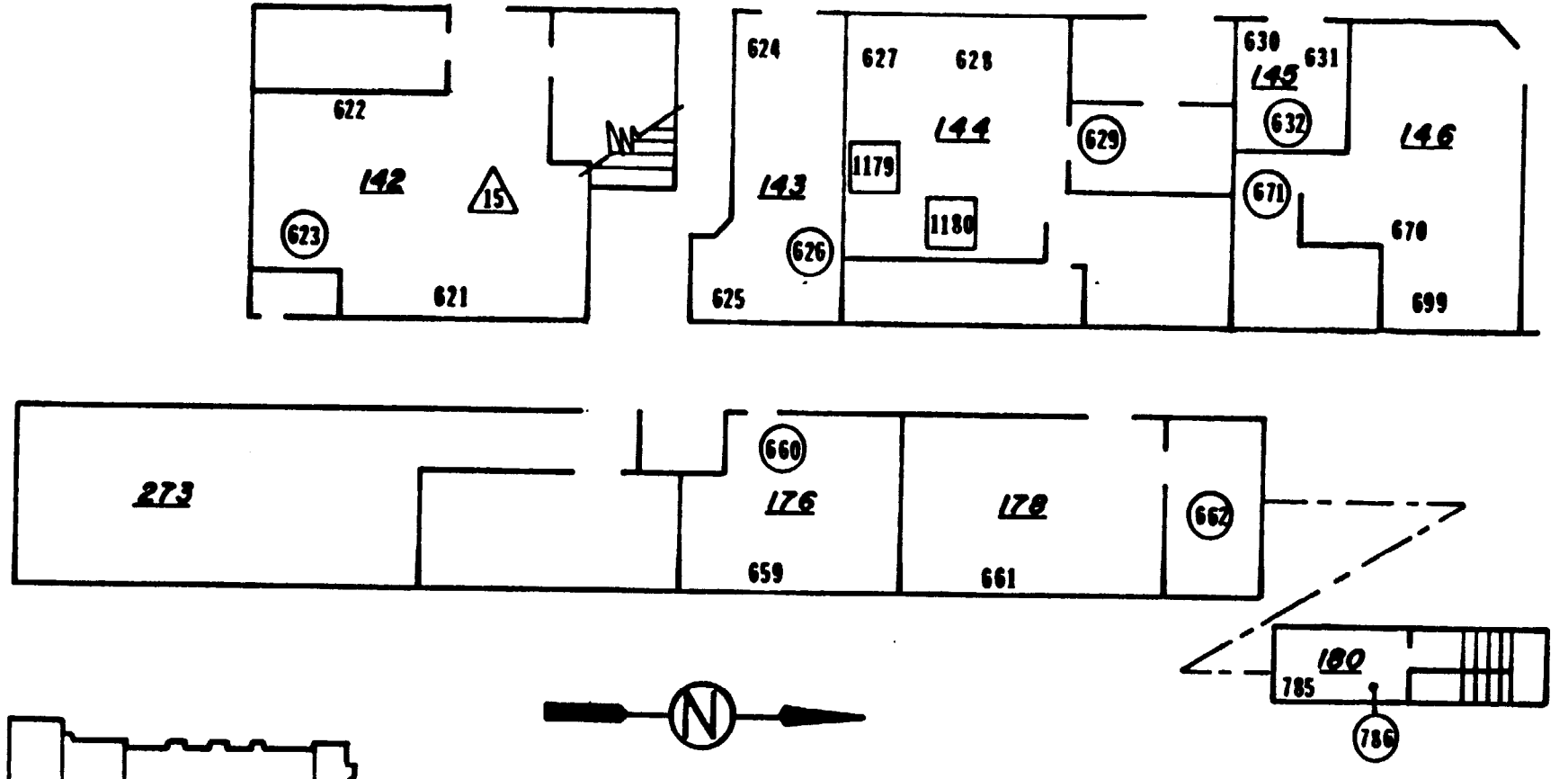
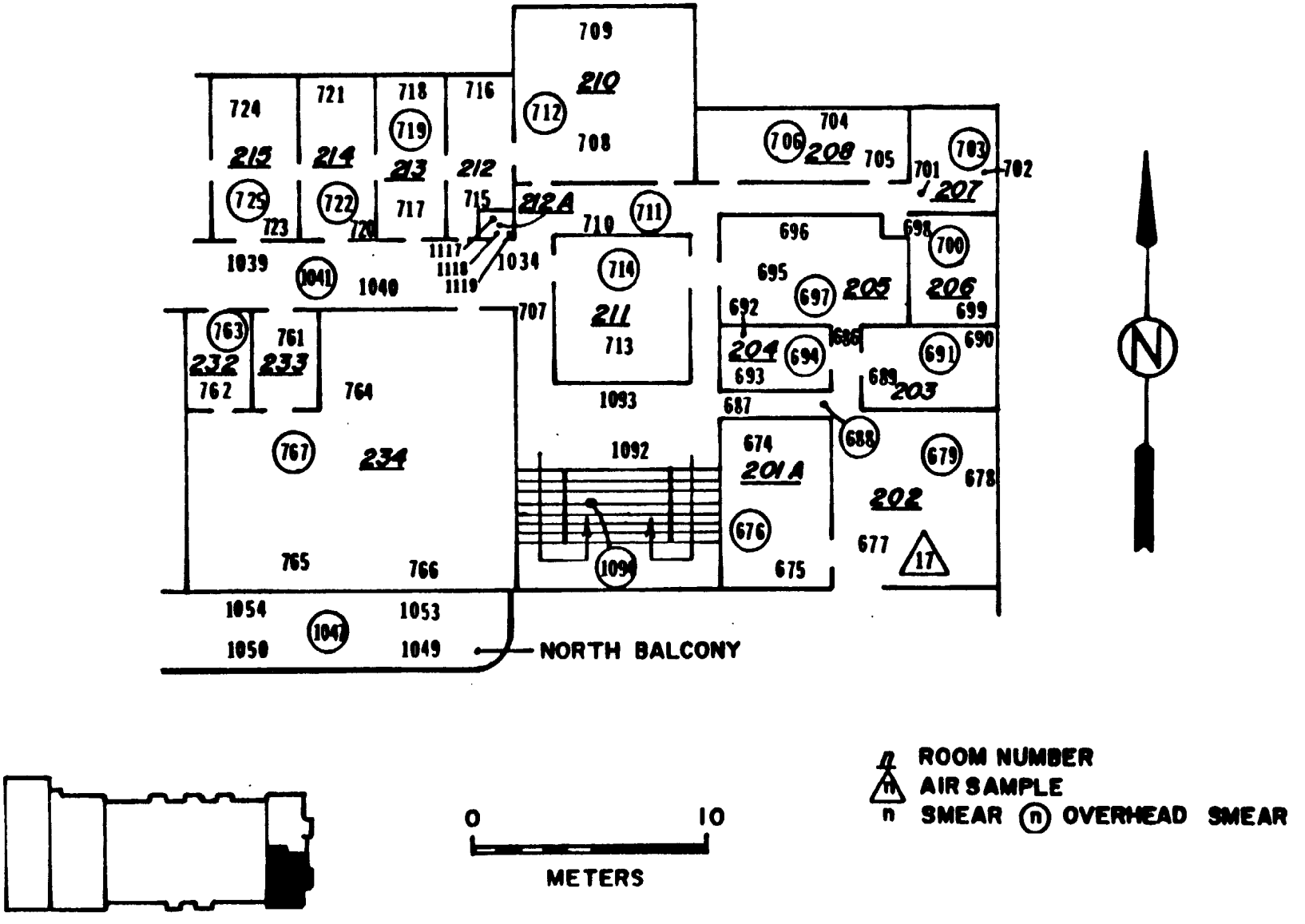


FIGURE 13

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 201A, 202, 203, 204, 205, 206, 207, 208, 210, 211, 212, 212A, 213, 214, 215, 232, 233, 234 and NORTH BALCONY

ANL-HP DWG. NO. 79-17



0 10

METERS

n ROOM NUMBER

n AIR SAMPLE

n SMEAR (n) OVERHEAD SMEAR

FIGURE 14

SURVEY LOCATIONS IN ROOMS 202A and 202B

ANL-HP DWG. NO. 79-18

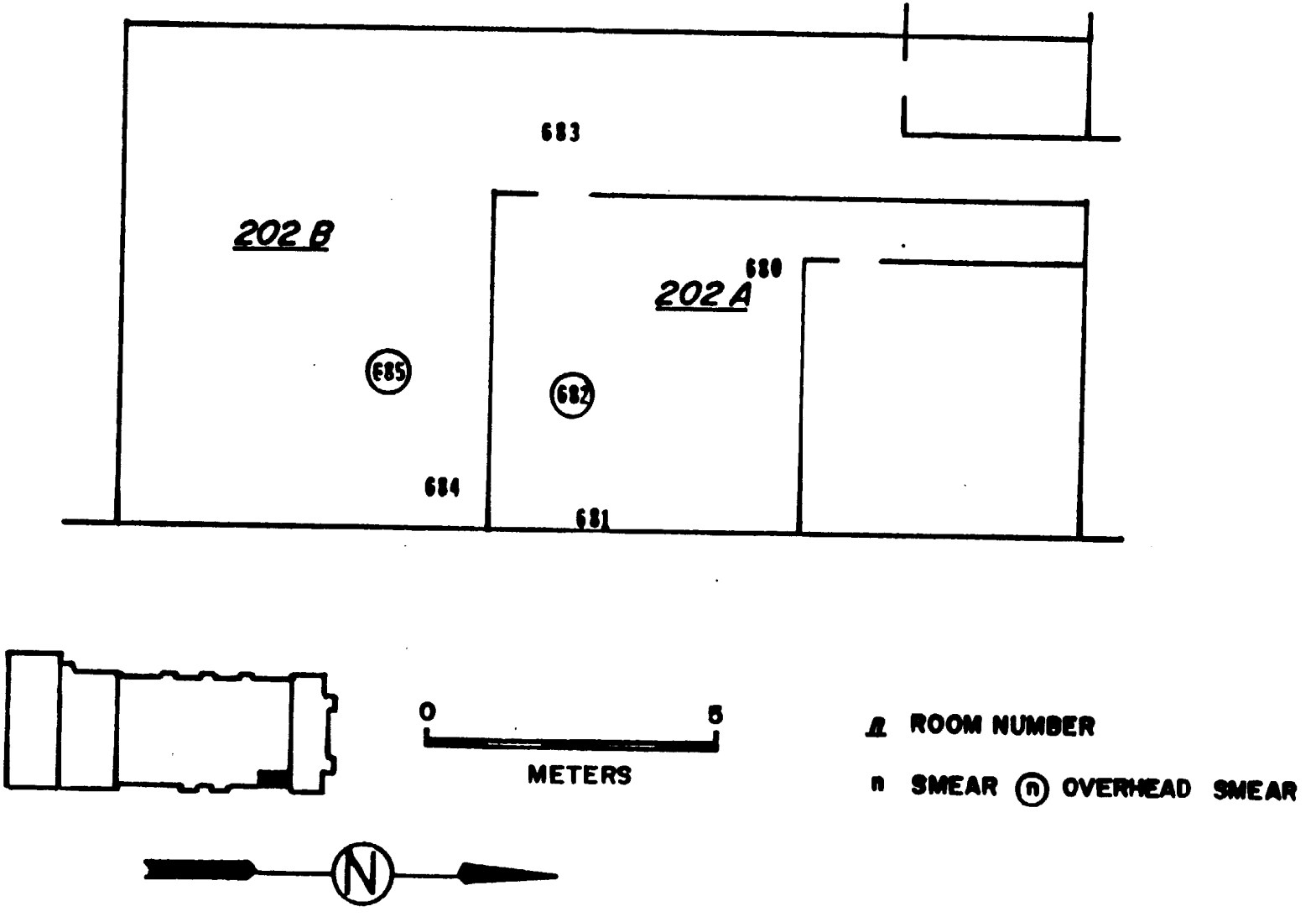


FIGURE 15

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 216, 217, 218, 220, 221, 221A, 223, 224, 225, 225A, 225B, 225C, 230, 231, 231A and NORTH BALCONY

ANL-HP DWG. NO. 79-19

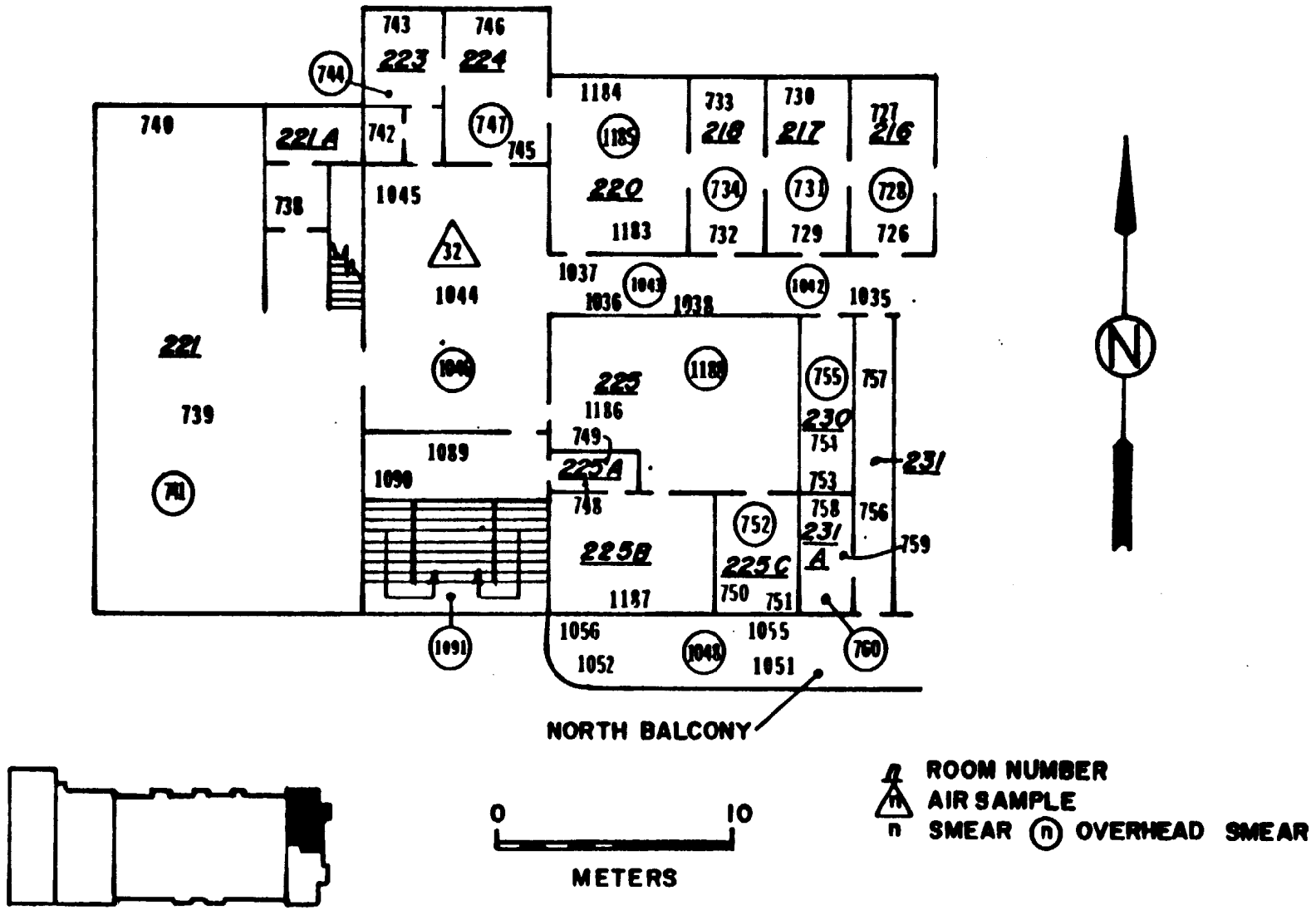


FIGURE 16

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 244, 245, 258, 260, 299 and 299A

ANL-HP DWG. NO. 79-22

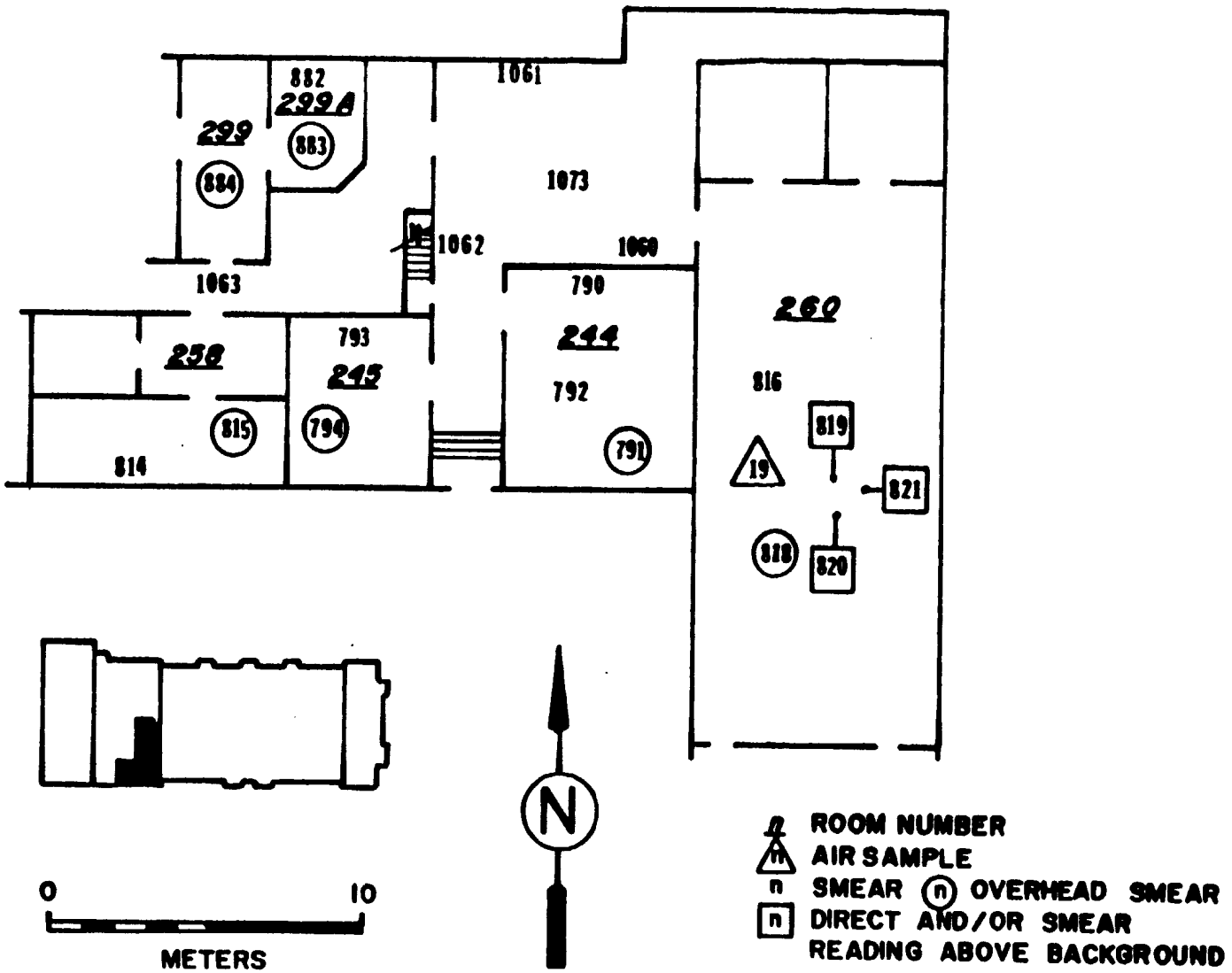


FIGURE 17

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 246, 246A and 246B

ANL-HP DWG. NO. 79-34

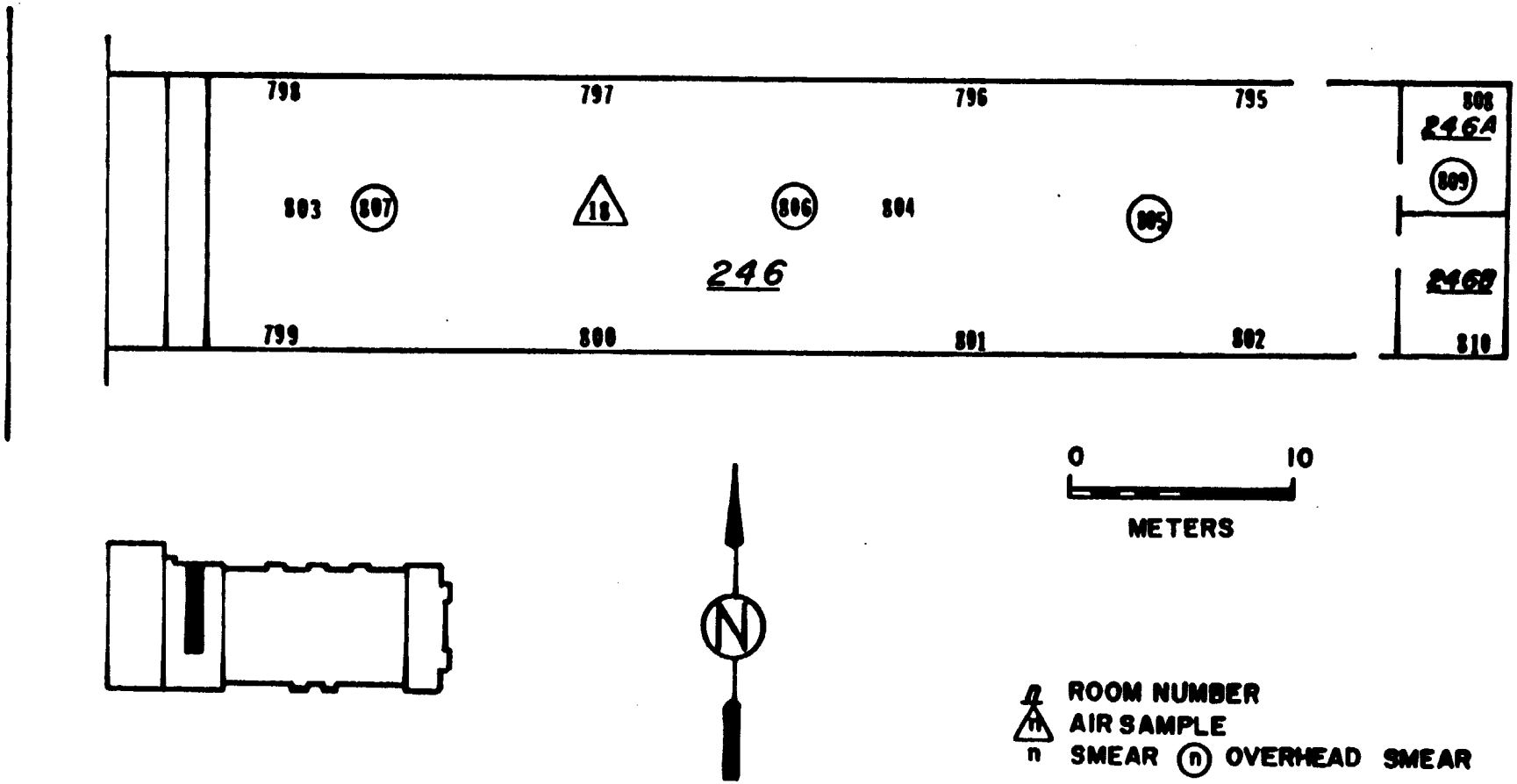


FIGURE 18

SURVEY LOCATIONS IN ROOMS 261, 262, 263, 265, 266, 267, 269, 270 and 271

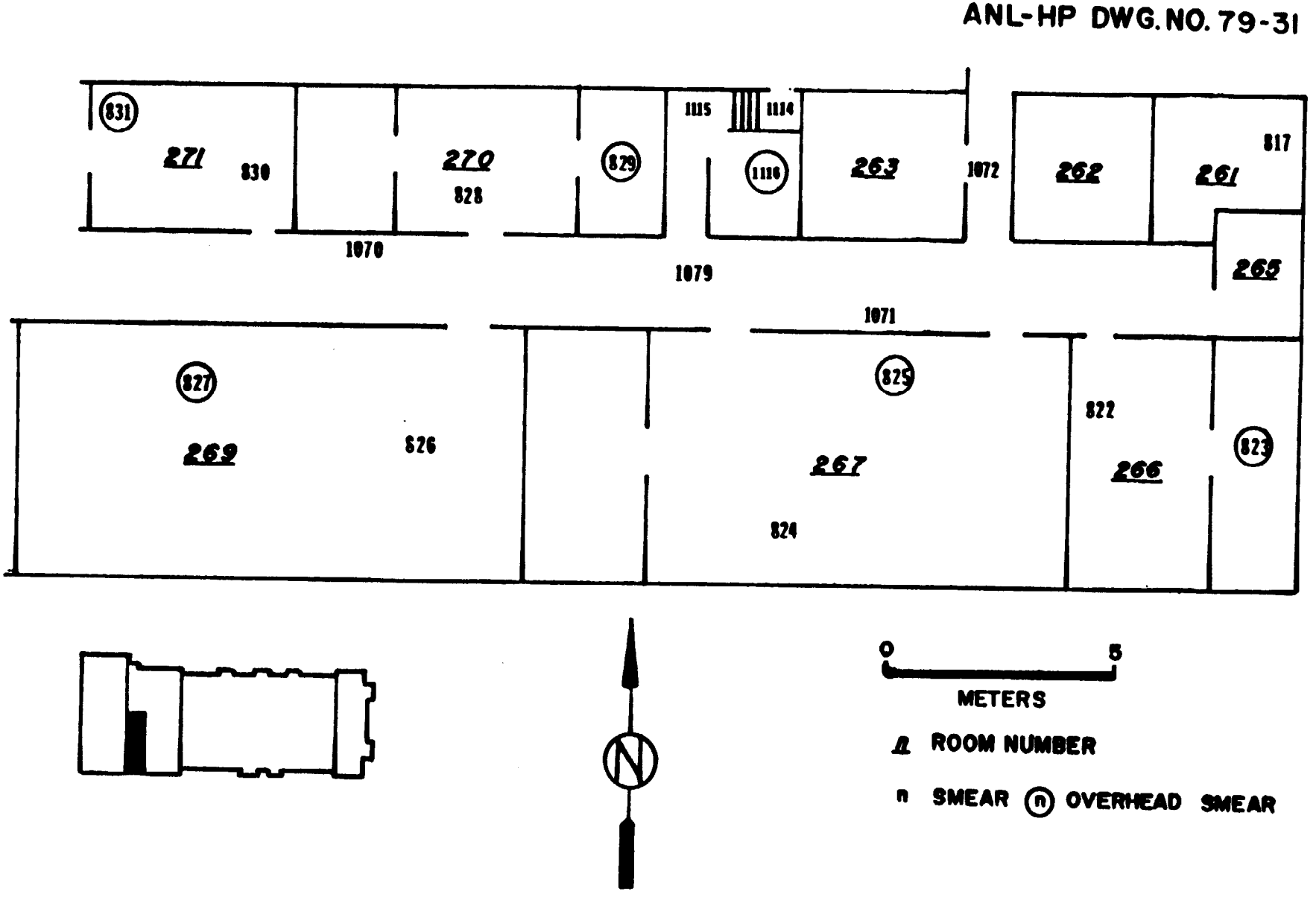


FIGURE 19

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 272, 274, 275, 277, 278, 279, 280, 281, 282, 283 and 284

ANL-HP DWG. NO. 79-33

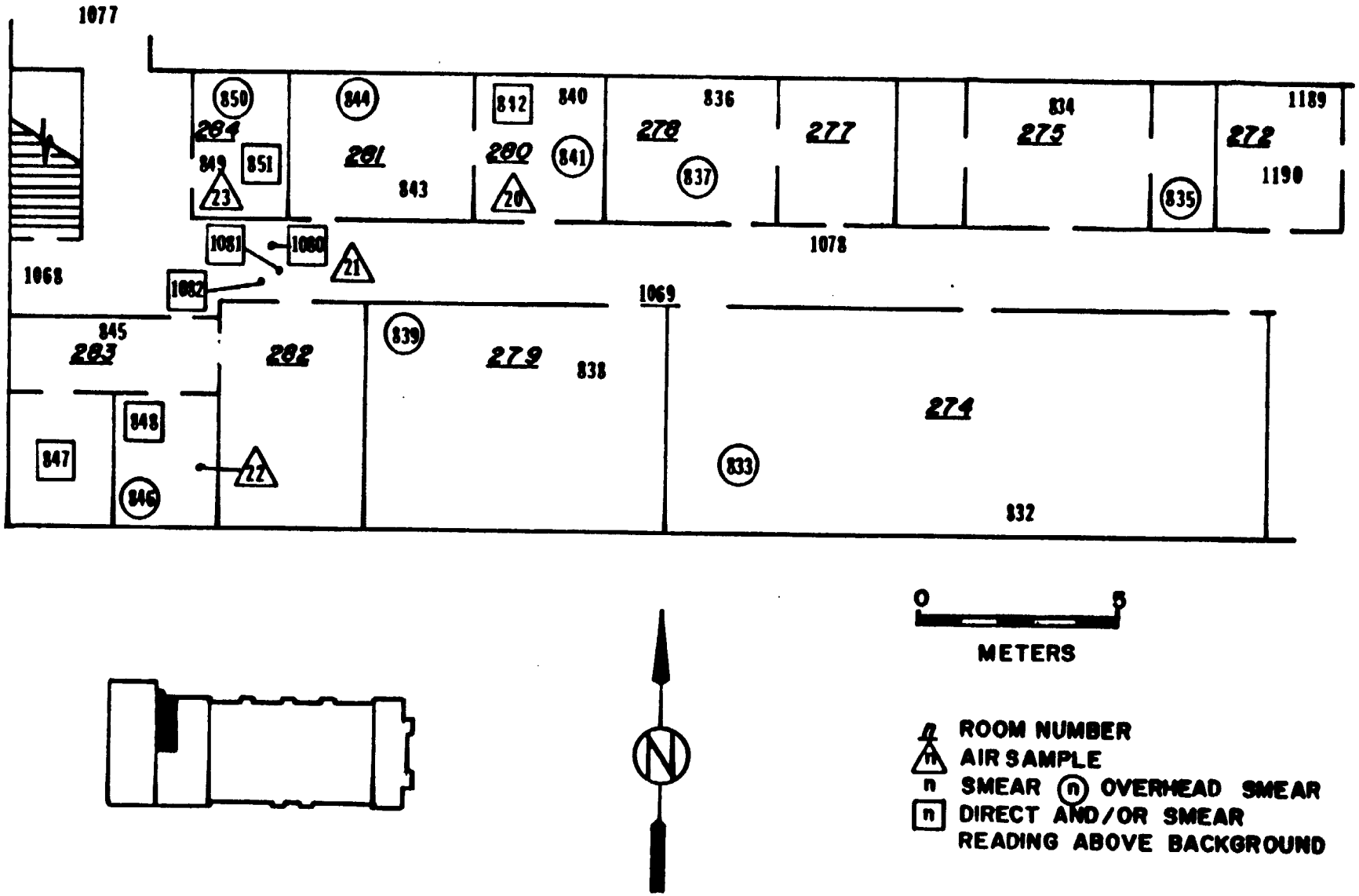


FIGURE 20

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 242, 285, 286, 287, 288, 289, 290, 291, 292 293, 294, 295, 296, 297 and 298

ANL-HP DWG. NO. 79-32

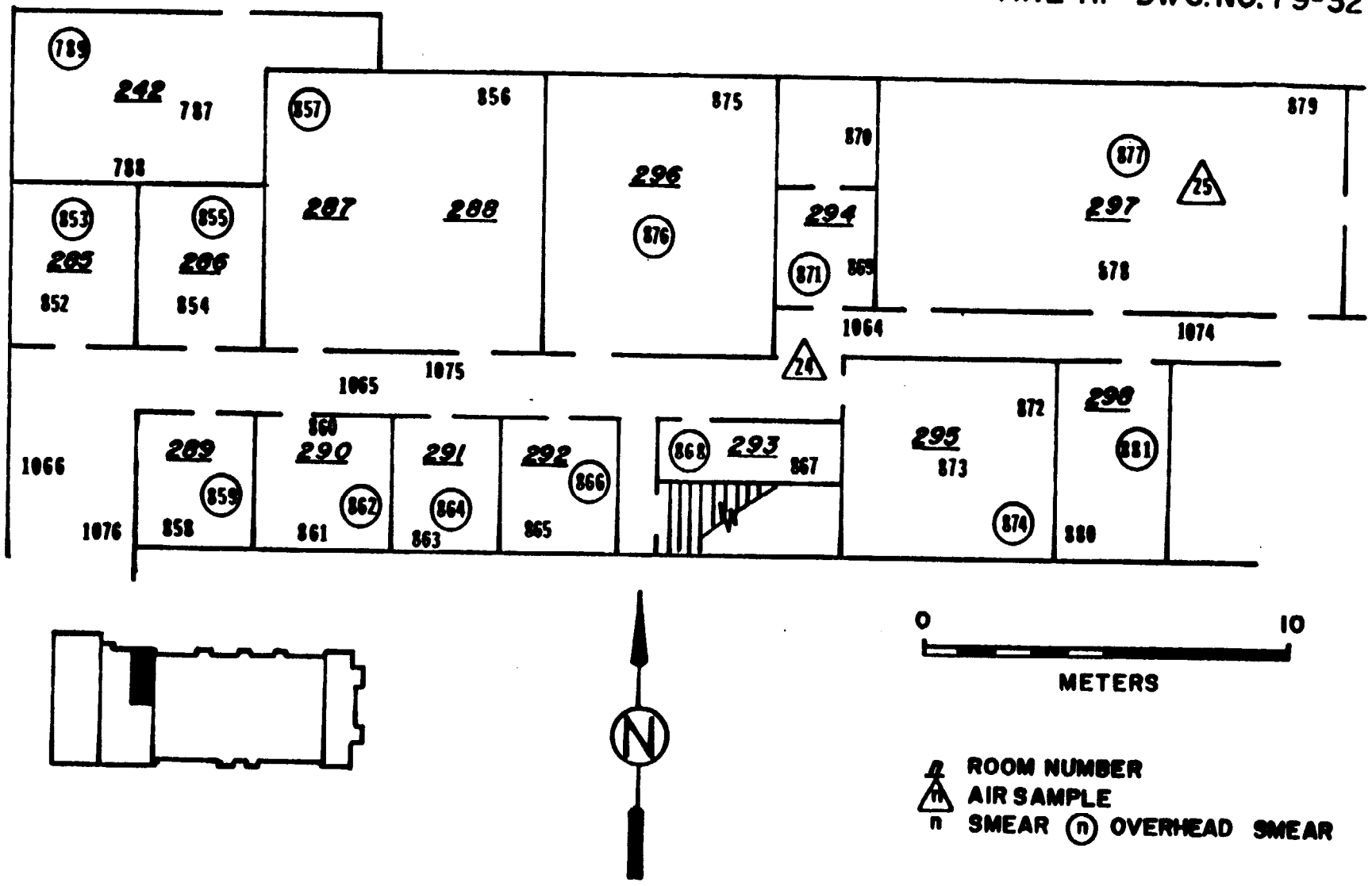


FIGURE 21

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 301, 302, 302A, 303, 304, 305, 306, 307, 308, 310 and 311

SOUTH END

ANL-HP DWG. NO. 79-27

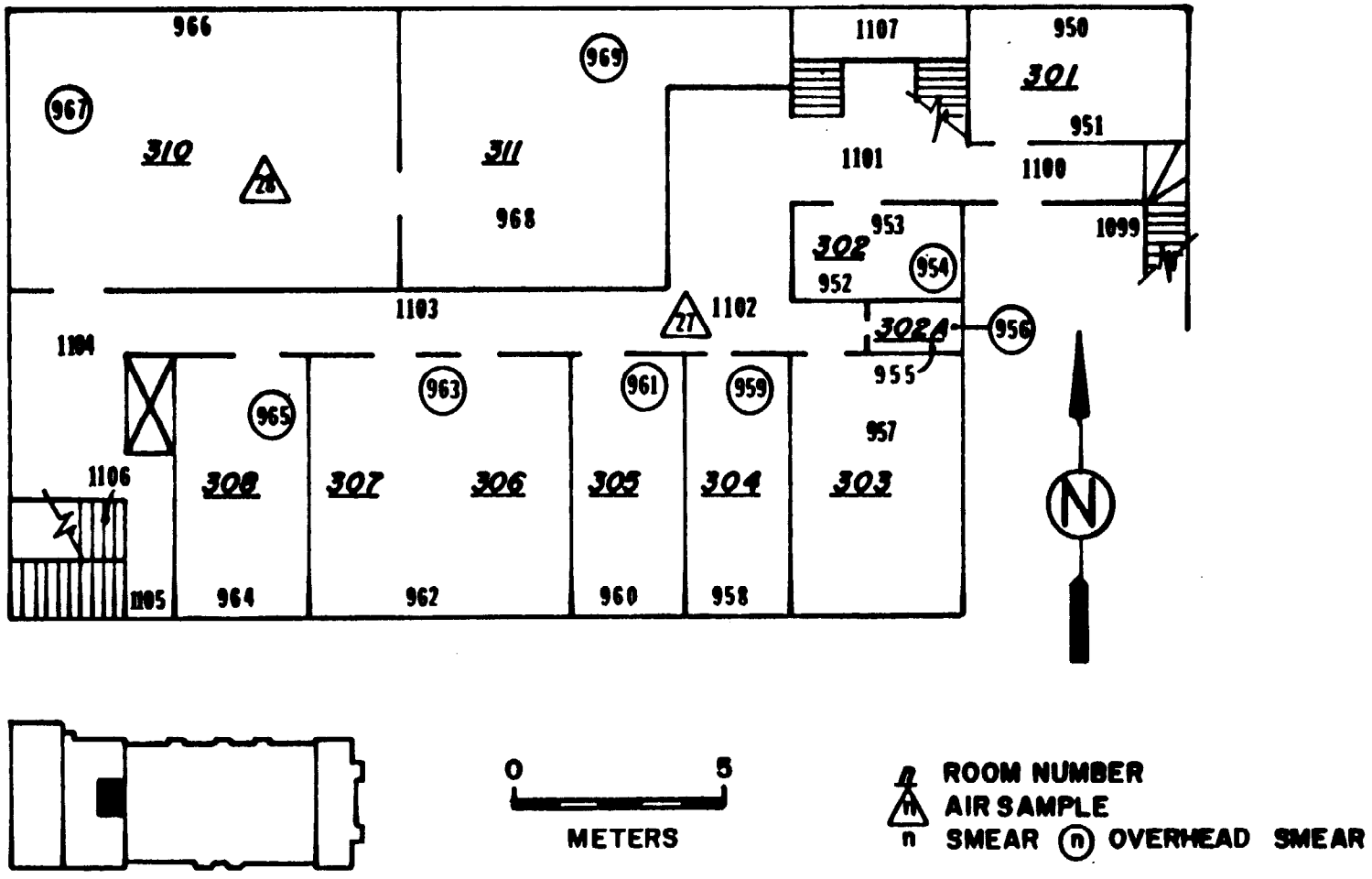


FIGURE 22

AIR SAMPLE AND SURVEY LOCATIONS IN ROOMS 301, 302, 303, 304, 305, 306, 307, 308, 309, 316 and 317

NORTH END

ANL-HP DWG.NO.79-20

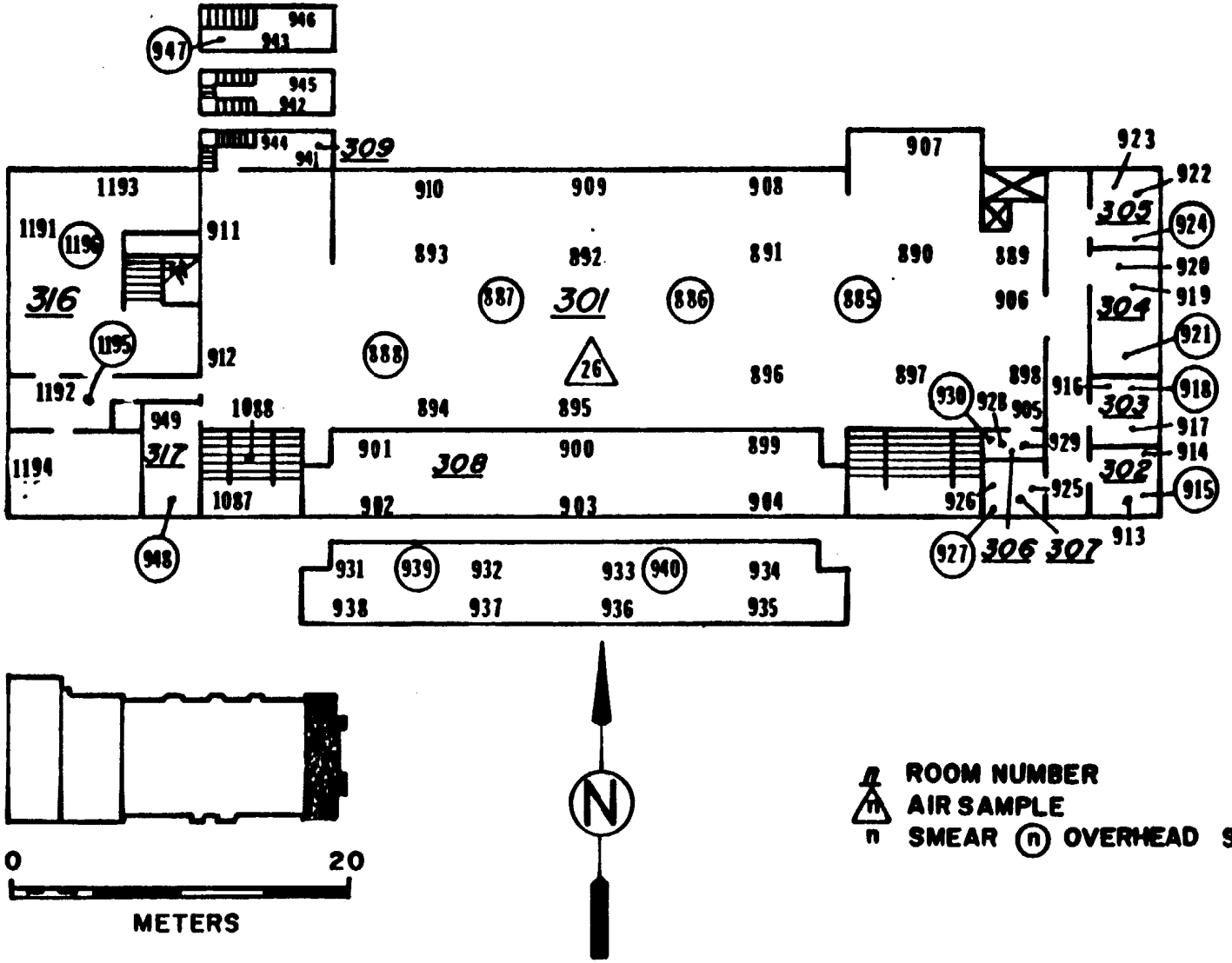


FIGURE 23

AIR SAMPLE AND SURVEY LOCATIONS IN ROOM 401

SOUTH END

ANL-HP DWG. NO. 79-28

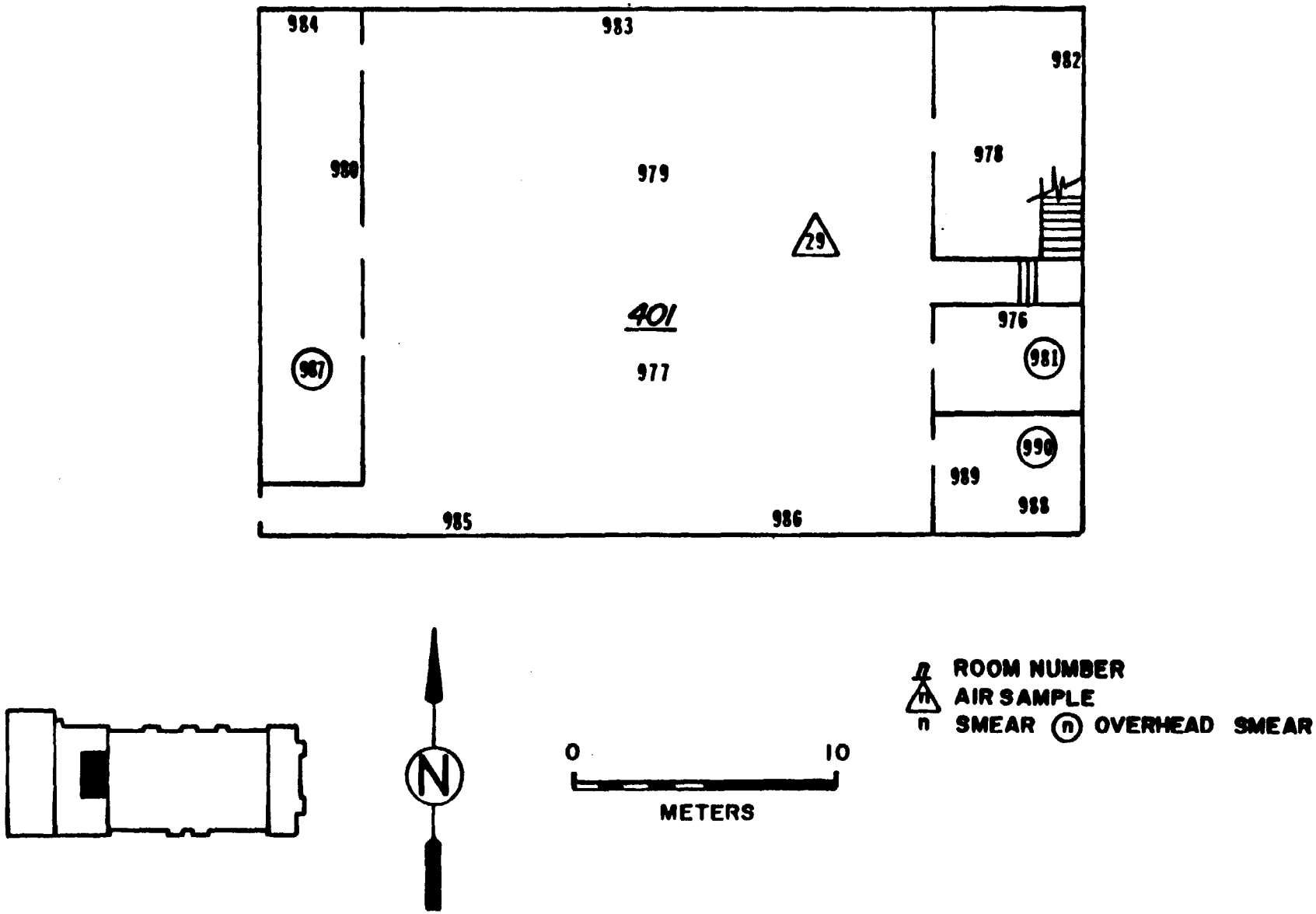


FIGURE 24

AIR SAMPLE AND SURVEY LOCATIONS ON SERVICE FLOOR

ANL-HP DWG. NO. 79-21

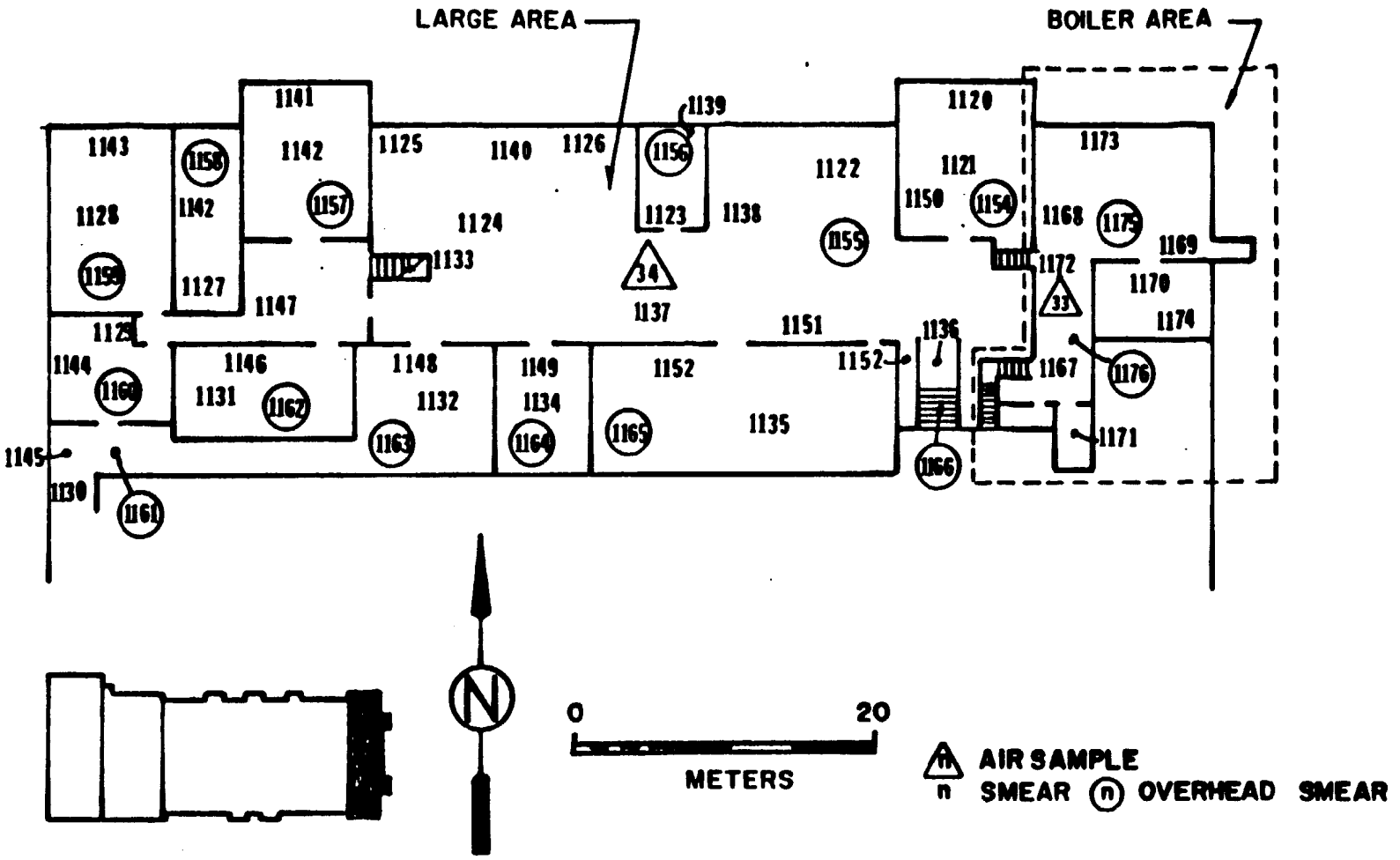


FIGURE 25

SURVEY LOCATIONS - ROOF OF ROOM 2

ANL-HP DWG.NO.79-30

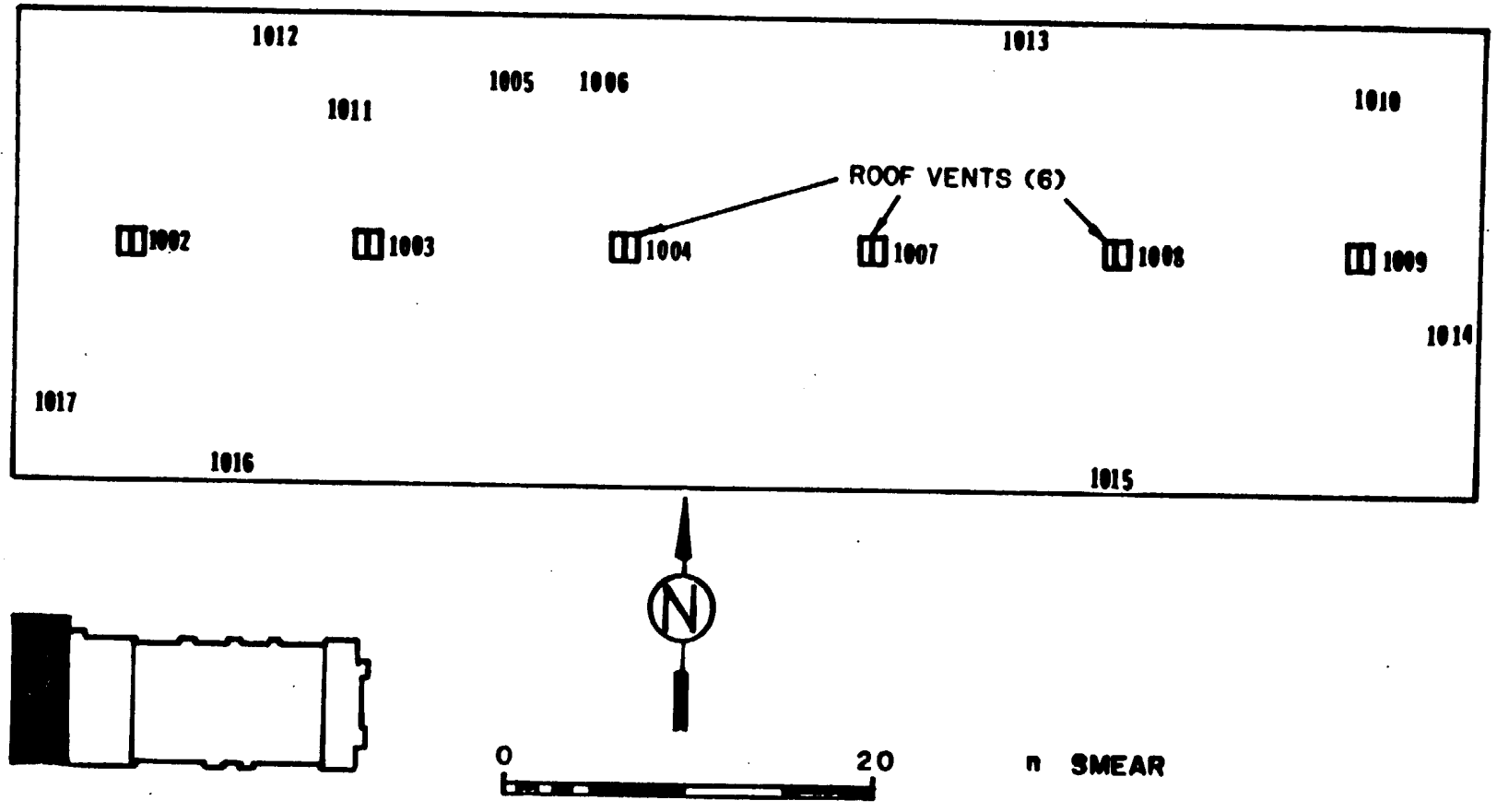


FIGURE 26

SURVEY LOCATIONS - ROOF OF ROOMS 1, 5 and 6

ANL-HP DWG.NO.79-29

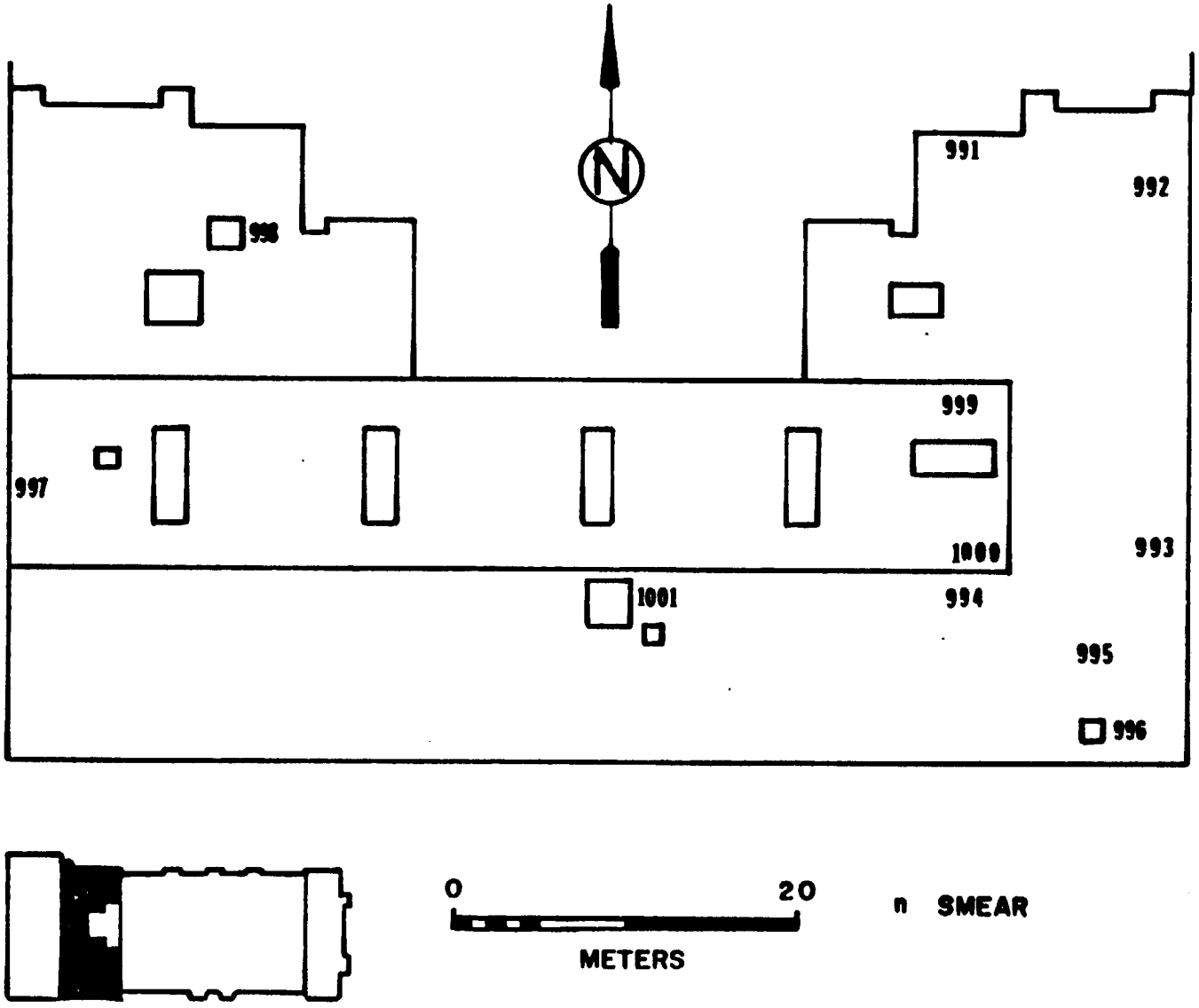


FIGURE 27

DRAINAGE SYSTEM FOR ROOM 1 AND 5 FLOORS

ANL-HP DWG. NO. 82-25

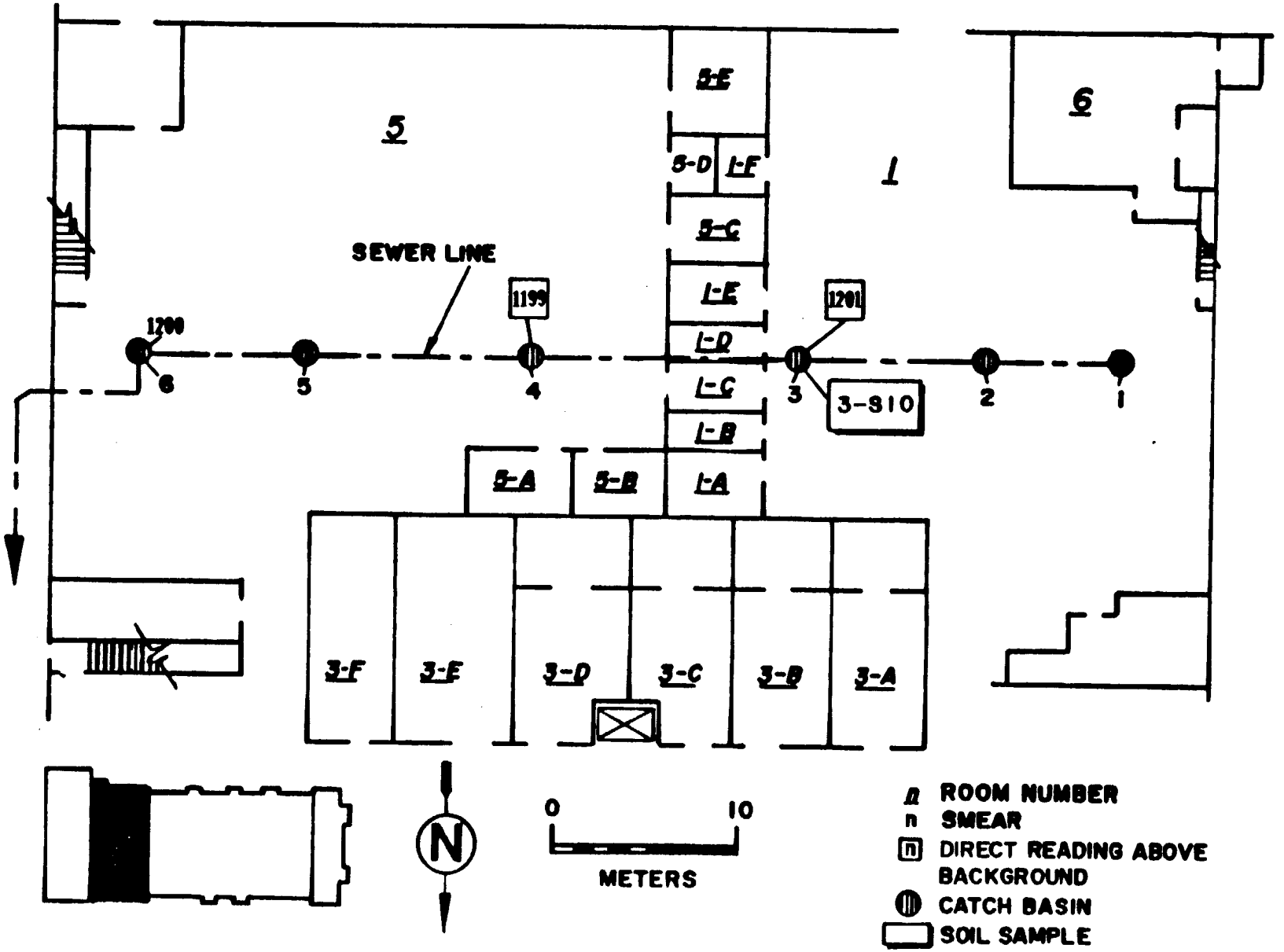


FIGURE 28

ILLINOIS NATIONAL GUARD ARMORY ENVIROMENTAL SOIL SAMPLE LOCATIONS

ANL-HP DWG.NO. 79-4

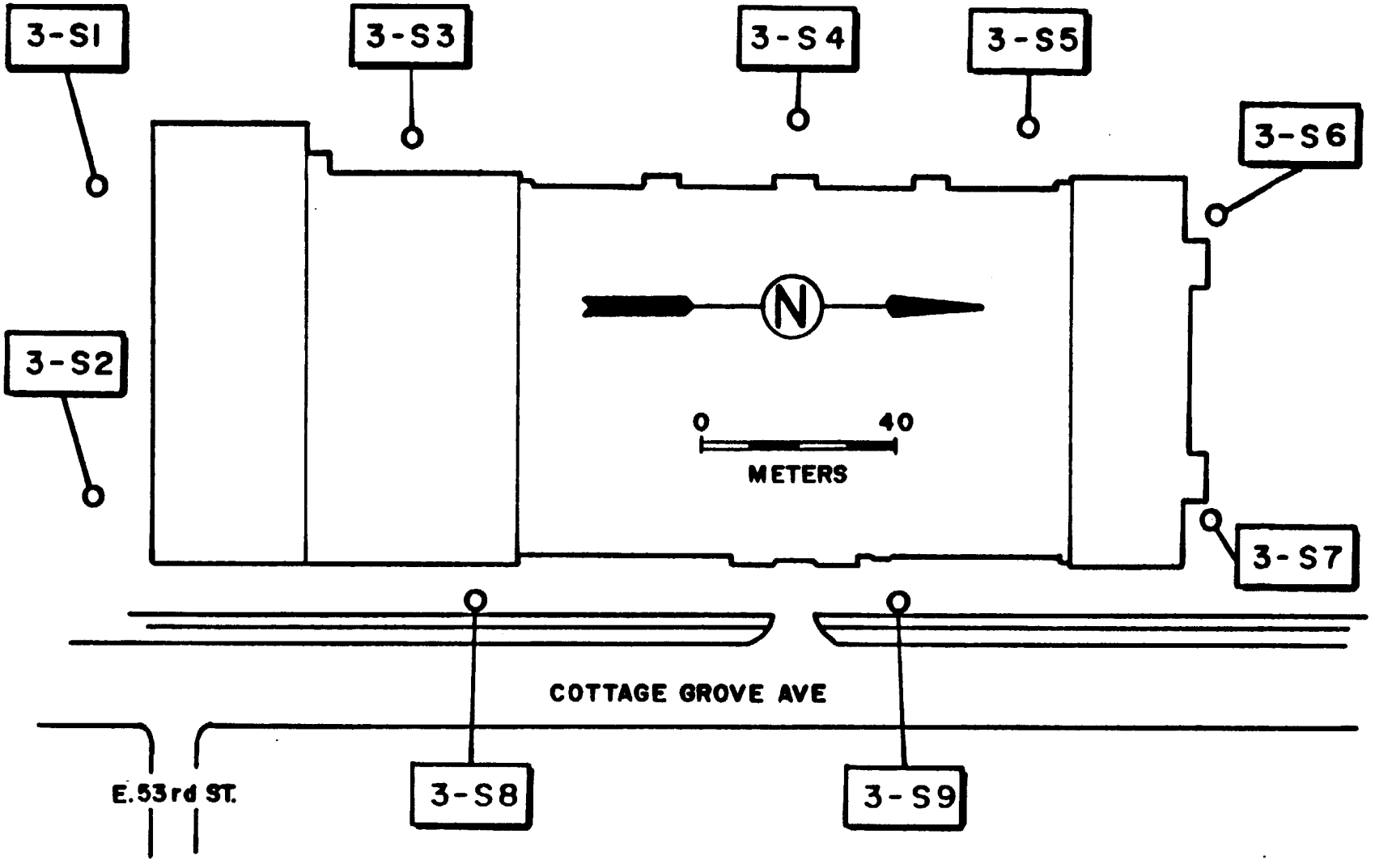


FIGURE 29

DIAGRAM OF BALLOON SMEAR APPARATUS

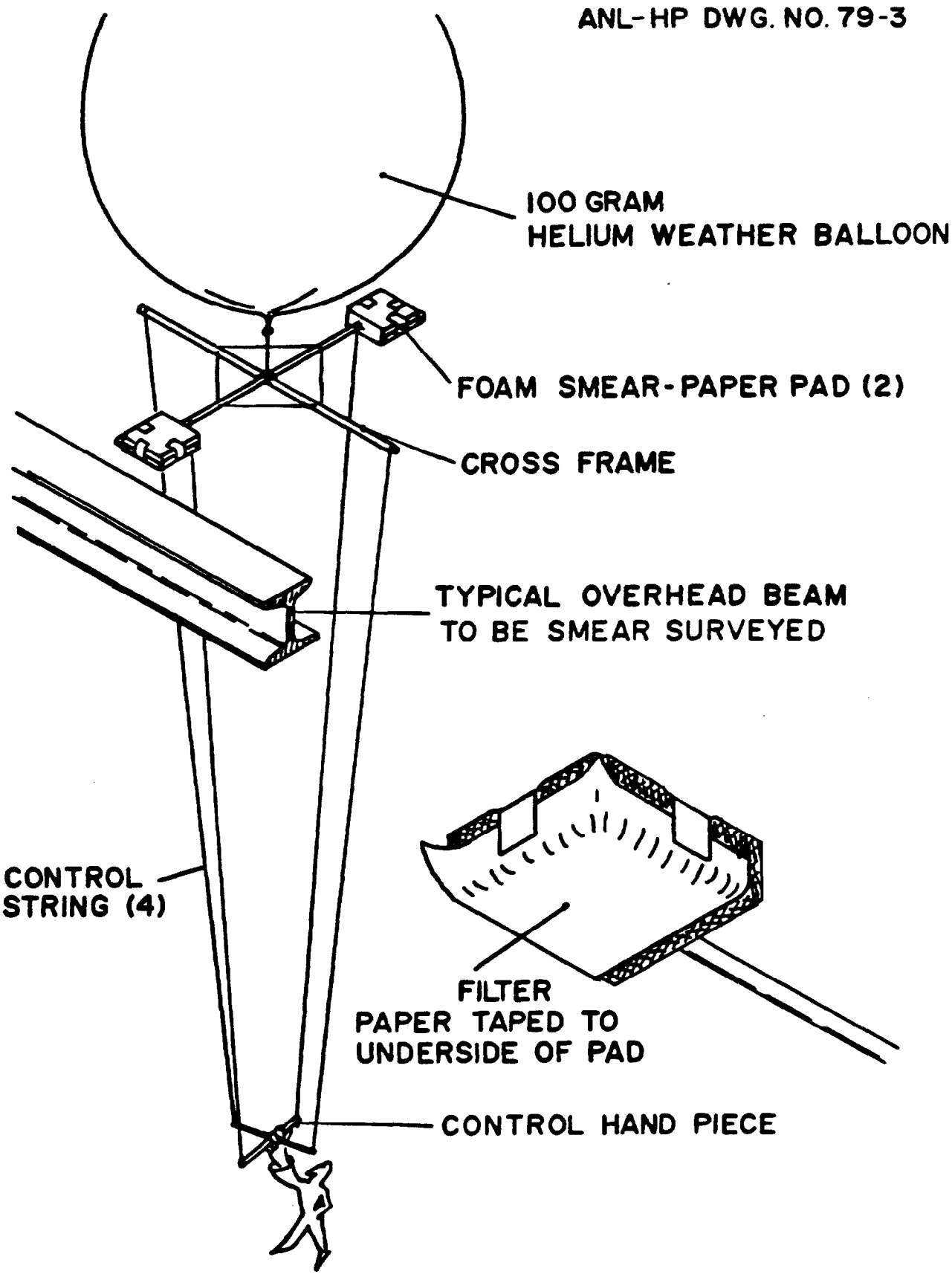


FIGURE 30

GAMMA SPECTRUM ANALYSIS OF SLUDGE

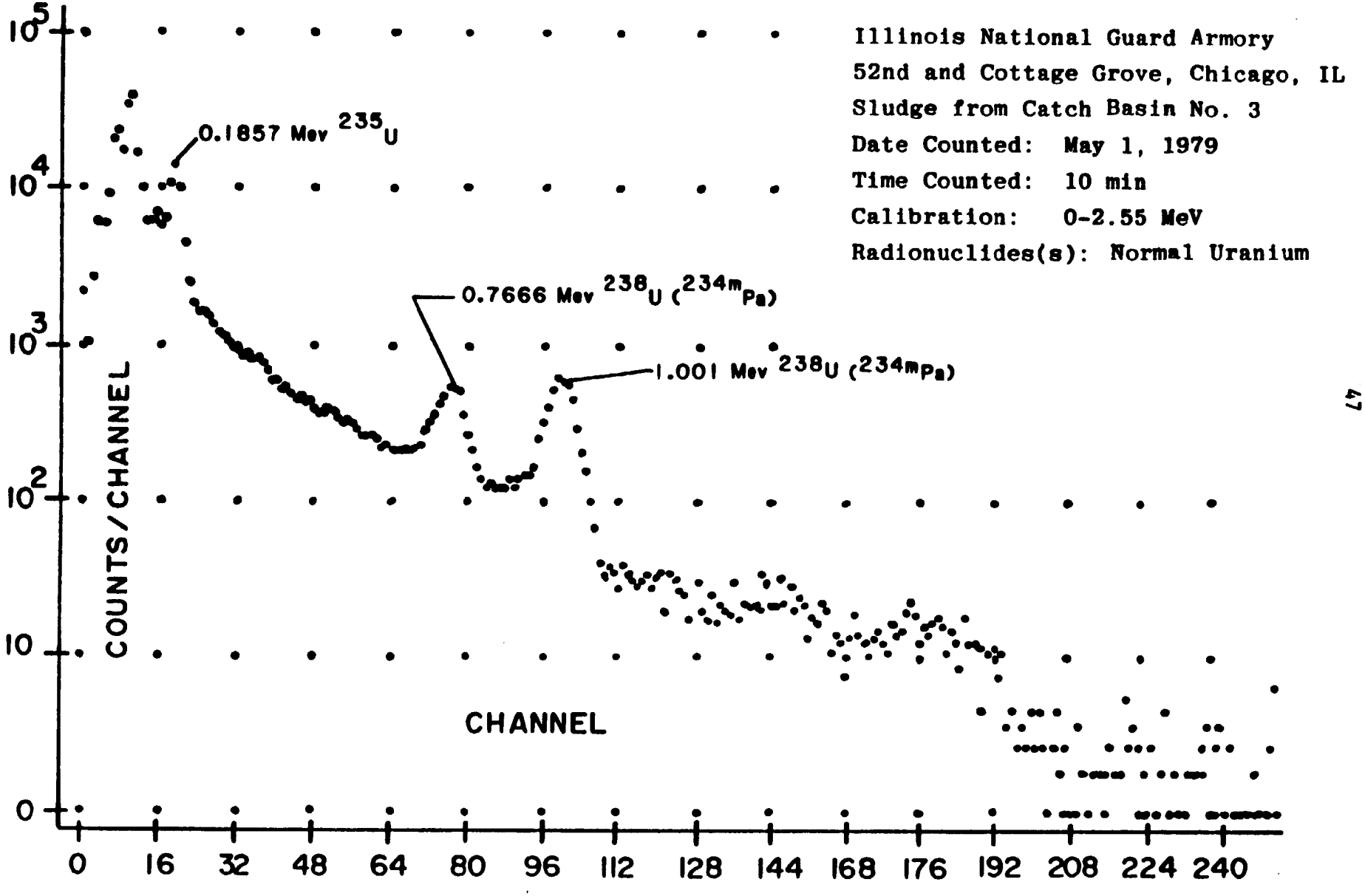


FIGURE 31

SOIL-SAMPLING PROCEDURE AND PROCESSING DIAGRAM

ANL-HP-DWG. 78-2

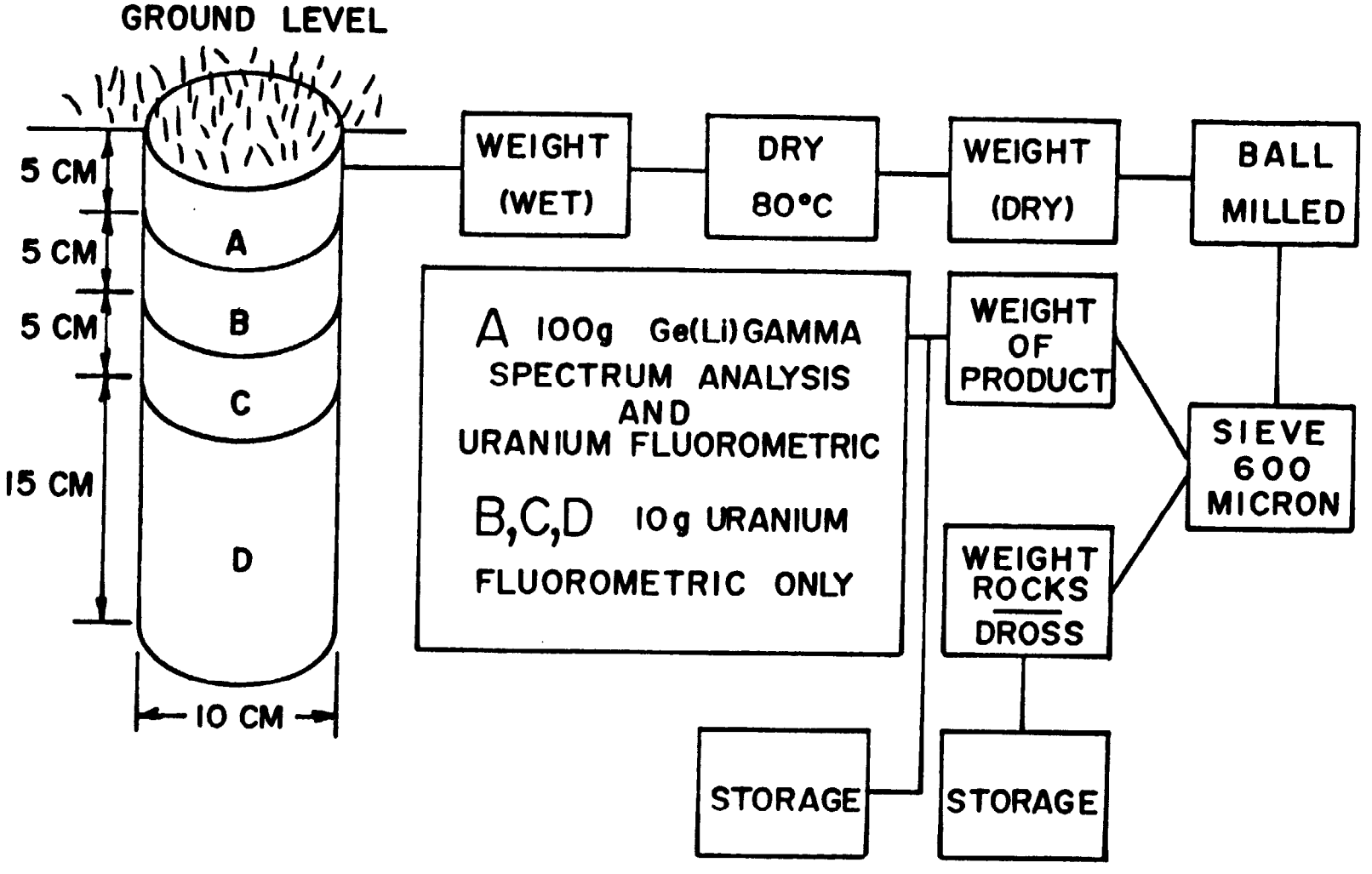


TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
1	100	95	0.0006						Air Sample 1
				2.1×10^4	BKGD[c]	0.3	BKGD	BKGD	Location 97, Spot on concrete floor
				2.0×10^4	BKGD	2.0	BKGD	BKGD	Location 98, Spot on concrete floor
				1.0×10^4	BKGD	0.1	BKGD	BKGD	Location 99, Spot on concrete floor
				1.2×10^4	3.7×10^2	0.1	BKGD	BKGD	Location 100, Spot on concrete floor
				3.4×10^4	BKGD	0.1	BKGD	BKGD	Location 101, Spot on concrete floor
				1.6×10^4	BKGD	BKGD	BKGD	BKGD	Location 102, Spot on concrete floor
				2.0×10^4	BKGD	BKGD	BKGD	BKGD	Location 103, Spot on concrete floor
				3.4×10^5	BKGD	3.0	BKGD	α =470[e] $\beta\gamma=1.3\times10^3$	Location 104, Spot on cast iron manhole cover of Catch Basin 3
				2.3×10^4	BKGD	0.12	BKGD	BKGD	Location 105, Spot on concrete pillar
				3.4×10^2	2.9×10^3	NRR[g]	NRR	α =43 $\beta\gamma$=110	Location 106, Spot on concrete overhead

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
1 (cont'd)				2.0×10^4	BKGD[c]	0.2	BKGD	BKGD	Location 107, Spot on concrete floor
				3.4×10^2	2.3×10^3	BKGD	BKGD	α =15[e] $\beta\gamma$=31	Location 108, Spot on concrete overhead
				BKGD	NA[d]	NA	NA	α =BKGD $\beta\gamma$=20	Location 109, Spot on concrete overhead
				BKGD	NA	NA	NA	α =BKGD $\beta\gamma$=46	Location 110, Spot on concrete overhead
				BKGD	NA	NA	NA	α =BKGD $\beta\gamma$=20	Location 111, Spot on concrete overhead
				BKGD	NA	NA	NA	α =BKGD $\beta\gamma$=20	Location 112, Spot on concrete overhead
				BKGD	NA	NA	NA	α =BKGD $\beta\gamma$=27	Location 113, Spot on concrete overhead
				BKGD	NA	NA	NA	α =BKGD $\beta\gamma$=24	Location 114, Spot on concrete overhead
				BKGD	NA	NA	NA	α =18 $\beta\gamma$=BKGD	Location 115, Spot on concrete overhead
				BKGD	NA	NA	NA	α =7 $\beta\gamma$=BKGD	Location 116, Spot on concrete overhead
				BKGD	NA	NA	NA	α =20 $\beta\gamma$=63	Location 117, Spot on concrete overhead

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
1 (cont'd)				6.7×10^4	5.8×10^4	0.1	BKGD[c]	$\alpha = 1.7\times10^3$[e] $\beta\gamma = 2.5\times10^3$	Location 121, Spot on concrete overhead
				BKGD	NA[d]	NA	NA	α =BKGD $\beta\gamma$=15	Location 122, Spot on concrete overhead
				BKGD	NA	NA	NA	α =BKGD $\beta\gamma$=32	Location 123, Spot on concrete overhead
				1.5×10^4	2.9×10^4	BKGD	BKGD	α =500 $\beta\gamma$=760	Location 126, Spot on concrete overhead
				3.1×10^4	6.9×10^3	BKGD	BKGD	α =175 $\beta\gamma$=140	Location 127, Spot on concrete overhead
				6.3×10^4	6.9×10^3	BKGD	BKGD	α =170 $\beta\gamma$=140	Location 128, Spot on concrete overhead
				6.3×10^4	6.9×10^3	NRR[g]	NRR	α =33 $\beta\gamma$=59	Location 129, Spot on concrete overhead (vertical beam)
				1.5×10^5	2.9×10^4	0.2	BKGD	α =140 $\beta\gamma$=250	Location 131, Spot on concrete overhead
				5.4×10^4	BKGD	NRR	NRR	α =510 $\beta\gamma$=920	Location 132, Spot on concrete overhead
				1.7×10^5	5.8×10^4	0.5	BKGD	α =710 $\beta\gamma = 1.2\times10^3$	Location 133, Spot on concrete overhead

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
1 (cont'd)				2.6×10^4	1.2×10^4	BKGD[c]	BKGD	α =90[e] $\beta\gamma$=95	Location 134, Spot on concrete overhead
				1.6×10^4	BKGD	BKGD	BKGD	α =210 $\beta\gamma$=170	Location 135, Spot on concrete overhead
				2.3×10^4	1.7×10^4	BKGD	BKGD	α =92 $\beta\gamma$=140	Location 136, Spot on concrete overhead
				5.7×10^4	1.7×10^4	0.1	BKGD	α =84 $\beta\gamma$=170	Location 137, Spot on concrete overhead
				1.5×10^5	3.5×10^4	0.1	BKGD	α =830 $\beta\gamma=1.0\times10^3$	Location 138, Spot on concrete overhead
				1.4×10^5	5.8×10^4	0.5	BKGD	α =800 $\beta\gamma=1.2\times10^3$	Location 139, Spot on concrete overhead
				1.7×10^3	BKGD	BKGD	BKGD	α =28 $\beta\gamma$=37	Location 140, Spot on concrete overhead
				3.4×10^2	BKGD	BKGD	BKGD	α =10 $\beta\gamma$=38	Location 141, Spot on concrete overhead
				3.4×10^2	BKGD	BKGD	BKGD	α =21 $\beta\gamma$=29	Location 142, Spot on concrete overhead
				3.4×10^2	BKGD	BKGD	BKGD	α =8 $\beta\gamma$=BKGD	Location 143, Spot on concrete overhead
				6.9×10^2	BKGD	BKGD	BKGD	α =10 $\beta\gamma$=BKGD	Location 144, Spot on concrete overhead

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey: Floor	Percent of Area Accessible for Survey: Wall	Air Sample (WL)	Direct Readings[a] (dis/min-100 cm²): Beta	Direct Readings[a] (dis/min-100 cm²): Alpha	End Window (mR/h): Contact	End Window (mR/h): 1 meter	Smear Results (dis/min-100 cm²)	Comments
1 (cont'd)				BKGD[c]	BKGD	NA[d]	NA	α =BKGD[e] βγ=20	Location 145, Spot on concrete overhead
				$9.3x10^3$	BKGD	BKGD	BKGD	α =23 βγ=41	Location 146, Spot on concrete overhead
				$1.1x10^4$	$2.3x10^3$	BKGD	BKGD	α =25 βγ=28	Location 147, Spot on concrete overhead
				$3.4x10^2$	BKGD	NRR	NRR	α =6 βγ=BKGD	Location 148, Spot on concrete overhead
				BKGD	BKGD	NA	NA	α =12 βγ=36	Location 149, Spot on concrete overhead
				$2.4x10^3$	BKGD	BKGD	BKGD	α =28 βγ=57	Location 150, Spot on concrete overhead
				$9.3x10^3$	BKGD	BKGD	BKGD	α =38 βγ=87	Location 151, Spot on concrete overhead
				$1.3x10^4$	BKGD	BKGD	BKGD	α =49 βγ=55	Location 152, Spot on concrete overhead (in cracks)
				BKGD	BKGD	BKGD	BKGD	α =BKGD βγ=17	Location 153, Spot on concrete overhead
				BKGD	BKGD	BKGD	BKGD	α =BKGD βγ=14	Location 154, Spot on concrete overhead
				$1.4x10^5$	$5.8x10^4$	0.5	BKGD	α =330 βγ=405	Location 155, Spot on concrete overhead

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey Floor	Wall	Air Sample (WL)	Direct Readings[a] (dis/min-100 cm²) Beta	Alpha	End Window (mR/h) Contact	1 meter	Smear Results (dis/min-100 cm²)	Comments
1 (cont'd)				1.4×10^5	5.8×10^4	0.3	BKGD[c]	$\alpha = 1.4 \times 10^3$[e] $\beta\gamma = 1.8 \times 10^3$	Location 156, Spot on concrete overhead
				BKGD	BKGD	BKGD	BKGD	$\alpha = 6$ $\beta\gamma = 42$	Location 157, Spot on concrete overhead
				BKGD	BKGD	BKGD	BKGD	$\alpha = 4$ $\beta\gamma$=BKGD	Location 158, Spot on concrete overhead
				BKGD	NA[d]	NA	BKGD	BKGD	Rest of survey was BKGD
1A	60	20	NS[b]	BKGD	NA	NA	BKGD	BKGD	
1B	10	60	NS	BKGD	NA	NA	BKGD	BKGD	
1C	40	50	NS	BKGD	NA	NA	BKGD	BKGD	
1D	10	20	NS	BKGD	NA	NA	BKGD	BKGD	
1E	40	40	0.0089	2.5×10^4	BKGD	0.1	BKGD	$\alpha = 11$ $\beta\gamma$=BKGD	Air Sample 2 Location 174, Spot on concrete floor
				BKGD	NA	NA	BKGD	BKGD	Rest of Survey was BKGD
1F	30	40	NS	BKGD	NA	NA	BKGD	BKGD	Washroom
2	100	95	0.0032	1.7×10^3	BKGD	BKGD	BKGD	BKGD	Air Sample 3 Location 232, Spot on north wall
				BKGD	NA	NA	BKGD	BKGD	Rest of Survey was BKGD

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
3 (Arena)	100	95	0.0029	BKGD[c]	NA[d]	NA	BKGD	BKGD	Air Sample 4 Locations 284-315, Arena Floor
								BKGD	Locations 316-342, Balloon smears
				BKGD	NA	NA	BKGD	BKGD	Locations 343-362, Overhead girders
				BKGD	NA	NA	BKGD	BKGD	Locations 363-370, Stairways
				BKGD	NA	NA	BKGD	BKGD	Locations 371-452, Bleachers and walls
3A	30	20	0.0193	BKGD	NA	NA	BKGD	BKGD	Air Sample 5 Store room
3B	25	10	0.0089	BKGD	NA	NA	BKGD	BKGD	Air Sample 6 Store room
3C	15	20	0.0087	BKGD	NA	NA	BKGD	BKGD	Air Sample 7 Store room
3D	10	10	0.0095	4.1×10^5	1.6×10^4	10	BKGD	NST[f]	Air Sample 8 Location 453, Radium dial on radio[h], equated to radium

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey Floor	Wall	Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2) Beta	Alpha	End Window (mR/h) Contact	1 meter	Smear Results (dis/min-100 cm^2)	Comments
3D (cont'd)				BKGD[c]	NA[d]	NA	BKGD	BKGD BKGD	Rest of survey was
3E	20	50	0.0113	BKGD	BKGD	NA	BKGD	BKGD	Air Sample 9 Store room
3F	40	30	0.0041	BKGD	BKGD	NA	BKGD	BKGD	Air Sample 10 Store room
Elevator	100	90	NS[b]	BKGD	BKGD	NA	BKGD	BKGD	Elevator to balcony
5	100	95	0.0031	1.2×10^4	BKGD	0.07	BKGD	α =BKGD[e] $\beta\gamma$=14	Location 497, Spot on concrete floor
				2.7×10^3	BKGD	BKGD	BKGD	BKGD	Location 498, Spot on concrete floor
				BKGD	NA	NA	BKGD	BKGD	Rest of survey was BKGD
5A	60	70	NS	BKGD	NA	NA	BKGD	BKGD	
5B	20	25	0.0049	2.3×10^4	BKGD	0.1	BKGD	BKGD	Air Sample 12 Location 503, Spot on concrete floor
				BKGD	NA	NA	BKGD	BKGD	Rest of survey was BKGD

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
5C	60	70	NS[b]	BKGD[c]	NA[d]	NA	BKGD	BKGD	
5D	60	70	NS	BKGD	NA	NA	BKGD	NST[f]	
5E	60	70	NS	BKGD	NA	NA	BKGD	BKGD	
6	60	50	NS	BKGD	NA	NA	BKGD	BKGD	Boiler room
Northwest Lobby	100	100	0.0056	BKGD	NA	NA	BKGD	BKGD	Air Sample 30
Ticket Office Northwest Lobby	60	30	NS	BKGD	NA	NA	BKGD	BKGD	
Northeast Lobby	100	100	0.0091	BKGD	NA	NA	BKGD	BKGD	Air Sample 31
Ticket Office Northeast Lobby	40	40	NS	BKGD	NA	NA	BKGD	NST	
101	40	35	NS	BKGD	NA	NA	BKGD	BKGD	
101A	80	70	NS	9.0×10^4	BKGD	1.0	BKGD	NST	Radio knobs[h], equated to radium

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey Floor	Wall	Air Sample (WL)	Direct Readings[a] (dis/min-100 cm²) Beta	Alpha	End Window (mR/h) Contact	1 meter	Smear Results (dis/min-100 cm²)	Comments
101A (cont'd)				BKGD[c]	NA[d]	NA	BKGD	BKGD	Rest of survey was BKGD
103-104	70	75	NS[b]	BKGD	NA	NA	BKGD	BKGD	
105	50	50	NS	BKGD	NA	NA	BKGD	BKGD	
106	65	80	NS	BKGD	NA	NA	BKGD	BKGD	
East-west corr.	100	100	NS	BKGD	NA	NA	BKGD	BKGD	
107	90	80	NS	BKGD	NA	NA	BKGD	BKGD	
108/ 108A	70	80	NS	BKGD	NA	NA	BKGD	BKGD	
109	80	80	NS	BKGD	NA	NA	BKGD	BKGD	
110	95	5	NS	BKGD	NA	NA	BKGD	BKGD	95% Wall by offset
111	90	90	NS	BKGD	NA	NA	BKGD	BKGD	
112/ 113	80	80	0.0080	BKGD	NA	NA	BKGD	BKGD	Air Sample 13
114/ 115	80	60	NS	BKGD	NA	NA	BKGD	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
116	85	80	NS[b]	BKGD[c]	NA[d]	NA	BKGD	BKGD	
117	50	70	NS	BKGD	NA	NA	BKGD	BKGD	
118	60	80	NS	BKGD	NA	NA	BKGD	BKGD	
119	90	60	NS	BKGD	NA	NA	BKGD	BKGD	
120	60	65	NS	BKGD	NA	NA	BKGD	BKGD	
121	60	50	NS	4.6×10^5	BKGD	2	BKGD	NST[f]	Location 1177[h] Radio speaker knobs, equated to radium
				BKGD	NA	NA	BKGD	BKGD	Rest of survey was BKGD
122/123 Main Floor	80	80	0.0046	BKGD	NA	NA	BKGD	BKGD	Air Sample 14
125	50	30	NS	BKGD	NA	NA	BKGD	BKGD	
136	50	40	NS	BKGD	NA	NA	BKGD	BKGD	
136A	5	15	NS	BKGD	NA	NA	BKGD	BKGD	
136B	45	20	NS	BKGD	NA	NA	BKGD	BKGD	
137	60	10	NS	BKGD	NA	NA	BKGD	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey Floor	Wall	Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2) Beta	Alpha	End Window (mR/h) Contact	1 meter	Smear Results (dis/min-100 cm^2)	Comments
139	30	30	NS[b]	BKGD[c]	NA[d]	NA	BKGD	BKGD	
140	65	50	NS	BKGD	NA	NA	BKGD	BKGD	
141	75	80	NS	8.9×10^5	9.3×10^3	8	BKGD	NST[f]	Location 1178[h], Radio control knobs, equated to radium
				BKGD	NA	NA	BKGD	BKGD	Rest of survey was BKGD
142	45	10	0.0076	BKGD	NA	NA	BKGD	BKGD	Air Sample 15
143	70	80	NS	BKGD	NA	NA	BKGD	BKGD	
144	80	60	NS	2.3×10^6	BKGD	5	BKGD	NST	Location 1179[h], Lensatic compass dial, equated to radium
				3.4×10^5	BKGD	0.1	BKGD	NST	Location 1180[h], Gas mantle
				BKGD	NA	NA	NA	BKGD	Rest of survey was BKGD
145	90	85	NS	BKGD	NA	NA	NA	BKGD	Snack Shop
146	75	85	NS	BKGD	NA	NA	NA	BKGD	
146A	2	0	NS	BKGD	NA	NA	NA	BKGD	Old barber shop used as storage area

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm²)		End Window (mR/h)		Smear Results (dis/min-100 cm²)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
147 and stairway	60	20	NS[b]	7.4×10^5	6.3×10^4	16	BKGD[c]	NST[f]	Radio knobs[h], equated to radium
				BKGD	NA[d]	NA	NA	BKGD	Rest of survey was BKGD
147A&B	80	20	NS	BKGD	NA	NA	NA	BKGD	
148	90	85	0.0091	BKGD	NA	NA	NA	BKGD	Air Sample 16
149	60	70	NS	BKGD	NA	NA	NA	BKGD	
150	100	70	NS	2.3×10^5	BKGD	6	BKGD	NST	Location 1181, Compass dial[h], equated to radium
				NRR[g]	NRR	10	BKGD	NST	Location 1182, Compass dial[h]
				BKGD	NA	NA	BKGD	BKGD	Rest of survey was BKGD
151	70	55	NS	BKGD	NA	NA	NA	BKGD	
152	80	55	NS	BKGD	NA	NA	NA	BKGD	
176	50	25	NS	BKGD	NA	NA	NA	BKGD	
178	60	10	NS	BKGD	NA	NA	BKGD	BKGD	
180	80	80	NS	BKGD	NA	NA	NA	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
East Stair 2nd Floor	100	100	NS[b]	BKGD[c]	NA[d]	NA	NA	BKGD	
201A	80	60	NS	BKGD	NA	NA	NA	BKGD	
202	80	60	0.0074	BKGD	NA	NA	NA	BKGD	Air Sample 17
202A	80	60	NS	BKGD	NA	NA	NA	BKGD	
202B	80	75	NS	BKGD	NA	NA	NA	BKGD	
202/ 203	100	100	NS	BKGD	NA	NA	NA	BKGD	
203	60	70	NS	BKGD	NA	NA	BKGD	BKGD	
204	30	40	NS	BKGD	NA	NA	BKGD	BKGD	
205	60	40	NS	BKGD	NA	NA	BKGD	BKGD	
206	55	50	NS	BKGD	NA	NA	BKGD	BKGD	
207	60	60	NS	BKGD	NA	NA	BKGD	BKGD	
208	75	90	NS	BKGD	NA	NA	BKGD	BKGD	
210	25	50	NS	BKGD	NA	NA	BKGD	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm²)		End Window (mR/h)		Smear Results (dis/min-100 cm²)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
Corridor between 210/211	100	100	NS[b]	BKGD[c]	NA[d]	NA	BKGD	BKGD	
211	55	45	NS	BKGD	NA	NA	BKGD	BKGD	
212/ 212A	35	40	NS	BKGD	NA	NA	BKGD	BKGD	
213	100	60	NS	BKGD	NA	NA	BKGD	BKGD	
214	60	65	NS	BKGD	NA	NA	BKGD	BKGD	
215	60	60	NS	BKGD	NA	NA	BKGD	BKGD	
216	60	60	NS	BKGD	NA	NA	BKGD	BKGD	
217	80	80	NS	BKGD	NA	NA	BKGD	BKGD	
218	80	80	NS	BKGD	NA	NA	BKGD	BKGD	
220	80	40	NS	BKGD	NA	NA	BKGD	BKGD	
Foyer 2nd Floor West	100	100	0.0104	BKGD	NA	NA	BKGD	BKGD	Air Sample 32
Stairs 1st to 2nd Floor west end	100	100	NS	BKGD	NA	NA	BKGD	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
221/ 221A	100	80	NS[b]	BKGD[c]	NA[d]	NA	BKGD	BKGD	
223	60	60	NS	BKGD	NA	NA	BKGD	BKGD	
224	80	80	NS	BKGD	NA	NA	BKGD	BKGD	
225	80	80	NS	BKGD	NA	NA	BKGD	BKGD	
225A	80	75	NS	BKGD	NA	NA	BKGD	BKGD	
225B	40	90	NS	BKGD	NA	NA	BKGD	BKGD	
225C	25	30	NS	BKGD	NA	NA	BKGD	BKGD	
230	60	40	NS	BKGD	NA	NA	BKGD	BKGD	
231	100	100	NS	BKGD	NA	NA	BKGD	BKGD	
231A	70	50	NS	BKGD	NA	NA	BKGD	BKGD	
232/ 233/ 234	100	40	NS	BKGD	NA	NA	BKGD	BKGD	
2nd floor north corridor	100	100	NS	BKGD	NA	NA	BKGD	BKGD	
North Balcony	100	100	NS	BKGD	NA	NA	BKGD	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
240	80	60	NS[b]	BKGD[c]	NA[d]	NA	BKGD	BKGD	
242	55	20	NS	BKGD	NA	NA	BKGD	BKGD	
244	50	50	NS	BKGD	NA	NA	BKGD	BKGD	
245	40	20	NS	BKGD	NA	NA	BKGD	BKGD	
246	100	100	0.0003	BKGD	NA	NA	BKGD	BKGD	Air Sample 18 Firing Range
246A	25	15	NS	BKGD	NA	NA	BKGD	BKGD	
246B	40	50	NS	BKGD	NA	NA	BKGD	BKGD	
2nd Floor corridor, south side	100	100	0.0027 0.0006						Air Sample 21 Air Sample 24
				1.5×10^4	BKGD	BKGD	BKGD	BKGD	Location 1080, Spot on concrete floor
				3.2×10^4	5.8×10^2	BKGD	BKGD	BKGD	Location 1081, Spot on concrete floor
				2.7×10^3	BKGD	BKGD	BKGD	BKGD	Location 1082, Spot on concrete floor

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
2nd Floor corridor, south side (cont'd.)				BKGD[c]	NA[d]	NA	BKGD	BKGD	Rest of survey was BKGD
258	30	40	NS[b]	BKGD	NA	NA	NA	BKGD	
260	50	75	0.0024						Air Sample 19
Mess Hall				1.7×10^5	BKGD	0.3	BKGD	BKGD	Location 819, Spot on concrete floor
				6.7×10^4	BKGD	0.2	BKGD	BKGD	Location 820, Spot on concrete floor
				3.1×10^5	BKGD	0.5	BKGD	BKGD	Location 821, Spot on concrete floor
				BKGD	NA	NA	BKGD	BKGD	Rest of survey was BKGD
261	50	75	NS	BKGD	NA	NA	BKGD	BKGD	
262	50	75	NS	BKGD	NA	NA	BKGD	NST[f]	
263	50	75	NS	BKGD	NA	NA	BKGD	NST	
266	70	95	NS	BKGD	BKGD	NA	NA	BKGD	
267	80	95	NS	BKGD	BKGD	NA	NA	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
269	40	60	NS[b]	BKGD[c]	BKGD	NA[d]	NA	BKGD	
270	35	60	NS	BKGD	BKGD	NA	NA	BKGD	
271	40	25	NS	BKGD	NA	NA	BKGD	BKGD	
272	65	75	NS	BKGD	NA	NA	BKGD	BKGD	
273	90	85	NS	BKGD	NA	NA	BKGD	NST[f]	
274	80	75	NS	BKGD	NA	NA	BKGD	BKGD	
275	50	50	NS	BKGD	NA	NA	BKGD	BKGD	
277/ 278	35	50	NS	BKGD	NA	NA	BKGD	BKGD	
279	30	100	NS	BKGD	NA	NA	BKGD	BKGD	
280	80	80	0.0004						Air Sample 20
				1.0×10^5	BKGD	0.1	BKGD	BKGD	Location 842, Spot on brick wall
				BKGD	NA	NA	BKGD	BKGD	
281	75	60	NS	BKGD	NA	NA	BKGD	BKGD	
282	50	70	NS	BKGD	NA	NA	BKGD	BKGD	
283	50	70	0.0008						Air Sample 22
				2.2×10^3	BKGD	BKGD	BKGD	BKGD	Location 847, Spot on concrete floor

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey Floor	Wall	Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2) Beta	Alpha	End Window (mR/h) Contact	1 meter	Smear Results (dis/min-100 cm^2)	Comments
283 (cont'd)				2.2x10^3	BKGD[c]	BKGD	BKGD	BKGD	Location 848, Spot on concrete floor
				BKGD	NA[d]	NA	BKGD	BKGD	Rest of survey was BKGD
284	90	10	0.0011						Air Sample 23
				1.5x10^4	BKGD	BKGD	BKGD	BKGD	Location 851, Spot on concrete floor
				BKGD	NA	NA	BKGD	BKGD	Rest of survey was BKGD
285	50	40	NS[b]	BKGD	NA	NA	NA	BKGD	
286	60	45	NS	BKGD	NA	NA	NA	BKGD	
287/ 288	80	80	NS	BKGD	NA	NA	NA	BKGD	
289	20	10	NS	BKGD	NA	NA	NA	BKGD	
290	75	80	NS	BKGD	NA	NA	NA	BKGD	
291	60	90	NS	BKGD	NA	NA	NA	BKGD	
292	100	100	NS	BKGD	NA	NA	NA	BKGD	
293	80	50	NS	BKGD	NA	NA	NA	BKGD	
294	70	70	NS	BKGD	NA	NA	NA	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
295	95	95	NS[b]	BKGD[c]	NA[d]	NA	NA	BKGD	
296	40	50	NS	BKGD	NA	NA	NA	BKGD	
297	30	10	0.0011	BKGD	NA	NA	NA	BKGD	Air Sample 25
298	40	45	NS	BKGD	NA	NA	NA	BKGD	
299/ 299A	80	60	NS	BKGD	NA	NA	NA	BKGD	
301 South	45	20	NS	BKGD	NA	NA	NA	BKGD	
302 South	45	40	NS	BKGD	NA	NA	NA	BKGD	
302A South	90	85	NS	BKGD	NA	NA	NA	BKGD	
303 South	50	40	NS	BKGD	NA	NA	NA	BKGD	
304 South	60	70	NS	BKGD	NA	NA	NA	BKGD	
305 South	40	35	NS	BKGD	NA	NA	NA	BKGD	
306/ 307 South	50	50	NS	BKGD	NA	NA	NA	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
308 South	50	80	NS[b]	BKGD[c]	NA[d]	NA	NA	BKGD	
310 South	70	80	0.0024	BKGD	NA	NA	NA	BKGD	Air Sample 28
311 South	35	40	NS	BKGD	NA	NA	NA	BKGD	
3rd Floor south corr.	100	90	0.0107	BKGD	NA	NA	NA	BKGD	Air Sample 27
Stairs to Gym 2nd Floor-West	80	80	NS	BKGD	NA	NA	NA	BKGD	
301 North	100	100	0.0110						Air Sample 26
				BKGD	NA	NA	NA	BKGD	Gym
302 North	70	95	NS	BKGD	NA	NA	NA	BKGD	
303 North	50	95	NS	BKGD	NA	NA	NA	BKGD	
304 North	50	85	NS	BKGD	NA	NA	NA	BKGD	

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
305 North	60	70	NS[b]	BKGD[c]	NA[d]	NA	NA	BKGD	
306 North	80	80	NS	BKGD	NA	NA	NA	BKGD	
307 North	80	80	NS	BKGD	NA	NA	NA	BKGD	
308 North	80	75	NS	BKGD	NA	NA	NA	BKGD	Area under gym bleachers
309 North	80	80	NS	BKGD	NA	NA	NA	BKGD	Northwest tower
316 North	60	80	NS	BKGD	NA	NA	NA	BKGD	Northwest tower
317 North	35	60	NS	BKGD	NA	NA	NA	BKGD	
401 South	90	90	0.0126	BKGD	NA	NA	BKGD	BKGD	Air Sample 29
Service Floor Boiler Area	80	90	0.0056	BKGD	NA	NA	BKGD	BKGD	Air Sample 33 Boiler area

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm²)		End Window (mR/h)		Smear Results (dis/min-100 cm²)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
Service Floor Large Area	90	90	0.0066	BKGD[c]	NA[d]	NA	BKGD	BKGD	Air Sample 34
South-west Utility Pit	80	60	NS[b]	BKGD	NA	NA	BKGD	BKGD	
South Roof	100	100	NS	BKGD	NA	NA	BKGD	BKGD	
South Garage (Room 2) Roof	100	100	NS	BKGD	NA	NA	BKGD	BKGD	
Drainage System for Room 1 & 5 Floors									
Catch Basin 1	0	0	NS	NRR[g]	NA	BKGD	BKGD	NST[f]	Sealed shut, in-accessible for survey
Catch Basin 2	0	0	NS	NRR	NA	BKGD	BKGD	NST	Sealed shut, in-accessible for survey

TABLE 1

DATA SHEET OF ROOM SURVEYS

Room or Area No.	Percent of Area Accessible for Survey		Air Sample (WL)	Direct Readings[a] (dis/min-100 cm^2)		End Window (mR/h)		Smear Results (dis/min-100 cm^2)	Comments
	Floor	Wall		Beta	Alpha	Contact	1 meter		
Catch Basin 3	100	100	NS[b]	5.1×10^3	NRR[g]	NRR	NRR	NST[f]	Location 1201, Area on brick catch basin
Catch Basin 4	100	100	NS	5.1×10^3	NRR	NRR	NRR	NST	Location 1199, Area on brick catch basin
Catch Basin 5	0	0	NS	NRR	NA[d]	NA	NA	NST	Sealed shut, inaccessible for survey
Catch Basin 6	100	100	NS	BKGD[c]	NA	NA	NA	NST	

FOOTNOTES FOR TABLE 1

[a]The Beta Mode Direct Readings and Alpha Mode Direct Readings are taken with PAC-4G-3 instruments (see Appendix 1). The beta mode detects both electromagnetic and particulate radiation. If an area indicated an instrument reading higher than background, a beta-mode reading was obtained. The instrument was then switched to the alpha mode, and a reading of the alpha contamination was obtained. In the alpha mode the instrument only responds to particles with high-specific ionization, such as alpha particles. The beta-mode readings were compensated for any alpha contribution by subtracting the alpha-mode reading from the beta-mode reading.

[b]NS = Not Selected. Locations of air samples were chosen on a selected basis throughout the area surveyed. "NS" indicates that the room or area was not selected for an air sample.

[c]BKGD = Background. The following are the instrument background readings:

	Beta Mode	Alpha Mode
Floor Monitor	1500-2000 cts/min-325 cm^2	0-50 cts/min-325 cm^2
PAC-4G-3	150-200 cts/min-51 cm^2	0-50 cts/min-51 cm^2
PC-5 Counter	40.0±1.4 cts/min*	0.2±0.1 cts/min*
10-Wire	443.0±4.7 cts/min*	5.2±0.5 cts/min*

GM End Window Detector read 0.03 to 0.05 mR/h at 1 m above floor.

[d]NA = Nonapplicable. No contamination was detected above background in the beta mode; therefore, no alpha mode or contact GM End Window survey was necessary.

[e]α = Alpha
$\beta\gamma$ = Beta-Gamma
(The beta-gamma readings are compensated for any alpha contamination by subtracting the alpha reading from the beta-gamma reading.)

[f]NST = No Smear Taken.

[g]NRR = No Reading Recorded.

[h]Presumably not a result of MED/AEC occupancy.

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*One standard deviation due to counting statistics.

TABLE 2

RADON DETERMINATIONS

Sample Number	Location	Figure	dis/min-m^3	pCi/ℓ	WL[a]
1	Room 1	2	123	0.06	0.0006
2	Room 1E	2	1972	0.89	0.0089
3	Room 2	3	717	0.32	0.0032
4	Room 3 (Arena)	4	648	0.20	0.0029
5	Room 3A	5	4285	1.93	0.0193
6	Room 3B	5	1973	0.89	0.0089
7	Room 3C	5	1944	0.87	0.0087
8	Room 3D	5	2112	0.95	0.0095
9	Room 3E	5	2505	1.13	0.0113
10	Room 3F	5	902	0.41	0.0041
11	Room 5	6	689	0.31	0.0031
12	Room 5B	6	1091	0.49	0.0049
13	Room 112	9	1788	0.80	0.0080
14	Room 123	10	1029	0.46	0.0046
15	Room 142	12	1679	0.76	0.0076
16	Room 148	7	2031	0.91	0.0091
17	Room 202	13	1643	0.74	0.0074
18	Room 246	17	57	0.03	0.0003
19	Room 260	16	536	0.24	0.0024
20	Room 280	19	97	0.04	0.0004
21	Corridor South at Room 282	19	605	0.27	0.0027
22	Room 283	19	170	0.08	0.0008
23	Room 284	19	245	0.11	0.0011
24	2nd Floor Corridor at Room 294	20	127	0.06	0.0006
25	Room 297	20	245	0.11	0.0011
26	Room 301 North	22	2450	1.10	0.0110

TABLE 2
(cont'd)

Sample Number	Location	Figure	dis/min-m^3	pCi/ℓ	WL[a]
27	South Corridor by Room 305	21	2387	1.07	0.0107
28	Room 310 South	21	538	0.24	0.0024
29	Room 401 South	23	2810	1.26	0.0126
30	Northwest Lobby	7	1238	0.56	0.0056
31	Northeast Lobby	8	2029	0.91	0.0091
32	2nd Floor Foyer West side	15	2302	1.04	0.0104
33	Service Floor Boiler Area	24	1238	0.56	0.0056
34	Service Floor Large Area	24	1462	0.66	0.0066

Example Calculation: Air Sample 1, Room 1

$$\frac{123 \text{ dis/min}}{\text{m}^3} \times \frac{1 \text{ pCi}}{2.22 \text{ dis/min}} \times \frac{\text{m}^3}{10^3 \text{ ℓ}} \times \frac{\text{WL}}{100 \text{ pCi/ℓ}} = 0.0006 \text{ WL}$$

[a]A Working Level (WL) is defined as any combination of short-lived radon-daughter products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy. The numerical value of the WL is derived from the alpha energy released by the total decay through RaC' of the short-lived radon-daughter products, RaA, RaB, and RaC at radioactive equilibrium with 100 pCi of ^{222}Rn per liter of air.

TABLE 3

SOIL SAMPLE WEIGHTS
(grams)

Sample Number	Wet Weight	Dry Weight	Sieved Weight	Rocks and Dross
3-S1-A	648.5	503.6	406.2	92.4
3-S1-B	727.5	567.5	554.0	10.7
3-S1-C	721.8	576.2	550.5	25.0
3-S1-D	2623.1	2131.2	2009.6	115.5
3-S2-A	568.5	432.3	362.8	68.6
3-S2-B	623.7	491.1	458.4	22.9
3-S2-C	767.5	612.3	590.2	15.3
3-S2-D	2446.6	2078.0	2018.3	56.5
3-S3-A	516.4	400.1	347.5	50.0
3-S3-B	532.5	390.0	323.5	55.6
3-S3-C	578.0	438.6	303.6	130.0
3-S3-D	2073.7	1745.3	1660.1	75.3
3-S4-A	689.1	546.8	532.1	2.6
3-S4-B	712.2	588.1	554.1	30.0
3-S4-C	838.4	702.3	650.6	42.8
3-S4-D	2362.2	2085.7	1890.3	192.7
3-S5-A	631.8	434.0	365.5	65.6
3-S5-B	712.3	548.8	519.1	25.4
3-S5-C	980.8	759.5	745.2	9.2
3-S5-D	1723.0	1341.3	1223.6	94.7
3-S6-A	566.9	398.8	295.9	99.3
3-S6-B	794.3	635.1	603.9	29.0
3-S6-C	907.1	772.7	719.6	49.5
3-S6-D	2556.5	2528.8	1849.5	372.7
3-S7-A	443.1	317.1	264.7	47.8
3-S7-B	790.8	588.0	550.0	36.2
3-S7-C	1068.3	913.5	878.5	33.0
3-S7-D	1946.5	1685.9	1554.7	126.0
3-S8-A	809.0	641.1	618.3	17.0
3-S8-B	691.3	474.0	444.6	27.1
3-S8-C	956.5	832.4	540.0	286.3
3-S8-D	2346.0	1927.6	1677.0	238.4
3-S9-A	776.0	661.0	642.7	14.0
3-S9-B	896.9	675.1	641.0	14.2
3-S9-C	769.0	670.7	623.7	40.4
3-S9-D	1477.2	1159.0	1095.5	56.1
3-S10	24.0	16.0	10.0	6.0

TABLE 4

GAMMA-RAY SPECTRAL AND URANIUM-FLUOROMETRIC ANALYSES OF SOIL SAMPLES

Sample Number	Ge(Li) Spectra pCi/g received wt ± σ[a,b]			Uranium	
	^{137}CS	^{232}Th Decay Chain	^{226}Ra Decay Chain	μg/g ± σ[a,b]	pCi/g ± σ[a,c]
3-S1-A	0.62 ± 0.05	0.28 ± 0.04	0.43 ± 0.03	5.1 ± 0.3	3.6 ± 0.2
3-S1-B				3.4 ± 0.2	2.4 ± 0.1
3-S1-C				4.8 ± 0.3	3.4 ± 0.2
3-S1-D				1.5 ± 0.2	1.0 ± 0.1
3-S2-A	0.71 ± 0.06	0.15 ± 0.06	0.57 ± 0.06	0.4 ± 0.3	0.3 ± 0.2
3-S2-B				0.5 ± 0.2	0.3 ± 0.1
3-S2-C				0.7 ± 0.3	0.5 ± 0.2
3-S2-D				<0.2	<0.1
3-S3-A	3.57 ± 0.18	0.50 ± 0.13	0.64 ± 0.10	<0.3	<0.2
3-S3-B				0.7 ± 0.4	0.5 ± 0.3
3-S3-C				1.6 ± 0.4	1.1 ± 0.3
3-S3-D				1.5 ± 0.4	1.0 ± 0.3
3-S4-A	1.26 ± 0.06	0.16 ± 0.05	0.36 ± 0.05	0.6 ± 0.3	0.4 ± 0.2
3-S4-B				0.7 ± 0.3	0.5 ± 0.2
3-S4-C				0.4 ± 0.2	0.3 ± 0.1
3-S4-D				0.4 ± 0.3	0.3 ± 0.2
3-S5-A	1.54 ± 0.08	0.35 ± 0.13	0.56 ± 0.11	1.6 ± 0.3	1.1 ± 0.2
3-S5-B				1.4 ± 0.3	1.0 ± 0.2
3-S5-C				1.1 ± 0.3	0.8 ± 0.2
3-S5-D				1.3 ± 0.3	0.9 ± 0.2
3-S6-A	2.13 ± 0.11	0.48 ± 0.11	0.68 ± 0.09	1.4 ± 0.3	1.0 ± 0.2
3-S6-B				1.5 ± 0.3	1.0 ± 0.2
3-S6-C				0.5 ± 0.2	0.3 ± 0.1
3-S6-D				0.6 ± 0.3	0.4 ± 0.2
3-S7-A	2.51 ± 0.13	0.39 ± 0.09	0.47 ± 0.07	1.6 ± 0.3	1.1 ± 0.2
3-S7-B				0.6 ± 0.3	0.4 ± 0.2
3-S7-C				0.4 ± 0.3	0.3 ± 0.2
3-S7-D				<0.3	<0.2
3-S8-A	0.91 ± 0.05	0.26 ± 0.08	0.30 ± 0.07	<0.3	<0.2
3-S8-B				0.4 ± 0.3	0.3 ± 0.2
3-S8-C				1.8 ± 0.3	1.3 ± 0.2
3-S8-D				0.9 ± 0.3	0.6 ± 0.2

TABLE 4
(cont'd)

Sample Number	Ge(Li) Spectra pCi/g received wt ± σ[a,b]			Uranium	
	^{137}CS	^{232}Th Decay Chain	^{226}Ra Decay Chain	μg/g ± σ[a,b]	pCi/g ± σ[a,c]
3-S9-A	0.90 ± 0.05	0.28 ± 0.06	0.42 ± 0.05	0.6 ± 0.4	0.4 ± 0.3
3-S9-B				0.7 ± 0.3	0.5 ± 0.2
3-S9-C				0.7 ± 0.3	0.5 ± 0.2
3-S9-D				1.7 ± 0.3	1.2 ± 0.2
3-S10[d]	3.3 ± 1.1	3 ± 1	1 ± 1	$1.5 \times 10^4 \pm 10\%$	$1.1 \times 10^4 \pm 10\%$

[a]One standard deviation due to counting statistics.

[b]All data results from LFE, except for 3-S10 from ANL. All data decay corrected to 3/30/78.

[c]ANL conversion from Appendix 5.

[d]Sample 3-S10 consisted of sludge/dirt collected from Catch Basin 3 of the floor drainage system for Rooms 1 and 5. The gamma-ray spectral analysis indicated that the sample also contained 7.4 ± 1.2 pCi/g ^{152}Eu (decay corrected to 3/30/78). Mass spectral analysis indicated that the uranium present in the sample was normal uranium.

TABLE 5

BACKGROUND SOIL SAMPLE DATA[a]
Radionuclides in Soil, 1978
(Concentration in pCi/g)

Date Collected	Locations	Cesium-137	Thorium-232	Uranium (natural)
June 23	Argonne Area[b]	0.8 ± 0.2	0.26 ± 0.02	1.0 ± 0.1
June 23	Argonne Area	0.3 ± 0.1	0.60 ± 0.04	2.2 ± 0.2
June 23	Argonne Area	1.3 ± 0.3	0.40 ± 0.03	1.3 ± 0.1
June 23	Argonne Area	1.2 ± 0.3	0.38 ± 0.03	1.5 ± 0.1
June 23	Argonne Area	1.2 ± 0.3	0.38 ± 0.3	1.7 ± 0.1
October 17	Argonne Area	3.0 ± 0.7	0.18 ± 0.02	1.2 ± 0.1
October 17	Argonne Area	1.3 ± 0.4	0.36 ± 0.04	1.0 ± 0.1
October 17	Argonne Area	1.1 ± 0.3	0.40 ± 0.04	1.2 ± 0.3
October 17	Argonne Area	1.5 ± 0.4	0.48 ± 0.04	1.3 ± 0.2
October 17	Argonne Area	1.0 ± 0.3	0.40 ± 0.02	1.5 ± 0.2
	Average	1.3 ± 0.4	0.38 ± 0.07	1.4 ± 0.2
June 16	Naperville, IL	1.2 ± 0.3	0.53 ± 0.03	1.6 ± 0.2
June 20	Channahon, IL	1.1 ± 0.3	0.36 ± 0.02	1.5 ± 0.1
June 20	Morris, IL	1.2 ± 0.3	0.27 ± 0.03	1.2 ± 0.1
June 20	Starved Rock State Park, IL	0.9 ± 0.3	0.19 ± 0.02	0.6 ± 0.1
June 21	Willow Springs, IL	0.9 ± 0.3	0.31 ± 0.03	1.4 ± 0.1
October 19	McKinley Woods State Park, IL	1.3 ± 0.4	0.39 ± 0.05	1.4 ± 0.3
October 19	Dresden Lock and Dam, IL	1.6 ± 0.5	- - - -	1.3 ± 0.1
October 20	Romeoville, IL	2.9 ± 0.7	0.42 ± 0.04	2.2 ± 0.3
October 20	Lemont, IL	0.8 ± 0.3	0.37 ± 0.04	1.1 ± 0.1
October 20	McGinnis Slough, IL	1.3 ± 0.4	0.37 ± 0.04	1.6 ± 0.1
October 20	Saganashkee Slough, IL	1.1 ± 0.3	0.37 ± 0.04	1.8 ± 0.1
	Average	1.3 ± 0.3	0.36 ± 0.06	1.4 ± 0.2

[a]These results are transcribed from "Environmental Monitoring at Argonne National Laboratory: Annual Report for 1978" (ANL-79-24) by N. W. Golchert, T. L. Duffy, and J. Sedlet.

[b]All samples marked "Argonne Area" were collected at Argonne National Laboratory near Lemont, IL, southwest of Chicago.

TABLE 6

LOCATIONS WHERE MED/AEC RESIDUAL CONTAMINATION EXCEEDED ACCEPTABLE LIMITS[a,b]

Room Number	Location Number	Estimated Area of Contamination (cm^2)	Maximum PAC Reading (dis/min-100 cm^2)		Contact GM Reading (mR/h)	Smear Results (dis/min-100 cm)	
			Beta-Gamma	Alpha		Beta-Gamma	Alpha
1	97	300	$2.1x10^4$	BKGD[c]	0.3	BKGD	BKGD
	98	300	$2.1x10^4$	BKGD	2.0	BKGD	BKGD
	99	300	$1.0x10^4$	BKGD	0.1	BKGD	BKGD
	100	300	$1.2x10^4$	$3.7x10^2$	0.1	18	6
	101	300	$3.4x10^4$	BKGD	0.1	BKGD	BKGD
	102	300	$1.6x10^4$	BKGD	BKGD	BKGD	BKGD
	103	300	$2.0x10^4$	BKGD	BKGD	BKGD	BKGD
	104	300	$3.4x10^5$	BKGD	3.0	$1.3x10^3$	470
	105	300	$2.3x10^4$	BKGD	0.12	BKGD	BKGD
	107	300	$2.0x10^4$	BKGD	0.2	BKGD	BKGD
	121	2000[d]	$6.7x10^4$	$5.8x10^4$	0.1	$2.5x10^3$	$1.7x10^3$
	126	500[d]	$1.5x10^4$	$2.9x10^4$	BKGD	760	500
	127	500[d]	$3.1x10^4$	$6.9x10^3$	BKGD	140	175
	128	500[d]	$6.3x10^4$	$6.9x10^3$	BKGD	140	170
	129	500[d]	$6.3x10^4$	$6.9x10^3$	--	59	33
	131	500[d]	$1.5x10^5$	$2.9x10^4$	0.2	250	140
	132	500[d]	$5.4x10^4$	BKGD	--	920	510
	133	500[d]	$1.7x10^5$	$5.8x10^4$	0.5	$1.2x10^3$	710
	134	500[d]	$2.6x10^4$	$1.2x10^4$	BKGD	95	90
	135	500[d]	$1.6x10^4$	BKGD	BKGD	170	210
	136	500[d]	$2.3x10^4$	$1.7x10^4$	BKGD	140	92
	137	500[d]	$5.7x10^4$	$1.7x10^4$	0.1	170	84
	138	500[d]	$1.5x10^5$	$3.5x10^4$	0.1	$1.0x10^3$	830
	139	500[d]	$1.4x10^5$	$5.8x10^4$	0.5	$1.2x10^3$	800
	146	500[d]	$9.3x10^3$	BKGD	BKGD	41	23
	147	500[d]	$1.1x10^4$	$2.3x10^3$	BKGD	28	25
	151	500[d]	$9.3x10^3$	BKGD	BKGD	87	38
	152	500[d]	$1.3x10^4$	BKGD	BKGD	55	49

TABLE 6 (continued)

Room Number	Location Number	Estimated Area of Contamination (cm^2)	Maximum PAC Reading (dis/min-100 cm^2)		Contact GM Reading (mR/h)	Smear Results (dis/min-100 cm)	
			Beta-Gamma	Alpha		Beta-Gamma	Alpha
	155	500[d]	$1.4x10^5$	$5.8x10^4$	0.5	405	330
	156	500	$1.4x10^5$	$5.8x10^4$	0.3	$1.8x10^3$	$1.4x10^3$
1E	174	300	$2.5x10^4$	BKGD	0.1	BKGD	11
5	497	300	$1.2x10^4$	BKGD	0.07	14	BKGD
5B	503	300	$2.3x10^4$	BKGD	0.1	BKGD	BKGD
2nd Floor	1080	300	$1.5x10^4$	BKGD	BKGD	BKGD	BKGD
Corr.	1081	300	$3.2x10^4$	$5.8x10^2$	BKGD	BKGD	BKGD
260	819	10^4	$1.7x10^5$	BKGD	0.3	BKGD	BKGD
	820	10^4	$6.7x10^4$	BKGD	0.2	BKGD	BKGD
	821	10^4	$3.1x10^5$	BKGD	0.5	BKGD	BKGD
280	842	300	$1.0x10^5$	BKGD	0.1	BKGD	BKGD
284	851	300	$1.5x10^4$	BKGD	BKGD	BKGD	BKGD
Drainage System for Room 1 and 5 Floors	1199	10^4	$5.1x10^3$	--	--	--	--
	1201	10^4	$5.1x10^3$	--	--	--	--

[a]Locations are indicated in Table 1 and Figures 2-26.

[b]The surface contamination limits for uranium as given in the ANSI Standard N13.12 and the average and maximum radiation levels at 1 cm as given in the NRC Guidelines were used as the standards for "acceptable levels" of contamination.

[c]BKGD = Background.

[d]Estimated area of higher readings. Total area of contaminated overheads is estimated as 200 m^2.

TABLE 7

ESTIMATED VOLUME, MASS, AND ACTIVITY OF MATERIAL THAT COULD BE GENERATED BY REMEDIAL ACTION[a]

Type of Material	Estimated Volume (m^3)	Estimated Mass (kg)	Estimated Activity (μCi)
Concrete[b] (ρ=2.35)	1.0×10^{1}	2.4×10^{4}	2.9×10^{1}
Brick (ρ=2.2)	1.1×10^{-1}	2.3×10^{2}	5.9×10^{-1}
Iron (ρ=7.8)	8.7×10^{-3}	6.8×10^{1}	4.6×10^{-1}
Total	1.05×10^{1} m^3	2.5×10^{4} kg	3.0×10^{1} μCi

[a]See text for assumptions upon which estimates are based.

[b]The assumed density for the purpose of calculating mass of material.

APPENDIX 1

INSTRUMENTATION

I. PORTABLE RADIATION SURVEY METERS

A. Gas-Flow Proportional Survey Meters

The Eberline PAC-4G-3 was the primary instrument used for surveying. This instrument is a gas-flow proportional alpha counter which utilizes a gas-proportional probe, 51 cm^2 (PAC-4G-3) or 325 cm^2 (FM-4G) in area, with a thin double-aluminized Mylar window (~0.85 mg/cm^2).

Since this instrument has three high-voltage positions, it can be used to distinguish between alpha and beta-gamma contamination. This instrument was initially used in the beta mode. In the beta mode, the detector responds to alpha and beta particles and x- and gamma-rays. When areas indicated a higher count rate than the average instrument background, the beta-mode reading was recorded, and the instrument was then switched to the alpha mode to determine any alpha contribution. In the alpha mode, the instrument only responds to particles with high specific ionization. This instrument is calibrated in the alpha mode with a flat-plate infinitely thin NBS traceable ^{239}Pu standard, and in the beta mode with a flat-plate infinitely thin NBS traceable ^{90}Sr-^{90}Y standard. The PAC-4G-3 instruments are calibrated to an apparent 50% detection efficiency.

B. Beta-Gamma End Window Survey Meter

When an area of contamination is found with a PAC instrument, a reading is taken with an Eberline Beta-gamma Geiger-Mueller Counter Model E-530 with a HP-190 probe. This probe has a thin mica end window and is, therefore, sensitive to alpha and beta particles and x- and gamma-rays. A thin piece of aluminum is added to the mica, thus making the window density ~7 mg/cm^2. At this density, the instrument is not sensitive to alpha particles. A maximum reading is obtained with the probe placed in contact with the area of contamination. In this position, the response (in mR/h) to gamma radiation is generally conservative relative to a determination of mrad/h at 1 cm; however, the response (in mR/h) to beta radiation is nonconservative by a factor of up to about four relative to a determination of mrad/h through 7 mg/cm^2. Another reading is obtained with the probe held 1 m from the contaminated area. This instrument is calibrated in mR/h with a ^{226}Ra standard source.

C. Low-Energy Gamma Scintillation Survey Meter

An Eberline Pulse Rate Meter Model PRM-5-3 with a PG-2 Low Energy Gamma Scintillation Detector was used to detect low-energy x and gamma radiation. The detector consists of a thin scintillation crystal, 5.1 cm in diameter by 2 mm thick NaI(Tl) with a 0.025-mm-thick aluminum window. (~7 mg/cm^2). This instrument is calibrated with NBS traceable ^{239}Pu, ^{241}Am, and ^{235}U sources.

D. High-Energy Micro "R" Scintillation Survey Meter

An Eberline Micro-R meter, Model PRM-7, was used to detect high-energy gamma radiation. This instrument contains an internally mounted 2.5-cm diameter by 2.5-cm-long NaI(Tl) scintillation crystal and can be used for counting fields of low-level radiation from 10 to 5000 μR/h. This instrument is calibrated with an NBS traceable ^{137}Cs source.

II. SMEAR-COUNTING INSTRUMENTATION

The 10-Wire instrument consists of a gas-flow proportional probe (ANL design) which uses an Eberline Mini Scaler Model MS-2. The double-aluminized Mylar probe (400 cm^2) uses P-10 (90% argon and 10% methane) as the counting gas. This system consists of two Mini Scalers and two probes. One is used for counting in the alpha mode; the other is used in the beta mode. The metal smear holder has been machined so that it can hold ten smears. The probe is placed over the smears and a count is taken.

All smears of contaminated areas are counted in a Nuclear Measurements Corporation PC-5 Gas-Flow Proportional Counter (PC counter) using a double-aluminized Mylar spun top. The Mylar spun top is placed over nonconducting media such as paper to negate the dielectric effect. This counter also uses P-10 counting gas. Smears are counted in both the alpha and beta modes of the detector. These instruments are calibrated using ^{239}Pu and ^{90}Sr-^{90}Y NBS traceable sources.

III. AIR-SAMPLING DEVICE

The air samples were collected with a commercial vacuum cleaner modified at ANL. The air was drawn at a flow rate of 40 m^3/h. The collection medium consisted of a 200 cm^2 sheet of Hollingsworth-Vose (HV-70-0.23 mm) filter paper. The collection efficiency at this flow rate for 0.3-micron particles is about 99.9%.

IV. GAMMA-SPECTRAL INSTRUMENTATION

A Nuclear Data Multichannel Analyzer Model ND-100 with a 7.6 cm diameter by 7.6 cm long NaI(Tℓ) crystal, was used to determine the gamma spectrum. This instrument was calibrated with NBS traceable sources. Samples of contaminated areas were counted with the analyzer, and the radionuclides of contamination were determined.

V. INSTRUMENTATION USED IN SURVEY

	Inventory Number	Probe Area	Window Thickness, mg/cm^2
Eberline Floor Monitor FM-4G using a PAC-4G-3	181501	325 cm^2	~0.85

	Inventory Number	Probe Area	Window Thickness mg/cm^2
Eberline Floor Monitor FM-4G using a PAC-4G-3	183413	325 cm^2	~0.85
PAC-4G-3	183414	51 cm^2	~0.85
PAC-4G-3	183415	51 cm^2	~0.85
PAC-4G-3	183416	51 cm^2	~0.85
PAC-4G-3	184339	51 cm^2	~0.85
PAC-4G-3	184340	51 cm^2	~0.85
PAC-4G-3	184341	51 cm^2	~0.85
Eberline 530 with HP-190 Beta-Gamma End Window Probe	184576	-	~7
Eberline Pulse Rate Meter Model PRM-5-3 with a Model PG-2 Low-Energy Gamma Detector	184344	5 cm x 2 mm NaI(Tl)	~7
Eberline Micro-R meter Model PRM-7	188537	2.5 cm x 2.5 cm NaI(Tl)	
Nuclear Measurements Corp. PC-5 2π Internal-Gas-Flow Counter	184065	-	~0.85
Argonne National Laboratory 10-Wire Flat-Plate Gas-Flow Proportional Detector Eberline Mini Scaler MS-2	184342 & 184343	400 cm^2	~0.85
Argonne National Laboratory Filter Queen Air Sampler using HV-70 filter media	-	-	-
Nuclear Data Multichannel Analyzer Model ND-100 with 7.6 cm dia x 7.6 cm NaI(Tl) crystal	184764	-	-

VI. AVERAGE INSTRUMENT BACKGROUND READINGS

Instrument	Alpha Mode (cts/min)	Beta Mode (cts/min)	1 m above floor
Eberline Floor Monitor FM-4G using PAC-4G-3			
181501	0-50	1500-2000	
183413	0-50	1500-2000	

APPENDIX 1
(cont'd)

Instrument	Alpha Mode (cts/min)	Beta Mode (cts/min)	1 m above floor
Eberline PAC-4G-3			
183414	0-50	150-200	
183415	0-50	150-200	
183416	0-50	150-200	
184339	0-50	150-200	
184340	0-50	150-200	
184341	0-50	150-200	
Eberline 530 With HP-190 Beta-Gamma End Window Probe			0.03-0.05 mR/h
Eberline Pulse Rate Meter Model PRM-5-3 with a Model PG-2 Low Energy Gamma Detector			500 cts/min
Eberline Micro R Meter Model PRM-7			5-7 μR/h
Nuclear Data Multichannel Analyzer Model 100	-	-	
Nuclear Measurements Corporation PC-5 2π Internal Gas-Flow Counter	0.2±0.1[b]	40.0±1.4[b]	
Argonne National Laboratory 10-Wire Flat-Plate Gas-Flow Proportional Detector with Eberline Mini Scaler MS-2	5.2±0.5	443.0±4.7	

[a]Background readings were initially taken in the mobile laboratory and rechecked throughout the various areas while surveying.

[b]One standard deviation due to counting statistics.

APPENDIX 2

CONVERSION FACTORS

I. INSTRUMENTATION

The conversion factors used to convert the instrument readings into units of disintegrations per minute per 100 cm^2 (dis/min-100 cm^2) and the derivation of those factors are given below.

A. Conversion Factors

	PAC-4G-3		Floor Monitor (FM-4G)	
	Alpha	Beta	Alpha	Beta
To 100 cm^2	1.96	1.96	0.31	0.31
cts/min to dis/min ^{239}Pu	2	-	2	-
cts/min to dis/min ^{90}Sr-^{90}Y	-	2	-	2
cts/min to dis/min for normal uranium	5.9	3.5	5.9	3.5
cts/min to dis/min ^{226}Ra plus daughters	1.6	4.7	-	-

B. Derivation of Conversion Factors

- Floor Monitor (FM-4G)

  Window Area: ~325 cm^2
  Conversion to 100 cm^2 = 0.31 times Floor Monitor readings

- PAC-4G-3

  Window Area: ~51 cm^2
  Conversion to 100 cm^2 = 1.96 times PAC reading

- 2π Internal Gas Flow Counter, PC-5

  Geometry: Solid Steel Spun Top - 0.50

  Geometry: Mylar Spun Top - 0.43
  Mylar spun top counting [double-aluminized Mylar window (~0.85 mg/cm^2)] utilizes the well of the PC-5 and is a method developed and used by the Argonne National Laboratory Health Physics Section for negating the dielectric effect in counting samples on nonconducting media.

With a 3.2 x 3.2 x 0.3 cm normal uranium plate as a source of uranium-alpha emissions, the plate was counted in the well of a 2π Internal-Gas-Flow Counter (PC Counter) with the source leveled to an apparent 2π geometry. The alpha reading was found to be 4.7×10^4 cts/min, or $4.7 \times 10^4 \div 0.50 = 9.4 \times 10^4$ dis/min with the PC Counter.

The same uranium source, when counted in the alpha mode of the PAC instrument, was found to be 1.6×10^4 cts/min at contact. The conversion factor for cts/min to dis/min for the PAC instrument is $9.4 \times 10^4 \div 1.6 \times 10^4 = 5.9$ dis/min alpha to cts/min alpha.

The same normal uranium source covered with two layers of conducting paper, each 6.65 mg/cm^2 to absorb the alpha emissions, was counted for composite beta and gamma emissions in the PC counter; however, no provision was made for backscatter. The composite beta-gamma count was found to be 5.2×10^5 cts/min or $5.2 \times 10^5 \div 0.50 = 1.04 \times 10^6$ dis/min beta-gamma.

The covered normal uranium source, when centered on the probe and counted in the beta mode with the PAC instrument, gave 3.0×10^5 cts/min. The conversion factor for cts/min to dis/min is $1.04 \times 10^6 \div 3.0 \times 10^5 = 3.5$ dis/min beta-gamma to cts/min beta gamma.

A similar method was used to determine the conversion factors for ^{226}Ra plus daughters.

II. SMEAR COUNT

The conversion factors for cts/min-100 cm^2 to dis/min-100 cm^2 for smears are given below.

A. Conversion Equation (Alpha)

$$\frac{\text{cts/min - (Bkgd)}}{g \cdot bf \cdot sa \cdot waf} = \text{dis/min } \alpha$$

A geometry (g) of 0.43 is standard for all flat-plate counting using the Mylar spun top.

A backscatter factor (bf) of 1.0 is used when determining alpha activity on a filter media.

The self-absorption factor (sa) was assumed to be 1, unless otherwise determined.

If the energies of the isotope were known, the appropriate window air factor (waf) was used; if the energies of the isotopes were unknown, the (waf) of ^{239}Pu (0.713) was used.

The (waf) for normal-uranium alphas is 0.54.

The (waf) for alphas from ^{226}Ra plus daughters is 0.55.

B. Conversion Equation (Beta)

$$\frac{\text{cts/min} - [\text{Beta Bkgd (cts/min)} + \alpha\ \text{cts/min}]}{g \cdot bf \cdot sa \cdot waf} = \text{dis/min}\ \beta$$

A geometry (g) of 0.43 is standard for all flat-plate counting using the Mylar spun top.

A backscatter factor (bf) of 1.1 is used when determining beta activity on a filter media.

A self-absorption factor (sa) was assumed to be 1, unless otherwise determined.

If the energies of the isotopes were known, the appropriate window air factor (waf) was used; if the energies of the isotopes were unknown, the (waf) of ^{90}Sr-^{90}Y (0.85) was used.

The (waf) for normal-uranium betas is 0.85.

The (waf) for betas from ^{226}Ra plus daughters is 0.85.

APPENDIX 3

RADON-DETERMINATION CALCULATIONS

The air-sampling calculations for samples collected with an Argonne National Laboratory-designed air sampler with HV-70 filter media are summarized in this appendix. The appendix includes the basic assumptions and calculations used to derive the air concentrations.

I. RADON CONCENTRATIONS BASED ON RaC' RESULTS

The following postulates are assumed in deriving the radon-222 (^{222}Rn) concentrations as based on the RaC' alpha count results:

A. RaA, RaB, RaC, and RaC' are in equilibrium.

B. RaA is present only in the first count and not the 100-minute decay count.

C. One-half of the radon progeny is not adhered to airborne particulates and therefore is not collected on the filter media.

D. The geometry factor (g) is 0.43 for both the alpha and beta activity.

E. The backscatter factor (bf) of 1.0 is used for the alpha activity, which is determined from RaC'.

F. The sample absorption factor (sa) for RaC' is 0.77.

G. The window air factor (waf) for RaC' is 0.8.

H. RaB and RaC, being beta emitters, are not counted in the alpha mode.

I. The half-life of the radon progeny is approximately 36 minutes, based on the combined RaB and RaC half-lives.

J. No long-lived alpha emitters are present, as evidenced by the final count.

K. For all practical purposes, RaC' decays at the rate of the composite of RaB and RaC, which is about 36 minutes.

II. EQUATIONS USED TO DERIVE AIR CONCENTRATIONS

The activity present at the end of the sampling period is determined by the equation:

$$A_o = \frac{A}{e^{-\lambda t}}$$

Where: A_o = Activity (dis/min) present at the end of the sampling period (usually 40 min)

A = Activity (dis/min) at some time, t, after end of sampling period

t = Time interval (min) from end of sampling period to counting interval (usually ~ 100 min)

$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

$t_{\frac{1}{2}}$ = Half-life of isotope (min)

Concentration (C) is determined by the equation:

$$C = \frac{A_o \lambda}{f} \cdot \frac{1}{1-e^{-\lambda t_s}}$$

Where: C = Concentration (dis/min-m^3)

A_o = Activity on filter media at end of sampling period (dis/min)

f = Sampling rate (m^3/min = m^3/h x 1h/60 min)

t_s = Length of sampling time (min)

$\lambda = \frac{0.693}{t_{\frac{1}{2}}}$

$t_{\frac{1}{2}}$ = Half-life of isotope or controlling parent (min).

III. EXAMPLE CALCULATION

Data obtained from air sample 4, collected in Room 3, have been used to illustrate the application of the equations for determining activity and concentration.

$$A_o = \frac{876}{\exp \frac{-0.693 \cdot 100}{36}} = 6004 \text{ dis/min}$$

$$C = \frac{6004 \cdot \frac{0.693}{36}}{40/60} \cdot \frac{1}{1 - \exp \frac{-0.693 \cdot 40}{36}}$$

$$= 324 \text{ dis/min-m}^3.$$

Since we assume that half of the radon progeny is not adhered to the airborne particulates, the above concentration is multiplied by a factor of two to determine the actual concentration:

C actual = C measured x progeny correction factor

= 324 dis/min-m^3 x 2 = 648 dis/min-m^3

The resultant concentration is thus 648 dis/min-m^3.

APPENDIX 4

SOIL-ANALYSIS PROCEDURE FOR TOTAL URANIUM AND GAMMA-EMITTING NUCLIDES*

A 60-milliliter volume of the received soil was counted in a petri dish for 500 minutes on a Ge(Li) detector over the energy range 0-1.5 MeV. This corresponded to 60-100 g of soil, depending upon bulk soil density. Positive photopeaks above instrument background were converted to dis/min using a line efficiency curve based upon a National Bureau of Standards Multi-Gamma standard. The natural thorium-232 (^{232}Th) and radium-226 (^{226}Ra) decay chains were calculated using the 0.910 MeV actinium-228 (^{228}Ac) and 0.609 MeV bismuth-214 (^{214}Bi) photopeaks, respectively. Cesium-137 is reported for each sample as a representative gamma emitter. Potassium-40 (^{40}K) was observed on all soil samples, as expected, but was not calculated or reported.

One gram of the soil sample was ashed and dissolved in $HF-HNO_3$ for the total uranium analysis. A 100-λ aliquot of the dissolved sample was fused with 98% NaF-2% LiF and the fluorescence determined using a Jarrell-Ash fluorometer. A quenching factor was determined for each sample by using an internal spike.

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*The procedures used by LFE Environmental Analysis Laboratories to analyze the soil samples collected near the National Guard Armory.

APPENDIX 5

CALCULATION OF NORMAL-URANIUM SPECIFIC ACTIVITY

Radioactive half-lives of ^{234}U, ^{235}U, and ^{238}U, as well as the percent abundance for each isotope, were obtained as current best values from the "Table of Isotopes"--6th Edition by C.M. Lederer, J.M. Hollander, and I. Perlman, 1967. The values used are:

Isotope	Half-life (years)	% Abundance
^{234}U	2.47×10^5	0.0057
^{235}U	7.1×10^8	0.7196
^{238}U	4.51×10^9	99.2760
		100.0013

Note that the abundance totals 100.0013%. Since it cannot be determined which isotope(s) are in error, the calculations are made with the 0.0013% error unaccounted for.

Specific activity, or activity per unit mass, is determined by the equation:

$$SpA = \lambda N$$

where: SpA = Specific Activity

$\lambda = \ell n 2 / t_{\frac{1}{2}}$

N = Number of radioactive atoms per unit mass

$$= \frac{\text{Avogadro's Number}}{\text{gram atomic weight}}$$

Avogadro's Number = 6.025×10^{23}

$t_{\frac{1}{2}}$ = Half-life in years (a)

Therefore:

$$SpA = (\ell n 2) N / t_{\frac{1}{2}}$$

$$= \frac{0.693 \times 6.025 \times 10^{23}}{t_{\frac{1}{2}}(a) \times 5.256 \times 10^5 \frac{\text{min}}{a} \times \text{gram atomic weight}} = \text{dis/min-gram.}$$

For ^{234}U, the specific activity would be:

$$\text{SpA } ^{234}U = \frac{0.693 \times 6.025 \times 10^{23}}{2.47 \times 10^{5} \times 5.256 \times 10^{5} \times 2.34 \times 10^{2}}$$

$= 1.374 \times 10^{10}$ dis/min-gram

$= 1.374 \times 10^{4}$ dis/min-µg $\times 5.70 \times 10^{-5}$

= 0.783 dis/min-µg of normal uranium.

For ^{235}U, the specific activity would be:

$$\text{SpA } ^{235}U = \frac{0.693 \times 6.025 \times 10^{23}}{7.1 \times 10^{8} \times 5.256 \times 10^{5} \times 2.35 \times 10^{2}}$$

$= 4.76 \times 10^{6}$ dis/min-gram

$= 4.76$ dis/min-µg $\times 7.196 \times 10^{-3}$

= 0.034 dis/min-µg of normal uranium.

For ^{238}U, the specific activity would be:

$$\text{SpA } ^{238}U = \frac{0.693 \times 6.025 \times 10^{23}}{4.51 \times 10^{9} \times 5.256 \times 10^{5} \times 2.38 \times 10^{2}}$$

$= 7.4 \times 10^{5}$ dis/min-gram

$= 0.74$ dis/min-µg $\times 9.9276 \times 10^{-1}$

= 0.735 dis/min-µg of normal uranium.

Therefore, the activity of 1 µg of normal uranium is

0.783 dis/min ^{234}U + 0.034 dis/min ^{235}U + 0.735 dis/min ^{238}U

= 1.552 dis/min-µg.

Conversion of µg/g to pCi/g

$$= \frac{1.552 \text{ dis/min-µg}}{2.22 \text{ dis/min-pCi}}$$

= 0.6991 pCi/µg normal uranium

Example Calculation: 3-S1-A

5.1 ± 0.3 µg/gram x 0.6991 pCi/µg = 3.6 ± 0.2 pCi/gram.

APPENDIX 6

PERTINENT RADIOLOGICAL REGULATIONS STANDARDS, AND GUIDELINES

I. **Excerpts From**

DRAFT AMERICAN NATIONAL STANDARD

N13.12

Control of Radioactive Surface Contamination

On Materials, Equipment, and Facilities to be

Released for Uncontrolled Use

Where potentially contaminated surfaces are not accessible for measurement (as in some pipes, drains, and ductwork), such property shall not be released pursuant to this standard, but shall be made the subject of case-by-case evaluation.

Property shall not be released for uncontrolled use unless measurements show the total and removable contamination levels to be no greater than the values in Table 1 or Table 2. (The values in Table 2 are easier to apply when the contaminants cannot be individually identified.)

Coatings used to cover the contamination shall not be considered a solution to the contamination problem. That is, the monitoring techniques shall be sufficient to determine, and such determination shall be made, that the total amount of contamination present on and under any coating does not exceed the Table 1 or Table 2 values before release.

APPENDIX 6
(cont'd)

TABLE 1

SURFACE CONTAMINATION LIMITS*

Contaminants			Limit (Activity) (dis/min-100 cm^2)+	
Group	Description	Nuclides (Note 1)	Removable	Total (Fixed plus Removable)
1	Nuclides for which the nonoccupational MPC_a (Note 2) is 2×10^{-13} Ci/m^3 or less or for which the nonoccupational MPC_w (Note 4) is 2×10^{-7} Ci/m^3 or less	^{227}Ac $^{241,242m,243}Am$ $^{249,250,251,252}Cf$ $^{243,244,245,246,247,248}Cm$ $^{125,129}I$ ^{237}Np ^{231}Pa ^{210}Pb $^{238,239,240,242,244}Pu$ $^{226,228}Ra$ $^{228,230}Th$	20	Nondetectable (Note 3)
2	Those nuclides not in Group 1 for which the nonoccupational MPC_a (Note 2) is 1×10^{-12} Ci/m^3 or less or for which the nonoccupational MPC_w (Note 4) is 1×10^{-6} Ci/m^3 or less	^{254}Es ^{256}Fm $^{126,131,133}I$ ^{210}Po ^{223}Ra ^{90}Sr ^{232}Th ^{232}U	200	2000 α Nondetectable β,γ (Note 5)
3	Those nuclides not in Group 1 or Group 2		1000	5000

APPENDIX 6
(cont'd)

SURFACE CONTAMINATION LIMITS*

*The levels may be averaged over one square meter provided the maximum activity in any area of 100 cm^2 is less than three times the limit value. For purposes of averaging with regard to isolated spots of activity, any square meter of surface shall be considered to be contaminated above the limit L, applicable to 100 cm^2, if (1) from measurements of a representative number n of sections it is determined that $1/n \sum_{i}^{n} S_i \geq L$, where S_i is the dis/min-100 cm^2 determined from measurement of section i; or (2) it is determined that the activity of all isolated spots or particles in any area less than 100 cm^2 exceeds 3 L.

+Disintegrations per minute per square decimeter.

NOTES:

(1) Values presented here are obtained from the Code of Federal Regulations, Title 10, Part 20, April 30, 1975. The most limiting of all given MPC values (for example, soluble versus insoluble) are to be used. In the event of the occurrence of mixtures of radionuclides, the fraction contributed by each constituent of its own limit shall be determined and the sum of the fraction shall be less than 1.

(2) Maximum permissible concentration in air applicable to continuous exposure of members of the public as published by or derived from an authoritative source such as the National Committee on Radiation Protection and Measurements (NCRP), the International Commission on Radiological Protection (ICRP), or the Nuclear Regulatory Commission (NRC). From the Code of Federal Regulations, Title 10, Part 20, Appendix B, Table 2, Column 1.

(3) The instrument utilized for this measurement shall be calibrated to measure at least 100 pCi of any Group 1 contaminants uniformly spread over 100 cm^2.

(4) Maximum permissible concentration in water applicable to members of the public.

(5) The instrument utilized for this measurement shall be calibrated to measure at least 1 nCi of any Group 2 beta or gamma contaminants uniformly spread over an area equivalent to the sensitive area of the detector. Direct survey for unconditional release should be performed in areas where the background is ≤ 100 counts per minute. When the survey must be performed in a background exceeding 100 counts per minute, it may be necessary to use the indirect survey method to provide the additional sensitivity required.

ALTERNATE SURFACE CONTAMINATION LIMITS

(All Alpha Emitters, except U_{nat} and Th_{nat}, Considered as a Group)*

Contamination Contingencies	Limit (Activity) (dis/min-100 cm^2)+ Removable	Total (Fixed Plus Removable)
If the contaminant cannot be identified; or if alpha emitters other than U_{nat} (Note 1) and Th_{nat} are present; or if the beta emitters comprise ^{227}Ac or ^{228}Ra.	20	Nondetectable (Note 2)
If it is known that all alpha emitters are generated from U_{nat} (Note 1) and Th_{nat}; and if beta emitters are present that, while not identified, do not include ^{227}Ac, ^{125}I, ^{226}Ra, and ^{228}Ra.	200	2000 α Nondetectable β,γ (Note 3)
If it is known that alpha emitters are generated only from U_{nat} (Note 1) and Th_{nat} in equilibrium with its decay products; and if the beta emitters, while not identified, do not include ^{227}Ac, ^{125}I, ^{129}I, ^{90}Sr, ^{223}Ra, ^{228}Ra, ^{126}I, ^{131}I and ^{133}I.	1000	5000

ALTERNATE SURFACE CONTAMINATION LIMITS

*The levels may be averaged over one square meter provided the maximum activity in any area of 100 cm^2 is less than three times the limit value. For purposes of averaging with regard to isolated spots of activity, any square meter of surface shall be considered to be contaminated above the limit L, applicable to 100 cm^2, if (1) from measurements of a representative number n of sections it is determined that $1/n \Sigma_n S_i \geq L$, where S_i is the dis/min-100 cm^2 determined from measurement of section i; or (2) it is determined that the activity of all isolated spots or particles in any area less than 100 cm^2 exceeds 3 L.

+Disintegrations per minute per square decimeter.

NOTES:

(1) U_{nat} and decay products.

(2) The instrument utilized for this measurement shall be calibrated to measure at least 100 pCi of any Group 1 contaminants uniformly spread over 100 cm^2.

(3) The instrument utilized for this measurement shall be calibrated to measure at least 1 nCi of any Group 2 beta or gamma contaminants uniformly spread over an area equivalent to the sensitive area of the detector. Direct survey of unconditional release should be performed in areas where the background is ≤ 100 counts per minute. When the survey must be performed in a background exceeding 100 counts per minute, it may be necessary to use the indirect survey method to provide the additional sensitivity required.

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

(These have been retyped for purposes of this report.)

The instructions in this guide, in conjunction with Table 1, specify the radioactivity and radiation exposure rate limits which should be used in accomplishing the 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 will be 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 applying 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 duct work 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 duct work. Surfaces of 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 request 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 Director of the Regional Office of the Office of Inspection and Enforcement, USNRC, 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.

APPENDIX 6
(cont'd)

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

NUCLIDES[a]	AVERAGE[bcf]	MAXIMUM[bdf]	REMOVABLE[bef]
U-nat, ^{235}U, ^{238}U and associated decay products	5000 dis/min-100 cm^2 α	15,000 dis/min-100 cm^2 α	1000 dis/min-100 cm^2 α
Transuranics, ^{226}Ra, ^{228}Ra, ^{230}Th, ^{228}Th, ^{231}Pa, ^{227}Ac, ^{125}I, ^{129}I	100 dis/min-100 cm^2	300 dis/min-100 cm^2	20 dis/min-100 cm^2
Th-nat, ^{232}Th, ^{90}Sr, ^{223}Ra, ^{224}Ra, ^{232}U, ^{126}I, ^{131}I, ^{133}I	1000 dis/min-100 cm^2	3,000 dis/min-100 cm^2	200 dis/min-100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except ^{90}Sr and others noted above.	5000 dis/min-100 cm^2 $\beta\gamma$	15,000 dis/min-100 cm^2 $\beta\gamma$	1000 dis/min-100 cm^2 $\beta\gamma$

TABLE 1
(Footnotes)

ACCEPTABLE SURFACE CONTAMINATION LEVELS

[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, dis/min (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.

III. SURGEON GENERAL'S GUIDELINES
as included in 10 CFR Part 712
Grand Junction Remedial Action Criteria

712.1 Purpose

(a) The regulations in this part establish the criteria determination by DOE of the need for, priority of and selection of appropriate remedial action to limit the exposure of individuals in the area of Grand Junction, Colorado, to radiation emanating from uranium mill tailings which have been used as construction-related material.

(b) The regulations in this part are issued pursuant to Pub. L. 92-314 (86 Stat. 222) of June 16, 1972.

712.2 Scope

The regulations in this part apply to all structures in the area of Grand Junction, Colorado, under or adjacent to which uranium mill tailings have been used as a construction-related material between January 1, 1951, and June 16, 1972, inclusive.

712.3 Definitions

As used in this part:

(a) "Administrator" means the Administrator of Energy Research and Development or his duly authorized representative.

(b) "Area of Grand Junction, Colorado," means Mesa County, Colorado.

(c) "Background" means radiation arising from cosmic rays and radioactive material other than uranium mill tailings.

(d) "DOE" means the U. S. Department of Energy or any duly authorized representative thereof.

(e) "Construction-related material" means any material used in the construction of a structure.

(f) "External gamma radiation level" means the average gamma radiation exposure rate for the habitable area of a structure as measured near floor level.

(g) "Indoor radon daughter concentration level" means that concentration of radon daughters determined by: (1) averaging the results of six air samples each of at least 100 hours duration, and taken at a minimum of 4-week intervals throughout the year in a habitable area of a structure, or (2) utilizing some other procedure approved by the Commission.

(h) "Milliroentgen" (mR) means a unit equal to one-thousandth (1/1000) of a roentgen which roentgen is defined as an exposure dose of X or gamma radiation such that the associated corpuscular emission per 0.001293 gram of air produces, in air, ions carrying one electrostatic unit of quantity of electricity of either sign.

(i) "Radiation" means the electromagnetic energy (gamma) and the particulate radiation (alpha and beta) which emanate from the radioactive decay of radium and its daughter products.

(j) "Radon daughters" means the consecutive decay products of radon-222. Generally, these include Radium A (polonium-218), Radium B (lead-214), Radium C (bismuth-214), and Radium C' (polonium-214).

(k) "Remedial action" means any action taken with a reasonable expectation of reducing the radiation exposure resulting from uranium mill tailings which have been used as construction-related material in and around structures in the area of Grand Junction, Colorado.

(l) "Surgeon General's Guidelines" means radiation guidelines related to uranium mill tailings prepared and released by the Office of the U.S. Surgeon General, Department of Health, Education and Welfare on July 27, 1970.

(m) "Uranium mill tailings" means tailings from a uranium milling operation involved in the Federal uranium procurement program.

(n) "Working Level" (WL) means any combination of short-lived radon daughter products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

712.4 Interpretations

Except as specifically authorized by the Administrator in writing, no interpretation of the meaning of the regulations in this part by an officer or employee of DOE other than a written interpretation by the General Counsel will be recognized to be binding upon DOE.

712.5 Communications

Except where otherwise specified in this part, all communications concerning the regulations in this part should be addressed to the Director, Division of Safety, Standards, and Compliance, U.S. Department of Energy, Washington, D.C. 20545.

712.6 General radiation exposure level criteria for remedial action.

The basis for undertaking remedial action shall be the applicable guidelines published by the Surgeon General of the United States. These guidelines recommended the following graded action levels for remedial action in terms of external gamma radiation level (EGR) and indoor radon daughter concentration

level (RDC) above background found within dwellings constructed on or with uranium mill tailings.

EGR	RDC	Recommendation
Greater than 0.1 mR/h	Greater than 0.05 WL	Remedial action indicated
From 0.05 to 0.1 mR/h	From 0.01 to 0.05 WL	Remedial action may be suggested.
Less than 0.05 mR/h	Less than 0.01 WL	No remedial action indicated.

712.7 Criteria for determination of possible need for remedial action

Once it is determined that a possible need for remedial action exists, the record owner of a structure shall be notified of that structure's eligibility for an engineering assessment to confirm the need for remedial action and to ascertain the most appropriate remedial measure, if any. A determination of possible need will be made if as a result of the presence of uranium mill tailings under of adjacent to the structure, one of the following criteria is met:

(a) Where DOE approved data on indoor radon daughter concentration levels are available.

(1) For dwellings and schoolrooms: An indoor radon daughter concentration level of 0.01 WL or greater above background.

(2) For other structures: An indoor radon daughter concentration level of 0.03 WL or greater above background.

(b) Where DOE approved data on indoor radon daughter concentration levels are not available:

(1) For dwellings and schoolrooms:

(i) An external gamma radiation level of 0.05 mR/h or greater above background.

(ii) An indoor radon daughter concentration level of 0.01 WL or greater above background (presumed).

(A) It may be presumed that if the external gamma radiation level is equal to or exceed 0.02 mR/h above background, the indoor radon daughter concentration level equals or exceeds 0.01 WL above background.

(B) It should be presumed that if the external gamma radiation level is less than 0.001 mR/h above background, the indoor radon daughter concentration level is less than 0.01 WL above background, and no possible need for remedial action exists.

(C) If the external gamma radiation level is equal to or greater than 0.001 mR/h above backgrond but is less than 0.02 mR/h above background, measurements will be required to ascertain the indoor radon daughter concentration level.

(2) For other structures:

(i) An external gamma radiation level of 0.15 mR/h above background averaged on a room-by-room basis.

(ii) No presumptions shall be made on the external gamma radiation level/indoor radon daughter concentration level relationship. Decisions will be made in individual cases based upon the results of actual measurements.

712.8 Determination of possible need for remedial action where criteria have not been met.

The possible need for remedial action may be determined where the criteria in 712.7 have not been met if various other factors are present. Such factors include but are not necessarily limited to, size of the affected area, distribution of radiation levels in the affected area, amount of tailings, age of individuals occuping affected area, occupancy time, and use of the affected area.

712.9 Factors to be considered in determination of order of priority for remedial action.

In determining the order or priority for execution of remedial action, consideration shall be given, but not necessarily limited to, the following factors:

(a) Classification of structure. Dwellings and schools shall be considered first.

(b) Availability of data. Those structures for which data on indoor radon daughter concentration levels and/or external gamma radiation levels are available when the program starts and which meet the criteria in 712.7 will be considered first.

(c) Order of application. Insofar as feasible remedial action will be taken in the order in which the application is received.

(d) Magnitude of radiation level. In general, those structures with the highest radiation levels will be given primary consideration.

(e) Geographical location of structures. A group of structures located in the same immediate geographical vicinity may be given priority consideration particularly where they involve similar remedial efforts.

(f) Availability of structures. An attempt will be made to schedule remedial action during those periods when remedial action can be taken with minimum interference.

(g) Climatic conditions. Climatic conditions or other seasonable considerations may affect the scheduling of certain remedial measures.

712.10 Selection of appropriate remedial action.

(a) Tailings will be removed from those structures where the appropriately averaged external gamma radiation level is equal to or greater than 0.05 mR/h above background in the case of dwellings and schools and 0.15 mR/h above background in the case of other structures.

(b) Where the criterion in paragraph (a) of this section is not met, other remedial action techniques, including but not limited to sealants, ventilation, and shielding may be considered in addition to that of tailings removal. DOE shall select the remedial action technique or combination of techniques, which it determines to be the most appropriate under the circumstances.

IV. EXCERPTS FROM DOE 5480.1 Chg. 6, CHAPTER XI

"Requirements for Radiation Protection"

Exposure of Individuals and Population Groups in Uncontrolled Areas. Exposures to members of the public shall be as low as reasonably achievable levels within the standards prescribed below.

Radiation Protection Standards
for External and Internal Exposure
of Members of the Public

	Annual Dose Equivalent or Dose Commitment	
Type of Exposure	Based on Dose to Individuals at Points of Maximum Probable Exposure	Based on Average Dose to a Suitable Sample of the Exposed Population
Whole body, gonads, or bone marrow	0.5 rem (or 500 mrem)	0.17 rem (or 170 mrem)
Other organs	1.5 rem (or 1500 mrem)	0.5 rem (or 500 mrem)

V. EXCERPTS FROM LA-UR-79-1865-Rev.,

"Interim Soil Limits for D&D Projects"

Table XXIII. Recommended Soil Limits[a,b] (in pCi/g)

		Ingestion			
	Inhalation	Home Gardener	Full Diet	External Radiation	All Pathways[c]
^{231}Pa	50	740	150	250	40
^{227}Ac	200[d]	4,900	1,000	300	120[d]
^{232}Th	45	670	140	40	20
^{228}Th	1,000	37,000	7,800	55	50
^{230}Th (No Daught.)	300	4,400	940	36,000	280
^{238}U-^{234}U	750	44	8	6,000	40
^{90}Sr	$2x10^6$	100	19	-	100
^{137}Cs	$7x10^6$	800	1	90	80

[a]Soil limits for ^{241}Am and $^{239,240}Pu$ are available from EPA recommendations, and a soil limit for ^{226}Ra has been reported by Healy and Rodgers.

[b]Limits are to apply to only one nuclide present in the soil. If more than one is present a weighted average should apply.

[c]Based on diet of a home gardener.

[d]Modified from LA-UR-79-1865-Rev. values to correct apparent error.

APPENDIX 7

DOSE-DETERMINATION CALCULATIONS

To assess the internal radiological hazard from inhalation/ingestion of contamination possibly due to MED/AEC occupancy, a hypothetical, yet conceivable, worst-case situation involving the ceiling in Room 1 has been constructed. Since the results of gamma-spectral and mass-spectral analysis indicated normal uranium, normal uranium has been used as the nuclide of concern in the scenario that follows.

The highest level of contamination on the ceiling of Room 1 (at location 133) was 1.7×10^5 dis/min-100 cm^2 equated to normal uranium. The activity (A) in units of μCi is:

$$A = 1.7 \times 10^5 \text{ dis/min-100 cm}^2 \times \frac{1 \text{ Ci of normal U*}}{4.54 \times 10^{12} \text{ dis/min}} \times \frac{10^6 \text{ μCi}}{1 \text{ Ci}}$$

$$= 3.74 \times 10^{-2} \text{ μCi/100 cm}^2.$$

A probable situation that could arise would involve the cutting of the ceiling for an exhaust vent using a concrete-core driller. Since much of the ceiling was contaminated, it is assumed that the entire area of the ceiling being cut is uniformly contaminated at a level of 3.74×10^{-2} μCi/100 cm^2. It also is assumed that a concrete-core driller having a diameter of 30.5 cm (1 ft) and a cutting edge of 1.5 cm is used to cut the holes. The area of concrete (B) displaced by the driller would be:

$$B = \pi[(15.2 \text{ cm})^2 - (13.7 \text{ cm})^2] = 1.36 \times 10^2 \text{ cm}^2.$$

It is assumed that the concrete is dry and that a maximum dust disturbance would be created. Since the cutting operation would probably produce many small particles (or dust) of concrete rather than large pieces, the assumption is made that 90% of the concrete becomes airborne and respirable. The total amount of activity that becomes airborne and respirable (C) due to the cutting is then:

$$C = 3.74 \times 10^{-2} \text{ μCi/100 cm}^2 \times 1.36 \times 10^2 \text{ cm}^2 \times 0.90$$

$$= 4.59 \times 10^{-2} \text{ μCi}$$

The total volume of Room 1 is about 2.2×10^3 m^3. If the dust created would become dispersed throughout the room and suspended in this volume of air, the concentration of normal uranium in the air (D) would be:

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*A Curie of normal uranium normalized to ^{238}U, i.e., the sum of 3.7×10^{10} dis/s from ^{238}U, plus 3.7×10^{10} dis/s from ^{234}U, plus 1.7×10^9 dis/s from ^{235}U. This equals 7.57×10^{10} dis/s or 4.54×10^{12} dis/min. A standard Curie is 3.7×10^{10} dis/s or 2.22×10^{12} dis/min.

$D = 4.59 \times 10^{-2}\ \mu Ci / 2.2 \times 10^{3}\ m^3$

$= 2.1 \times 10^{-5}\ \mu Ci/m^3$.

More than two people would probably not be involved in this operation, and the job should require no more than an hour. The drilling of this small area should not take very long and the particles would soon fall out of suspension. Assuming a person would inhale 1.2 m^3 of air per hour (Ref. 1) and would be involved in this job for a one-hour period, the amount of activity (E) that would be inahled is:

$E = 2.1 \times 10^{-5}\ \mu Ci/m^3 \times 1.2\ m^3/h \times 1\ h$

$= 2.5 \times 10^{-5}\ \mu Ci$

$= 2.5 \times 10^{1}\ pCi$.

The adult inhalation dose commitment factors for the bone, kidney, lung, and total body from ^{238}U, ^{234}U, ^{235}U, and short-lived daughters (Ref. 2) are presented in Table 7.1. The sum of the factors for ^{238}U and ^{234}U and short-lived daughters is also presented. The results of the calculations given in Appendix 5, i.e., that 2.2% of normal U disintegrations per minute are due to ^{235}U and 97.8% due to $^{238,234}U$ (or 48.9% each) can be used to obtain the dose commitment factors for normal uranium in terms of pCi of ^{238}U.

The 50-year dose commitment (F) from the inhalation of 2.5×10^{1} pCi of normal uranium is:

$F = 2.5 \times 10^{1}$ pCi x

(1) 1.0×10^{-1} mrem/pCi inhaled = 2.5 mrem, lung

(2) 2.04×10^{-2} mrem/pCi inhaled = 5.1×10^{-1} mrem, bone

(3) 4.78×10^{-3} mrem/pCi inhaled = 1.2×10^{-1} mrem, kidney

(4) 1.24×10^{-3} mrem/pCi inhaled = 3.1×10^{-2} mrem, total body

Thus, the person would receive a 2.5-mrem dose commitment to the lung, a 0.51-mrem dose commitment to the bone, a 0.12-mrem dose commitment to the kidneys, and a 0.031-mrem dose commitment to the total body under this scenario.

Even though these calculations are based on reasonable hypothesized values, the actual total inhaled and the subsequent dose commitments could differ from those hypothesized. This is due to uncertainties in the estimation of the fraction that becomes airborne and respirable, in the estimation of the breathing rate and duration of inhalation, and in the application of the dose commitment factors to the persons involved. The hypothesized case is, however, based on reasonably conservative assumptions.

TABLE 7.1

ADULT DOSE COMMITMENT FACTORS
(mrem/50 yr-pCi inhaled in the 1st year)

Radionuclide	Bone	Kidney	Lung	Total Body
^{238}U	9.58×10^{-3}	2.18×10^{-3}	4.58×10^{-2}	5.67×10^{-4}
^{234}Th	1.63×10^{-6}	5.41×10^{-7}	1.89×10^{-4}	4.7×10^{-8}
^{234}U	1.04×10^{-2}	2.49×10^{-3}	5.22×10^{-2}	6.46×10^{-4}
^{235}U	1.0×10^{-2}	2.34×10^{-3}	4.90×10^{-2}	6.07×10^{-4}
^{234}U & ^{238}U & short-lived daughters (per pCi of ^{238}U)	2.0×10^{-2}	4.67×10^{-3}	9.82×10^{-2}	1.21×10^{-3}
Normal U[a] (per pCi of ^{238}U)	2.04×10^{-2}	4.78×10^{-3}	1.0×10^{-1}	1.24×10^{-3}

[a]Normal U is 2.2% ^{235}U and 97.8 ^{234}U and ^{238}U, by pCi (see Appendix 5).

REFERENCES FOR APPENDIX 7

1. Bureau of Radiological Health. 1970. "Radiological Health Handbook." Rev. ed., pg. 216

2. Holmes, G. R. and J. K. Soldat. 1977. "Age Specific Radiation Dose Commitment Factors for a One Year Chronic Intake." NUREG-0172, U.S. Nuclear Regulatory Commission, pg. 39.

APPENDIX 8

EVALUATION OF RADIATION EXPOSURES AT THE NATIONAL GUARD ARMORY

I. PREFACE

The U.S. Department of Energy has initiated a program to determine the present radiological condition of sites formerly used for work with radioactive material by the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC). Beginning in March 1942, the Illinois National Guard Armory at Washington Park, 52nd Street and Cottage Grove Avenue, Chicago, Illinois, was used jointly by the MED Metallurgical Laboratory and the University of Chicago. Personnel involved with this facility during the MED/AEC era recalled that some type of uranium processing was conducted there and that the grandstands surrounding the arena were used for storage of radioactive materials. The use of the arena could have involved both the chemical processing and metal casing of uranium. The use of the facility was terminated in 1951 and the property returned to the State of Illinois. Since existing documentation was insufficient to determine whether any decontamination work done at the time nuclear activities ceased was adequate by current guidelines, a comprehensive radiological assessment of the armory was conducted during the period September 19, 1979, to October 11, 1978.

The Illinois National Guard Armory is a 70 m x 190 m concrete building. The arena, which is 70 m x 110 m, is located on the first floor; the areas surrounding the arena are three stories high. The armory is occupied by the Illinois National Guard and houses the 1st Battalion, 178th Infantry, and the 2nd Battalion, 122nd Field Artillery. It is used for offices, classrooms, and storage and garage areas.

II. INTRODUCTION

A. Types of Radiation

Radiation is the emission or transmission of energy in the form of waves or particles. Examples are acoustic waves (i.e., sound), electromagnetic waves (such as radio, light, x- and gamma-rays), and particulate radiations (such as alpha particles, beta particles, neutrons, protons, and the elementary particles).

The class of radiation of importance to this report is known as ionizing radiation. Ionizing radiations are those, either electromagnetic or particulate, with sufficient energy to ionize matter, i.e., to remove or displace electrons from atoms and molecules. The most common types of ionizing radiation are x- and gamma-rays, alpha particles, beta particles, and neutrons.

X- and gamma-rays are electromagnetic waves of pure energy, having no charge and no mass or existence at rest. Gamma-rays and x-rays are identical except that x-rays originate in the atom and gamma-rays originate in the

nucleus of an atom. X- and gamma-rays are highly penetrating and can pass through relatively thick materials before interacting. Upon interaction, some or all of the energy is transferred to electrons, which, in turn, produce additional ionizations while coming to rest.

Alpha particles are positively charged particulates composed of two neutrons and two protons, identical to the nucleus of a helium atom. Due to its comparatively large mass and double charge, an alpha particle interacts readily with matter and penetrates only a very short distance before coming to rest, causing intense ionization along its path.

Beta particles are negatively charged free electrons moving at high speeds. Due to its comparatively small mass and single charge, a beta particle's penetration through matter is intermediate between that of the alpha particle and the gamma-ray, causing fewer ionizations per unit path length than an alpha particle.

B. Sources of Radiation

Ionizing radiations arise from terrestrial radioactive materials (both naturally-occurring and man-made), extra-terrestrial (cosmic) sources, and radiation-producing machines. The sources of ionizing radiation important to this report are radioactive materials and cosmic sources.

Most atoms of the elements in our environment remain structurally stable. With time, an atom of potassium, for instance, may change its association with other atoms in chemical reactions and become part of other compounds, but it will always remain a potassium atom. Radioactive atoms, on the other hand, are not stable and will spontaneously emit radiation in order to achieve a more stable state. Through spontaneous transformation, the ratio of protons and neutrons in the nucleus is altered toward a more stable condition. Radiation may be emitted from the nucleus as alpha particles, beta particles, neutrons, or gamma-rays, depending uniquely upon each particular radionuclide. Radionuclides decay at characteristic rates dependent upon the degree of stability and characterized by a period of time called the half-life. In one half-life, the number of radioactive atoms and, therefore, the amount of radiation emitted, decreases by one-half.

The exposure of man to terrestrial radiation is due to naturally occuring radionuclides and also to "man-made" or technologically enhanced radioactive materials. Several dozen radionuclides occur naturally, some having half-lives of at least the same order of magnitude as the estimated age of the earth. The majority of these naturally occurring radionuclides are isotopes of the heavy elements and belong to three distinct radioactive series headed by uranium-238, uranium-235, and thorium-232. Each of these decays to stable isotopes of lead (Pb) through a sequence of radionuclides of widely varying half-lives. Other naturally occurring radionuclides, which decay directly to a stable nuclide, are potassium-40 and rubidium-87. It should be noted that even though the isotopic abundance of potassium-40 is less than 0.012%, potassium is so widespread that potassium-40 contributes about one-third of the radiation dose received by man from natural background radiation. A major

portion of the exposure (dose) of man to external terrestrial radiation is due to the radionuclides in the soil, primarily potassium-40 and the radioactive decay chain products of thorium-232 and uranium-238. The naturally occurring radionuclides deposited internally in man through uptake by inhalation/ingestion of air, food, and drinking water containing the natural radioactive material also contribute significantly to his total dose. Many other radionuclides are referred to as "man made" in the sense that they can be produced in large quantities by such means as nuclear reactors, accelerators, or nuclear weapons tests.

The term "cosmic radiation" refers both to the primary energetic particles of extra-terrestrial origin that are incident on the earth's atmosphere and to the secondary particles that are generated by the interaction of these primary particles with the atmosphere and reach ground level. Primary radiation consists of "galactic" particles, externally incident on the solar system, and "solar" particles emitted by the sun. This radiation is composed primarily of energetic protons and alpha particles. The first generation of secondary particles (secondary cosmic radiation), produced by nuclear interactions of the primary particles with the atmosphere, consists predominantly of neutrons, protons, and pions. Pion decay, in turn, results in the production of electrons, photons, and muons. At the lower elevations, the highly penetrating muons and their associated decay and collision electrons are the dominant components of the cosmic-ray particle flux density. These particles, together with photons from the gamma-emitting, naturally occurring radionuclides in the local environment, form the external penetrating component of the background environmental radiation field which produces a significant portion of the whole-body radiation dose to man.

In addition to the direct cosmic radiation, cosmic sources include cosmic-ray-produced radioactivity, i.e., cosmogenic radionuclides. The major production of cosmogenic radionuclides is through interaction of the cosmic rays with the atmospheric gases through a variety of spallation or neutron-capture reactions. The four cosmogenic radionuclides that contribute a measurable radiation dose to man are carbon-14, sodium-22, beryllium-7, and tritium (hydrogen-3), all produced in the atmosphere.

III. BACKGROUND RADIATION DOSES

Background radiation doses are comprised of an external component of radiation impinging on man from outside the body and an internal component due to radioactive materials taken into the body by inhalation or ingestion.

Radiation dose may be expressed in units of rads or rems, depending upon whether the reference is to the energy deposited or to the biological effect. A rad is the amount of radiation that deposits a certain amount of energy in each gram of material. It applies to all radiations and to all materials which absorb that radiation.

Since different types of radiation produce ionizations at different rates as they pass through tissue, differences in damage to tissues, and hence the biological effectiveness of different radiations, has been noticed. A rem is

defined as the amount of energy absorbed (in rads) from a given type of radiation multiplied by the factor appropriate for the particular type of radiation in order to approximate the biological damage that it causes relative to a rad of x or gamma radiation. The rem permits evaluation of potential effects from radiation exposure without regard to the type of radiation or its source. One rem received from cosmic radiation results in the same biological effects as one rem from medical x-rays or one rem from the radiations emitted by naturally occurring or man-made radioactive materials.

The external penetrating radiation dose to man derives from both terrestrial radioactivity and cosmic radiation. The terrestrial component is due primarily to the gamma dose from potassium-40 and the radioactive decay products of thorium-232 and uranium-238 in soil as well as from the beta-gamma dose from radon daughters in the atmosphere. Radon is a gaseous member of the uranium-238 chain. The population-weighted external dose to an individual's whole body from terrestrial sources in the United States has been estimated as 15 mrem per year for the Atlantic and Gulf Coastal Plain, 57 mrem per year for an indeterminate area along the Rocky Mountains, and 29 mrem per year for the majority of the rest of the United States. The overall population-weighted external dose for the U.S. population as a whole has been estimated to be 26 mrem per year.

The cosmic radiation dose, due to the charged particle and neutrons from secondary cosmic rays, is typically about 30% to 50% of the total from all external environmental radiation. The cosmic-ray dose to the population is estimated to be 26 mrem per year for those living at sea level, and increases with increasing altitude. Considering the altitude distribution of the U.S. population, the population-weighted external cosmic-ray dose is 28 mrem per year. The population-weighted total external dose from terrestrial plus cosmic sources is thus 54 mrem per year for the U.S. population as a whole.

The internal radiation doses derive from terrestrial and cosmogenic radionuclides deposited within the body through uptake by inhalation/ingestion of air, food, and drinking water. Once deposited in the body, many radioactive materials can be incorporated into tissues because the chemical properties of the radioisotopes are identical or similar to stable isotopes in the tissues. Potassium-40, for instance, is incorporated into tissues in the same manner as stable potassium atoms because the chemical properties are identical; radioactive radium and strontium can be incorporated into tissues in the same manner as calcium because their chemical properties are similar. Once deposited in tissue, these radionuclides emit radiation that results in the internal dose to individual organs and/or the whole body as long as it is in the body.

The internal dose to the lung is due primarily to the inhalation of polonium-218 and -214 (radon daughters), lead-212 and bismuth-212 (thoron daughters) and polonium-210 (one of the longer-lived radon decay products). The dose to the lung is about 100 mrem per year from inhaled natural radioactivity. The internal dose from subsequent incorporation of inhaled or ingested radioactivity is due to a beta-gamma dose from incorporation of potassium-40, rubidium-87, and cosmogenic nuclides, and an alpha dose from

incorporation of primarily polonium-210, radium-226 and -228, and uranium-238 and -234. The dose to man from internally incorporated radionuclides is about 28 mrem per year to the gonads, about 25 mrem per year to the bone marrow, lung, and other soft tissues, and about 117 mrem per year to the bone (osteocytes). The bone dose arises primarily from the alpha-emitting members of the naturally occurring series, with polonium-210 being the largest contributor. The gonadal and soft tissue doses arise primarily from the beta and gamma emissions from potassium-40. The total internal dose from inhaled plus incorporated radioactivity is about 28 mrem per year to the gonads (or whole-body dose), about 125 mrem per year to the lung, about 25 mrem per year to the bone marrow, and about 117 mrem per year to the bone (osteocytes).

The total natural background radiation dose is the sum of the external and internal components. The population-weighted dose for the U.S. population as a whole is about 82 mrem per year to the gonads or whole body, about 179 mrem per year to the lung, about 79 mrem per year to the bone marrow, and about 171 mrem per year to the bone (osteocytes) (Ref. 1).

Besides the natural background radiation, background radiation doses include contributions from man-made or technologically enhanced sources of radiation. By far, the most significant are x-ray and radiopharmaceutical medical examinations. These contribute a population-averaged dose estimated to be 70 mrem per year for the U.S. population as a whole. Fallout from nuclear weapons testing through 1970 has contributed 50-year dose commitments estimated as 80 mrem external, and 30, 20, and 45 mrem internal to the gonads, lung, and bone marrow, respectively. Contributions from the use of fossil fuels (natural gas and coal) and nuclear reactors; mining, milling, and tailings piles; television sets, smoke detectors, and watch dials could be responsible for an additional 5 mrem per year, averaged over the U.S. population as a whole. In addition, the use of radiation or radioactivity for scientific, industrial, or medical purposes may cause workers in the industry and, to a lesser extent, members of the general public to receive some radiation exposure above natural background.

IV. EVALUATION OF RADIATION DOSE AND POTENTIAL HAZARD

Radiation, regardless of its sources, is considered to be a hazard because of its potential for producing adverse effects on human life. Very large amounts of radiation received over a brief period, i.e., hundreds of rem delivered within a few hours, can produce severe injury or death within days or weeks. Distributed over longer intervals, however, these same doses would not cause early illness or fatality. At doses and rates too low to produce these immediate symptoms, chronic or repeated exposure to radiation can bring about biological damage which does not appear until years or decades later. These low-level effects are stochastic in nature; their probability rather than their severity increases with dose. Primary among these latent or delayed effects are somatic effects, where insults such as cancers occur directly to the individual exposed, and genetic defects, where, through damage to the reproductive cells of the exposed individual, disability and disease ranging from subtle to severe are transmitted to his offspring.

Clinical or observed evidence of a relationship between radiation and human cancers arise from several sources. The most important data come from the victims of Hiroshima and Nagasaki, patients exposed during medical therapy, radium dial painters, and uranium miners. Data exist only for relatively large doses; there have been no direct measurements of increased incidence of cancer for low-level radiation exposures. Evaluation of the available data has lead to estimates of the risk of radiation-induced cancer; estimated risks for the lower doses have been derived by linear extrapolation from the higher doses. All radiation exposures then, no matter how small, are assumed to be capable of increasing an individual's risk of contracting cancer.

Data on genetic defects resulting from radiation exposure of humans is not available to the extent necessary to allow an estimate of the risk of radiation-induced effects. Data from animals, along with general knowledge of genetics, have been used to derive an estimate of the risks of genetic effects.

Estimates of health effects from radiation doses are usually based on risk factors as provided in reports issued by International Commission on Radiological Protection (ICRP) (Ref. 2), National Research Council Advisory Committee on the Biological Effects of Ionizing Radiation (BEIR) (Refs. 3, 4), or United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) (Ref. 5). Multiplying the estimated dose by the appropriate risk factor provides an estimate of the risk or probability of induction of health effects to an individual or his descendants as a result of that exposure. The evaluation of these risk factors is presently subject to large uncertainties and, therefore, potential continual revision. The risk factors recommended by the ICRP for cancer mortality and hereditary ill health to the first and second generations are 10^{-4} per rem of whole-body dose and 4×10^{-5} per rem of gonadal dose, respectively. As an example, a whole-body dose of 1 rem would be estimated to add a risk of cancer mortality to the exposed invididual of 10^{-4}, i.e., 1 chance in 10,000. However, a precise numerical value cannot be assigned with any certainty to a particular individual's increase in risk attributable to radiation exposure. The reasons for this are numerous and include the following: (1) uncertainties over the influence of the individual's age, state of health, personal habits, family medical history, and previous or concurrent exposure to other cancer-causing agents, (2) the variability in the latent period (time between exposure and physical evidence of disease), and (3) the uncertainty in the risk factor itself.

To be meaningful, an attempt should be made to view such risk estimates in the appropriate context. One useful comparison is with risks encountered in normal life. Another comparison, potentially more useful, is with an estimation of the risks attributable to natural background radiation. Radiation from natural external and internal radioactivity results in the same types of interactions with body tissues as that from "man-made" radioactivity. Hence, the risks from a specified dose are the same regardless of the source. Rather than going through an intermediate step involving risk factors, doses can also be compared directly to natural background radiation doses.

Besides being used as the basis for estimation of risks and comparisons to natural background, doses may be compared to standards and regulations. The appropriate standards, the Department of Energy "Requirements for Radiation Protection," give limits for external and internal exposure for the whole body and specified organs which are expressed as the permissible dose or dose commitment annually in addition to natural background and medical exposures. There are in general two sets of limits, one applicable to occupationally exposed persons and the second applicable to individuals and population groups of the general public. The limits for individuals of the public are one-tenth of those permitted for occupationally exposed individuals. The set of limits important to this report are those applicable to individuals and population groups of the public. The limits for individuals of the public are 500 mrem per year to the whole body, gonads, or bone marrow and 1500 mrem per year to other organs. The limits for population groups of the public are 170 mrem to the whole body, gonads, or bone marrow and 500 mrem per year to other organs, averaged over the group. In either case, exposures are to be limited to the lowest levels reasonably achievable within given limits.

V. RESULTS OF SITE RADIOLOGICAL SURVEY

The comprehensive radiological survey performed at the Illinois National Guard Armory was conducted on an intermittent basis between September 1977 and October 1978. Direct instrument surveys and smear surveys indicated that some areas of contamination were present in the facility. Contamination possibly due to MED/AEC occupancy was found at 73 locations in 11 rooms or areas. With the exception of Rooms 1, 260, and the floor drain system for Rooms 1 and 5, the contamination consisted of small localized spots, mainly on floors. The contamination in Room 1 was extensive and involved about 200 m^2 of concrete ceiling and floor. The contamination in Room 260 involved about 3 m^2 of concrete floor. The contamination on the floors was not easily removable, whereas most of the contamination on the ceiling was easily removable when smeared. The contamination in the floor drain system for Rooms 1 and 5 consisted of about 2 m^2 of contaminated brick and sludge within two catch basins. Gamma-spectral analyses indicated that the contaminant is predominantly normal uranium. Air sampling indicated ranges of radon and daughter concentrations within normally expected background concentrations. No long-lived radionuclides were detected on any air sample. Environmental soil sampling about the grounds of the National Guard Armory indicated uranium concentrations essentially the same as natural background.

The survey data may be evaluated in terms of the potential doses that exposed persons could receive. Doses were calculated for a scenario involving the ceiling in Room 1 that could result in an internal radiation dose from inhalation of radioactivity. The maximum potential internal dose was calculated to be 2.5 mrem to the lung, 0.51 mrem to the bone, 0.12 mrem to the kidney, and 0.031 mrem to the whole body. For the lung, bone, and kidney, these doses represent additions of about 1.4%, 0.3% and 0.15%, to the 179-mrem, 171-mrem, and 82-mrem annual natural background lung, bone, and kidney (soft tissue) doses, respectively, and 0.2%, 0.03% and 0.008% of the 1500-mrem limit for a member of the public. For the whole body, this represents an increase of about 0.04% to the 82-mrem annual natural background whole body dose and 0.006% of the 500-mrem limit for a member of the public.

To reduce the potential for radiation exposures, remedial measures such as stabilization of the contamination in place would be applicable as a short-term measure. To reduce the risk in the event that building modifications take place in the future, health physics procedures and coverage are recommended. The long-term solution would involve decontamination by removal of the radioactive residues from the 11 rooms or areas in the facility.

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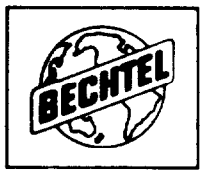
Chicago, Illinois

January 1988



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RADIOLOGICAL AND LIMITED CHEMICAL CHARACTERIZATION REPORT FOR THE NATIONAL GUARD ARMORY CHICAGO, ILLINOIS

JANUARY 1988

Prepared for

UNITED STATES DEPARTMENT OF ENERGY

OAK RIDGE OPERATIONS OFFICE

Under Contract No. DE-AC05-81OR20722

By

C.R. Hickey, R.C. Robertson,
and T.M. Dravecky

Bechtel National, Inc.

Oak Ridge, Tennessee

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ABSTRACT

During January and February 1987, a radiological and limited chemical characterization was conducted at the National Guard Armory located in Chicago, Illinois. The characterization was performed as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), a U.S. Department of Energy effort to identify, clean up, or otherwise control sites where residual radioactive material remains from the early years of the nation's atomic energy program.

A radiological characterization conducted by Argonne National Laboratory established that contamination existed at the site. The 1987 characterization, conducted by the FUSRAP Program Management Contractor, Bechtel National, Inc., was necessary to define locations and boundaries of the contamination to support remedial action.

Measurements taken during the BNI characterization indicated that numerous isolated areas on building surfaces were contaminated in excess of current guidelines. Sludge samples collected from the catch basin system in Rooms 1 and 5 confirmed that the major contaminant was uranium-238. Contamination was found mainly on surfaces inside the building. In addition, contamination in excess of guidelines was found in the catch basin system between Rooms 1 and 5. This material is also contaminated with chemical constituents including volatiles, semi-volatiles, and priority pollutant metals.

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ABBREVIATIONS

cm	centimeter
cm^2	square centimeter
cpm	counts per minute
dpm/100 cm^2	disintegrations per minute per hundred square centimeter
ft	foot
ft^2	square feet
h	hour
µR/h	microroentgens per hour
mg	milligram
mg/kg	milligrams per kilogram
µg	microgram
µg/kg	micrograms per kilogram
MeV	million electron volts
mrad/h	millirad per hour
pCi/g	picocuries per gram

1.0 INTRODUCTION AND SUMMARY

1.1 INTRODUCTION

A radiological survey performed by Argonne National Laboratory (ANL) established that contamination existed at the National Guard Armory (NGA) in Chicago, Illinois (Ref. 1). This characterization is the basis for its inclusion in the Formerly Utilized Sites Remedial Action Program (FUSRAP). The United States Government initiated FUSRAP in 1974 to identify, clean up, or otherwise control sites where residual radioactive material (exceeding current guidelines) remains from the early years of the nation's atomic energy program or from commercial operations that resulted in conditions Congress has mandated DOE to remedy. FUSRAP is under the direction of the DOE Division of Facility and Site Decommissioning Projects.

FUSRAP is currently being managed by DOE Oak Ridge Operations in Oak Ridge, Tennessee. As the Project Management Contractor for FUSRAP, Bechtel National, Inc. (BNI) is responsible to DOE for planning, managing, and implementing FUSRAP.

1.2 PURPOSE AND OBJECTIVES

The current radiological characterization by BNI was necessary to define the locations and boundaries of the contamination identified in the ANL characterization, and design any necessary remedial action at the site. The limited chemical characterization was performed to determine health and safety requirements during remedial action and to identify any disposal restrictions for the contamination identified by the ANL and BNI characterization. BNI and its radiological subcontractor, Thermo Analytical/Eberline (TMA/E), performed the characterization in 1987.

1.3 SUMMARY

This report describes the procedures and results of the radiological and limited chemical characterization conducted during January and February 1987 at the NGA.

Characterization activities included a review of historical data, a walkover tour of the property to identify significant features of the building and grounds, exterior gamma surveys, exterior surface and subsurface soil sampling, interior surface surveys, and interior subsurface surveys.

Measurements taken during the 1987 radiological characterization indicate that numerous isolated areas on building surfaces are contaminated in excess of current guidelines, and that uranium-238 is the primary contaminant. An analysis of sludge samples collected from the catch basin system between Rooms 1 and 5 also confirmed that the major contaminant was uranium-238. This sludge is also contaminated with chemical constituents including volatiles, semi-volatiles, and priority pollutant metals.

2.0 SITE DESCRIPTION AND HISTORY

2.1 LOCATION AND DESCRIPTION

The National Guard Armory (NGA) site is located at East 52nd Street and Cottage Grove Avenue approximately 6 miles south of the downtown business district of Chicago, Illinois. The location of the site is shown in Figure 2-1. The site is an active facility presently occupied by the Illinois National Guard, 1st Battalion, 178th Infantry, and 2nd Battalion, 122nd Field Artillery. The NGA is a 230- by 620-ft concrete building (approximately 290,000 ft^2) with outer walls of stone. An arena occupies the center of the building, and offices, classrooms, storage areas, and garages are located on four floors at the north and south ends (Figure 2-2). The 230- by 360-ft arena has a ceiling more than 100-ft high, with stadium bleachers located on the east and west sides. Before the dirt floor was surfaced with concrete, the arena had been used by the cavalry to train horses, and later for polo (Ref. 1).

2.2 SITE HISTORY

The NGA was used by the Manhattan Project to alleviate space shortages at the University of Chicago and the Metallurgical Laboratory (Ref. 1). Beginning in March 1942, the building was used jointly by the Manhattan Engineer District (MED) Metallurgical Laboratory and the University of Chicago. The Atomic Energy Commission (AEC), which succeeded the MED, terminated use of this facility in 1951, and the property was returned to the State of Illinois.

It is suspected that the arena in the armory could have involved both chemical processing and metal casting of uranium. After MED stopped using the facility, contaminated dirt from the arena was removed. No record could be found of where the dirt was taken. Later more dirt was removed from the arena and replaced with a concrete pad. Conversations with personnel who worked at the

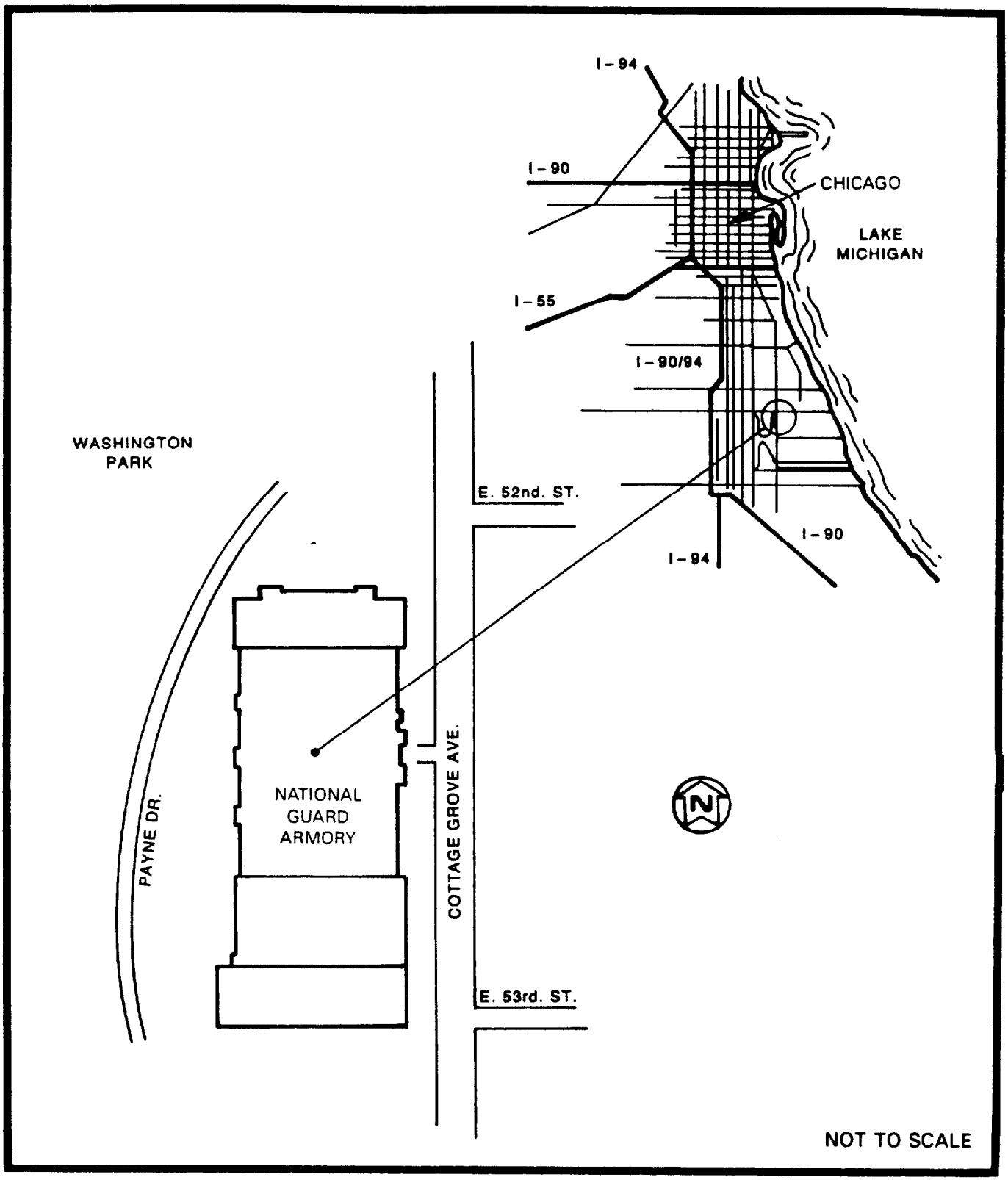


FIGURE 2-1 LOCATION OF THE NGA

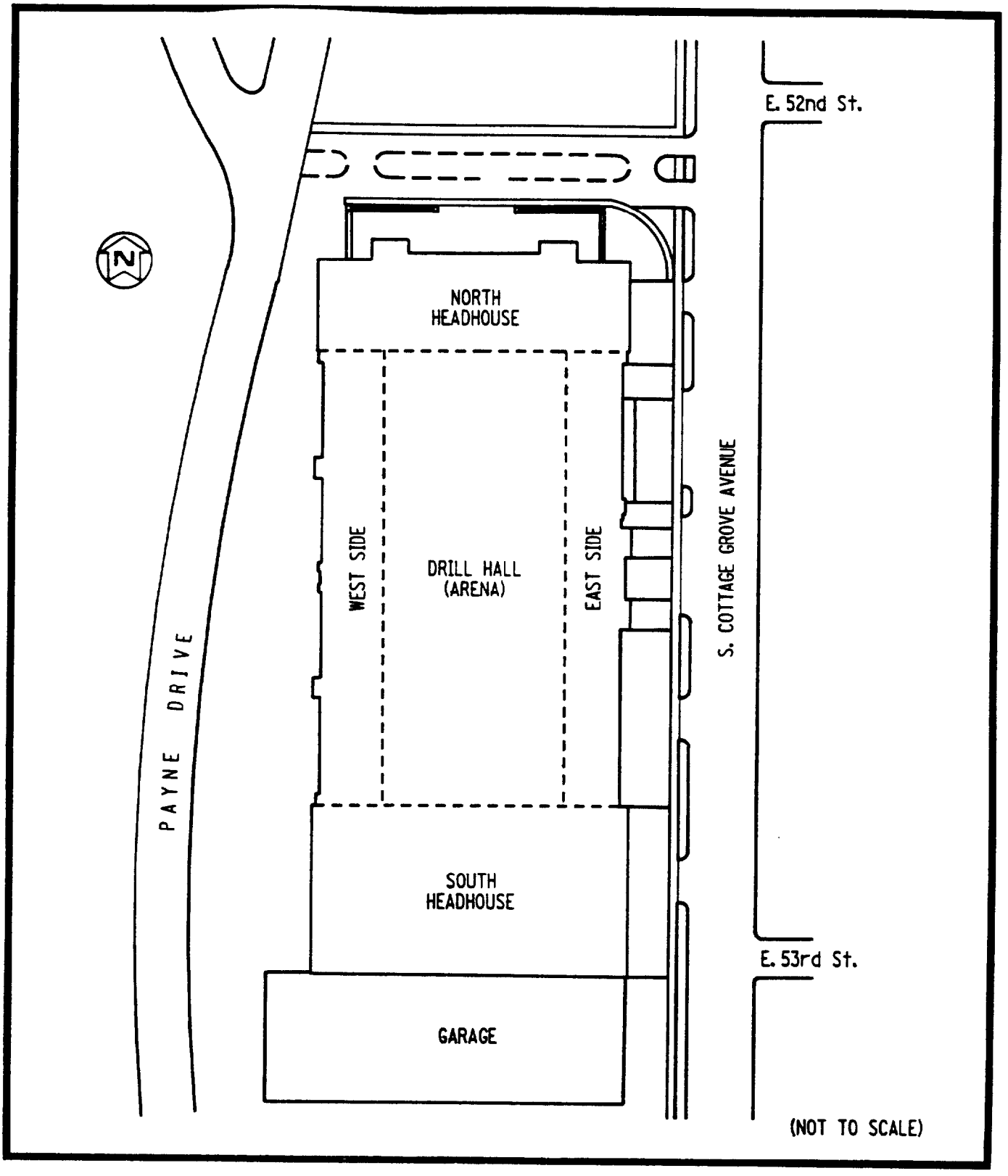


FIGURE 2-2 GENERAL FLOOR PLAN OF THE NGA

facility revealed that there was an effort to decontaminate some of the bleachers in the arena. However, no reports of radiological characterizations or decontamination efforts conducted at the facility upon termination of MED/AEC activities could be found (Ref. 1).

From available correspondence, it appears that the site was used at least for storing and processing uranium metal. In 1943 the building was the central procurement and shipping location for the Metallurgical Laboratory, and records from 1944 indicate that uranium metal stock was received and temporarily stored in the shipping and receiving room.

The armory storeroom (believed to be Room 1 in the ANL report) was apparently used to store uranium shavings and grinding wastes, because at least one of several uranium fires in the armory was reported to have occurred in the northeast corner of that room. That particular fire contaminated both the receiving and storerooms. These areas/rooms have not been positively identified in the historical data available to date; however, on the basis of current radiological findings, these areas may have been in the western half of the south headhouse ground floor.

2.3 PREVIOUS RADIOLOGICAL SURVEYS

The NGA was shown to be radioactively contaminated during a radiological survey conducted by ANL (Ref. 1). In general, the areas of contamination identified during the BNI characterization paralleled those identified by ANL in 1983.

2.4 PRESENT SITE CONDITIONS

The building has remained essentially unchanged since the earlier survey by ANL. The NGA is currently fully active and in operation 24 hours a day.

3.0 HEALTH AND SAFETY PLAN

BNI is responsible for protecting the health of personnel assigned to work at the site. As such, all subcontractors and their personnel are required to comply with the provisions of the applicable project instructions cited in this section or as directed by the on-site BNI representative.

3.1 SUBCONTRACTOR TRAINING

Before the start of work, all subcontractor personnel attend an orientation session presented by the BNI representative to explain the nature of the material to be encountered in the work and the required personnel monitoring and safety measures.

3.2 SAFETY REQUIREMENTS

Subcontractor personnel must comply with the following BNI requirements.

- Bioassay - Subcontractor personnel submit bioassay samples before or at the beginning of on-site activity, upon completion of the activity, and periodically during site activities as requested by BNI.
- Protective Clothing/Equipment - Subcontractor personnel are required to wear the protective clothing/equipment specified in the subcontract or as directed by the BNI representative.
- Dosimetry - Subcontractor personnel are required to wear, and return daily, the dosimeters and monitors issued by BNI.
- Controlled Area Access/Egress - Subcontractor personnel and equipment entering areas wherein access and egress are controlled for radiation and/or chemical safety purposes are surveyed by the BNI representative for contamination before leaving those areas.
- Medical Surveillance - Upon written direction from BNI, subcontractor personnel, who work in areas where hazardous chemicals might exist, are given a baseline and periodic health assessment defined in BNI's Medical Surveillance Program.

Radiation and/or chemical safety surveillance of all activities related to the scope of work is under the direct supervision of personnel representing BNI.

The health physics requirements for all activities involving radiation or radioactive material are defined in Project Instruction No. 20.01, the Project Radiation Protection Manual, and implementing procedures.

The industrial hygiene requirements for activities involving chemicals or chemically contaminated materials are defined in Project Instruction No. 26.00, the Environmental Hygiene Manual, and implementing procedures.

Copies of these project instructions and manuals are located on-site for subcontractor's use.

In addition to the standard safety procedures addressed in the project instructions, additional site-specific requirements were issued (Ref. 2) and a 24-hour Occupational Safety and Health Administration training course was given to all personnel who worked on-site.

4.0 CHARACTERIZATION PROCEDURES

The radiological measurements taken and the methods used for taking the measurements are described in the following subsections.

The following areas were investigated: the exterior grounds of the property, the interior building surfaces, subsurface soil beneath the arena floor, and sludges from the catch basin system serving Rooms 1 and 5. Additionally, any suspect area was scanned and sampled.

4.1 SURFACE MEASUREMENTS TAKEN AND METHODS USED

4.1.1 Exterior Measurements

An initial walkover scan on the NGA property was performed using a Field Instrument for Detection of Low-Energy Radiation (FIDLER). The FIDLER is specially designed to detect the low-energy radiation, such as that emitted by uranium. An informal grid was plotted on all areas with radiation levels exceeding one and one-half times the background level.

4.1.2 Interior Measurements

The entire floor area (290,000 ft^2) of the NGA was scanned using a FIDLER. All areas exhibiting radiation levels exceeding one and one-half times the background radiation level were temporarily marked. Within these marked areas, beta-gamma measurements were made to better define the horizontal boundaries of contamination. The beta-gamma measurements were made using a pancake geometry (Geiger-Muller) probe coupled to a digital rate meter/scaler [Eberline Instrument Corporation (EIC) models HP-210 and PRS-1, respectively.] Based on these measurements, contaminated areas were permanently marked with spray paint. To determine that the outer boundaries of contamination had been accurately established, both alpha and beta-gamma measurements were taken along the perimeter of

the delineated areas. Alpha measurements were made using an EIC AC-3 detector coupled to an EIC PRS-1 rate-meter/scaler.

Ceilings, ledges, ventilation ducts, furniture, selected roof areas, and other surfaces suspected of being contaminated were surveyed for alpha and beta-gamma contamination. Surveys on non-floor surfaces were concentrated in rooms and areas where floor contamination had been identified. In rooms where no floor contamination was found, only suspect areas, such as air-moving systems and horizontal surfaces, were scanned. All areas identified by the ANL report were surveyed.

4.2 SAMPLE COLLECTION AND ANALYSES

4.2.1 Exterior Samples

In areas identified during the FIDLER walkover scan as having readings in excess of one and one-half times the background radiation level, surface and subsurface soil samples were collected to quantify radionuclide concentrations. All soil samples were analyzed using a GeLi (germanium lithium) gamma spectroscopy system for concentrations of uranium-238, radium-226, and thorium-232. GeLi spectroscopy involves counting each sample for 10 minutes using an intrinsic germanium detector housed in a lead counting cave lined with cadmium and copper. The pulse height distribution was sorted using a computer-based, multi-channel analyzer. Radionuclide concentrations were determined by comparing the gamma spectrum of each sample with the spectrum of a certified counting standard for the radionuclide of interest.

4.2.2 Interior Samples

Samples collected consisted of smear (or wipe) samples, a sample of caulk from an expansion joint in the floor of Room 1, soil samples from beneath the arena floor, brick and floor tile samples, and sludge samples from the catch basin system in Rooms 1 and 5.

Smear samples were taken to determine if the contamination was removable. Smear samples are taken by "wiping" an area of approximately 100 cm^2 with smear paper in a Z-shaped pattern. The smear is then counted in a low-background alpha scintillation detector (Eberline Model SAC-4) to determine the gross alpha activity. For the purposes of this characterization, all observed alpha activity on the smears was assumed to arise from uranium contamination.

One sample of a caulk-type expansion joint was collected to determine how deep contamination had penetrated into the joint and to correlate counts per minute (cpm) to picocuries per gram (pCi/g). The sample was analyzed for uranium-238, radium-226, and thorium-232 using GeLi spectroscopy.

Because the arena floor was dirt when the uranium processing occurred, eight boreholes were drilled into the subfloor beneath the concrete floor, and each hole was continuously sampled. Borehole locations are shown in Figure 4-1. Additionally, two boreholes were drilled in the southeast corner of Room 1 to determine if contamination extended below the concrete slab in that room. All soil samples were analyzed for uranium-238, radium-226, and thorium-232 using GeLi spectroscopy.

During the course of the characterization, elevated radiation levels were detected around some of the building materials (bricks and tiles) in the armory. To determine the radionuclides present in these materials, samples were collected, pulverized, and analyzed for uranium-238, radium-226, and thorium-232 using GeLi spectroscopy.

Acting on the information provided by the ANL characterization, samples of the sludge in the catch basins in Rooms 1 and 5 were collected. The catch basin system is shown in Figure 4-2. Samples were collected from all catch basins except Catch Basin 5, which was sealed. Two of three grease traps were also sampled (the third grease trap also being sealed). One catch basin downstream of all

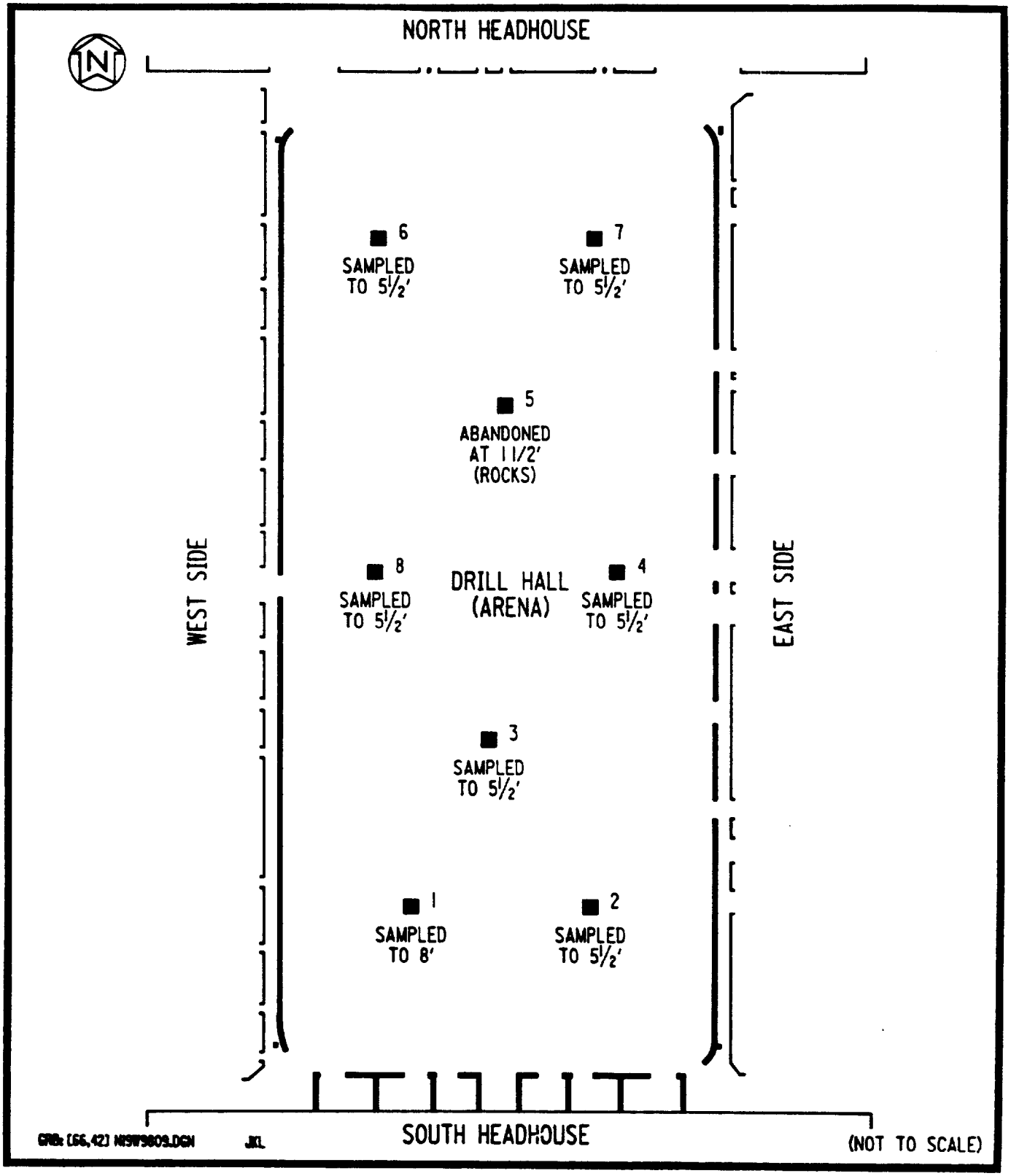


FIGURE 4-1 BOREHOLE LOCATIONS IN THE ARENA

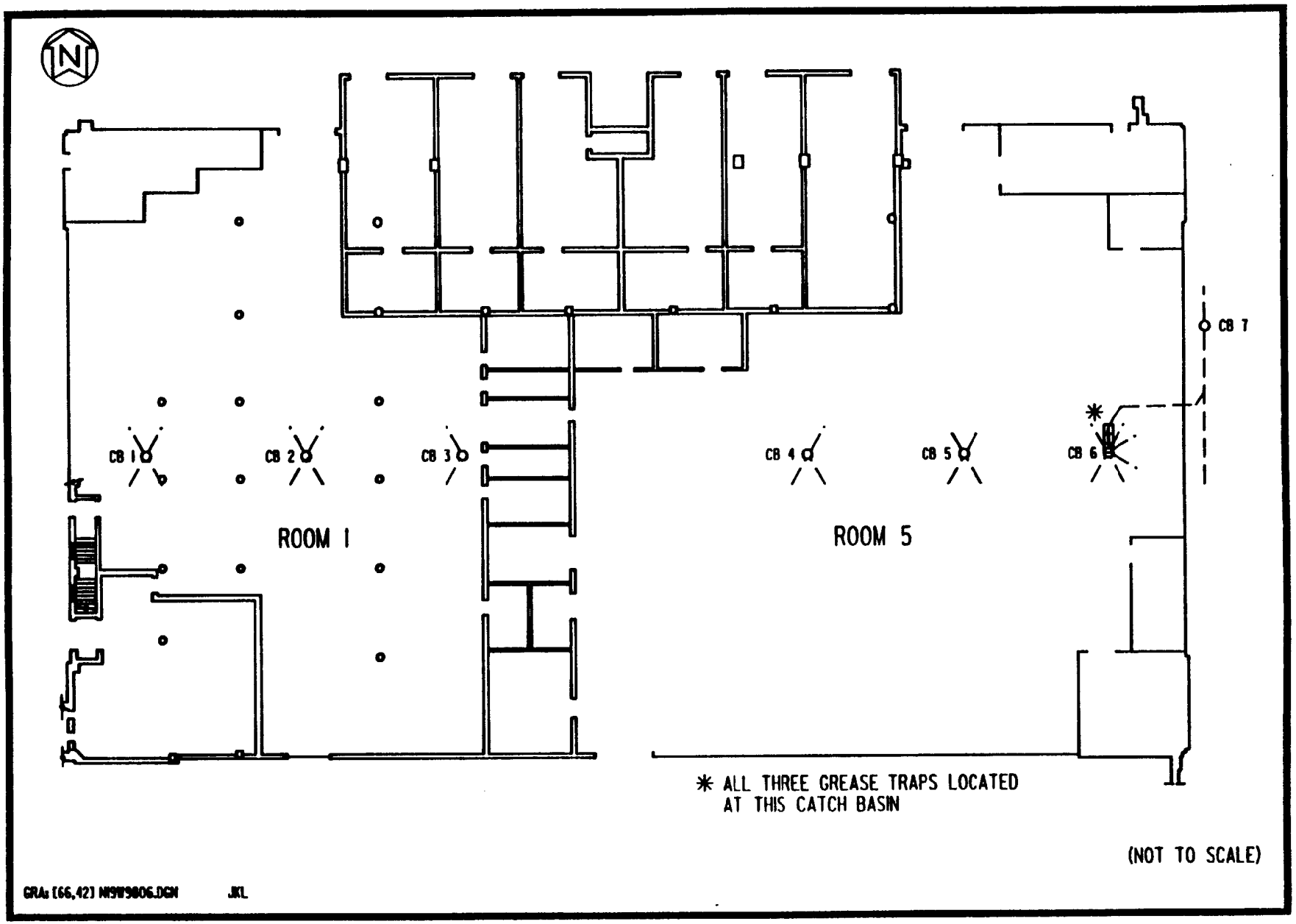


FIGURE 4-2 CATCH BASIN LOCATIONS — SOUTH HEADHOUSE

the other basins and grease traps and outside of the building also was sampled. Scrapings of the catch basin walls were also collected. All samples were analyzed by GeLi spectrometry for uranium-238, radium-226, and thorium-232. The sludge samples were also analyzed for various hazardous waste constituents. The procedures used to chemically sample the sludge, as well as the results of the chemical analysis, are contained in Appendix A.

5.0 CHARACTERIZATION RESULTS

5.1 REMEDIAL ACTION GUIDELINES

The DOE guidelines for residual contamination are summarized in Table 5-1. DOE developed these guidelines to be consistent with the guidelines established by the Environmental Protection Agency (EPA) for the Uranium Mill Tailings Remedial Action Program.

5.2 BACKGROUND RADIATION MEASUREMENTS

Surface gamma radiation was measured using a FIDLER (see Subsection 4.1.2). Surface beta-gamma radiation levels were measured with an HP-210 (see Subsection 4.1.2). Measurements were taken at five exterior background locations in the NGA area (Figure 5-1). The average surface gamma radiation level was approximately 8,500 cpm, and beta-gamma radiation levels at the ground surface averaged approximately 0.03 mrad/h. Individual background measurements are listed in Table 5-2.

Use of the "less than" (<) notation in reporting results indicates that the radionuclide was not present in concentrations that are quantitative with the instruments and techniques used. The less than value represents the lower bound of the quantitative capacity of the instrument and technique used and is based on various factors, including the volume, size, and weight of the sample; the type of detector used; the counting time, and the background count rate. The actual concentration of the radionuclide is less than the value indicated. In addition, since radioactive decay is a random process, a correlation between the rate of disintegration and a given radionuclide concentration cannot be precisely established. For this reason, the exact concentration of the radionuclide cannot be determined. As such, each value that can be quantitatively determined has an associated uncertainty term ($\pm$), which represents the amount by which the actual concentration can be expected to differ from the value given in the table. The uncertainty term has an associated confidence level of 95 percent.

The average background concentrations measured in the surface soil at the five background locations were less than 5.0 pCi/g for uranium-238, 1.0 pCi/g for radium-226, and 1.2 pCi/g for thorium-232. The analysis results for each background location are listed in Table 5-2.

5.3 EXTERIOR SURVEY RESULTS

The FIDLER survey of the grounds of the NGA identified three areas of elevated gamma activity. Figure 5-2 shows these general areas.

Area 1 was adjacent to the south end of the armory and abutted the building at a point which appeared to be a bricked-over vehicle entrance. The area was roughly rectangular and measured approximately 20 by 30 ft. Soil samples were collected from the area with elevated measurements and the adjacent areas. Surface (0 to 6 in.) and subsurface soil samples (6 to 12 in.) were collected from 36 locations. Two locations were augered and sampled to a depth of 5 ft. While a few of the samples exceed the guidelines when both the radium-226 and thorium-232 concentrations are considered, the ratios of radionuclides present in the samples indicate that the elevated concentrations are the result of naturally occurring material. The observed ratios and concentrations are typical of those found in cinder; observations by the field characterization team on the composition of the samples confirm this indication.

The maximum concentration detected for both radium-226 and thorium-232 was 5 pCi/g. No uranium-238 concentrations above the minimum detectable amount were detected. Table 5-3 gives the results of the soil sample analysis.

The second area with an elevated level of radioactivity identified during the FIDLER survey was approximately circular with a diameter of approximately 4 ft. Area 2 is located outside the west wall of Room 1. Surface and subsurface soil samples were collected. During

sample collection, a compass with a radium dial was discovered and removed. The subsurface soil sample showed a maximum radium-226 concentration of 360 pCi/g. Neither uranium-238 nor thorium-232 was present in detectable amounts. Table 5-3 gives the results of the soil sample analysis. Because the area of the contamination was small, it was decontaminated, and post-remedial action samples were collected. The results of the analysis of these samples will be reported in the post-remedial action report for the NGA.

A third area, along the outside west wall of the garage area (Room 2), found by the FIDLER survey was also small and measured approximately 4 ft in length. Two surface soil samples were collected from Area 2. Both showed elevated concentrations of uranium-238 (49 and 48 pCi/g) (Ref. 3); radium-226 and thorium-232 concentrations were at the background level. Table 5-3 gives the analysis results, which show these concentrations do not exceed remedial action guidelines (Ref. 4).

5.4 INTERIOR SURVEY RESULTS

Figures 5-3 and 5-4 illustrate the floor plans of the first and second floor in the south headhouse. Figures 5-5 through 5-23 show the areas of contamination and give the range of absorbed dose rates measured at each of the contaminated areas. Where only one measurement is given, only one measurement was taken.

5.4.1 Floor Survey

As previously stated, all floors were scanned with the FIDLER to identify general areas of concern. These areas were rechecked with beta-gamma and alpha survey instruments to define more precisely the boundaries of contamination. Within the contaminated areas, a smear survey was performed to determine if the radioactive materials were removable. For the floor areas, these surveys showed that virtually all of the contamination was fixed and not transferable. To document the extent of contamination, the identified areas were

spray painted to mark the areas for subsequent remedial action. To ensure that the boundaries of contamination were accurately identified, direct measurement and smear surveys were performed at various points surrounding the marked area. The locations at which these measurements were made are shown in the figures. The gross alpha measurements from the smear survey are presented in Table 5-4, and are identified by the sample numbers given in the figures.

Expansion joints and cracks were often identified as contaminated from direct measurement readings. To determine picocuries per gram (pCi/g) for these areas, one sample of the caulk-like material in the expansion joint was analyzed. This analysis indicated a uranium-238 concentration of approximately 2,600 pCi/g and a radium-226 concentration of 2 pCi/g. The concentration for thorium-232 was reported as less than detectable.

5.4.2 Wall and Ceiling Survey

Surveys of the walls and ceilings were conducted in rooms where floor contamination was found or where the ANL report had identified contamination. In other rooms, spot checks were made of some of the walls and/or ceilings. Areas of contamination were marked and documented as described in Subsection 5.4.1, and are shown in the figures. Measurements from the smear survey are reported in Table 5-4.

During the course of the wall surveys, it was noticed that elevated radiation levels corresponded to certain types of brick. To determine if the elevated readings were being caused by uranium-238, samples of three different types of brick were collected: white, red, and yellow. Each was analyzed for uranium-238, radium-226, and thorium-232. Concentrations are given in Table 5-5.

5.4.3 Survey of Miscellaneous Surfaces

Other surfaces were monitored to locate any contamination. These included ledges, columns, fans, ventilation ducts, and some roofs.

The methodology and documentation used were those described in Subsection 5.4.1. Areas exceeding guidelines are shown in the figures; measurements from the smear survey are reported in Table 5-4.

These surveys identified contamination on some columns and in several bolt holes in the columns. No contamination was found on the roofs.

5.4.4 Survey of Arena Floor Subsurface

Eight boreholes were drilled through the arena floor (Figure 4-1) to determine if contamination was present below the concrete slab. Six of the holes were advanced to 5.5 ft, one hole to 8 ft, and one hole reached refusal at only 1.5 ft. Natural soil was encountered at depths of 3 to 3.5 ft as determined by the geologist attending the drilling. Two additional boreholes were drilled in the southeast corner of Room 1 to determine if contamination had migrated below the concrete slab (Figure 5-6).

All holes were sampled in 0.5-ft increments from the concrete/soil interface to the bottom of the boreholes. Soil sampling results are provided in Table 5-6. In all samples, the uranium-238 concentration was less than detectable; radium-226 and thorium-232 concentrations were at background levels. Based on this sampling, contamination does not appear to be present under the arena floor, and no further action is warranted.

5.4.5 Catch Basin Survey

Material in each of the five accessible interior catch basins, two grease traps, and one exterior sediment trap (Catch Basin 7, Figure 4-2) was sampled. In Catch Basin 3 (see Figure 4-2), the material was sampled at discrete 6-in. depths. Composite samples were collected from all other catch basins and traps. All samples were analyzed for uranium-238, radium-226, and thorium-232. Results

are presented in Table 5-7. In all cases, uranium-238 concentrations are elevated above background radiation levels; however, only the material in Catch Basin 3 exceeded remedial action guidelines. Concentrations ranged from less than 7 to 220 pCi/g for uranium-238, from 0.3 to 3 pCi/g for radium-226, and from less than 0.3 to less than 1 pCi/g for thorium-232.

To determine if the walls of the catch basins were contaminated, scrapings of the walls were collected and analyzed. Table 5-8 shows the results of the analyses. Uranium-238 concentrations ranged from less than 22 to 16,000 pCi/g. Scrapings from Catch Basins 2, 3, and 4 all had concentrations above the remedial action guideline for uranium-238. Radium-226 concentrations ranged from 2 to 4 pCi/g and thorium-232 ranged from less than 1 to 5 pCi/g.

Because the presence of cesium-137 and europium-152 in some samples from Catch Basin 3 had been mentioned in the ANL survey report (Ref. 1), analyses for these radionuclides were performed on the three samples with the highest measured concentrations of other radionuclides. All analyses showed the cesium-137 and europium-152 concentrations were either less than detectable levels or were at levels of less than 0.2 pCi/g.

Samples of the sludges were also analyzed for hazardous waste constituents. Results of the analyses showed elevated levels of volatile and semi-volatile organic compounds as well as some metals such as lead and chromium (Ref. 5). In addition, the wastes were determined to be ignitable at a temperature of less than 70°F. These characteristics demonstrate that the sludges are hazardous waste. Appendix A contains a tabular summary of the sampling results.

5.5 DECONTAMINATION TEST SURVEYS

To allow remedial action planning to proceed based on the characterization results, additional information was needed to

assess the removability of the contamination. Two types of tests were performed: one to determine the depth of fixed contamination and one to test the ease of removing transferable contamination.

To test the depth of fixed contamination, an area in the mess hall identified during the floor survey as having contamination in excess of guidelines was selected. Direct readings were made at a particular point in the area and recorded. The designated area was then scabbled and remonitored. The process was repeated until the area conformed to applicable guidelines. Typically, the depth of contamination was less than 0.125 in. deep.

Decontamination tests were also performed on the transferable contamination on the ceiling of Room 1. This was done by wiping the ceiling and remonitoring the cleaned area. These tests showed that most of the contamination was easily removed. Only isolated spots remained after the wiping.

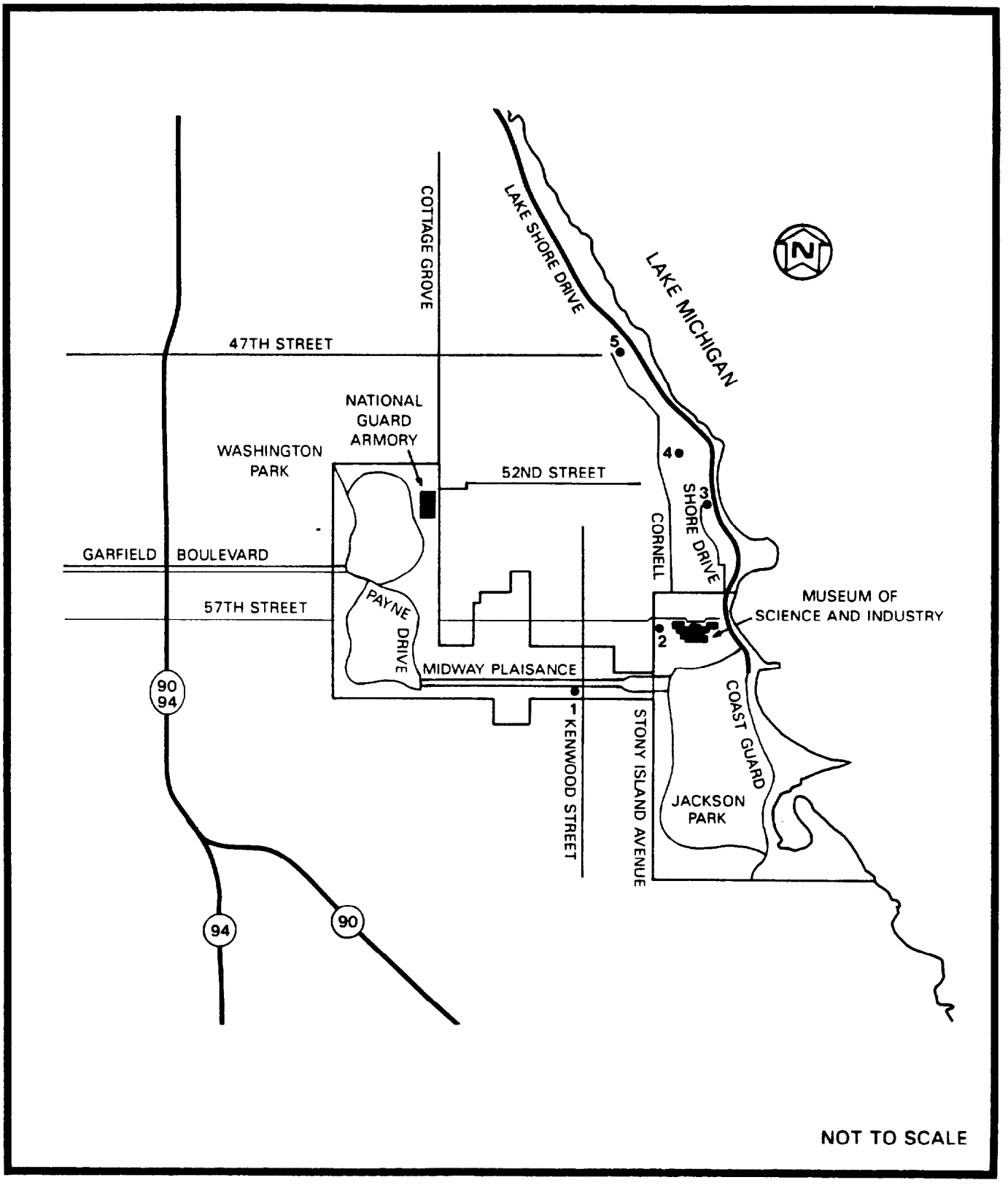


FIGURE 5-1 BACKGROUND RADIATION MEASUREMENT LOCATIONS

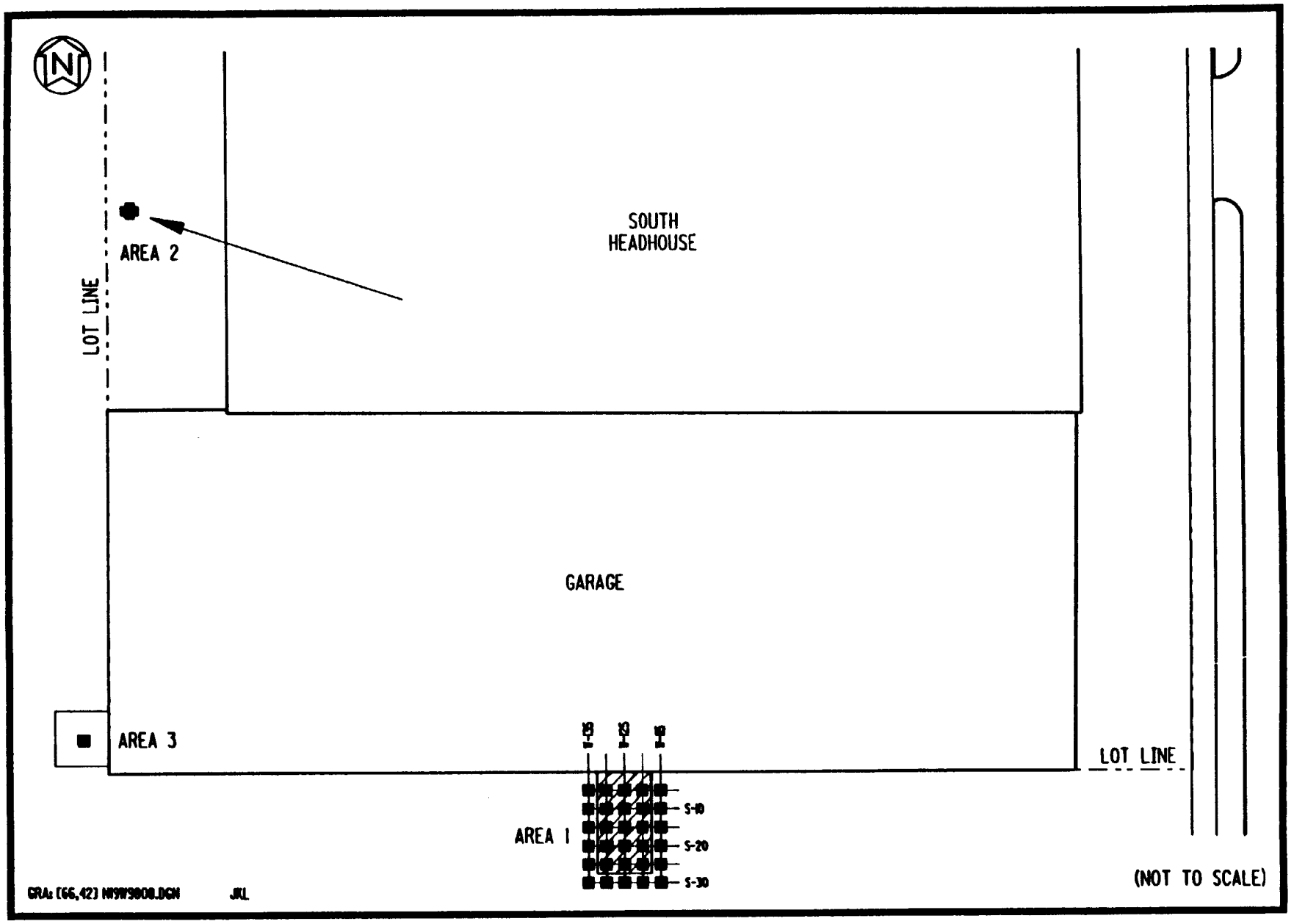


FIGURE 5-2 EXTERIOR AREAS OF CONTAMINATION

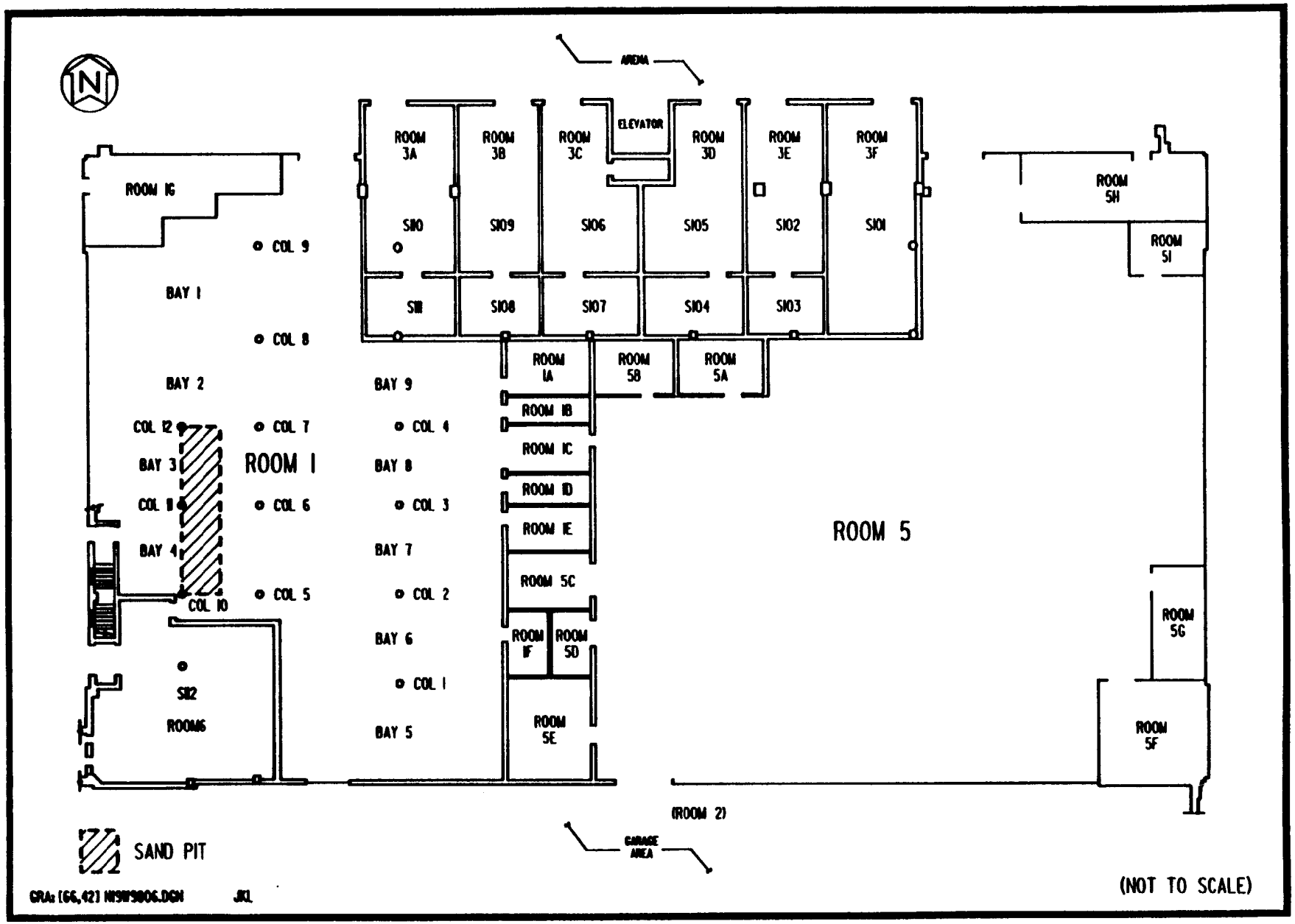


FIGURE 5-3 PLAN OF THE FIRST FLOOR - SOUTH HEADHOUSE

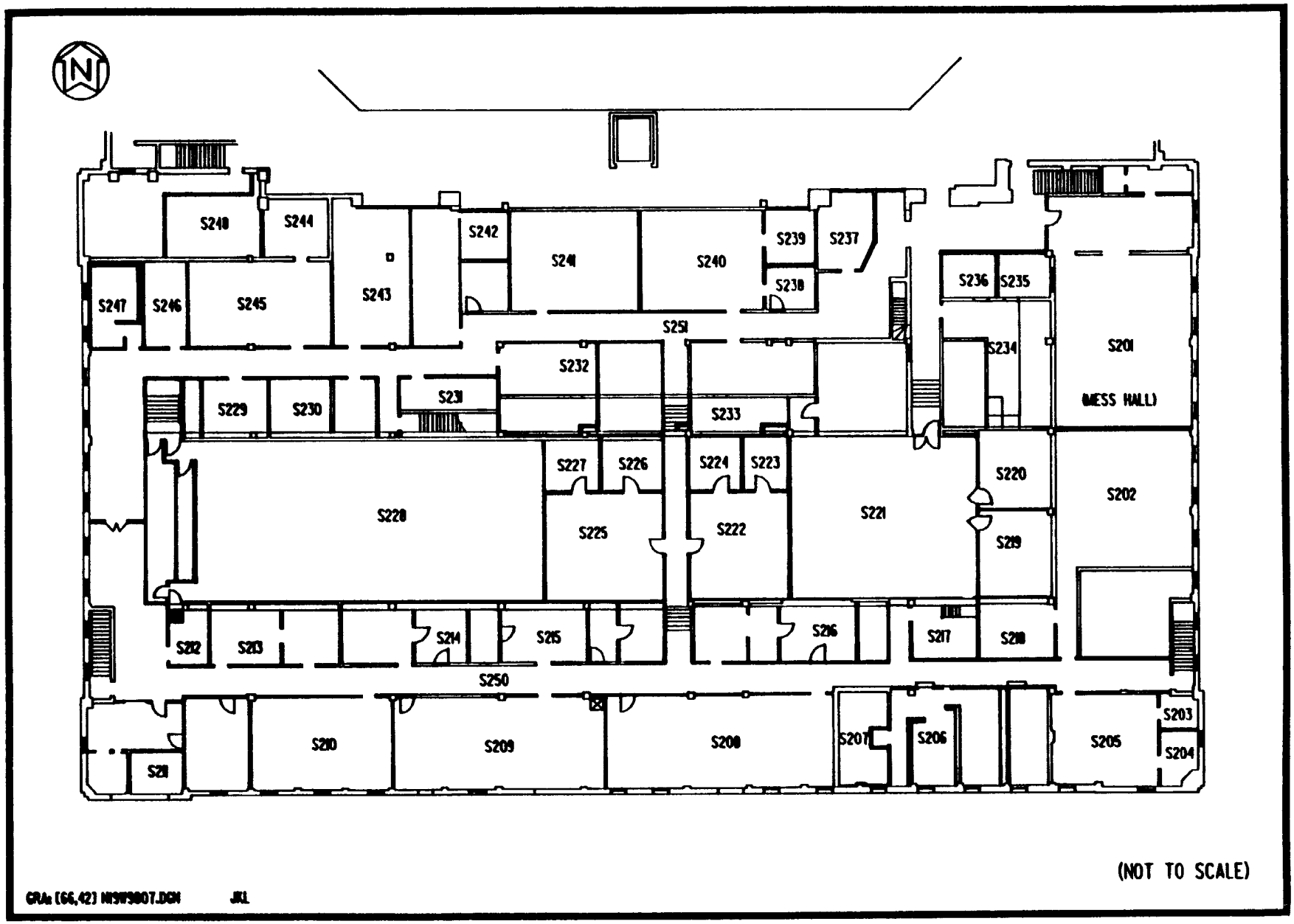


FIGURE 5-4 PLAN OF THE SECOND FLOOR - SOUTH HEADHOUSE

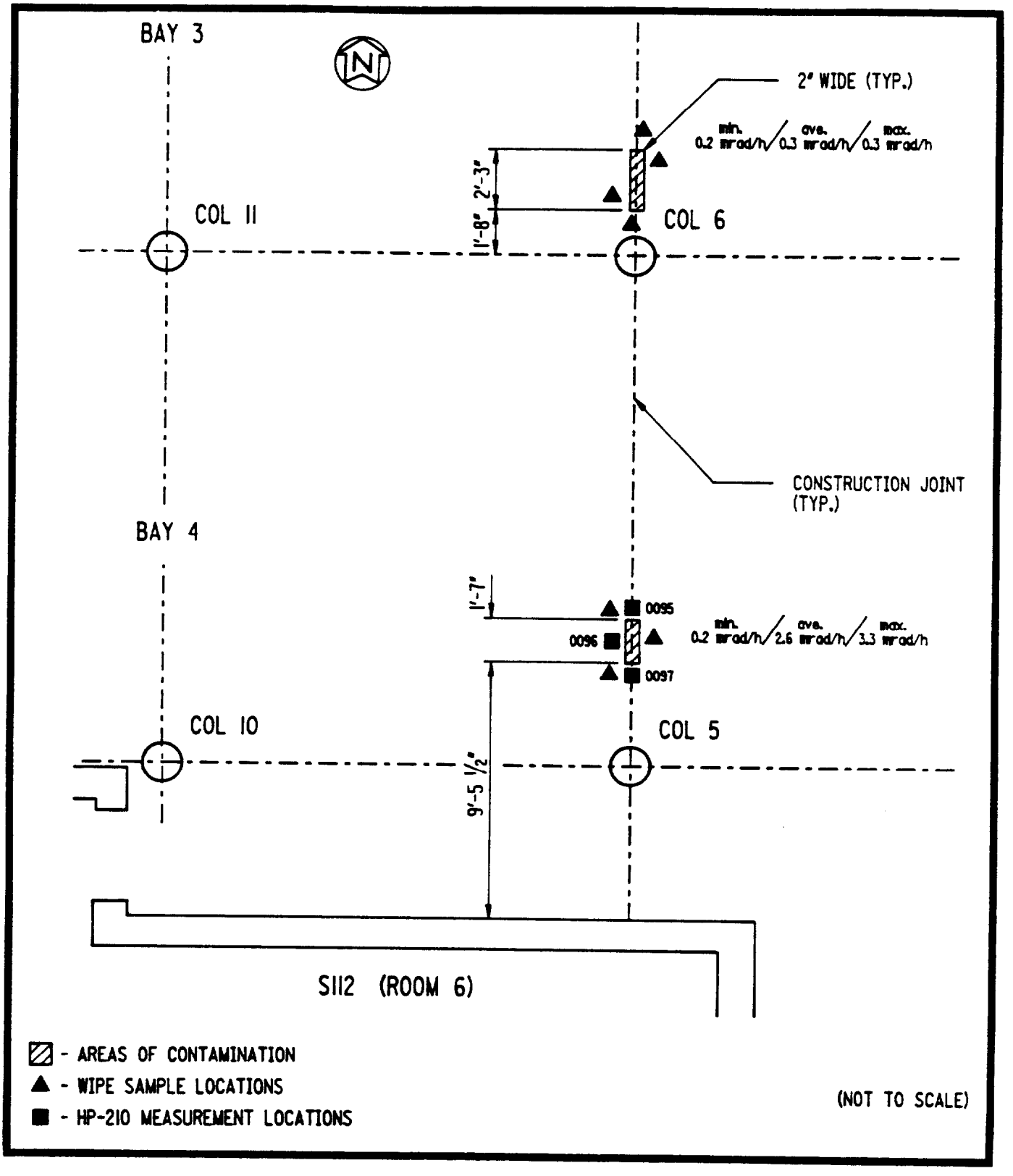


FIGURE 5-5 AREAS OF CONTAMINATION — BAYS 3 AND 4 (ROOM 1, FIRST FLOOR)

[illegible] JKL

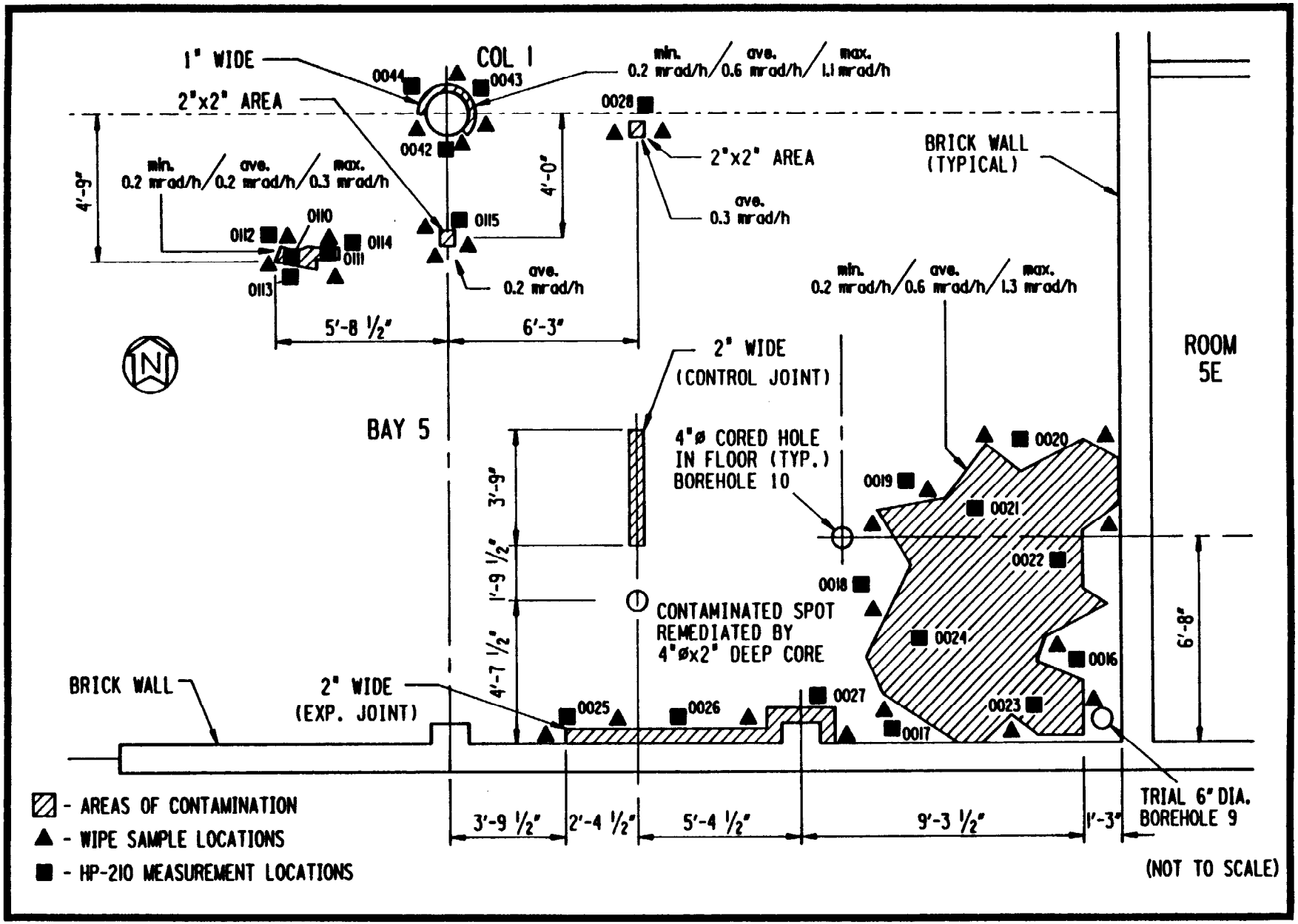


FIGURE 5-6 AREAS OF CONTAMINATION - BAY 5 (ROOM 1, FIRST FLOOR)

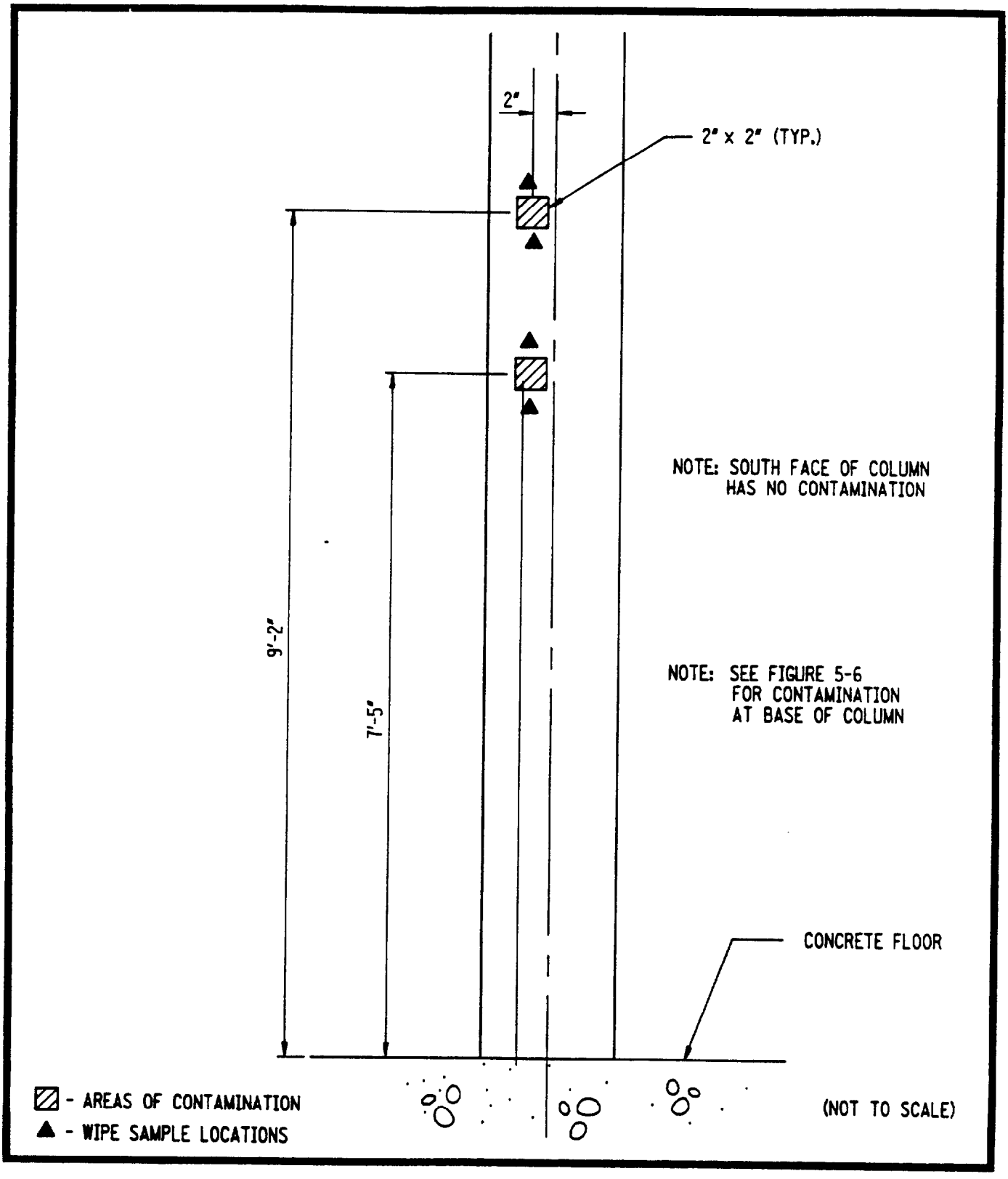
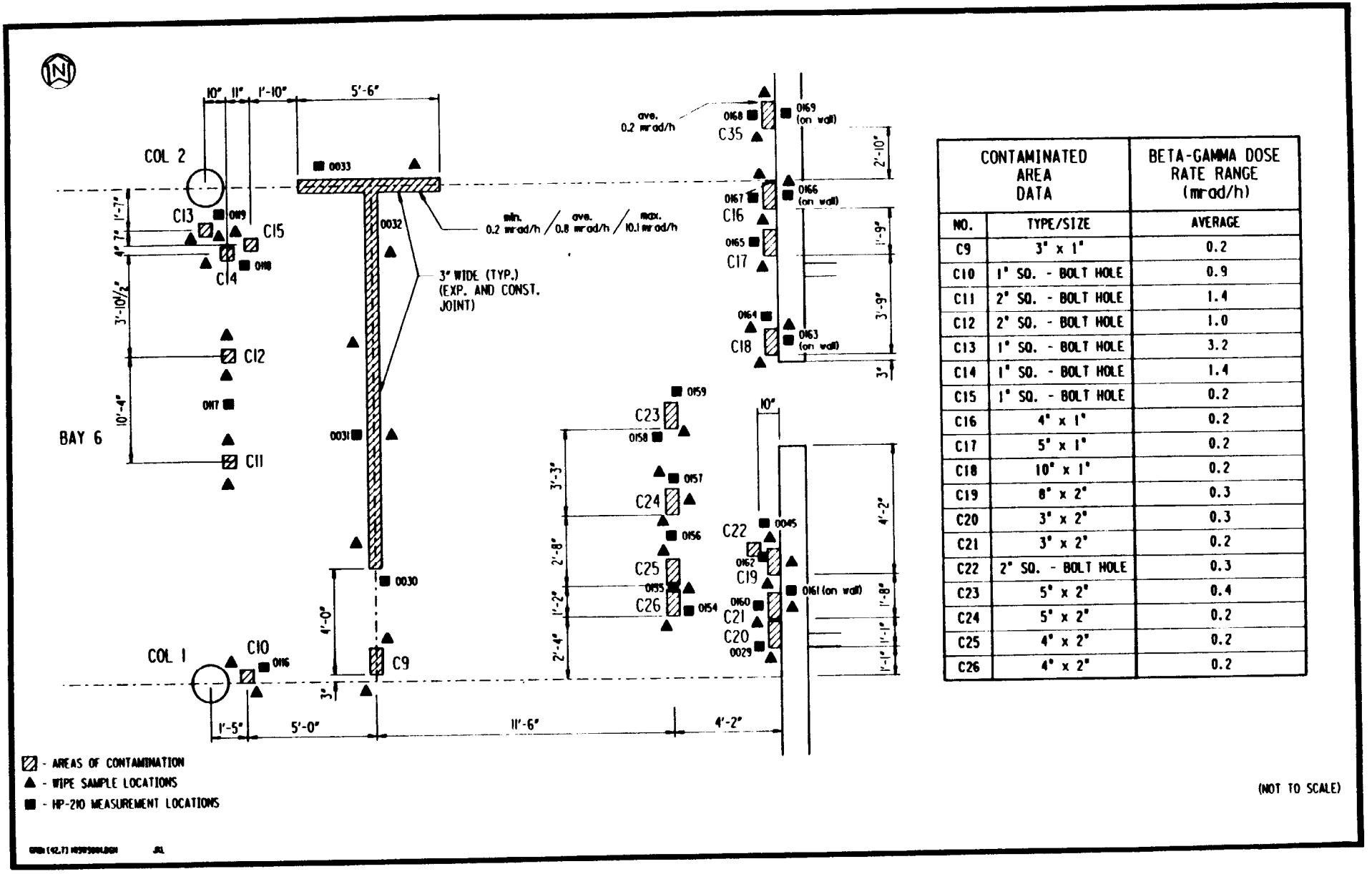


FIGURE 5-7 AREAS OF CONTAMINATION — COLUMN 1, NORTH FACE (ROOM 1, FIRST FLOOR)

GRB: (-2,7) N19W980LDGN JKL



CONTAMINATED AREA DATA		BETA-GAMMA DOSE RATE RANGE (mrad/h)
NO.	TYPE/SIZE	AVERAGE
C9	3" x 1"	0.2
C10	1" SQ. - BOLT HOLE	0.9
C11	2" SQ. - BOLT HOLE	1.4
C12	2" SQ. - BOLT HOLE	1.0
C13	1" SQ. - BOLT HOLE	3.2
C14	1" SQ. - BOLT HOLE	1.4
C15	1" SQ. - BOLT HOLE	0.2
C16	4" x 1"	0.2
C17	5" x 1"	0.2
C18	10" x 1"	0.2
C19	8" x 2"	0.3
C20	3" x 2"	0.3
C21	3" x 2"	0.2
C22	2" SQ. - BOLT HOLE	0.3
C23	5" x 2"	0.4
C24	5" x 2"	0.2
C25	4" x 2"	0.2
C26	4" x 2"	0.2

FIGURE 5-8 AREAS OF CONTAMINATION - BAY 6 (ROOM 1, FIRST FLOOR)

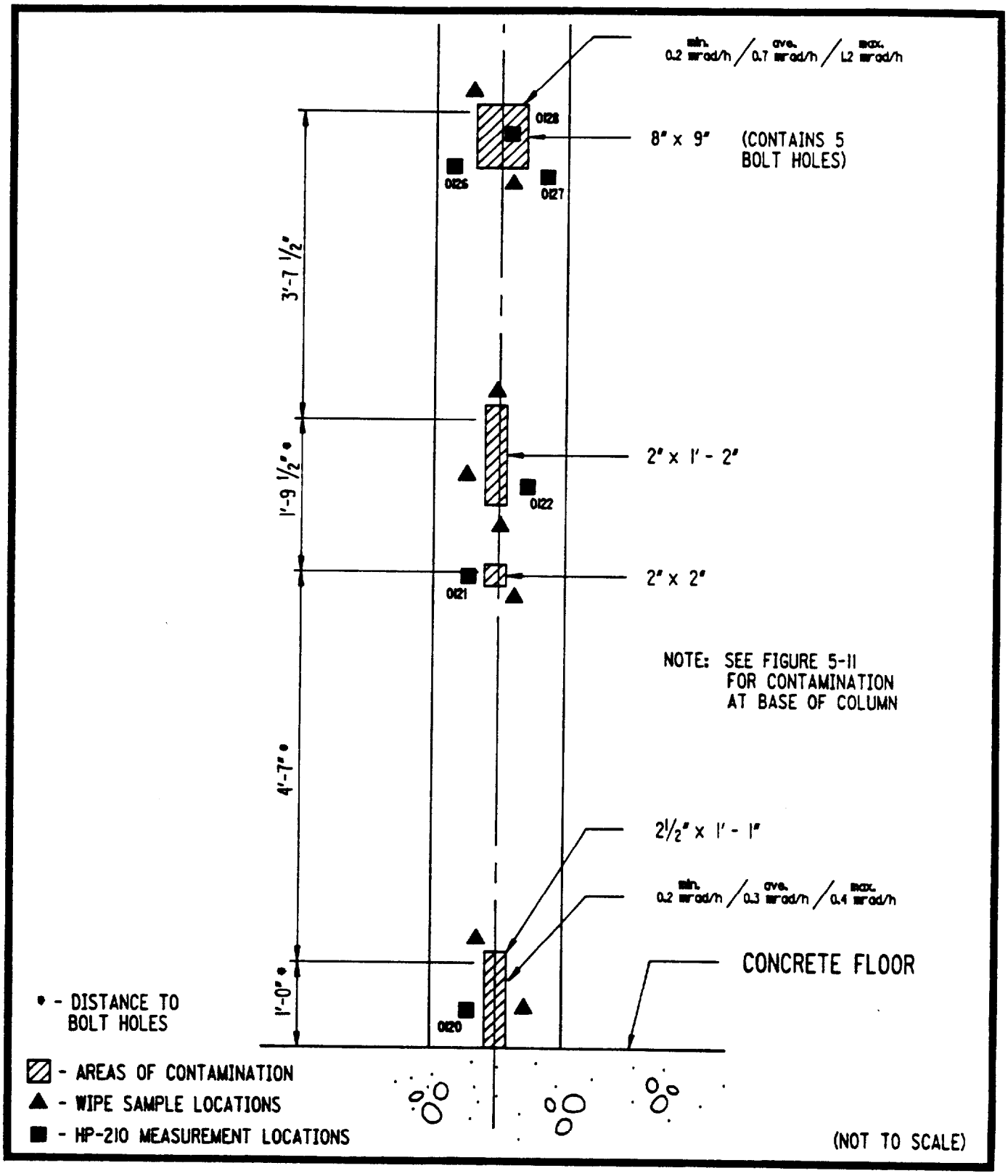


FIGURE 5-9 AREAS OF CONTAMINATION - COLUMN 2, SOUTH FACE (ROOM 1, FIRST FLOOR)

GRB: [42,7] N19W980LDGN JKL

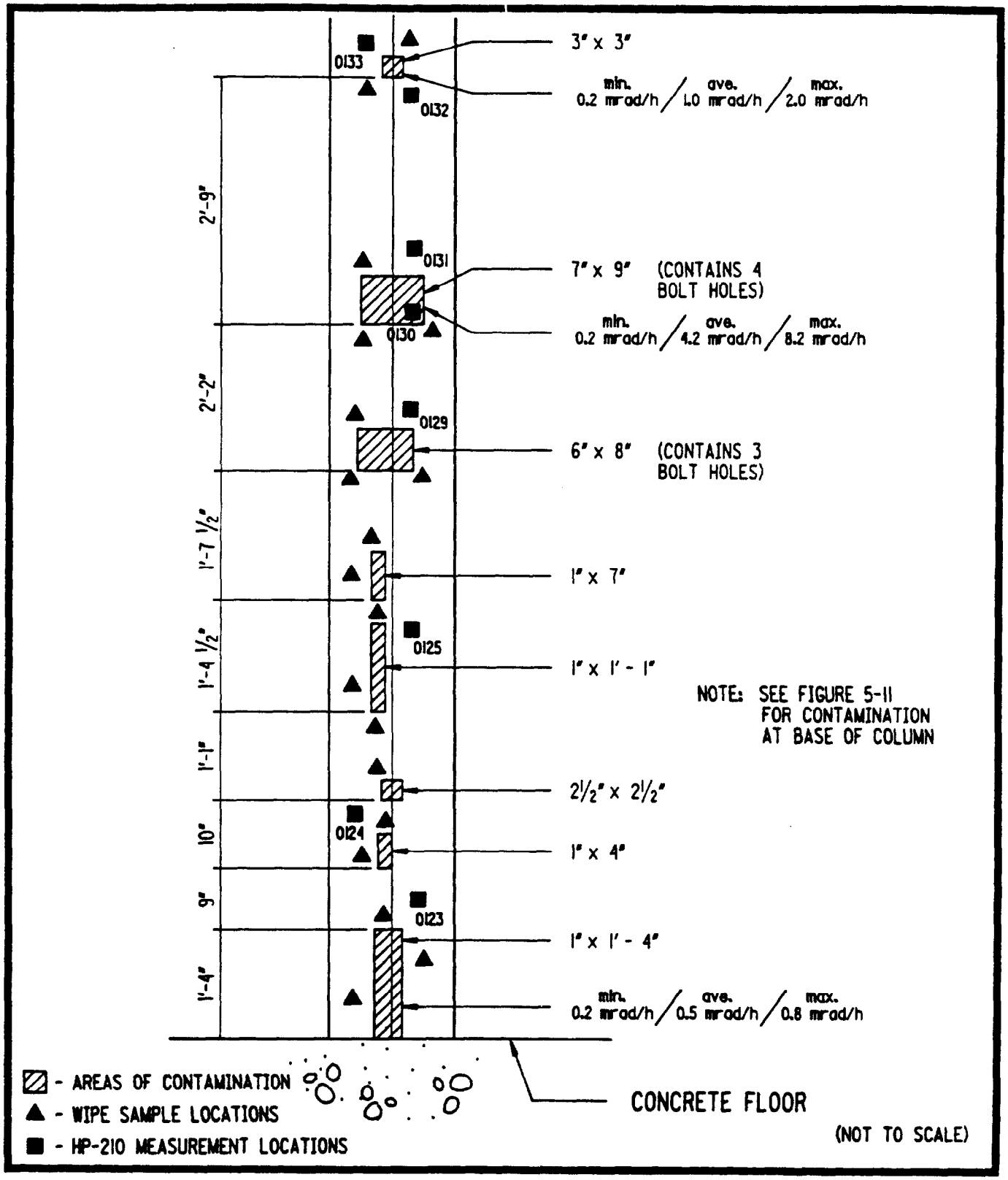
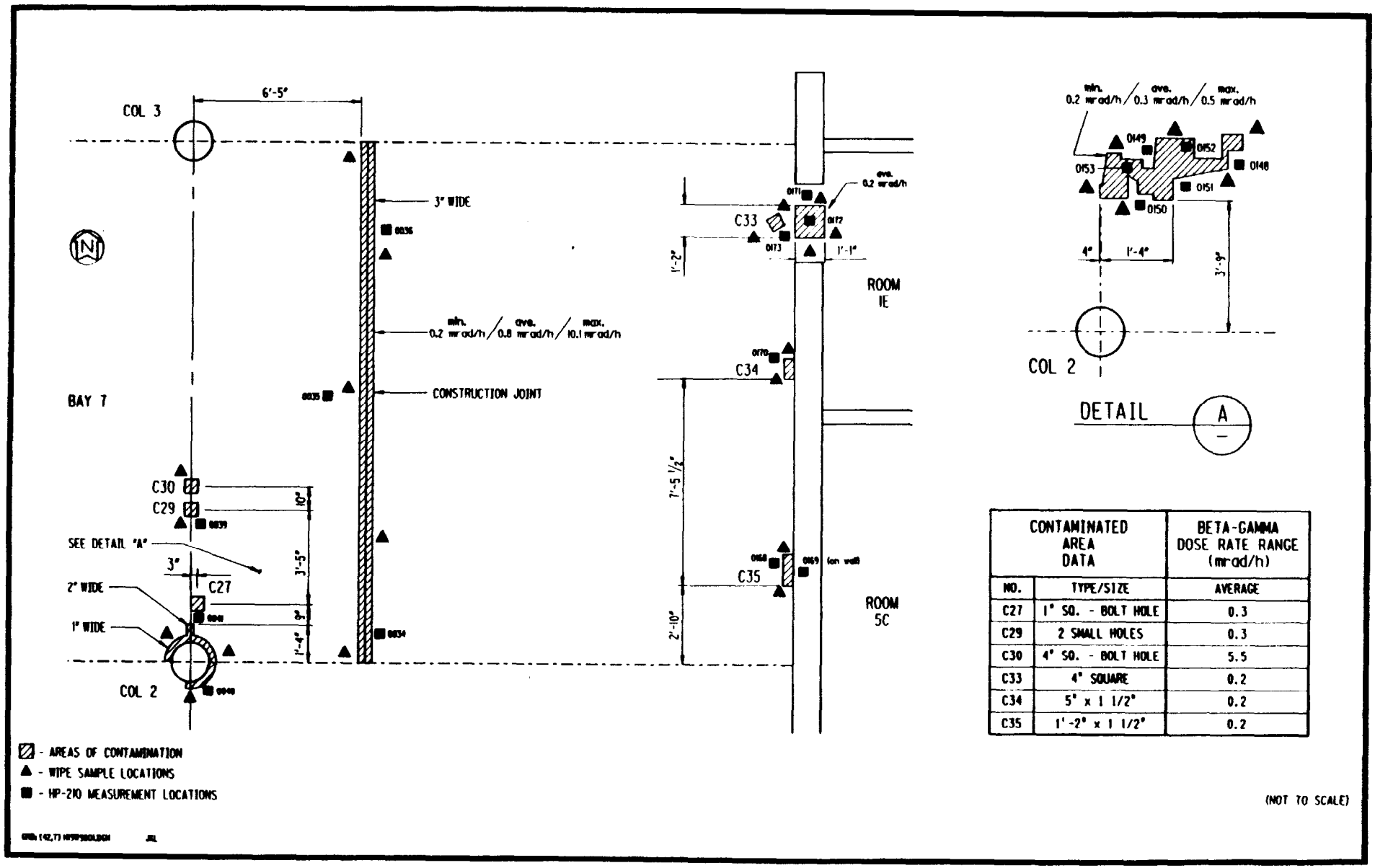


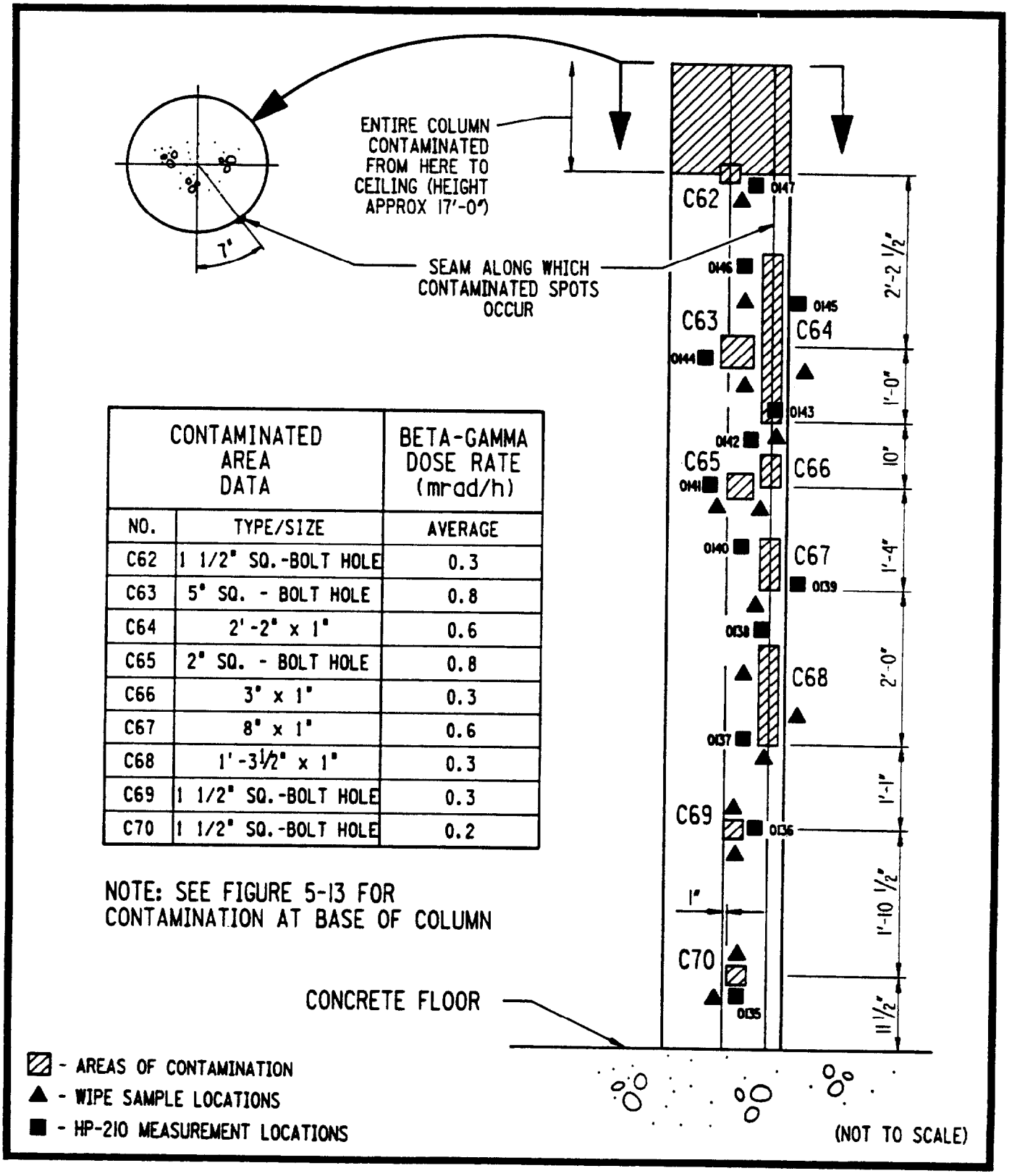
FIGURE 5-10 AREAS OF CONTAMINATION - COLUMN 2, NORTH FACE (ROOM 1, FIRST FLOOR)

GRB: [42,7] N19W980LDGN JKL



CONTAMINATED AREA DATA		BETA-GAMMA DOSE RATE RANGE (mrad/h)
NO.	TYPE/SIZE	AVERAGE
C27	1" SQ. - BOLT HOLE	0.3
C29	2 SMALL HOLES	0.3
C30	4" SQ. - BOLT HOLE	5.5
C33	4" SQUARE	0.2
C34	5" x 1 1/2"	0.2
C35	1'-2" x 1 1/2"	0.2

FIGURE 5-11 AREAS OF CONTAMINATION - BAY 7 (ROOM 1, FIRST FLOOR)

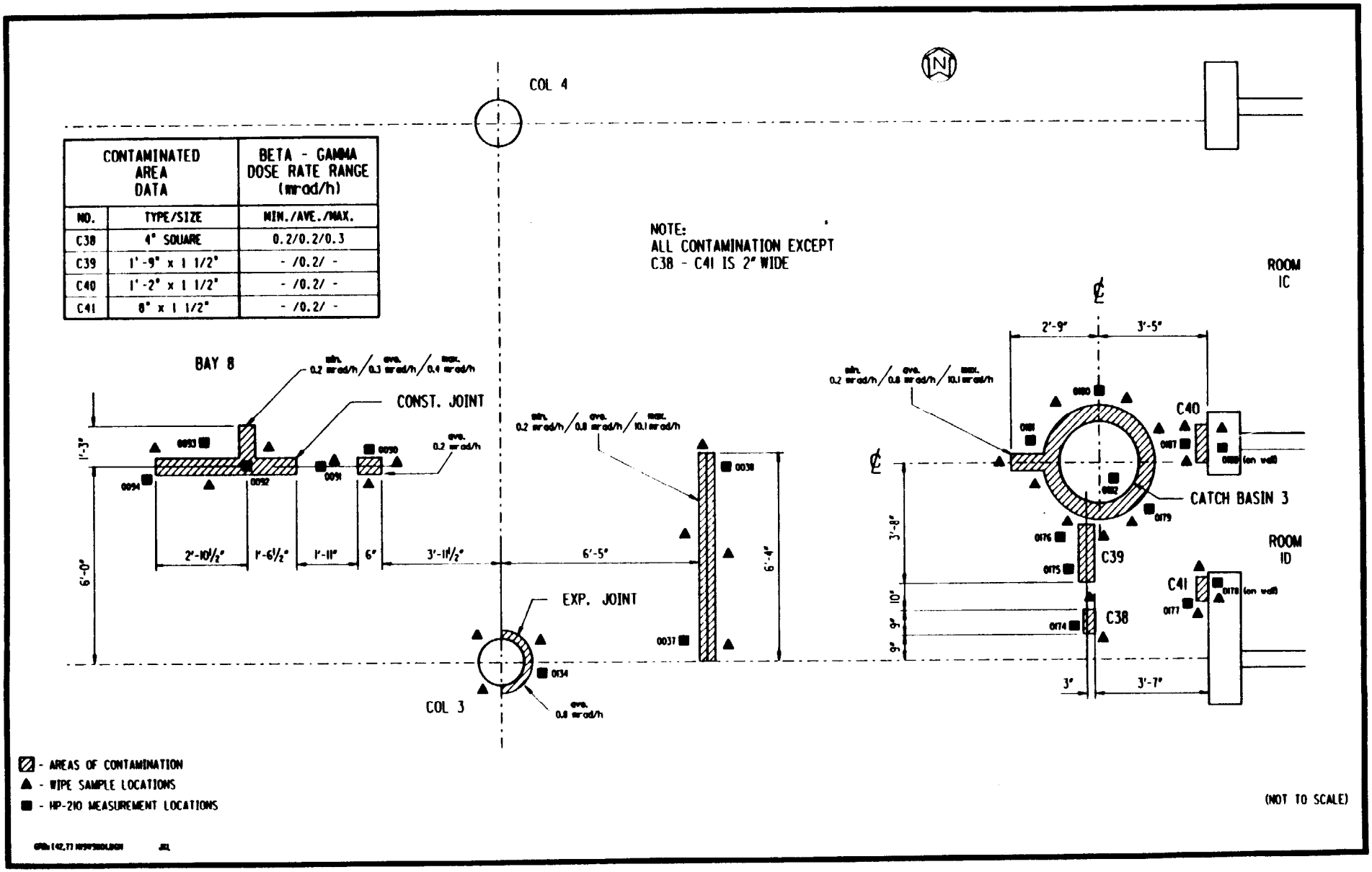


CONTAMINATED AREA DATA		BETA-GAMMA DOSE RATE (mrad/h)
NO.	TYPE/SIZE	AVERAGE
C62	1 1/2" SQ.-BOLT HOLE	0.3
C63	5" SQ. - BOLT HOLE	0.8
C64	2'-2" x 1"	0.6
C65	2" SQ. - BOLT HOLE	0.8
C66	3" x 1"	0.3
C67	8" x 1"	0.6
C68	1'-3½" x 1"	0.3
C69	1 1/2" SQ.-BOLT HOLE	0.3
C70	1 1/2" SQ.-BOLT HOLE	0.2

NOTE: SEE FIGURE 5-13 FOR CONTAMINATION AT BASE OF COLUMN

FIGURE 5-12 AREAS OF CONTAMINATION - COLUMN 3, SOUTH FACE (ROOM 1, FIRST FLOOR)

GRB: [42,7] NI9W980LDGN JKL



CONTAMINATED AREA DATA		BETA - GAMMA DOSE RATE RANGE (mrad/h)
NO.	TYPE/SIZE	MIN./AVE./MAX.
C38	4" SQUARE	0.2/0.2/0.3
C39	1'-9" x 1 1/2"	- /0.2/ -
C40	1'-2" x 1 1/2"	- /0.2/ -
C41	8" x 1 1/2"	- /0.2/ -

FIGURE 5 13 AREAS OF CONTAMINATION - BAY 8 (ROOM 1, FIRST FLOOR)

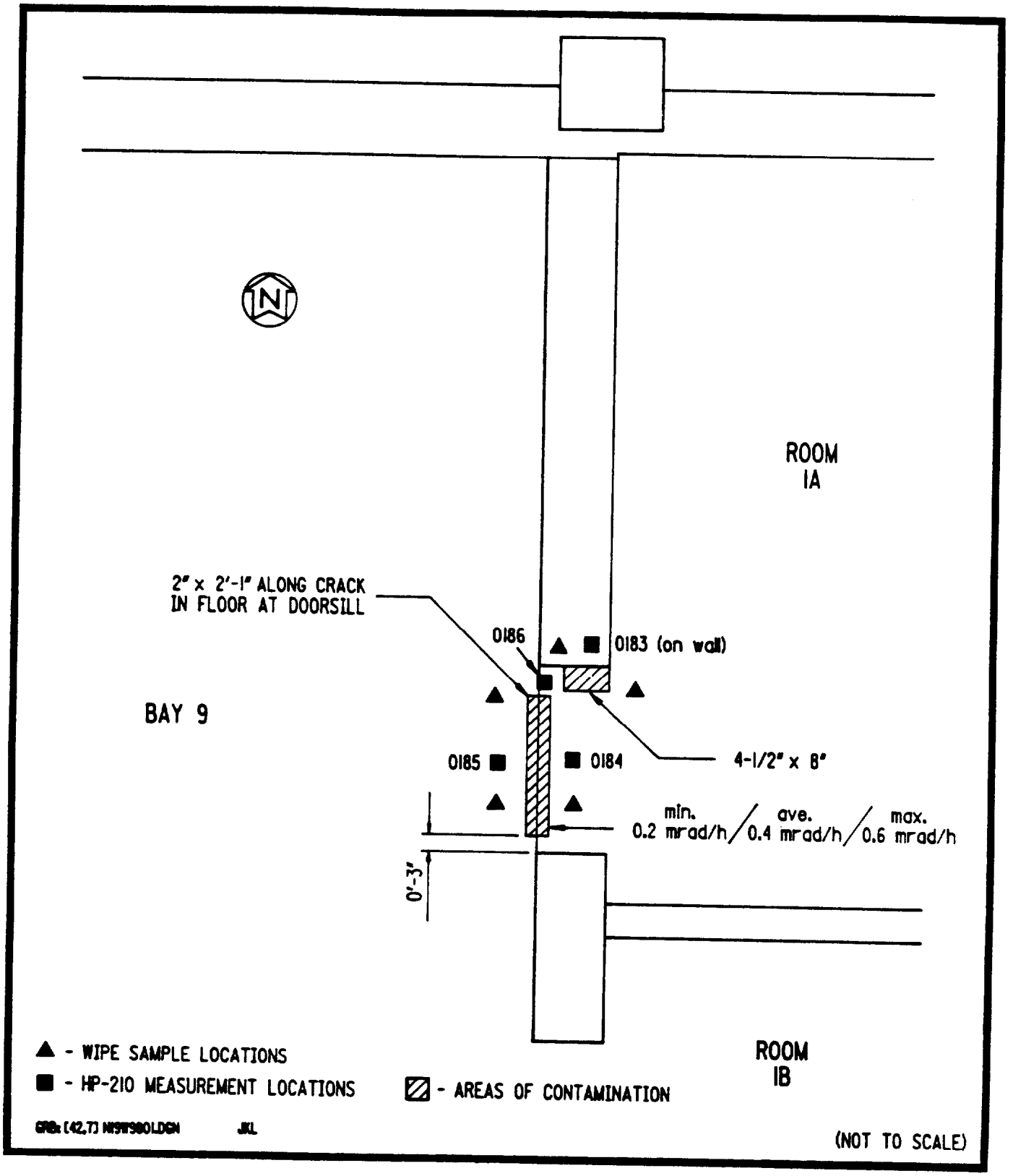


FIGURE 5-14 AREAS OF CONTAMINATION - BAY 9 / ROOM 1A

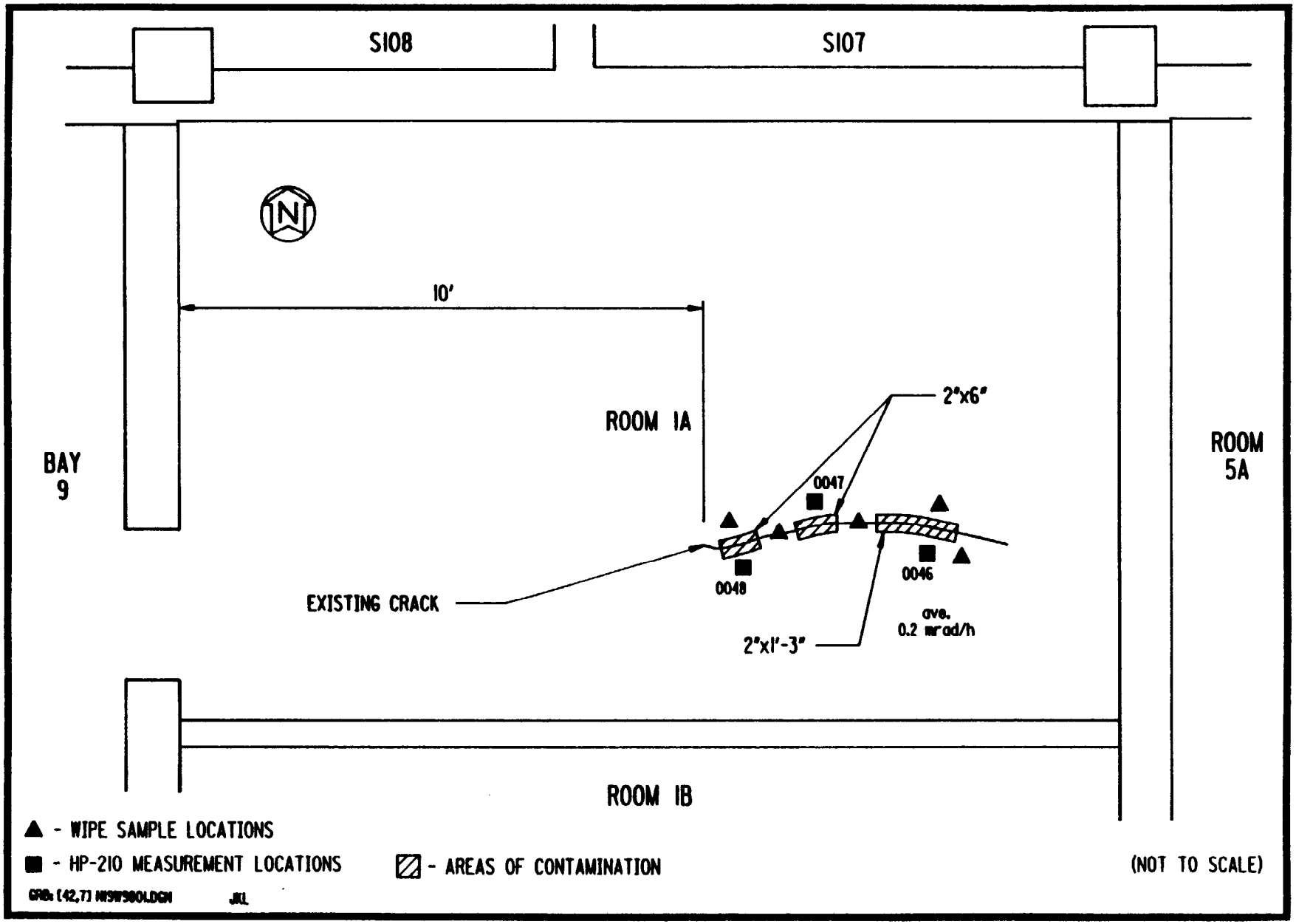


FIGURE 5-15 AREAS OF CONTAMINATION - ROOM 1A (FIRST FLOOR)

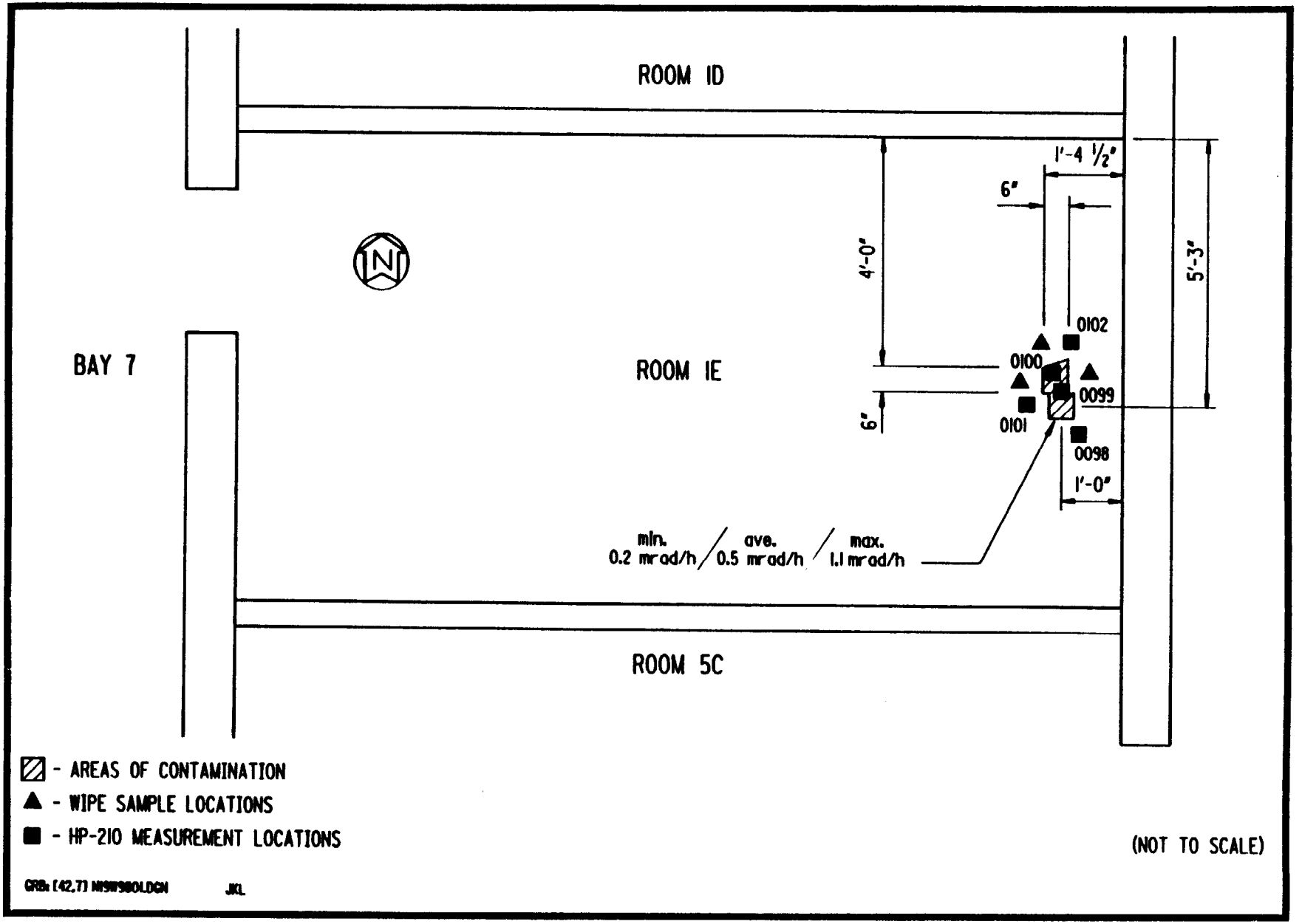


FIGURE 5-16 AREAS OF CONTAMINATION - ROOM 1E (FIRST FLOOR)

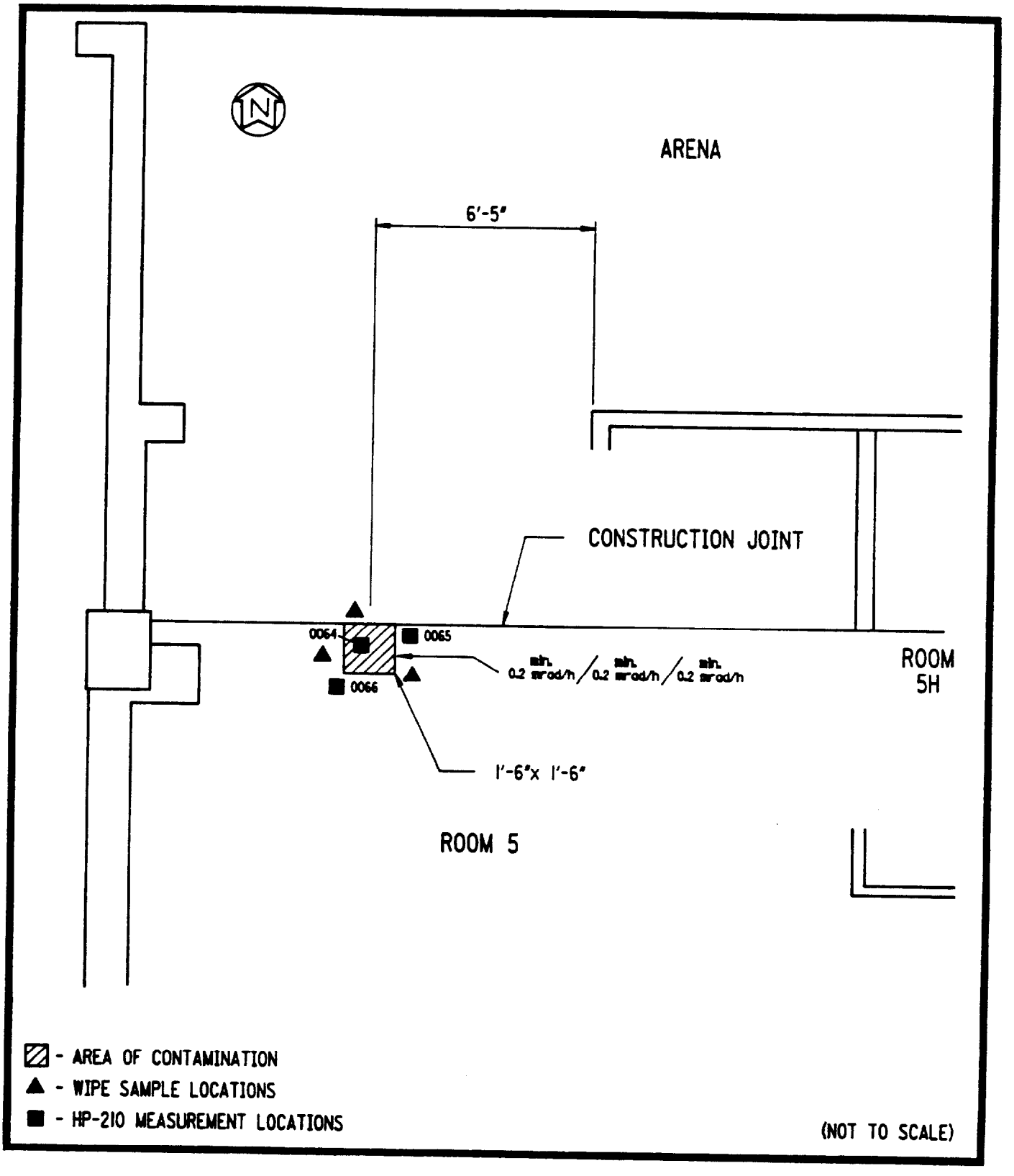


FIGURE 5-17 AREA OF CONTAMINATION - ROOM 5 (FIRST FLOOR)

GRB: [42,7] N19W90LDGN JKL

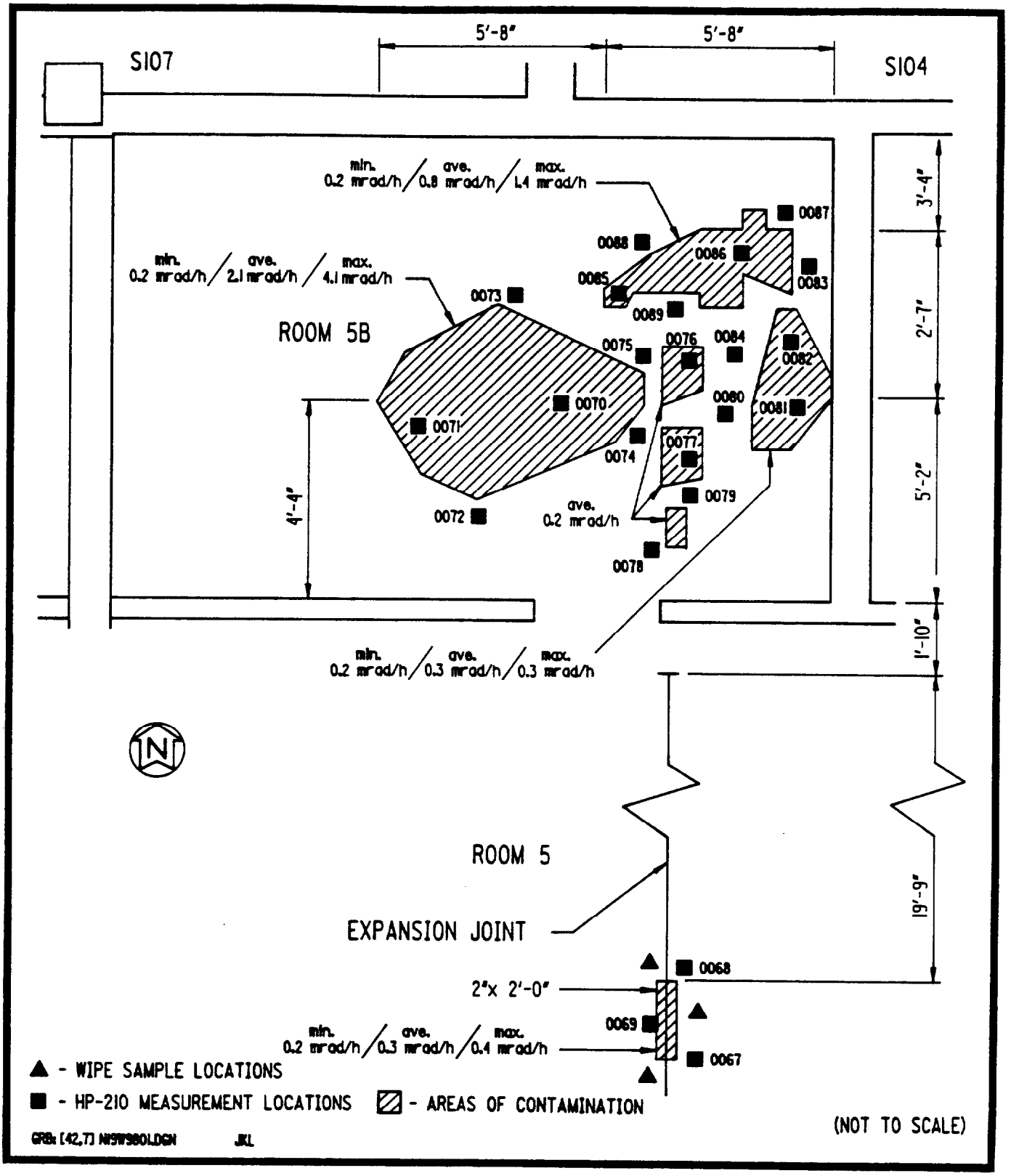


FIGURE 5-18 AREAS OF CONTAMINATION - ROOM 5B (FIRST FLOOR)

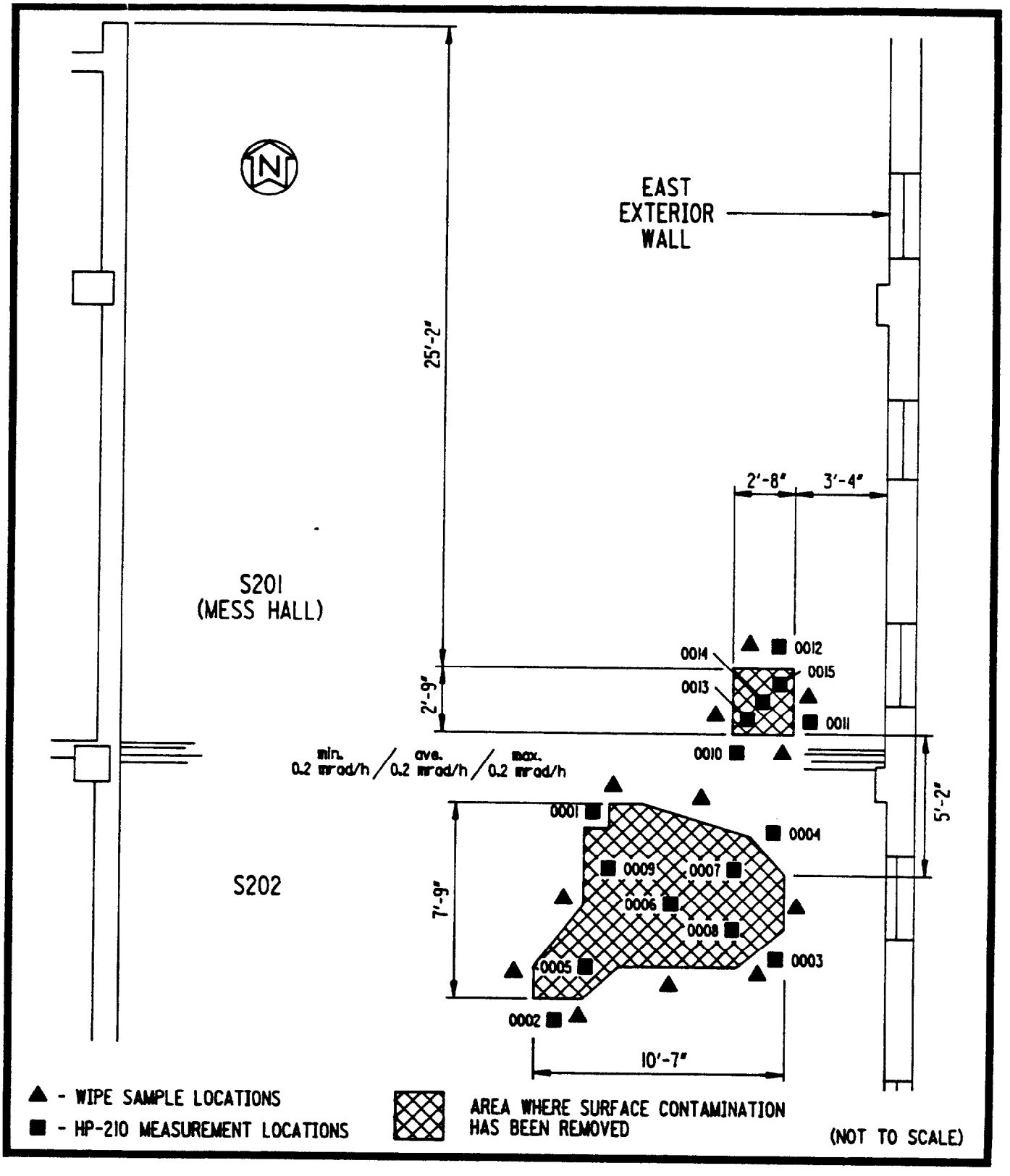


FIGURE 5-19 AREAS OF CONTAMINATION - ROOMS S201 / S202 (SECOND FLOOR)

GRA: [66,42] N9W9802.DGN JKL

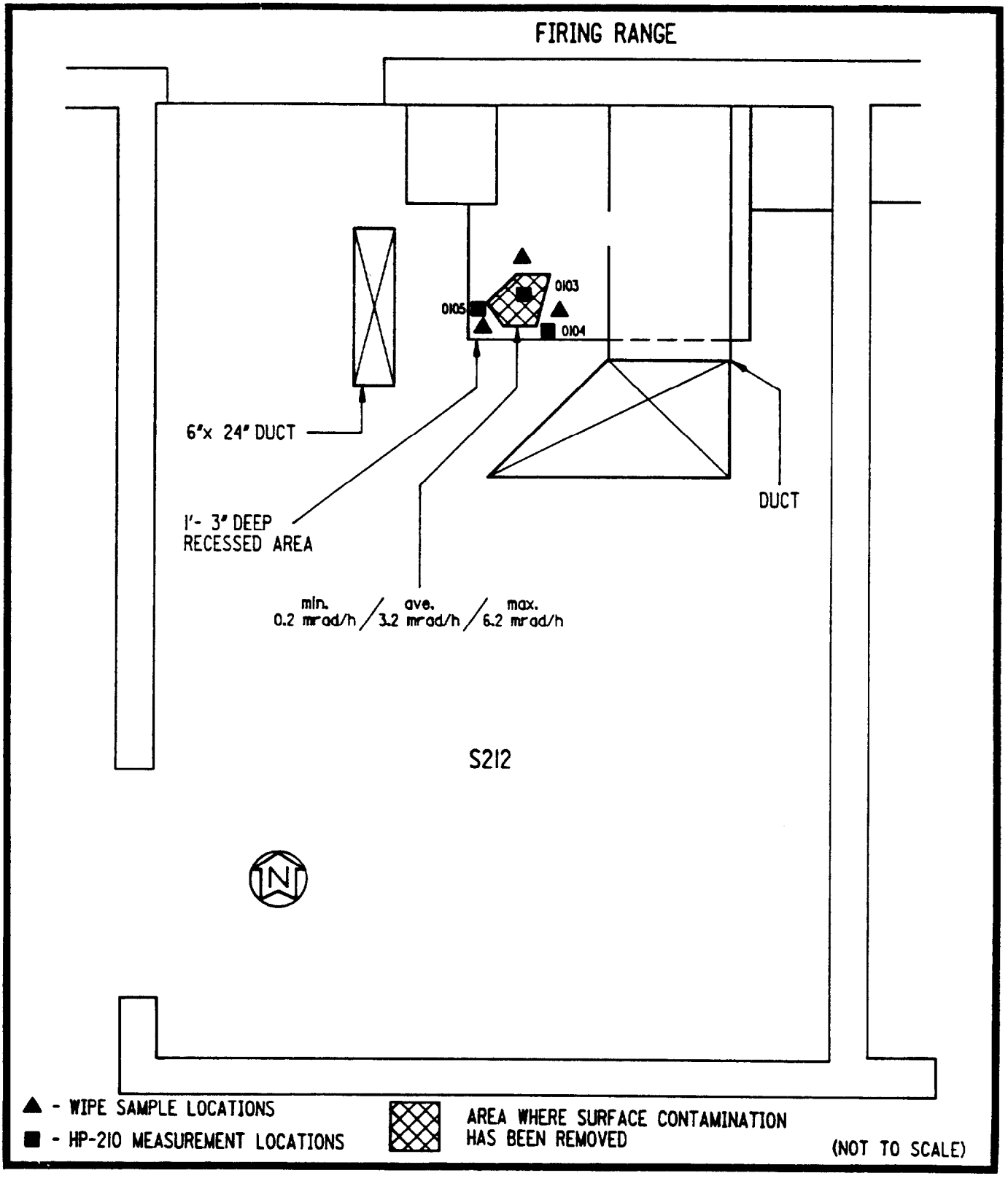


FIGURE 5-20 AREA OF CONTAMINATION - ROOM S212 (SECOND FLOOR)

GRB: [42,7] N19W9802.DGN JKL

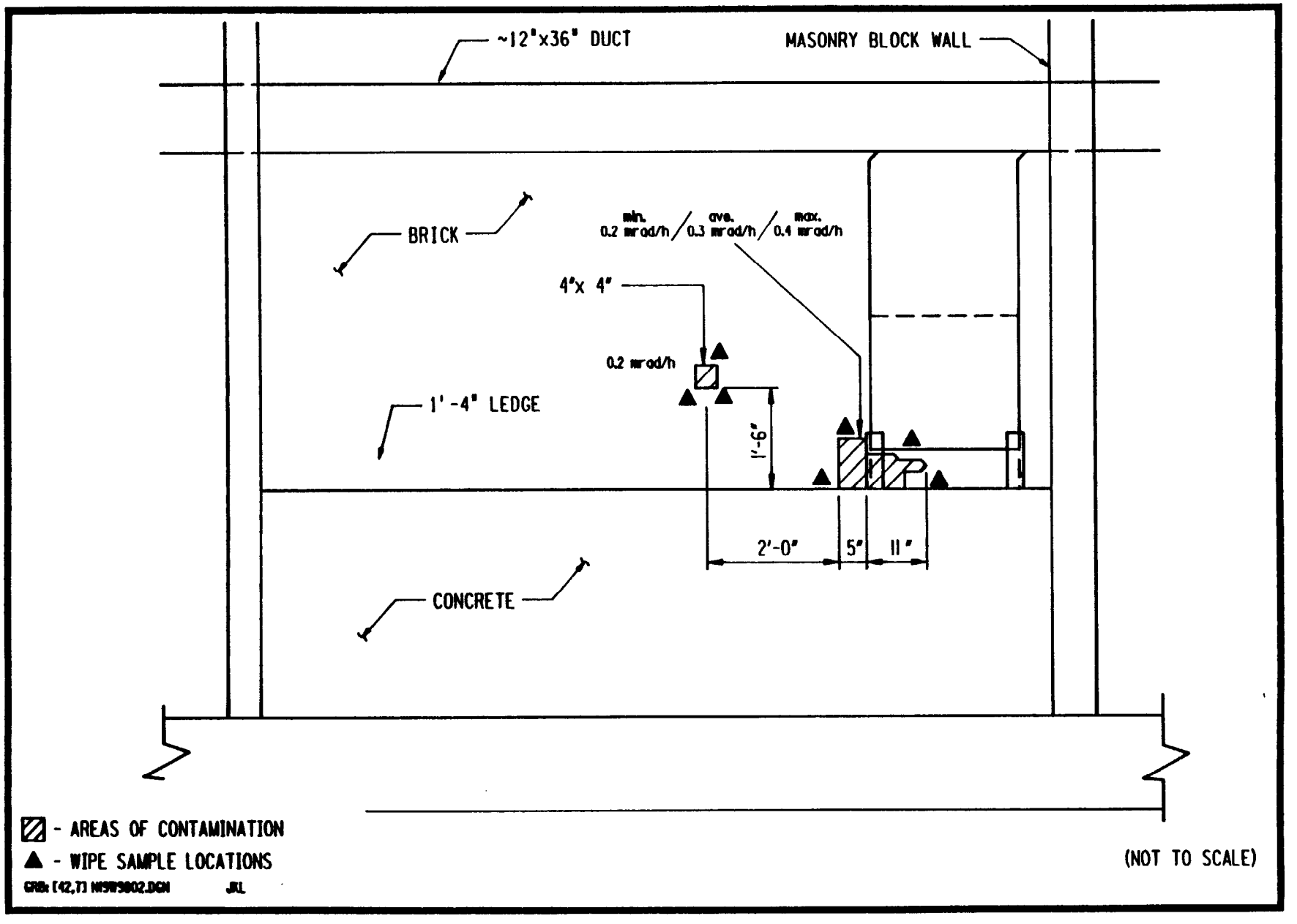


FIGURE 5-21 AREAS OF CONTAMINATION - ROOM S213, ELEVATION OF NORTH WALL (SECOND FLOOR)

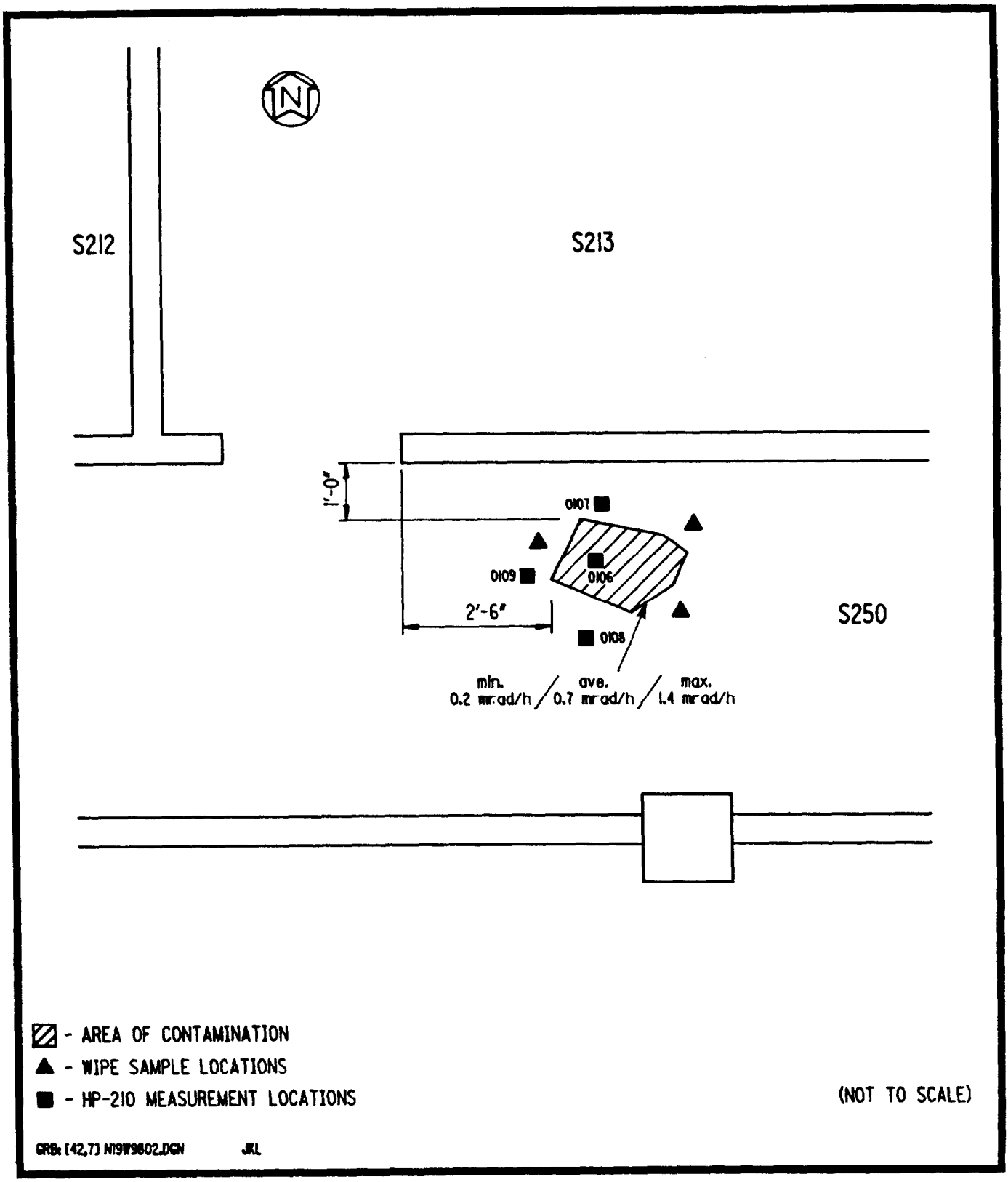


FIGURE 5-22 AREA OF CONTAMINATION - ROOM S250 (SECOND FLOOR)

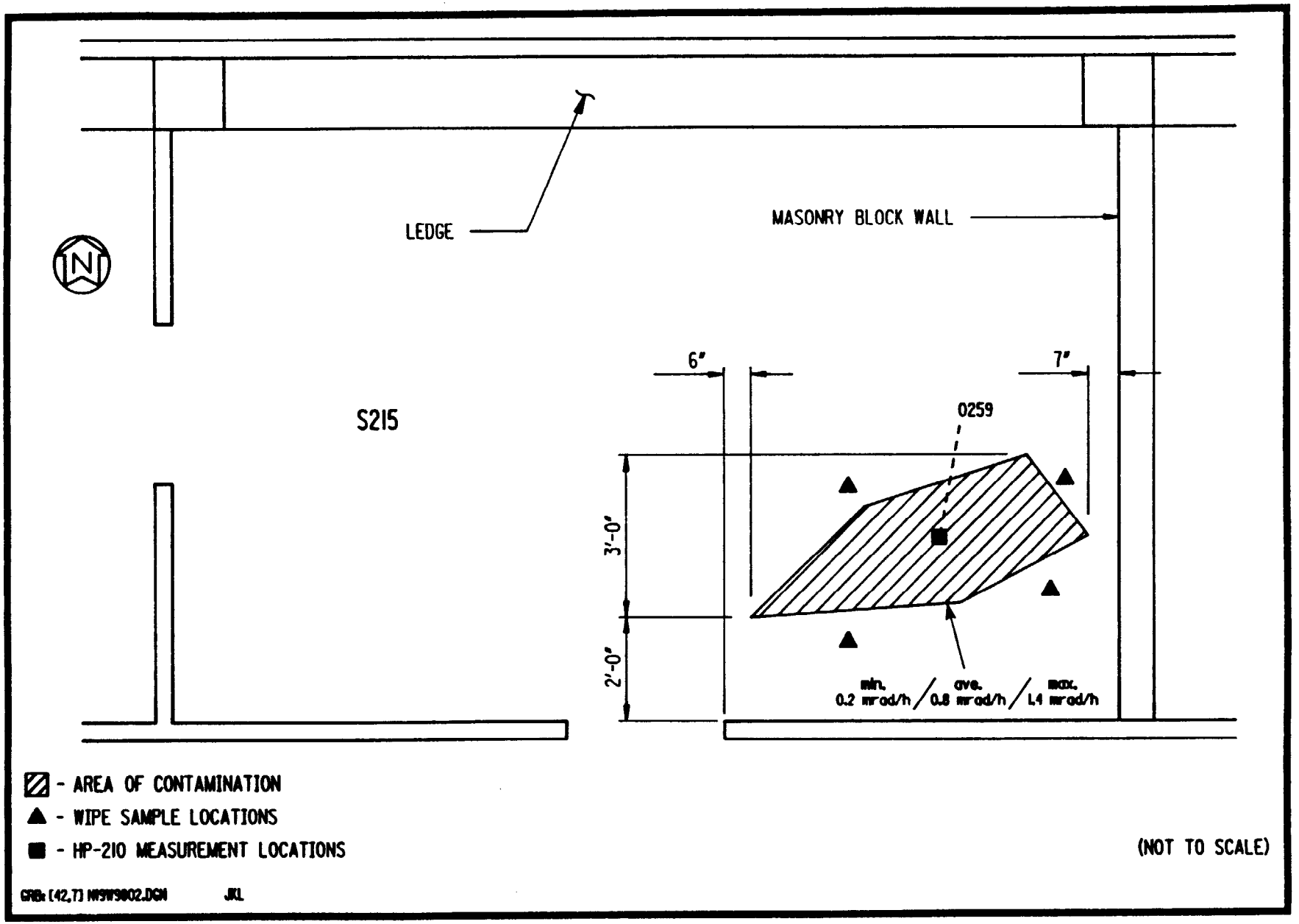


FIGURE 5-23 AREA OF CONTAMINATION - ROOM S215 (SECOND FLOOR)

TABLE 5-1

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES FOR THE NATIONAL GUARD ARMORY

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Radionuclide	Soil Concentration (pCi/g) above background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Uranium-238	150 pCi/g*
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[d] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

Indoor/Outdoor Structure Surface Contamination

Radionuclide[f]	Allowable Surface Residual Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
Transuranics, Ra-226, Ra-228, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224 U-232, I-126, I-131, I-133	1,000	3,000	200

*Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987.

TABLE 5-1

(continued)

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[f]	Allowable Surface Residual Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β-γ	15,000 β-γ	1,000 β-γ

[a]These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit.

[b]These guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100-m^2 surface area.

[c]Localized concentrations in excess of these limits are allowable provided that the average over a 100-m^2 area is not exceeded.

[d]A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

[e]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.

[f]Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[g]Measurements of average contamination should not be averaged over more than 1 m^2. For objects of less surface area, the average shall be derived for each such object.

[h]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

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

[j]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 measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

TABLE 5-2
EXTERIOR BACKGROUND RADIONUCLIDE CONCENTRATIONS AND RADIATION LEVELS IN THE AREA OF THE NGA
(MEASURED IN OUTSIDE AREAS)

Measurement Location[a]	Surface Gamma Radiation (cpm)	Surface Beta-Gamma Radiation (mrad/h)	Radionuclide Concentration (pCi/g ± 2 sigma)		
			Uranium-238	Radium-226	Thorium-232
1[b]	10000	0.03	<4.5	0.8 ± 0.6	1.5 ± 0.8
2[c]	7000	0.02	<5.0	1.1 ± 0.5	<1.0
3[d]	8000	0.03	<4.0	0.6 ± 0.5	1.1 ± 0.7
4[e]	8000	0.03	<5.5	1.0 ± 0.6	1.0 ± 0.7
5[f]	9000	0.03	<5.0	1.3 ± 0.5	1.5 ± 0.8
Average	8000	0.03	<4.8	1.0 ± 0.5	1.2 ± 0.8

[a]See Figure 5-1.
[b]Located at the University of Chicago, south of eastbound Midway Plaisance approximately 120 ft west of Kenwood Street, and 5 ft south of lightpole 13/7.
[c]Located west of the Museum of Science and Industry, east of northbound Stony Island Avenue approximately 5 ft east of the fourth lightpole south of 57th Street.
[d]Located east of northbound Shore Drive, directly across from Chicago Sinai Congregation Synagogue, approximately 10 ft east of the shoulder of the road.
[e]Located on the east side of northbound Lake Shore Drive, 5 ft east of lightpole 50/11.
[f]Located near the parking lot north of the intersection of 47th Street and Cornell, between the parking lot and 47th Street.

TABLE 5-3

EXTERIOR SUBSURFACE SOIL SAMPLING RESULTS

AT THE NATIONAL GUARD ARMORY

Coordinates E,W	Coordinates N,S	Depth (ft)	Concentrations (pCi/g +/- 2 sigma) Uranium-238	Radium-226	Thorium-232
Area 1*					
W115	S000	0.0-0.5	<11.0	0.8 ± 0.5	<1.0
W115	S000	0.5-1.0	<7.0	1.3 ± 0.7	1.1 ± 0.8
W115	S005	0.0-0.5	<11.0	1.3 ± 0.7	<1.0
W115	S005	0.5-1.0	<6.0	<1.0	<1.0
W115	S010	0.0-0.5	<5.0	1.6 ± 0.6	0.9 ± 0.6
W115	S010	0.5-1.0	<11.0	1.0 ± 0.6	0.9 ± 0.6
W115	S015	0.0-0.5	<8.0	1.3 ± 0.7	1.2 ± 0.8
W115	S015	0.5-1.0	<6.0	1.6 ± 0.7	1.8 ± 0.8
W115	S020	0.0-0.5	<12.0	1.5 ± 0.8	<1.0
W115	S020	0.5-1.0	<9.0	3.3 ± 0.9	2.0 ± 1.0
W115	S025	0.0-0.5	<14.0	1.5 ± 0.8	<1.0
W115	S025	0.5-1.0	<7.0	2.3 ± 0.8	1.2 ± 0.8
W115	S030	0.0-0.5	<13.0	2.4 ± 0.8	<1.0
W115	S030	0.5-1.0	<8.0	2.7 ± 0.8	2.0 ± 1.0
W120	S000	0.0-0.5	<8.0	1.0 ± 0.5	0.6 ± 0.6
W120	S000	0.5-1.0	<11.0	<1.0	<1.0
W120	S005	0.0-0.5	<6.0	<1.0	0.8 ± 0.6
W120	S005	0.5-1.0	<11.0	2.0 ± 0.7	2.0 ± 1.0
W120	S010	0.0-0.5	<12.0	0.9 ± 0.5	1.2 ± 0.8
W120	S010	0.5-1.0	<6.0	1.1 ± 0.5	0.9 ± 0.7
W120	S015	0.0-0.5	<6.0	2.4 ± 0.7	1.0 ± 0.7
W120	S015	0.5-1.0	<14.0	1.1 ± 0.5	<1.0
W120	S020	0.0-0.5	<7.0	2.2 ± 0.7	<1.0
W120	S020	0.5-1.0	<6.0	2.3 ± 0.7	1.1 ± 0.8
W120	S025	0.0-0.5	<13.0	2.7 ± 0.8	<1.0
W120	S025	0.5-1.0	<6.0	1.5 ± 0.6	<1.0
W120	S030	0.0-0.5	<15.0	2.6 ± 1.0	3.0 ± 1.0
W120	S030	0.5-1.0	<6.0	2.7 ± 0.8	<1.0
W125	S000	0.0-0.5	<7.0	2.1 ± 0.8	1.2 ± 1.0
W125	S000	0.5-1.0	<12.0	2.6 ± 0.9	1.3 ± 1.2
W125	S005	0.0-0.5	<7.0	1.5 ± 0.8	2.0 ± 1.0
W125	S005	0.5-1.0	<14.0	1.6 ± 0.7	<1.0
W125	S010	0.0-0.5	<9.0	3.1 ± 0.9	3.0 ± 1.0
W125	S010	0.5-1.0	<8.0	5.0 ± 1.0	2.0 ± 1.0
W125	S010	1.0-1.5	<11.0	1.7 ± 0.7	<1.0
W125	S010	1.5-2.0	<6.0	1.8 ± 0.6	1.3 ± 0.7
W125	S010	2.0-2.5	<6.0	1.3 ± 0.6	0.9 ± 0.8
W125	S010	2.5-3.0	<9.0	<1.0	<1.0
W125	S010	3.0-3.5	<5.0	0.5 ± 0.4	0.8 ± 0.6
W125	S010	3.5-4.0	<6.0	0.8 ± 0.4	0.7 ± 0.5
W125	S010	4.0-4.5	<4.0	0.7 ± 0.4	0.6 ± 0.4
W125	S010	4.5-5.0	<3.0	0.7 ± 0.4	0.7 ± 0.5
W125	S015	0.0-0.5	<8.0	2.4 ± 0.9	3.0 ± 1.0

TABLE 5-3

(Continued)

Coordinates E,W	Coordinates N,S	Depth (ft)	Concentrations (pCi/g +/- 2 sigma) Uranium-238	Radium-226	Thorium-232
W125	S015	0.5-1.0	<7.0	2.0 ± 0.8	2.0 ± 1.0
W125	S020	0.0-0.5	<12.0	5.0 ± 1.0	2.0 ± 1.0
W125	S020	0.5-1.0	<15.0	4.0 ± 1.0	3.0 ± 2.0
W125	S020	1.0-1.5	<8.0	3.8 ± 0.9	2.0 ± 1.0
W125	S020	1.5-2.0	<5.0	1.0 ± 0.5	1.2 ± 0.7
W125	S020	2.0-2.5	<10.0	0.8 ± 0.5	<1.0
W125	S020	2.5-3.0	<6.0	0.6 ± 0.5	1.0 ± 0.6
W125	S020	3.0-3.5	<10.0	0.6 ± 0.4	1.0 ± 0.6
W125	S020	3.5-4.0	<10.0	<1.0	<1.0
W125	S020	4.0-4.5	<9.0	0.6 ± 0.4	0.9 ± 0.5
W125	S020	4.5-5.0	<8.0	<1.0	<1.0
W125	S025	0.0-0.5	<8.0	1.1 ± 0.7	<1.0
W125	S025	0.5-1.0	<14.0	3.6 ± 0.9	2.0 ± 1.0
W125	S030	0.0-0.5	<8.0	2.1 ± 0.8	2.0 ± 1.0
W125	S030	0.5-1.0	<7.0	0.8 ± 0.5	1.4 ± 0.8
W130	S000	0.0-0.5	<11.0	1.4 ± 0.6	<1.0
W130	S000	0.5-1.0	<11.0	0.9 ± 0.6	0.8 ± 0.8
W130	S005	0.0-0.5	<14.0	4.0 ± 1.0	4.0 ± 2.0
W130	S005	0.5-1.0	<9.0	2.2 ± 0.8	2.0 ± 1.0
W130	S010	0.0-0.5	<7.0	2.1 ± 0.8	3.0 ± 1.0
W130	S010	0.5-1.0	<10.0	3.0 ± 1.0	2.0 ± 1.0
W130	S015	0.0-0.5	<14.0	3.1 ± 0.9	1.0
W130	S015	0.5-1.0	<15.0	4.0 ± 1.0	5.0 ± 2.0
W130	S020	0.0-0.5	<13.0	2.8 ± 0.9	2.0 ± 1.0
W130	S020	0.5-1.0	<10.0	4.0 ± 1.0	2.0 ± 1.0
W130	S025	0.0-0.5	<8.0	2.5 ± 0.9	2.0 ± 1.0
W130	S025	0.5-1.0	<13.0	2.2 ± 0.9	3.0 ± 1.0
W130	S030	0.0-0.5	<10.0	2.1 ± 0.8	2.0 ± 1.0
W130	S030	0.5-1.0	<7.0	1.3 ± 0.7	1.2 ± 0.9
W135	S000	0.0-0.5	<11.0	1.6 ± 0.8	<1.0
W135	S000	0.5-1.0	<10.0	<1.0	1.8 ± 0.7
W135	S005	0.0-0.5	<12.0	1.5 ± 0.7	1.6 ± 0.9
W135	S005	0.5-1.0	<13.0	1.2 ± 0.6	<1.0
W135	S010	0.0-0.5	<7.0	1.9 ± 0.7	1.6 ± 0.9
W135	S010	0.5-1.0	<13.0	1.8 ± 0.7	<1.0
W135	S015	0.0-0.5	<7.0	2.8 ± 0.9	1.1 ± 0.9
W135	S015	0.5-1.0	<13.0	3.0 ± 1.0	3.0 ± 1.0
W135	S020	0.0-0.5	<8.0	3.3 ± 0.9	<1.0
W135	S020	0.5-1.0	<14.0	3.0 ± 1.0	5.0 ± 2.0
W135	S025	0.0-0.5	<9.0	2.0 ± 1.0	<1.0
W135	S025	0.5-1.0	<14.0	3.0 ± 1.0	2.0 ± 1.0
W135	S030	0.0-0.5	<6.0	1.0 ± 0.7	<1.0
W135	S030	0.5-1.0	<14.0	4.0 ± 1.0	<1.0

TABLE 5-3

(Continued)

Coordinates E,W	Coordinates N,S	Depth (ft)	Concentrations (pCi/g +/- 2 sigma) Uranium-238	Radium-226	Thorium-232
Area 2*					
W263	N151	0.0-0.5	<7.0	1.0 ± 0.5	<1.0
W263	N151	0.5-1.0	<42.0	360.0 ±10.0	<4.0
Area 3*					
W295	N013	0.0-0.5	48.0 ±11.0	0.7 ± 0.5	1.6 ± 0.9
W297	N008	0.0-0.5	49.0 ±10.0	1.1 ± 0.7	<1.0

*See Figure 5-2.

TABLE 5-4

GROSS ALPHA CONTAMINATION FROM THE WIPE SAMPLES

AT THE NATIONAL GUARD ARMORY

Page 1 of 8

Location	Sample	Corresponding Figure	Gross Alpha dpm/100 cm^2
Rooms S201/202	0001	5-19	<1
Rooms S201/202	0002	5-19	<1
Rooms S201/202	0003	5-19	<1
Rooms S201/202	0004	5-19	<1
Rooms S201/202	0005	5-19	<1
Rooms S201/202	0006	5-19	<1
Rooms S201/202	0007	5-19	<1
Rooms S201/202	0008	5-19	1 ± 1
Rooms S201/202	0009	5-19	1 ± 1
Rooms S201/202	0010	5-19	<1
Rooms S201/202	0011	5-19	<1
Rooms S201/202	0012	5-19	<1
Rooms S201/202	0013	5-19	<1
Rooms S201/202	0014	5-19	<1
Rooms S201/202	0015	5-19	<1
Room 1	0016	5-6	2 ± 1
Room 1	0017	5-6	8 ± 2
Room 1	0018	5-6	7 ± 2
Room 1	0019	5-6	2 ± 1
Room 1	0020	5-6	2 ± 1
Room 1	0021	5-6	7 ± 2
Room 1	0022	5-6	8 ± 2
Room 1	0023	5-6	43 ± 6
Room 1	0024	5-6	6 ± 2
Room 1	0025	5-6	2 ± 1
Room 1	0026	5-6	2 ± 1
Room 1	0027	5-6	1 ± 1
Room 1	0028	5-6	1 ± 1
Room 1	0029	5-8	1 ± 1
Room 1	0030	5-8	2 ± 1
Room 1	0031	5-8	2 ± 1
Room 1	0032	5-8	2 ± 1
Room 1	0033	5-8	3 ± 2
Room 1	0034	5-11	1 ± 1
Room 1	0035	5-11	<1
Room 1	0036	5-11	<1
Room 1	0037	5-13	2 ± 1
Room 1	0038	5-13	4 ± 2
Room 1	0039	5-11	3 ± 1
Room 1	0040	5-11	4 ± 2
Room 1	0041	5-11	2 ± 1
Room 1	0042	5-6	2 ± 1
Room 1	0043	5-6	7 ± 2

TABLE 5-4
(continued)

Location	Sample	Corresponding Figure*	Gross Alpha dpm/100 cm^2
Room 1	0044	5-6	2 ± 1
Room 1	0045	5-8	1 ± 1
Room 1A	0046	5-15	<1
Room 1A	0047	5-15	<1
Room 1A	0048	5-15	<1
Rooms S201/202	0049	B	1300 ± 30
Rooms S201/202	0050	B	4500 ± 50
Rooms S201/202	0051	B	4940 ± 60
Rooms S201/202	0052	B	656 ± 20
Rooms S201/202	0053	C	<1
Rooms S201/202	0054	C	<1
Rooms S201/202	0055	C	<1
Rooms S201/202	0056	C	1 ± 1
Rooms S201/202	0057	C	<1
Rooms S201/202	0058	C	<1
Rooms S201/202	0059	C	<1
Rooms S201/202	0060	C	1 ± 1
Rooms S201/202	0061	C	<1
Rooms S201/202	0062	C	<1
Rooms S201/202	0063	C	<1
Room 5	0064	5-17	<1
Room 5	0065	5-17	<1
Room 5	0066	5-17	<1
Room 5	0067	5-18	<1
Room 5	0068	5-18	<1
Room 5	0069	5-18	<1
Room 5B	0070	5-18	5 ± 2
Room 5B	0071	5-18	<1
Room 5B	0072	5-18	<1
Room 5B	0073	5-18	<1
Room 5B	0074	5-18	<1
Room 5B	0075	5-18	<1
Room 5B	0076	5-18	<1
Room 5B	0077	5-18	<1
Room 5B	0078	5-18	<1
Room 5B	0079	5-18	<1
Room 5B	0080	5-18	<1
Room 5B	0081	5-18	<1
Room 5B	0082	5-18	<1
Room 5B	0083	5-18	<1
Room 5B	0084	5-18	1 ± 1
Room 5B	0085	5-18	<1
Room 5B	0086	5-18	<1

TABLE 5-4

(continued)

Page 3 of 8

Location	Sample	Corresponding Figure	Gross Alpha dpm/100 cm^2
Room 5B	0087	5-18	<1
Room 5B	0088	5-18	<1
Room 5B	0089	5-18	<1
Room 1	0090	5-13	1 ± 1
Room 1	0091	5-13	<1
Room 1	0092	5-13	3 ± 2
Room 1	0093	5-13	<1
Room 1	0094	5-13	<1
Room 1	0095	5-5	1 ± 1
Room 1	0096	5-5	2 ± 1
Room 1	0097	5-5	<1
Room 1E	0098	5-16	<1
Room 1E	0099	5-16	<1
Room 1E	0100	5-16	<1
Room 1E	0101	5-16	<1
Room 1E	0102	5-16	<1
Room S212	0103	5-20	18 ± 3
Room S212	0104	5-20	48 ± 6
Room S212	0105	5-20	57 ± 6
Room S250	0106	5-22	2 ± 1
Room S250	0107	5-22	<1
Room S250	0108	5-22	<1
Room S250	0109	5-22	<1
Room 1	0110	5-6	8 ± 2
Room 1	0111	5-6	4 ± 2
Room 1	0112	5-6	<1
Room 1	0113	5-6	1 ± 1
Room 1	0114	5-6	<1
Room 1	0115	5-6	3 ± 1
Room 1	0116	5-8	1 ± 1
Room 1	0117	5-8	1 ± 1
Room 1	0118	5-8	4 ± 2
Room 1	0119	5-8	<1
Room 1	0120	5-9	<1
Room 1	0121	5-9	3 ± 1
Room 1	0122	5-9	<1
Room 1	0123	5-10	<1
Room 1	0124	5-10	<1
Room 1	0125	5-10	2 ± 1
Room 1	0126	5-9	4 ± 2
Room 1	0127	5-9	4 ± 2
Room 1	0128	5-9	9 ± 3
Room 1	0129	5-10	30 ± 4

TABLE 5-4

(continued)

Location	Sample	Corresponding Figure	Gross Alpha dpm/100 cm^2
Room 1	0130	5-10	3 ± 1
Room 1	0131	5-10	28 ± 4
Room 1	0132	5-10	7 ± 2
Room 1	0133	5-10	1 ± 1
Room 1	0134	5-13	7 ± 2
Room 1	0135	5-12	<1
Room 1	0136	5-12	<1
Room 1	0137	5-12	<1
Room 1	0138	5-12	<1
Room 1	0139	5-12	<1
Room 1	0140	5-12	3 ± 1
Room 1	0141	5-12	3 ± 2
Room 1	0142	5-12	<1
Room 1	0143	5-12	<1
Room 1	0144	5-12	<1
Room 1	0145	5-12	<1
Room 1	0146	5-12	5 ± 2
Room 1	0147	5-12	97 ± 8
Room 1	0148	5-11	1 ± 1
Room 1	0149	5-11	3 ± 2
Room 1	0150	5-11	3 ± 2
Room 1	0151	5-11	2 ± 1
Room 1	0152	5-11	4 ± 2
Room 1	0153	5-11	8 ± 2
Room 1	0154	5-8	1 ± 1
Room 1	0155	5-8	1 ± 1
Room 1	0156	5-8	2 ± 1
Room 1	0157	5-8	<1
Room 1	0158	5-8	1 ± 1
Room 1	0159	5-8	<1
Room 1	0160	5-8	2 ± 1
Room 1	0161	5-8	<1
Room 1	0162	5-8	2 ± 1
Room 1	0163	5-8	<1
Room 1	0164	5-8	1 ± 1
Room 1	0165	5-8	1 ± 1
Room 1	0166	5-8	<1
Room 1	0167	5-8	1 ± 1
Room 1	0168	5-8, 5-11	5 ± 2
Room 1	0169	5-8, 5-11	<1
Room 1	0170	5-11	3 ± 1
Room 1	0171	5-11	<1
Room 1	0172	5-11	1 ± 1

TABLE 5-4

(continued)

Location	Sample	Corresponding Figure*	Gross Alpha dpm/100 cm^2
Room 1	0173	5-11	1 ± 1
Room 1	0174	5-13	2 ± 1
Room 1	0175	5-13	<1
Room 1	0176	5-13	1 ± 1
Room 1	0177	5-13	<1
Room 1	0178	5-13	<1
Room 1	0179	5-13	1 ± 1
Room 1	0180	5-13	1 ± 1
Room 1	0181	5-13	1 ± 1
Room 1	0182	5-13	3 ± 1
Room 1	0183	5-14	<1
Room 1	0184	5-14	<1
Room 1	0185	5-14	1 ± 1
Room 1	0186	5-14	1 ± 1
Room 1	0187	5-13	3 ± 1
Room 1	0188	5-13	<1
Room 1	0189	C	<1
Room 1	0190	C	<1
Room 1	0191	C	<1
Room 1	0192	C	<1
Room 1	0193	C	1 ± 1
Room 1	0194	C	<1
Room 1	0195	C	<1
Room 1	0196	C	<1
Room 1	0197	C	<1
Room 1	0198	C	<1
Room 1	0199	C	<1
Room 1	0200	C	25 ± 4
Room 1	0201	C	<1
Room 1	0202	C	<1
Room 1	0203	C	128 ± 9
Room 1	0204	C	27 ± 4
Room 1	0205	C	35 ± 5
Room 1	0206	C	41 ± 5
Room 1	0207	C	29 ± 4
Room 1	0208	C	86 ± 7
Room 1	0209	C	21 ± 4
Room 1	0210	C	35 ± 5
Room 1	0211	C	90 ± 8
Room 1	0212	C	33 ± 5
Room 1	0213	C	39 ± 5
Room 1	0214	C	65 ± 6
Room 1	0215	C	36 ± 5

TABLE 5-4
(continued)

Location	Sample	Corresponding Figure*	Gross Alpha dpm/100 cm^2
Room 1	0216	C	58 ± 6
Room 1	0217	C	33 ± 5
Room 1	0218	C	28 ± 4
Room 1	0219	C	43 ± 5
Room 1	0220	C	58 ± 6
Room 1	0221	C	111 ± 8
Room 1	0222	C	47 ± 6
Room 1	0223	C	34 ± 5
Room 1	0224	C	42 ± 5
Room 1	0225	C	30 ± 4
Room 1	0226	C	20 ± 4
Room 1	0227	C	46 ± 5
Room 1	0228	C	28 ± 4
Room 1	0229	C	50 ± 6
Room 1	0230	C	28 ± 4
Room 1	0231	C	23 ± 4
Room 1	0232	C	42 ± 5
Room 1	0233	C	56 ± 6
Room 1	0234	C	23 ± 4
Room 1	0235	C	24 ± 4
Room 1	0236	C	38 ± 5
Room 1	0237	C	83 ± 7
Room 1	0238	C	44 ± 5
Room 1	0239	C	<1
Room 1	0240	C	1 ± 1
Room 1	0241	C	<1
Room 1	0242	C	1 ± 1
Room 1	0243	C	<1
Room 1	0244	C	<1
Room 1	0245	C	1 ± 1
Room 1	0246	C	<1
Room 1	0247	C	<1
Room 1	0248	C	<1
Room 1	0249	C	<1
Room 1	0250	C	<1
Room 1	0251	C	192 ± 24
Room 1	0252	C	584 ± 19
Room 1	0253	C	4 ± 2
Room 1	0254	C	41 ± 5
Room S212	0256	C	<1
Room S250	0257	C	1 ± 1
Room S215	0258	C	<1
Room 1	0259	C	<1

TABLE 5-4
(continued)

Location	Sample	Corresponding Figure*	Gross Alpha dpm/100 cm^2
Room 1	0260	C	<1
Room 5B	0261	B	4 ± 2
Room 5B	0262	B	<1
Room 5	0263	B	<1
Room 5	0264	B	<1
Room S244	0265	B	12 ± 3
Room S212	0266	B	9 ± 2
Room S212	0267	B	<1
Arena Hall	0268	B	1 ± 1
Arena Hall	0269	B	<1
Arena Hall	0270	B	<1
Arena Hall	0271	B	<1
East Arena Hall	0272	B	1 ± 1
East Arena Hall	0273	B	<1
East Arena Hall	0274	B	<1
East Arena Hall	0275	B	1 ± 1
Room 5	0276	B	<1
Hall/Room S215	0277	B	<1
Hall/Room S213	0278	B	<1
South Headhouse	0279	B	<1
Hall/Room S231	0280	B	<1
Room S240	0281	B	1 ± 1
Room S212	0282	B	21 ± 4
Room S212	0283	B	5 ± 2
Room S212	0284	B	5 ± 2
Room 311	0285	B	<1
Hall/Room 311	0286	B	<1
Room 401	0287	B	3 ± 2
Room 401D	0288	B	<1
Room 401	0289	B	1 ± 1
North Headhouse	0290	B	<1
Bleacher	0291	B	<1
Room S203	0292	B	1 ± 1
North Headhouse	0293	B	<1
Room 5	0294	C	<1
Room 5	0295	C	<1
Room 5	0296	C	<1
Room 5	0297	C	<1
Room 5	0298	C	<1
Room 5	0299	C	<1
Room 5	0300	C	<1
Room 5	0301	C	<1
Room 5	0302	C	1 ± 1

TABLE 5-4
(continued)

Location	Sample	Corresponding Figure*	Gross Alpha dpm/100 cm^2
Room 5	0303	C	<1
Room 5	0304	C	<1
Room 5	0305	C	<1
Room 5	0306	C	<1
Room 5	0307	C	<1
Room 5	0308	C	<1
Room 5	0309	C	<1
Room 5	0310	C	<1
Room 5	0311	C	<1
Room 5	0312	C	<1
Room 5	0313	C	<1
Room 5	0314	C	<1
Room 5	0315	C	<1
Room 5	0316	C	<1
Room 5	0317	C	<1
Room 5	0318	C	<1
Room 5	0319	C	<1
Room 5	0320	C	<1
Room 5	0321	C	3 ± 2
Room 5	0322	C	4 ± 2
Room 5	0323	C	<1
Room 5	0324	C	<1
Room 5	0325	C	<1
Room 5	0326	C	4 ± 2
Room 5	0327	C	<1
Room 5	0328	C	<1
Room 5	0329	C	<1
Room 5	0330	C	<1
Room 5	0331	C	<1
Room 5	0332	C	<1
Room 5	0333	C	<1
Room 5	0334	C	<1
Room 5	0335	C	1 ± 1
Room 5	0336	C	<1
Room 5H	0337	B	5 ± 2
Room 5H	0338	B	<1
North Headhouse	0339	B	<1
North Headhouse	0340	B	1 ± 1
North Headhouse	0341	B	1 ± 1

*B indicates biased sample locations taken on horizontal surfaces suspected of being contaminated; C indicates samples taken from ceiling surfaces. The locations of these samples are not shown on figures.

TABLE 5-5

RADIONUCLIDE CONCENTRATION IN BRICK SAMPLES

Type of Brick	Concentration (pCi/g ± 2 sigma) Uranium-238	Radium-226	Thorium-232
White	11 ± 7	8 ± 2	2 ± 1
Red	7 ± 4	4 ± 1	2 ± 1
Yellow	<11	2 ± 1	5 ± 2

As the data in Table 5-5 indicates, the radium-226 and thorium-232 concentrations are elevated and even exceed guidelines when all radionuclides are considered. However, due to the ratio of the isotopes (elevated radium-226 and thorium-232, but only slightly elevated uranium-238), the elevated concentrations appear to arise from natural sources and are not characteristic of contamination which may have occurred during MED activities.

TABLE 5-6

INTERIOR SUBSURFACE SOIL SAMPLING RESULTS

AT THE NATIONAL GUARD ARMORY

Location	Depth (ft)	Concentrations (pCi/g ± 2 sigma) Uranium-238	Radium-226	Thorium-232
Arena+				
1	0.0-0.5	<4.0	<0.4	1.0 ± 0.5
1	0.5-1.0	<6.0	1.0 ± 0.5	0.6 ± 0.5
1	1.0-1.5	<10.0	<0.5	<0.8
1	1.5-2.0	<5.0	<0.5	0.6 ± 0.5
1	2.0-2.5	<11.0	<0.5	<0.8
1	2.5-3.0	<9.0	<0.4	<0.7
1	3.0-3.5	<4.0	<0.4	0.9 ± 0.6
1	3.5-4.0	<4.0	<0.4	0.7 ± 0.6
1	4.0-4.5	<9.0	<0.4	<0.7
1	4.5-5.0	<4.0	0.8 ± 0.3	<0.4
1	5.0-5.5	<4.0	0.7 ± 0.4	0.9 ± 0.5
1	5.5-6.0	<4.0	1.2 ± 0.4	1.0 ± 0.6
1	6.0-6.5	<5.0	<0.4	<0.5
1	6.5-7.0	<4.0	0.6 ± 0.5	0.8 ± 0.6
1	7.0-7.5	<6.0	1.7 ± 0.6	0.8 ± 0.7
1	7.5-8.0	<5.0	0.9 ± 0.5	<0.9
2	0.0-0.5	<11.0	0.5 ± 0.3	<0.7
2	0.5-1.0	<9.0	1.5 ± 0.6	<0.7
2	1.0-1.5	<10.0	1.4 ± 0.5	<0.8
2	1.5-2.0	<6.0	0.4 ± 0.4	1.2 ± 0.7
2	2.0-2.5	<11.0	<0.5	<0.9
2	2.5-3.0	<5.0	0.9 ± 0.4	0.8 ± 0.6
2	3.0-3.5	<5.0	<0.4	0.8 ± 0.5
2	3.5-4.0	<10.0	<0.5	1.6 ± 0.9
2	4.0-4.5	<3.0	1.0 ± 0.4	0.9 ± 0.7
2	4.5-5.0	<5.0	<0.3	0.7 ± 0.5
2	5.0-5.5	<9.0	0.8 ± 0.4	<0.7
3	0.0-0.5	<4.0	1.4 ± 0.4	0.9 ± 0.6
3	0.5-1.0	<5.0	1.1 ± 0.5	0.9 ± 0.6
3	1.0-1.5	<10.0	0.8 ± 0.4	<0.8
3	1.5-2.0	<4.0	0.5 ± 0.4	<0.5
3	2.0-2.5	<4.0	0.5 ± 0.4	<0.5
3	2.5-3.0	<10.0	<0.4	<0.7
3	3.0-3.5	<5.0	0.5 ± 0.4	0.8 ± 0.6
3	3.5-4.0	<4.0	1.0 ± 0.4	0.7 ± 0.5
3	4.0-4.5	<10.0	<0.5	<0.8
3	4.5-5.0	<5.0	0.7 ± 0.4	<0.5
3	5.0-5.5	<4.0	0.5 ± 0.4	0.7 ± 0.4
4	0.0-0.5	<10.0	1.3 ± 0.6	<0.7
4	0.5-1.0	<5.0	1.2 ± 0.5	1.3 ± 0.6
4	1.0-1.5	<4.0	0.6 ± 0.5	1.1 ± 0.6

TABLE 5-6

(continued)

Location	Depth (ft)	Concentrations (pCi/g ± 2 sigma) Uranium-238	Radium-226	Thorium-232
4	1.5-2.0	<11.0	1.0 ± 0.5	<0.9
4	2.0-2.5	<12.0	0.9 ± 0.4	<0.9
4	2.5-3.0	<4.0	0.7 ± 0.5	0.7 ± 0.5
4	3.0-3.5	<10.0	0.8 ± 0.4	1.0 ± 0.7
4	3.5-4.0	<4.0	0.8 ± 0.3	0.8 ± 0.5
4	4.0-4.5	<11.0	<0.5	<0.8
4	4.5-5.0	<4.0	<0.5	<0.7
4	5.0-5.5	<4.0	0.8 ± 0.3	0.8 ± 0.5
5	0.0-0.5	<4.0	<0.4	<0.7
5	0.5-1.0	<4.0	<0.4	1.0 ± 0.5
5	1.0-1.5	<4.0	0.7 ± 0.5	<0.5
6	0.0-0.5	<11.0	<0.6	<0.8
6	0.5-1.0	<5.0	0.6 ± 0.5	<0.6
6	1.0-1.5	<11.0	<0.5	<0.8
6	1.5-2.0	<5.0	0.5 ± 0.5	<0.7
6	2.0-2.5	<10.0	<0.5	<0.8
6	2.5-3.0	<5.0	0.6 ± 0.4	<0.6
6	3.0-3.5	<9.0	0.6 ± 0.3	<0.7
6	3.5-4.0	<4.0	<0.4	0.8 ± 0.6
6	4.0-4.5	<4.0	<0.4	1.0 ± 0.7
6	4.5-5.0	<10.0	<0.5	<0.8
6	5.0-5.5	<9.0	<0.4	<0.7
7	0.0-0.5	<4.0	1.0 ± 0.4	1.1 ± 0.6
7	0.5-1.0	<6.0	1.1 ± 0.5	<0.6
7	1.0-1.5	<9.0	0.7 ± 0.3	<0.7
7	1.5-2.0	<4.0	1.1 ± 0.5	1.3 ± 0.7
7	2.0-2.5	<4.0	0.9 ± 0.4	<0.6
7	2.5-3.0	<10.0	<0.5	<0.8
7	3.0-3.5	<4.0	<0.4	<0.5
7	3.5-4.0	<4.0	<0.4	<0.5
7	4.0-4.5	<10.0	<0.5	<0.8
7	4.5-5.0	<4.0	0.5 ± 0.4	1.0 ± 0.5
7	5.0-5.5	<9.0	<0.4	<0.7
8	0.0-0.5	<4.0	1.0 ± 0.5	1.1 ± 0.6
8	0.5-1.0	<9.0	0.7 ± 0.5	<0.7
8	1.0-1.5	<4.0	0.7 ± 0.4	1.0 ± 0.7
8	1.5-2.0	<9.0	<0.6	<0.8
8	2.0-2.5	<4.0	0.9 ± 0.5	1.1 ± 0.7
8	2.5-3.0	<4.0	<0.5	<0.5
8	3.0-3.5	<10.0	0.6 ± 0.5	<0.8
8	3.5-4.0	<10.0	0.8 ± 0.5	1.2 ± 0.6
8	4.0-4.5	<5.0	1.2 ± 0.5	1.0 ± 0.7
8	4.5-5.0	<6.0	<0.4	<0.7
8	5.0-5.5	<9.0	<0.5	<0.7

TABLE 5-6
(continued)

Location	Depth (ft)	Concentrations (pCi/g ± 2 sigma) Uranium-238	Radium-226	Thorium-232
Southeast Corner of Room 1*				
9	0.0-0.5	<4.0	0.8 ± 0.6	<0.6
9	0.5-1.0	<5.0	0.9 ± 0.5	1.6 ± 0.8
9	1.0-2.0	<10.0	1.1 ± 0.5	<0.7
9	2.0-2.5	<4.0	0.7 ± 0.4	1.5 ± 0.8
9	2.5-3.0	<11.0	0.9 ± 0.4	<0.9
9	3.0-3.5	<4.0	0.7 ± 0.4	<0.7
9	3.5-4.0	<9.0	0.9 ± 0.4	<0.7
9	4.0-4.5	<4.0	0.5 ± 0.4	1.1 ± 0.6
9	4.5-5.0	<4.0	0.4 ± 0.3	0.5 ± 0.5
9	5.0-5.5	<3.0	1.0 ± 0.4	0.7 ± 0.4
10	0.0-0.5	9.0 ± 5.0	0.8 ± 0.4	<1.0
10	0.5-1.0	<5.0	0.5 ± 0.5	<1.0

+See Figure 4-1.
*See Figure 5-6.

TABLE 5-7

RADIONUCLIDE CONCENTRATIONS IN SAMPLES

TAKEN FROM CATCH BASINS

Catch Basin Number	Depth (ft)	Concentration (pCi/g ± 2 sigma) Uranium-238	Radium-226	Thorium-232
1	Composite	<7	<1	<1
2	Composite	9 ± 4	0.9 ± 0.5	<1
3	0.0 - 0.5	15 ± 3	0.3 ± 0.2	<1
3	0.5 - 1.0	62 ± 6	0.4 ± 0.2	<1
3	1.0 - 1.5	220 ± 10	0.6 ± 0.4	0.4 ± 0.3
4	Composite	42 ± 11	1.0 ± 0.6	1.1 ± 0.8
6	Composite	35 ± 9	1.5 ± 0.6	<1
7	Composite	<6	<0.5	<0.7
Grease Traps (Room 5)				
Center	Composite	21 ± 9	<0.4	0.9 ± 0.6
North	Composite	20 ± 8	<0.5	<0.8

See Figure 4-2.

TABLE 5-8

RADIONUCLIDE CONCENTRATIONS IN SCRAPINGS

FROM CATCH BASIN WALLS

Catch Basin Number	Concentration (pCi/g ± 2 sigma)		
	Uranium-238	Radium-226	Thorium-232
1	<27	4 ± 2	<3
2	310 ± 30	2 ± 2	<2
3	16000 ± 1000	3 ± 2	<1
4	290 ± 50	<6	<3
6	<22	3 ± 2	5 ± 3

REFERENCES

1. Argonne National Laboratory. Radiological Survey of the National Guard Armory at Washington Park, 52nd Street and Cottage Grove Avenue, Chicago, IL, January 1983.

2. Memorandum, P.A. Williams, Industrial Safety Supervisor, Bechtel National, Inc., to C.A. Knoke, Construction Superintendent, Bechtel National, Inc. "Revised NGA Health and Safety Requirements," CCN 042584, January 13, 1987.

3. U.S. Department of Energy. Radiological Guidelines for Application to DOE's Formerly Utilized Sites Remedial Action Program, ORO-831, Oak Ridge, TN, March 1983 (reprinted with corrections, January 1984).

4. Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987.

5. Letter, G.P. Crotwell, Bechtel National, Inc., to R.G. Bowles, Department of Energy, Oak Ridge Operations. "Chemical Status of NGA Basins," CCN 044077, April 1, 1987.

APPENDIX A

SUMMARY OF THE PROCEDURES AND RESULTS OF THE LIMITED CHEMICAL CHARACTERIZATION AT THE NGA

APPENDIX A

SUMMARY OF THE PROCEDURES AND RESULTS OF THE LIMITED CHEMICAL CHARACTERIZATION AT THE NGA

A.1 PURPOSE

The limited chemical characterization was performed to determine personnel safety requirements during the characterization and disposal restrictions for the chemical contamination identified.

A.2 PROCEDURE

A representative sample was obtained from each catch basin for analysis. The sample consisted of four aliquots of the material in the catch basin, which then provided a profile of the material. The volume of each catch basin was noted, as well as the type of material, i.e., solid or liquid. Samples of the material were then sent to the laboratory and analyzed for hazardous waste constituents.

A.3 RESULTS

The results of the analysis are provided in Table A-1. Results of the analysis showed elevated levels of volatile and semi-volatile organic compounds as well as some metals such as lead and chromium. After reviewing the Resource Conservation and Recovery Act characteristics of the samples, it was determined that the waste is defined as hazardous because the flashpoint is less than 70°F which meets the criteria under the definition of ignitability in 40 CFR Part 261.21.

TABLE A-1

SUMMARY OF CHEMICAL ANALYSIS AT NGA

	Concentrations in Catch Basins				
	1	2	3	4	6
Organic Volatiles (µg/kg)					
Methylene chloride	--	40,000	--	--	--
Acetone	--	43,000	--	--	--
1,1-Dichloroethane	--	34,000	--	--	--
1,1-Dichloroethene	--	71,000	--	--	--
1,1,1-Trichloroethane	--	410,000	--	--	--
Trichloroethane	--	25,000	--	--	--
Toluene	43,000	230,000	270,000	230,000	51,000
Ethylbenzene	31,000	140,000	110,000	120,000	37,000
Total xylenes	160,000	730,000	620,000	1,000,000	200,000
Chloroform	--	--	23,000	--	--
Benzene	--	--	20,000	<56,000	--
Organic Semi-volatiles (µg/kg)					
1,3-Dichlorobenzene	--	<50,000	--	--	--
1,4-Dichlorobenzene	--	64,000	200,000	--	--
Naphthalene	--	150,000	97,000	740,000	--
2-Methylnaphthalene	--	210,000	140,000	1,300,000	<41,000
Acenaphthene	--	<50,000	--	--	--
Di-n-butylphthalate	--	<50,000	--	--	--
Bis (2-ethylhexyl) phthalate	--	110,000	54,000	130,000	70,000
Phenanthrene	--	43,000	<54,000	--	--
Fluorene	--	--	--	<110,000	--
Acid Extractible (µg/kg)					
Phenol	1,800	5,500	--	1,800	1,000
Metals (mg/kg)					
Lead	440	1,500	2,300	750	1,300
Chromium	23	200	230	55	150
Flashpoint (°F)	<70	<70	<70	<70	<70

Exhibit II (4) - NEPA Documents

The documents listed below fulfill NEPA requirements for the subject site and are included in this exhibit.

Page

Argonne National Laboratory. Action Description Memorandum, Proposed Decontamination of the National Guard Armory in Chicago, IL, Argonne, IL, March 1987. II-287

Memorandum, J.E. Baublitz for W.R. Voigt, Jr., Director, Office of Remedial Action and Waste Technology, Office of Nuclear Energy, Department of Energy Headquarters, to J. LaGrone, Manager, Oak Ridge Operations Office. "Review of Remedial Actions at the National Guard Armory, Chicago, Illinois," Washington, D.C., July 27, 1987. II-307

ARGONNE NATIONAL LABORATORY
9700 South Cass Avenue, Argonne, Illinois 60439

ACTION DESCRIPTION MEMORANDUM

PROPOSED DECONTAMINATION OF THE NATIONAL GUARD ARMORY IN CHICAGO, ILLINOIS

by

Energy and Environmental Systems Division

March 1987

work supported by

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations
Technical Services Division
Oak Ridge, Tennessee

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ACTION DESCRIPTION MEMORANDUM

PROPOSED DECONTAMINATION OF THE NATIONAL GUARD ARMORY IN CHICAGO, ILLINOIS

by

Energy and Environmental Systems Division

1 SUMMARY OF PROPOSED ACTION

As part of its Formerly Utilized Sites Remedial Action Program (FUSRAP), the U.S. Department of Energy (DOE), Oak Ridge Operations, proposes to decontaminate those areas of the National Guard Armory in Chicago, Illinois, that are radioactively contaminated as a result of programs previously conducted by the Manhattan Engineer District (MED) and the Atomic Energy Commission (AEC). This facility, once used for uranium processing, is now used for offices, classrooms, and storage and garage areas. The contamination associated with former MED/AEC activities consists primarily of small localized spots, mainly on floors (U.S. Dept. Energy 1983); the largest areas of surface contamination are located in Rooms 1 and 260 (mess hall) and in the drainage system for the floors of Rooms 1 and 5. The ground beneath the arena floor (Room 3) has been surveyed and determined not to be radioactively contaminated.

The purpose of decontamination and restoration is to reduce the amount of residual radioactivity to levels below the established DOE cleanup criteria. After cleanup, the Military Department of Illinois (i.e., Illinois National Guard) can proceed with planned renovation of the facility. Proposed project actions include:

- Identification of all areas requiring decontamination.
- Decontamination of identified areas.
- Packaging, in approved containers, of all waste generated during decontamination activities.
- Transport of all waste generated for off-site disposal --disposal of all radioactive waste at the DOE Hanford Reservation near Richland, Washington, and disposal of all nonradioactive waste in a nearby sanitary landfill.
- Restoration of decontaminated areas as appropriate for intended future uses and with the concurrence of the Illinois National Guard.
- Certification that the radioactivity levels meet criteria for unrestricted use.

A more detailed description of the proposed action is given in Section 3.

2 HISTORY AND NEED FOR ACTION

2.1 GENERAL SETTING AND HISTORY

The National Guard Armory is located in the northeast section of Washington Park at 52nd Street and Cottage Grove Avenue in Chicago, Illinois (Fig. 2.1). Washington Park is a municipal park covering an area of about 150 ha (370 acres) and is located about 10 km (6 mi) south of the Chicago downtown business district. The park is adjacent to residential areas and the University of Chicago, which is located to the east of the park on adjoining land. There are several hospitals in the immediate vicinity of the park. The Armory is located on the boundary of the Hyde Park-Kenwood Historic District, as listed in the *National Register of Historic Places* (U.S. Dept. Interior 1980).

The National Guard Armory, constructed in 1924, is a 71-m (230-ft) by 200-m (650-ft) concrete building with a facade of Indiana limestone. An arena occupies the center of the building, and offices are located on four floors at the north and south ends. The arena is 68 m (220 ft) by 110 m (350 ft) and has a ceiling over 30 m (100 ft) high of clear span (steel truss) construction. Stadium bleachers are located on the east and west sides of the arena. The arena was formerly used by a horse cavalry and later for horse polo games played on a dirt floor (U.S. Dept. Energy 1983; Jones 1986).

The Armory was leased from the state of Illinois 124th Field Artillery by the MED during World War II to support activities associated with development of the atomic bomb. Beginning in 1942, the building was used jointly by the MED Metallurgical Laboratory and the University of Chicago in support of federal programs involving nuclear materials. The AEC terminated use of this facility in 1951, and the property was returned to the state of Illinois for use by the National Guard (U.S. Dept. Energy 1980a, 1980b).

Various types of uranium processing were conducted in the Armory in support of MED/AEC activities. The arena was probably used for chemical processing and metal casting of uranium; the bleachers surrounding the arena were used for storage of radioactive materials. After MED stopped using the Armory, contaminated sediment from the arena dirt floor was removed and efforts were made to decontaminate some of the bleachers around the arena. A concrete slab was later poured over the dirt floor to facilitate use of the arena for maintenance of military vehicles (U.S. Dept. Energy 1983).

2.2 RADIOACTIVE CONTAMINATION AND NEED FOR ACTION

A radiological survey of the National Guard Armory was conducted in 1977 and 1978 (U.S. Dept. Energy 1983). This survey indicated that various locations of the Armory are radioactively contaminated above currently accepted guidelines for residual radioactivity (App. A). The results of the survey are summarized as follows.

The principal radioactive contaminant is processed natural uranium, and the contamination is generally limited to relatively small areas (less than 300 cm^2). The radiation level in the Armory as a result of the contamination is quite low. No exposure

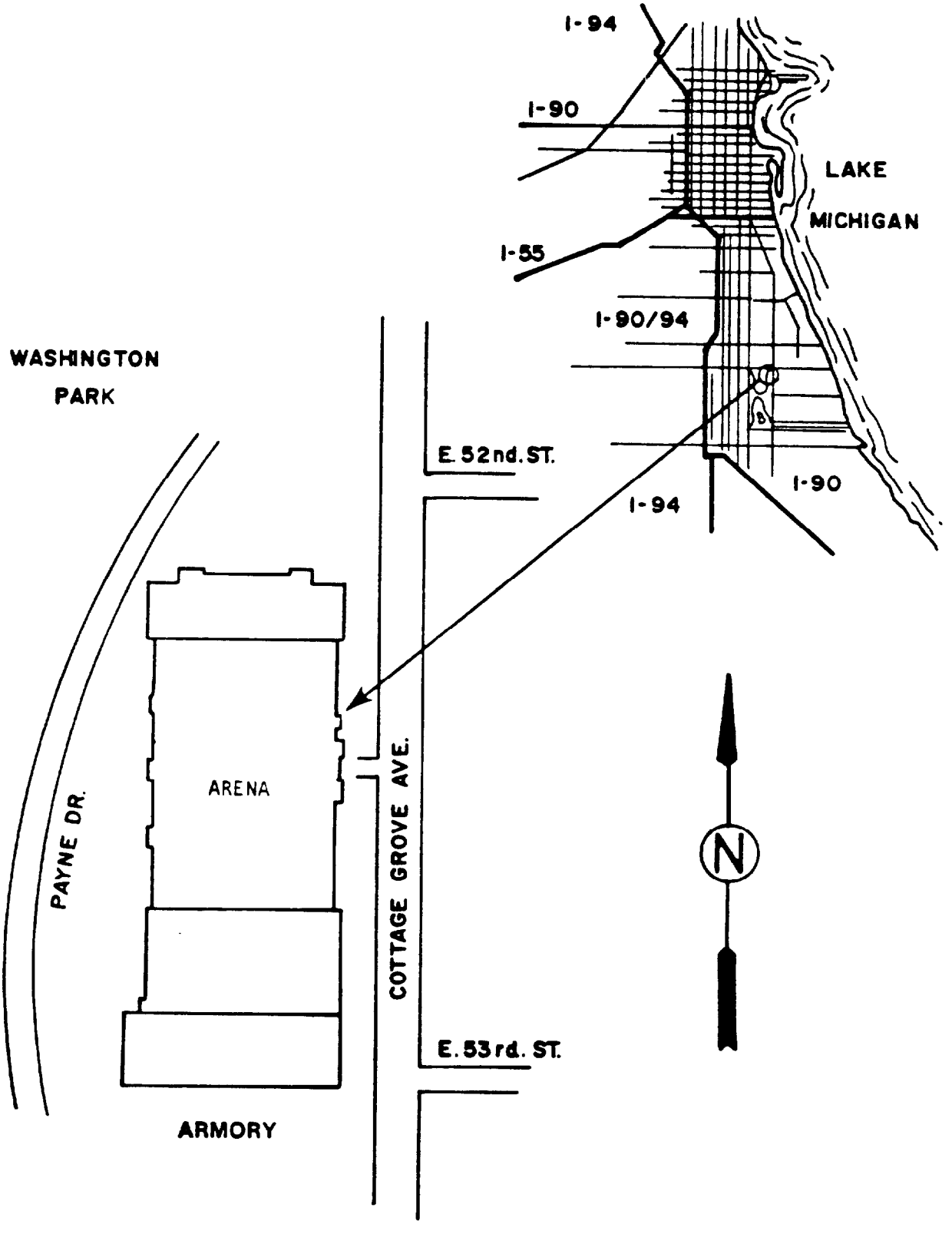

FIGURE 2.1 Location of the Illinois National Guard Armory, Chicago, Illinois (Source: Modified from U.S. Department of Energy 1983)

rates in excess of background levels were detected at 1 m from the surface. The maximum contact exposure rate measured was 3 mR/h on a catch basin manhole cover in Room 1.

The concentrations of radon-222 and its decay products in air in the building, as measured by grab-sampling techniques, were within the range of values normally expected for background concentrations. The concentrations of long-lived radionuclides in air samples and the concentrations of radionuclides in soil samples collected around the facility were also essentially at background levels.

Contamination possibly resulting from the previous MED/AEC activities was found at 73 locations in 11 rooms or areas. With the exceptions of Rooms 1 and 260, and the floor drainage system for Rooms 1 and 5, the contamination consisted of small localized spots, mainly on floors. The contamination in Room 1 was extensive and involved about 200 m^2 (2,200 ft^2) of concrete ceiling and floor. The contamination in Room 260 involved about 3 m^2 (30 ft^2) of concrete floor. The contamination on the floor was not easily removable, whereas most of the contamination on the ceiling was easily removable when smeared. The contamination in the floor drainage system for Rooms 1 and 5 consisted of about 2 m^2 (20 ft^2) of contaminated brick and sludge within two catch basins. Since the 1977-1978 radiological survey (U.S. Dept. Energy 1983), some minor relocation of partitions has occurred in areas determined to be contaminated (Jones 1986).

The Armory is currently occupied by the Illinois National Guard and houses the 1st Battalion, 178th Infantry, and the 2nd Battalion, 122nd Field Artillery. The Armory is used as offices, classrooms, and storage and garage areas. Under current use conditions, the potential for radiation exposure to occupants of this building is minimal. However, the National Guard is planning to renovate this facility in the near future. Planned renovation activities include areas previously identified as being radioactively contaminated above current guidelines (Jones 1986). The existing contamination poses a potential hazard to both construction personnel and current occupants because the renovation could produce airborne contaminants that might be ingested or inhaled. Therefore, prior to any renovation, DOE is proposing to decontaminate those areas of the Armory that were contaminated as a result of former MED/AEC activities.

3 DESCRIPTION OF PROPOSED ACTION

The results of the radiological survey conducted in 1977 and 1978 (U.S. Dept. Energy 1983) will be used as a guide to locate contaminated areas. In addition, all areas suspected of being radioactively contaminated as a result of former MED/AEC activities will be surveyed as part of this action to ensure that all contaminated areas are identified. Chemical sampling of drainage system sediments will also be performed. Appropriate precautions will be taken to protect against chemical hazards such as asbestos, which may be present in some floor tiles and piping insulation (Jones 1986).

Standard techniques will be utilized to decontaminate the areas identified. For example, water or special cleaners will be used to flush drainage systems, pipes, and ducts and to clean the exterior of metallic components. These solutions will remove the contamination but leave the surface material essentially intact. In situations where the radioactivity is imbedded in the material (e.g., contaminated concrete), the contaminated material will be removed by brushing, grinding, scabbling, etc., as appropriate. If necessary, entire components may be removed as radioactive waste. Contaminated sediments and sludges will be collected and placed in appropriate containers. Decontamination will continue until residual radioactivity levels are as low as reasonably achievable (ALARA) and meet criteria developed for FUSRAP (App. A).

All radioactive waste resulting from decontamination will be transported off-site to an approved disposal site. The waste will be packaged in DOE-approved containers that meet or exceed U.S. Department of Transportation (DOT) requirements for shipment. Current plans call for shipment of the waste in 55-gallon drums to the DOE Hanford Reservation near Richland, Washington. Decontamination of the Armory is expected to generate approximately 40 m^3 (50 yd^3) of low-level radioactive waste. Any radioactive waste that contains chemically hazardous constituents will be packaged, transported, and disposed of in compliance with all applicable regulations. All non-salvageable or otherwise unusable nonradioactive waste will be disposed of in a local sanitary landfill.

After decontamination, the affected areas will be restored in a manner consistent with their intended future uses. All decontamination and restoration activities will be performed by Bechtel National, Inc., DOE's project management contractor. Because many of the areas to be decontaminated are currently being used, it will be necessary to schedule activities with the Illinois National Guard to minimize disruption of ongoing activities. All restoration activities will be subject to concurrence by the National Guard prior to implementation.

It is expected that decontamination will be initiated during the spring of 1987 and completed in about eight weeks. Following completion of decontamination and restoration, the affected areas of the Armory will be surveyed to ensure compliance with applicable cleanup criteria. If necessary, additional decontamination and restoration of selected areas will be performed.

4 ENVIRONMENTAL CONSEQUENCES

4.1 RADIOLOGICAL

The incremental radiation doses to the general public from decontamination of the National Guard Armory and from transport of the radioactive waste to the Hanford Reservation will be immeasurably small relative to doses received from natural sources of radiation. The amount of contamination in the Armory is very small. The results of the 1977-1978 radiological survey (U.S. Dept. Energy 1983) indicate that the estimated total amount of processed natural uranium remaining within the building is 30 μCi* and that the exposure rates at 1 m from the surface are at background levels. Use of good health-physics practices to reduce the airborne releases of radioactivity will ensure that the general public is not exposed to any measurable amount of radioactivity.

The potential radiation doses to workers performing the remedial action will be kept as low as reasonably achievable (ALARA) by standard health-physics practices and strict compliance with DOE environmental protection, safety and health protection guidelines given in DOE Order 5480.1A. Because the measured exposure rates at 1 m from the surface were all at background levels, no external radiation hazard exists. In addition, the measured airborne radioactivity and the radioactivity in soil samples were at background levels. The only pathway by which workers could incur radiation doses in excess of background exposure is by inhalation of airborne radioactive contaminants generated during the decontamination and waste-packaging activities. Radioactive waste-handling and transportation activities will comply with all applicable DOE, DOT, and state of Illinois requirements.

The potential doses to workers will be kept low by minimizing the amount of airborne contamination through use of such practices as wetting the concrete during removal activities. In addition, workers will wear respiratory protection equipment, when required, to reduce the likelihood of inhaling radioactively contaminated particulates; local ventilation will be used if needed, and the work environment will be monitored by collection of air samples to ensure a safe work environment. Procedures to minimize radiation doses will also serve to minimize exposure to any hazardous chemicals that may be present.

The occupational dose commitment was estimated using data presented in the 1977-1978 radiological survey report (U.S. Dept. Energy 1983), a particulate deposition velocity of 1 cm/s, and a particulate resuspension rate of 1×10^{-6}/s (i.e., 1×10^{-6} of the total amount of contamination in the Armory is assumed to be released per second). This deposition velocity and resuspension rate are assumed to be representative of those associated with mechanical disturbances of concrete such as will be required to

*1 curie of natural uranium means the sum of 3.7×10^{10} disintegrations per second (dps) from uranium-238 plus 3.7×10^{10} dps from uranium-234 plus 1.7×10^{9} dps from uranium-235, as defined in DOE Order 5480.1A, Chapter XI. (Chapter XI of Order 5480.1A has been amended -- see Vaughan [1985] and U.S. Department of Energy [1986].)

decontaminate the Armory. The airborne concentration of processed natural uranium is estimated to be about 3.3 pCi/m^3. The total length of time associated with decontamination activities is estimated to be 100 hours. During all activities that have the potential for generating airborne radioactivity, it is assumed that workers will wear respiratory protection equipment providing a protection factor of 10 (the same factor that is provided by half-masks -- see 10 CFR Part 20). A worker is estimated to incur a dose of about 10 mrem during the 100-hour period, assuming a breathing rate of 1.2 m^3/h and a lung clearance class of Y. This dose estimate is based on the dose conversion factors recommended by the International Commission on Radiological Protection (1979). The entire occupational dose commitment to a crew of 15 workers is estimated to be 0.15 person-rem.

4.2 NONRADIOLOGICAL

The nonradiological impacts of the proposed action are expected to be minimal. There will be no impacts on surface water or groundwater because current plans do not include any below-grade activities or any discharges to water bodies. There may be small atmospheric releases related to concrete removal activities, but such releases will be low and further mitigated by using such procedures as wetting the concrete during removal activities. Impacts on local biota in the park will be negligible because all activities will occur within the Armory. Transportation of the radioactive waste to the Hanford Reservation will not have a significant impact because only four or five truckloads will be required according to current projections.

The proposed action will have a negligible effect on the local economy due to the relatively small size of the work force and the short duration of the proposed decontamination activities. Because the Armory is located in a park, there will be limited impact on local traffic patterns, residences, and businesses. The small increase in noise during cleanup activities may cause a short-term nuisance to users of the park but is expected to be minimal.

Because the Armory is located on the boundary of the Hyde Park-Kenwood Historic District, DOE notified the Illinois Historic Preservation Agency (IHPA) about the proposed decontamination activities to determine if there might be any potential adverse effects on this district. The Department received a "determination of no effect" from IHPA on January 21, 1987 (Farrar 1987).

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6 LIST OF CONTRIBUTORS

Name	Education/Expertise	Contribution
John F. Hoffecker	Ph.D. Anthropology 13 yr experience in archeological research 3 yr experience in environmental assessment	General setting and non-radiological impacts
John M. Peterson	M.S., P.E. Nuclear Engineering 11 yr experience in nuclear programs, including 8 yr in environmental assessment	History, radiological environment, description of proposed action
John H.C. Wang	Ph.D. Health Physics 5 yr experience in health physics	Radiological impacts
Dimis J. Wyman	M.S. Botany; M.A. Library Science 11 yr experience in technical editing	Overall editorial responsibility

APPENDIX A. DOE GUIDELINES FOR RESIDUAL RADIOACTIVITY

U.S. DEPARTMENT OF ENERGY GUIDELINES FOR RESIDUAL RADIOACTIVITY AT FORMERLY UTILIZED SITES REMEDIAL ACTION PROGRAM AND REMOTE SURPLUS FACILITIES MANAGEMENT PROGRAM SITES

(Rev. 1, July 1985)

A. INTRODUCTION

This document presents U.S. Department of Energy (DOE) radiological protection guidelines for cleanup of residual radioactive materials and management of the resulting wastes and residues. It is applicable to sites identified by the Formerly Utilized Sites Remedial Action Program (FUSRAP) and remote sites identified by the Surplus Facilities Management Program (SFMP).* The topics covered are basic dose limits, guidelines and authorized limits for allowable levels of residual radioactivity, and requirements for control of the radioactive wastes and residues.

Protocols for identification, characterization, and designation of FUSRAP sites for remedial action; for implementation of the remedial action; and for certification of a FUSRAP site for release for unrestricted use are given in a separate document (U.S. Dept. Energy 1984). More detailed information on applications of the guidelines presented herein, including procedures for deriving site-specific guidelines for allowable levels of residual radioactivity from basic dose limits, is contained in a supplementary document--referred to herein as the "supplement" (U.S. Dept. Energy 1985).

"Residual radioactivity" includes: (1) residual concentrations of radionuclides in soil material,** (2) concentrations of airborne radon decay products, (3) external gamma radiation level, and (4) surface contamination. A "basic dose limit" is a prescribed standard from which limits for quantities that can be monitored and controlled are derived; it is specified in terms of the effective dose equivalent as defined by the International Commission on Radiological Protection (ICRP 1977, 1978). Basic dose limits are used explicitly for deriving guidelines for residual concentrations of radionuclides in soil material, except for thorium and radium. Guidelines for

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located outside a major operating DOE research and development or production area.

**The term "soil material" refers to all material below grade level after remedial action is completed.

residual concentrations of thorium and radium and for the other three quantities (airborne radon decay products, external gamma radiation level, and surface contamination) are based on existing radiological protection standards (U.S. Environ. Prot. Agency 1983; U.S. Nucl. Reg. Comm. 1982). These standards are assumed to be consistent with basic dose limits within the uncertainty of derivations of levels of residual radioactivity from basic limits.

A "guideline" for residual radioactivity is a level of residual radioactivity that is acceptable if the use of the site is to be unrestricted. Guidelines for residual radioactivity presented herein are of two kinds: (1) generic, site-independent guidelines taken from existing radiation protection standards, and (2) site-specific guidelines derived from basic dose limits using site-specific models and data. Generic guideline values are presented in this document. Procedures and data for deriving site-specific guideline values are given in the supplement.

An "authorized limit" is a level of residual radioactivity that must not be exceeded if the remedial action is to be considered completed. Under normal circumstances, expected to occur at most sites, authorized limits for residual radioactivity are set equal to guideline values. Exceptional conditions for which authorized limits might differ from guideline values are specified in Sections D and F. A site may be released for unrestricted use only if the residual radioactivity does not exceed guideline values at the time remedial action is completed. Restrictions and controls on use of the site must be established and enforced if the residual radioactivity exceeds guideline values. The applicable controls and restrictions are specified in Section E.

DOE policy requires that all exposures to radiation be limited to levels that are as low as reasonably achievable (ALARA). Implementation of ALARA policy is specified as procedures to be applied after authorized limits have been set. For sites to be released for unrestricted use, the intent is to reduce residual radioactivity to levels that are as far below authorized limits as reasonable considering technical, economic, and social factors. At sites where the residual radioactivity is not reduced to levels that permit release for unrestricted use, ALARA policy is implemented by establishing controls to reduce exposure to levels that are as low as is reasonably achievable. Procedures for implementing ALARA policy are described in the supplement. ALARA policies, procedures, and actions must be documented and filed as a permanent record upon completion of remedial action at a site.

B. BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 500 mrem/yr for a period of exposure not to exceed 5 years and an average of 100 mrem/yr over a lifetime. The committed effective dose equivalent, as defined in ICRP Publication 26 (ICRP 1977) and calculated by dosimetry models described in ICRP Publication 30 (ICRP 1978), shall be used for determining the dose.

C. GUIDELINES FOR RESIDUAL RADIOACTIVITY

C.1 Residual Radionuclides in Soil Material

Residual concentrations of radionuclides in soil material shall be specified as above-background concentrations averaged over an area of 100 m^2. If the concentration in any area is found to exceed the average by a factor greater than 3, guidelines for local concentrations shall also be applicable. These "hot spot" guidelines depend on the extent of the elevated local concentrations and are given in the supplement.

The generic guidelines for residual concentrations of Th-232, Th-230, Ra-228, and Ra-226 are:

- 5 pCi/g, averaged over the first 15 cm of soil below the surface
- 15 pCi/g, averaged over 15-cm-thick layers of soil more than 15 cm below the surface

These guidelines take into account ingrowth of Ra-226 from Th-230 and of Ra-228 from Th-232, and assume secular equilibrium. If either Th-230 and Ra-226 or Th-232 and Ra-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit. Explicit formulas for calculating residual concentration guidelines for mixtures are given in the supplement.

The guidelines for residual concentrations in soil material of all other radionuclides shall be derived from basic dose limits by means of an environmental pathway analysis using site-specific data. Procedures for deriving these guidelines are given in the supplement.

C.2 Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.* In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

C.3 External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

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*A working level (WL) is any combination of short-lived radon decay products in one liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

C.4 Surface Contamination

The following generic guidelines, adapted from standards of the U.S. Nuclear Regulatory Commission (1982), are applicable only to existing structures and equipment that will not be demolished and buried. They apply to both interior and exterior surfaces. If a building is demolished and buried, the guidelines in Section C.1 are applicable to the resulting contamination in the ground.

Radionuclides[b]	Allowable Total Residual Surface Contamination (dpm/100 cm²)[a]		
	Average[c,d]	Maximum[d,e]	Removable[d,f]
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
U-Natural, U-235, U-238, and associated decay products	5,000α	15,000α	1,000α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000β-γ	15,000β-γ	1,000β-γ

[a] As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute measured by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

[b] Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[c] Measurements of average contamination should not be averaged over an area of more than 1 m². For objects of less surface area, the average should be derived for each such object.

[d] The average and maximum dose rates associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

[e] The maximum contamination level applies to an area of not more than 100 cm².

[f] The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm² is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

D. AUTHORIZED LIMITS FOR RESIDUAL RADIOACTIVITY

The remedial action shall not be considered complete unless the residual radioactivity is below authorized limits. Authorized limits shall be set equal to guidelines for residual radioactivity unless: (1) exceptions specified in Section F of this document are applicable, in which case an authorized limit may be set above the guideline value for the specific location or condition to which the exception is applicable; or (2) on the basis of site-specific data not used in establishing the guidelines, it can be clearly established that limits below the guidelines are reasonable and can be achieved without appreciable increase in cost of the remedial action. Authorized limits that differ from guidelines must be justified and established on a site-specific basis, with documentation that must be filed as a permanent record upon completion of remedial action at a site. Authorized limits differing from the guidelines must be approved by the Director, Oak Ridge Technical Services Division, for FUSRAP and by the Director, Richland Surplus Facilities Management Program Office, for remote SFMP--with concurrence by the Director of Remedial Action Projects for both programs.

E. CONTROL OF RESIDUAL RADIOACTIVITY AT FUSRAP AND REMOTE SFMP SITES

Residual radioactivity above the guidelines at FUSRAP and remote SFMP sites must be managed in accordance with applicable DOE Orders. The DOE Order 5480.1A requires compliance with applicable federal, state, and local environmental protection standards.

The operational and control requirements specified in the following DOE Orders shall apply to interim storage, interim management, and long-term management.

a. 5440.1B, Implementation of the National Environmental Policy Act

b. 5480.1A, Environmental Protection, Safety, and Health Protection Program for DOE Operations

c. 5480.2, Hazardous and Radioactive Mixed Waste Management

d. 5480.4, Environmental Protection, Safety, and Health Protection Standards

e. 5482.1A, Environmental, Safety, and Health Appraisal Program

f. 5483.1, Occupational Safety and Health Program for Government-Owned Contractor-Operated Facilities

g. 5484.1, Environmental Protection, Safety, and Health Protection Information Reporting Requirements

h. 5484.2, Unusual Occurrence Reporting System

i. 5820.2, Radioactive Waste Management

E.1 Interim Storage

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 50 years and, in any case, at least 25 years.

b. Above-background Rn-222 concentrations in the atmosphere above facility surfaces or openings shall not exceed: (1) 100 pCi/L at any given point, (2) an annual average concentration of 30 pCi/L over the facility site, and (3) an annual average concentration of 3 pCi/L at or above any location outside the facility site (DOE Order 5480.1A, Attachment XI-1).

c. Concentrations of radionuclides in the groundwater or quantities of residual radioactive materials shall not exceed existing federal, state, or local standards.

d. Access to a site shall be controlled and misuse of onsite material contaminated by residual radioactivity shall be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These control features should be designed to ensure, to the extent reasonable, an effective life of at least 25 years. The federal government shall have title to the property.

E.2 Interim Management

a. A site may be released under interim management when the residual radioactivity exceeds guideline values if the residual radioactivity is in inaccessible locations and would be unreasonably costly to remove, provided that administrative controls are established to ensure that no member of the public shall receive a radiation dose exceeding the basic dose limit.

b. The administrative controls, as approved by DOE, shall include but not be limited to periodic monitoring, appropriate shielding, physical barriers to prevent access, and appropriate radiological safety measures during maintenance, renovation, demolition, or other activities that might disturb the residual radioactivity or cause it to migrate.

c. The owner of the site or appropriate federal, state, or local authorities shall be responsible for enforcing the administrative controls.

E.3 Long-Term Management

Uranium, Thorium, and Their Decay Products

a. Control and stabilization features shall be designed to ensure, to the extent reasonably achievable, an effective life of 1,000 years and, in any case, at least 200 years.

b. Control and stabilization features shall be designed to ensure that Rn-222 emanation to the atmosphere from the waste shall not: (1) exceed an annual average release rate of 20 pCi/m^2/s, and (2) increase the annual average Rn-222 concentration at or above any location outside the boundary of the contaminated area by more than 0.5 pCi/L. Field verification of emanation rates is not required.

c. Prior to placement of any potentially biodegradable contaminated wastes in a long-term management facility, such wastes shall be properly conditioned to ensure that (1) the generation and escape of biogenic gases will not cause the requirement in paragraph b of this section (E.3) to be exceeded, and (2) biodegradation within the facility will not result in premature structural failure in violation of the requirements in paragraph a of this section (E.3).

d. Groundwater shall be protected in accordance with 40 CFR 192.20(a)(2) and 192.20(a)(3), as applicable to FUSRAP and remote SFMP sites.

e. Access to a site should be controlled and misuse of onsite material contaminated by residual radioactivity should be prevented through appropriate administrative controls and physical barriers--active and passive controls as described by the U.S. Environmental Protection Agency (1983--p. 595). These controls should be designed to be effective to the extent reasonable for at least 200 years. The federal government shall have title to the property.

Other Radionuclides

f. Long-term management of other radionuclides shall be in accordance with Chapters 2, 3, and 5 of DOE Order 5820.2, as applicable.

F. EXCEPTIONS

Exceptions to the requirement that authorized limits be set equal to the guidelines may be made on the basis of an analysis of site-specific aspects of a designated site that were not taken into account in deriving the guidelines. Exceptions require approvals as stated in Section D. Specific situations that warrant exceptions are:

a. Where remedial actions would pose a clear and present risk of injury to workers or members of the general public, notwithstanding reasonable measures to avoid or reduce risk.

b. Where remedial actions--even after all reasonable mitigative measures have been taken--would produce environmental harm that is clearly excessive compared to the health benefits to persons living on or near affected sites, now or in the future. A clear excess of environmental harm is harm that is long-term, manifest, and grossly disproportionate to health benefits that may reasonably be anticipated.

c. Where the cost of remedial actions for contaminated soil is unreasonably high relative to long-term benefits and where the residual radioactive materials do not pose a clear present or future risk after taking necessary control measures. The likelihood that buildings will be erected or that people will spend long periods of time at such a site should be considered in evaluating this risk. Remedial actions will generally not be necessary where only minor quantities of residual radioactive materials are involved or where residual radioactive materials occur in an inaccessible location at

which site-specific factors limit their hazard and from which they are costly or difficult to remove. Examples are residual radioactive materials under hard-surface public roads and sidewalks, around public sewer lines, or in fence-post foundations. In order to invoke this exception, a site-specific analysis must be provided to establish that it would not cause an individual to receive a radiation dose in excess of the basic dose limits stated in Section B, and a statement specifying the residual radioactivity must be included in the appropriate state and local records.

d. Where the cost of cleanup of a contaminated building is clearly unreasonably high relative to the benefits. Factors that shall be included in this judgment are the anticipated period of occupancy, the incremental radiation level that would be effected by remedial action, the residual useful lifetime of the building, the potential for future construction at the site, and the applicability of remedial actions that would be less costly than removal of the residual radioactive materials. A statement specifying the residual radioactivity must be included in the appropriate state and local records.

e. Where there is no feasible remedial action.

G. SOURCES

Limit or Guideline	Source
Basic Dose Limits	
Dosimetry Model and Dose Limits	International Commission on Radiological Protection (1977, 1978)
Generic Guidelines for Residual Radioactivity	
Residual Concentrations of Radium and Thorium in Soil Material	40 CFR 192
Airborne Radon Decay Products	40 CFR 192
External Gamma Radiation	40 CFR 192
Surface Contamination	Adapted from U.S. Nuclear Regulatory Commission (1982)
Control of Radioactive Wastes and Residues	
Interim Storage	DOE Order 5480.1A
Long-Term Management	DOE Order 5480.1A; 40 CFR 192

H. REFERENCES

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DOE F 1325.8
(10-84)

United States Government | Department of Energy

memorandum

DATE: JUL 27 1987

REPLY TO ATTN OF: NE-20

SUBJECT: Review of Remedial Actions at the National Guard Armory, Chicago, Illinois

TO: File

As part of its Formerly Utilized Sites Remedial Action Program (FUSRAP), the Department of Energy (DOE) conducted remedial actions at the National Guard Armory site in Chicago, Illinois. The actions served to decontaminate those areas in the Armory that were radioactively contaminated as a result of programs previously conducted by the Manhattan Engineer District and the Atomic Energy Commission.

The remedial actions included decontamination of the building and the excavation and removal of a below grade catch basin. The estimated 50 cubic yards of contaminated material generated by these activities were packaged in 55 gallon drums and transported to the Hanford site near Richland, Washington, for disposal.

Sampling of the catch basins determined the presence of radioactively contaminated sludges and hazardous chemicals. These catch basin sludges and chemicals have been packaged in approved steel drums and are currently stored at the Armory pending the location of a suitable disposal facility.

The State of Illinois specified that no effluent releases were permitted during DOE's remedial action efforts. Therefore, extreme care was taken to capture and collect the airborne particulates generated during removal of surface contamination and the liquids used to clean equipment and piping systems. The materials so collected were solidified and packaged for disposal at the Hanford site.

The radiological impacts of the remedial actions both to the workers and members of the general public were reviewed in the Attachment and were determined to be negligibly small.

There were no surface or groundwater impacts from the remedial actions since no discharges of liquids were made and since all remedial action efforts took place within the building and were therefore sheltered from dispersion by the natural elements such as wind or rain.

008307

The project clearly had no significant effects on the quality of the human environment within the meaning of Section 102(2)(c) of the National Environmental Policy Act. Accordingly, neither an environmental assessment nor an environmental impact statement was required.

for John E. Baublitz

William R. Voigt, Jr.
Director
Office of Remedial Action
and Waste Technology
Office of Nuclear Energy

Attachment

cc:
C. Osborne, EH-25 w/attach.
J. Wagoner, NE-23 w/out attach.
S. Ahrends, OR w/out attach.
R. Atkin, OR w/out attach.

Exhibit II (5) - Access Agreements

An access agreement was obtained from the Illinois Military and Naval Department before remedial action activities began. A copy of the agreement is included in this exhibit.

Page

Access Agreement with the Illinois Military and and Naval Department, owner of National Guard Armory located at 52nd Street and Cottage Grove Avenue, Chicago, Illinois. II-310

DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
P. O. BOX E
OAK RIDGE, TENNESSEE 37831

CONTRACT NO. DE-AC05-810R20722

AGREEMENT

THIS AGREEMENT, entered into this 16th day of April, 1987, effective as of the 16th day of April, between THE UNITED STATES OF AMERICA (hereinafter called the "Government"), acting through the DEPARTMENT OF ENERGY (hereinafter called the "DOE"), and THE ILLINOIS MILITARY AND NAVAL DEPARTMENT (hereinafter called the "DEPARTMENT"), owner of an armory and related facilities (hereinafter referred to as the "Property") located at 52nd Street and Cottage Grove Avenue, Chicago, Illinois.

WITNESSETH THAT:

WHEREAS, the DOE through its contractor, Bechtel National, Inc., is conducting a low-level radioactive waste remedial action program related to operations conducted by predecessor agencies to the DOE; and

WHEREAS, the DEPARTMENT owns real property described above which requires remedial action; and

WHEREAS, the DEPARTMENT has agreed to such remedial action under the terms set forth below:

NOW THEREFORE, in consideration of the mutual promises, the parties hereto agree as follows:

1. The DEPARTMENT hereby grants to the DOE or its designees a permit giving: (a) the right to enter upon the property for the purpose of removing low-level radioactive material from such property; and (b) the right to enter upon the property to take soil samples, perform radiological surveys, and to perform or take any other reasonable action consistent with the expeditious completion of the subject remedial action; and (c) the right to restrict access to such parts of the property, as may be necessary, to facilitate remedial action; and (d) the right to periodically enter upon the property after completion of the remedial action for the purpose of conducting follow-up radiological surveys.

2. The Government shall be responsible for any loss or destruction of or damage to the DEPARTMENT's real or personal property caused by the activities of the DOE or its designees in exercising any of the rights given in this Agreement. This responsibility shall be limited to restoring the property to a condition comparable to its original condition by techniques of repair, replacement, backfilling, and such other methods as may be agreed to between the parties at the time of restoration work in accordance with the terms and conditions of this Agreement. Effective upon completion of the restoration work in accordance with the terms and conditions of this Agreement and upon certification by the DOE that the DEPARTMENT's property meets all applicable radiological criteria, the DEPARTMENT will release the Government, its contractors, and the officers, employees, servants, and agents of either of them from all further responsibility related to the remedial action covered by this agreement.

3. The DEPARTMENT will notify the DOE in writing if the property is, or at any time during the term of this Agreement shall become, leased, sold or otherwise transferred to another party. The DEPARTMENT will also give written notice to any purchaser, lessee, or transferee of the applicability of the rights contained in this Agreement when such purchase, lease, or transfer takes place during the term of this Agreement. The DEPARTMENT hereby consents to any Lessee of the property entering into a suitable agreement with the Government to cover any part of the remedial action that may affect such Lessee.

4. No member of or delegate to Congress, or Resident Commissioner, shall be admitted to any share or part of this Agreement, or to any benefit that may arise therefrom; but this provision shall not be construed to extend to this Agreement if made with a corporation for its general benefit.

5. The DEPARTMENT warrants that no person or selling agency has been employed or retained to solicit or secure this Agreement upon an agreement or understanding for a commission, percentage, brokerage, or contingent fee, excepting bona fide employees and bona fide established commercial or selling agencies maintained by the DEPARTMENT for the purpose of securing business. For breach or violation of this warranty, the Government shall have the right to annul this Agreement without liability or in its discretion to deduct from the Agreement price or consideration, or otherwise recover, the full amount of such commission, percentage, brokerage, or contingent fee.

6. To the extent that provisions of this Agreement call for the expenditure of appropriated funds in fiscal years subsequent to Fiscal Year 1987, such provisions shall be subject to the availability of funds appropriated by the Congress which the DOE may legally spend for such purposes.

7. This Agreement shall terminate upon completion of the restoration work and upon certification by the DOE that the DEPARTMENT's property meets applicable radiological criteria to the maximum extent practicable.

8. The Government and the DOE agree to indemnify and save harmless the DEPARTMENT for any damages or claims for damages arising out of or in connection with said remedial action plan described in this agreement.

IN WITNESS WHEREOF, the parties have executed this Agreement in several counterparts.

ILLINOIS MILITARY AND NAVAL DEPARTMENT

BY: _____
HAROLD G. HOLESINGER
Major General

TITLE: The Adjutant General

DATE: 9 April 1987

THE UNITED STATES OF AMERICA

BY: DEPARTMENT OF ENERGY

BY: _____

TITLE: Director, Technical Services Div.

DATE: April 16, 1987

Exhibit II (6) - Post-Remedial Action Report

The following report documents remedial action activities performed at the NGA and the radiological status of the NGA following the completion of remedial action. The post-remedial action report is included in this section of the docket by reference.

Page

Bechtel National, Inc. Post-Remedial Action Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-184, Revision 1, Oak Ridge, TN, November 1988. II-315

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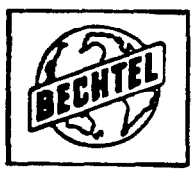
DOE/OR/20722-184
REVISION 1

Formerly Utilized Sites Remedial Action Program (FUSRAP)
Contract No. DE-AC05-81OR20722

POST-REMEDIAL ACTION REPORT FOR THE NATIONAL GUARD ARMORY

Chicago, Illinois

December 1988



Bechtel National, Inc.

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DOE/OR/20722-184
Revision 1

POST-REMEDIAL ACTION REPORT FOR THE NATIONAL GUARD ARMORY SITE CHICAGO, ILLINOIS

DECEMBER 1988

Prepared for

UNITED STATES DEPARTMENT OF ENERGY
OAK RIDGE OPERATIONS OFFICE
Under Contract No. DE-AC05-81OR20722

By

E. M. McNamee

Bechtel National, Inc.
Oak Ridge, Tennessee

Bechtel Job No. 14501

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ABBREVIATIONS

cm	centimeter
cm^2	square centimeter
cpm	counts per minute
dpm	disintegrations per minute
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
ft	foot
g	grams
gal	gallon
in.	inch
l	liter
m	meter
m^2	square meter
mi	mile
µR/h	microRoentgens per hour
mrad	millirad
mrad/h	millirad per hour
mrad/h/m^2	millirad per hour per square meter
mrem	millirem
mrem/yr	millirem per year
pCi/g	picocuries per gram
yr	year

1.0 INTRODUCTION

This report documents the radiological condition of the National Guard Armory site in Chicago, Illinois, following remedial action. The remedial action was conducted by Bechtel National, Inc. (BNI) from April 1987 to July 1987. The work was performed under the Formerly Utilized Sites Remedial Action Program (FUSRAP), a U.S. Department of Energy (DOE) program to identify, decontaminate, or otherwise control sites where residual radioactive contamination (exceeding current guidelines) remains from the early years of the nation's atomic energy program. BNI is the Project Management Contractor for DOE and represents DOE in the planning, management, and implementation of FUSRAP.

1.1 LOCATION AND DESCRIPTION

The National Guard Armory site is located at East 52nd Street and Cottage Grove Avenue, approximately 6 mi south of the downtown business district of Chicago, Illinois (Figure 1-1). The site is an active facility, presently occupied by the Illinois National Guard, 1st and 2nd Battalion, 178th Infantry, and 122nd Field Artillery.

The National Guard Armory is a 230-ft by 620-ft concrete building with stone outer walls. A 230-ft by 360-ft arena with a ceiling more than 100 ft high occupies the center of the building. Stadium bleachers are located on the east and west sides of the arena. Before the dirt floor was surfaced with concrete, the arena was used by the cavalry to train horses and later for playing polo (Ref. 1). The north and south ends of the building are divided into four floors that contain offices, classrooms, storage areas, and garages (Figure 1-2).

1.2 SITE HISTORY

In 1942, the Manhattan Engineer District (MED) leased the National Guard Armory to alleviate space shortages at the nearby University of Chicago where research was being conducted by the university and

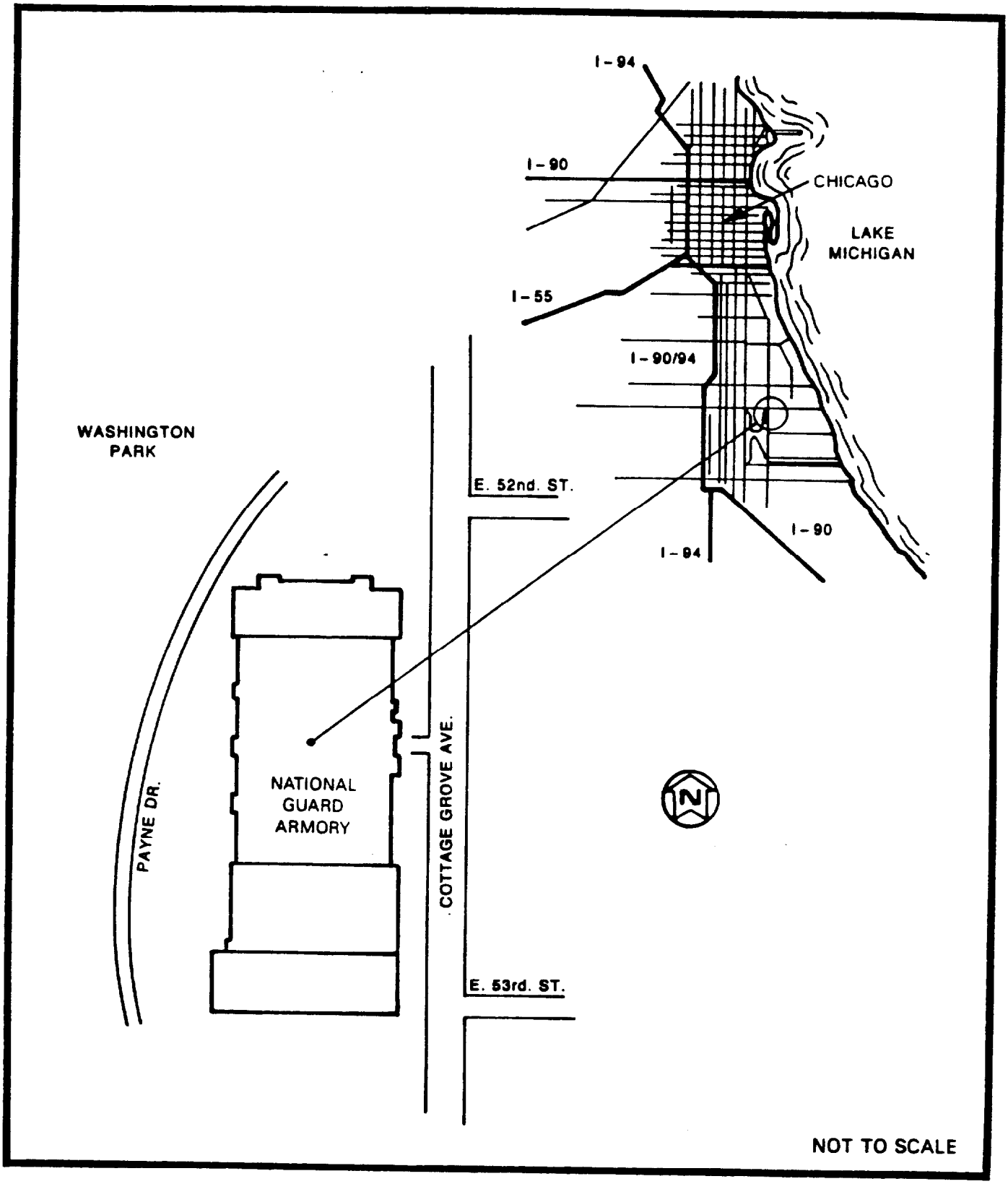

FIGURE 1-1 LOCATION OF THE NATIONAL GUARD ARMORY

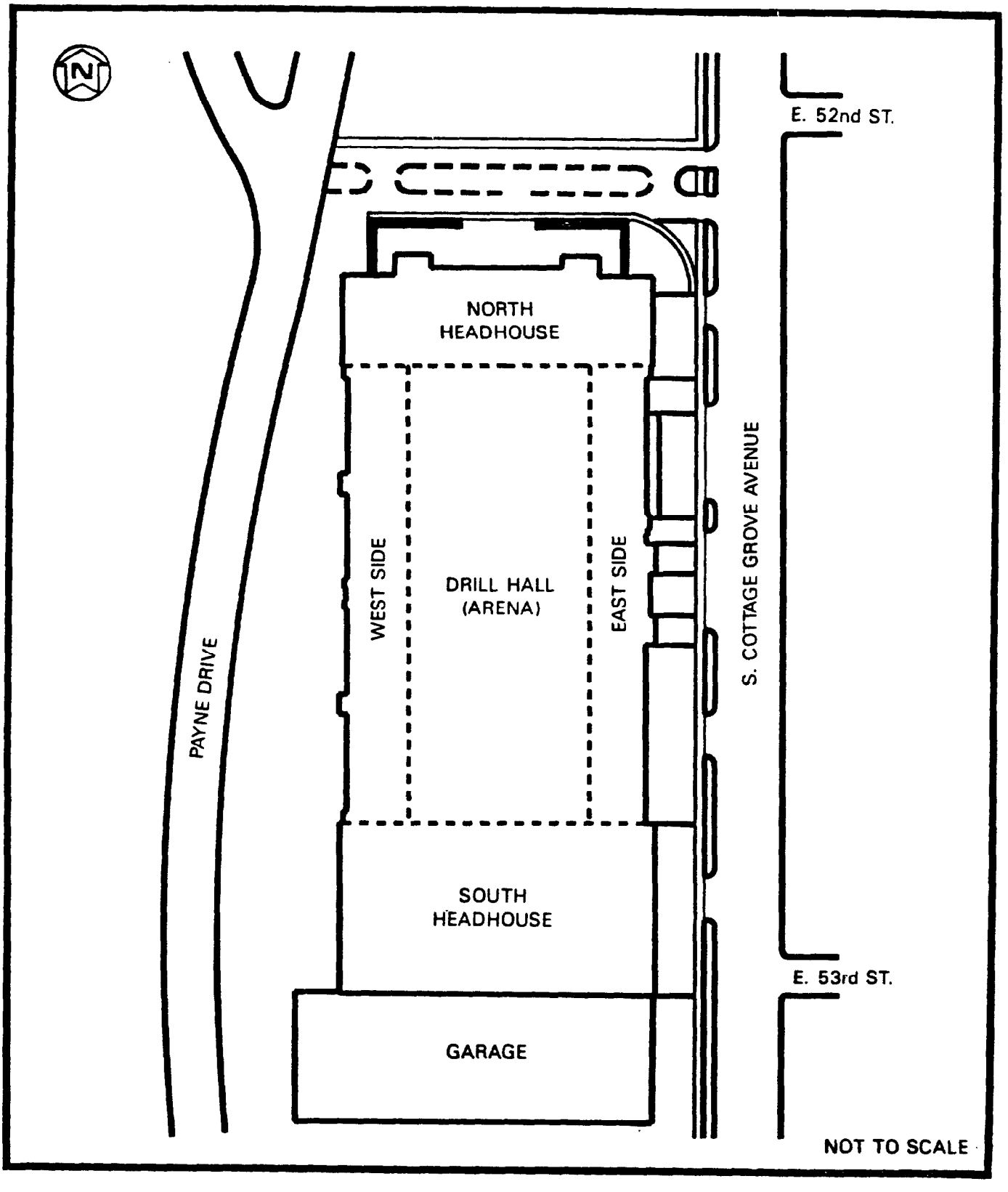

FIGURE 1-2 PLAN VIEW OF THE NATIONAL GUARD ARMORY

the MED Metallurgical Laboratory. Available correspondence indicates that the National Guard Armory was used primarily for the storage and processing of uranium metal. Records indicate that in 1943 the National Guard Armory was the central procurement and shipping location for the Metallurgical Laboratory. In 1951, the Atomic Energy Commission (AEC), which succeeded the MED, terminated the use of this facility, and the property was returned to the State of Illinois.

It is suspected that most of the MED activities were carried out in the arena and the south headhouse. The arena was probably used for both chemical processing and metal casting of uranium. The armory storeroom (believed to be Room 1) was apparently used to store uranium shavings and grinding waste. One of several uranium fires in the armory was reported to have occurred in the northeast corner of this room (Ref. 1). Other portions of the south headhouse, particularly the west half of the ground floor, were apparently used for shipping, receiving, and storage.

When operations ceased at the National Guard Armory, some effort was apparently made to decontaminate the facility. After the MED terminated its use of the facility, contaminated soil from the arena was removed and disposed of. However, no records of this operation could be located. Later, more soil was removed, and a concrete pad was installed. Conversations with personnel who worked at the facility revealed that an effort had been made to decontaminate some bleachers in the arena; however, no records of radiological surveys or decontamination efforts conducted at the facility upon termination of MED/AEC activities could be found (Ref. 2).

During 1977 and 1978, Argonne National Laboratory (ANL) performed a radiological survey of the National Guard Armory (Ref. 2). Results of this survey indicated that residual contamination in excess of DOE guidelines was present at the National Guard Armory. In January 1987, a more detailed characterization was performed by BNI (Ref. 1), and remedial action was carried out from April 1987 to July 1987.

2.0 REMEDIAL ACTION GUIDELINES

The principal radionuclide of concern at the National Guard Armory was uranium-238. A site-specific uranium guideline was derived on the basis of very conservative scenarios for future use of the National Guard Armory. ANL derived a guideline (Ref. 3) of 150 pCi/g of uranium-238 in soil on the basis of a scenario in which a person would live in the armory, drink water from a shallow on-site well, and raise 10 percent of his plant-food diet in an on-site garden. DOE residual contamination guidelines governing the release of the property for unrestricted use are listed in Table 2-1. DOE implemented these guidelines on the basis of their compatibility with the criteria used for the same purpose by the Environmental Protection Agency (EPA) (Ref. 4). The guidelines presented in Table 2-1 were applied primarily to surfaces, such as walls, ceilings, floors, and columns. On surfaces where contamination exceeded the applicable criteria, remedial action was performed until measurements indicated that guidelines were met.

TABLE 2-1

SUMMARY OF RESIDUAL CONTAMINATION GUIDELINES FOR THE NATIONAL GUARD ARMORY

BASIC DOSE LIMITS

The basic limit for the annual radiation dose received by an individual member of the general public is 100 mrem/yr.

SOIL (LAND) GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Radionuclide	Soil Concentration (pCi/g) above background[a,b,c]
Radium-226 Radium-228 Thorium-230 Thorium-232	5 pCi/g, averaged over the first 15 cm of soil below the surface; 15 pCi/g when averaged over any 15-cm-thick soil layer below the surface layer.
Uranium-238	150 pCi/g*
Other radionuclides	Soil guidelines will be calculated on a site-specific basis using the DOE manual developed for this use.

STRUCTURE GUIDELINES (MAXIMUM LIMITS FOR UNRESTRICTED USE)

Airborne Radon Decay Products

Generic guidelines for concentrations of airborne radon decay products shall apply to existing occupied or habitable structures on private property that are intended for unrestricted use; structures that will be demolished or buried are excluded. The applicable generic guideline (40 CFR 192) is: In any occupied or habitable building, the objective of remedial action shall be, and reasonable effort shall be made to achieve, an annual average (or equivalent) radon decay product concentration (including background) not to exceed 0.02 WL.[d] In any case, the radon decay product concentration (including background) shall not exceed 0.03 WL. Remedial actions are not required in order to comply with this guideline when there is reasonable assurance that residual radioactive materials are not the cause.

External Gamma Radiation

The average level of gamma radiation inside a building or habitable structure on a site to be released for unrestricted use shall not exceed the background level by more than 20 μR/h.

Indoor/Outdoor Structure Surface Contamination

Radionuclide[f]	Allowable Surface Residual Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
Transuranics, Ra-226, Ra-228, Th-230, Th-228 Pa-231, Ac-227, I-125, I-129	100	300	20
Th-Natural, Th-232, Sr-90, Ra-223, Ra-224 U-232, I-126, I-131, I-133	1,000	3,000	200

*Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987.

TABLE 2-1

(continued)

Indoor/Outdoor Structure Surface Contamination (continued)

Radionuclide[f]	Allowable Surface Residual Contamination[e] (dpm/100 cm^2) Average[g,h]	Maximum[h,i]	Removable[h,j]
U-Natural, U-235, U-238, and associated decay products	5,000 α	15,000 α	1,000 α
Beta-gamma emitters (radionuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above	5,000 β - γ	15,000 β - γ	1,000 β - γ

[a]These guidelines take into account ingrowth of radium-226 from thorium-230 and of radium-228 from thorium-232, and assume secular equilibrium. If either thorium-230 and radium-226 or thorium-232 and radium-228 are both present, not in secular equilibrium, the guidelines apply to the higher concentration. If other mixtures of radionuclides occur, the concentrations of individual radionuclides shall be reduced so that the dose for the mixtures will not exceed the basic dose limit.

[b]These guidelines represent unrestricted-use residual concentrations above background averaged across any 15-cm-thick layer to any depth and over any contiguous 100-m^2 surface area.

[c]Localized concentrations in excess of these limits are allowable provided that the average over a 100-m^2 area is not exceeded.

[d]A working level (WL) is any combination of short-lived radon decay products in 1 liter of air that will result in the ultimate emission of 1.3×10^5 MeV of potential alpha energy.

[e]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.

[f]Where surface contamination by both alpha- and beta-gamma-emitting radionuclides exists, the limits established for alpha- and beta-gamma-emitting radionuclides should apply independently.

[g]Measurements of average contamination should not be averaged over more than 1 m^2. For objects of less surface area, the average shall be derived for each such object.

[h]The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h and 1.0 mrad/h, respectively, at 1 cm.

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

[j]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 measuring the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of surface area less than 100 cm^2 is determined, the activity per unit area should be based on the actual area and the entire surface should be wiped. The numbers in this column are maximum amounts.

3.0 REMEDIAL ACTION

After determining that the National Guard Armory was contaminated, DOE designated the building for remedial action. Because the armory was found to be contaminated in excess of DOE guidelines, it was eligible for remedial action under FUSRAP. Radiological surveys determined that a total of 12 rooms and one isolated area outside the armory would require remedial action. Plan views of the first and second floors of the south headhouse are shown in Figures 3-1 and 3-2. Surface contamination was present on either the floor, walls, or ceiling in all 12 rooms. Furthermore, contaminated sludges were found in the catch basin system in Rooms 1, 1D, and 5. Detailed figures indicating the areas where remedial action was performed inside the armory are provided in Sections 4.1 and 4.2. The soil in one area outside the west wall of Room 1 was found to be contaminated with uranium in concentrations in excess of 150 pCi/g (Ref. 3). Figure 3-3 indicates the location of this area outside the building.

The National Guard was notified when DOE designated the armory for remedial action, and BNI began engineering design and related activities to perform the remedial action.

3.1 REMEDIAL ACTION ACTIVITIES

Remedial action consisted of the removal of radioactive contamination from the contaminated areas. Four types of remedial action were performed at the National Guard Armory.

The first type of remedial action was the decontamination of surfaces with removable contamination by vacuum with a high-efficiency filtered exhaust or by cleaning the area with a cloth. This type of remedial action was conducted on the ceiling in Room 1.

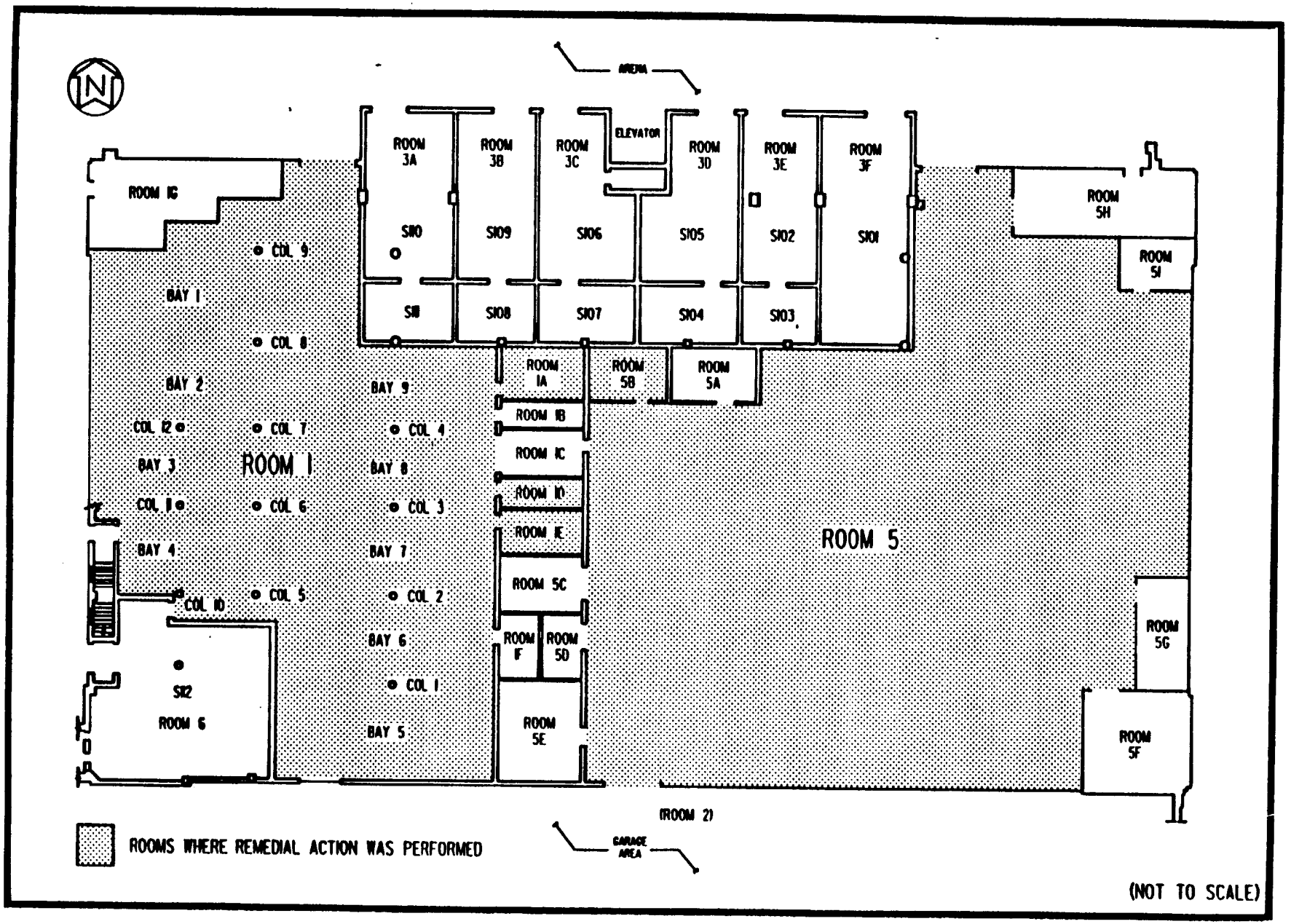

FIGURE 3-1 THE FIRST FLOOR OF THE SOUTH HEADHOUSE

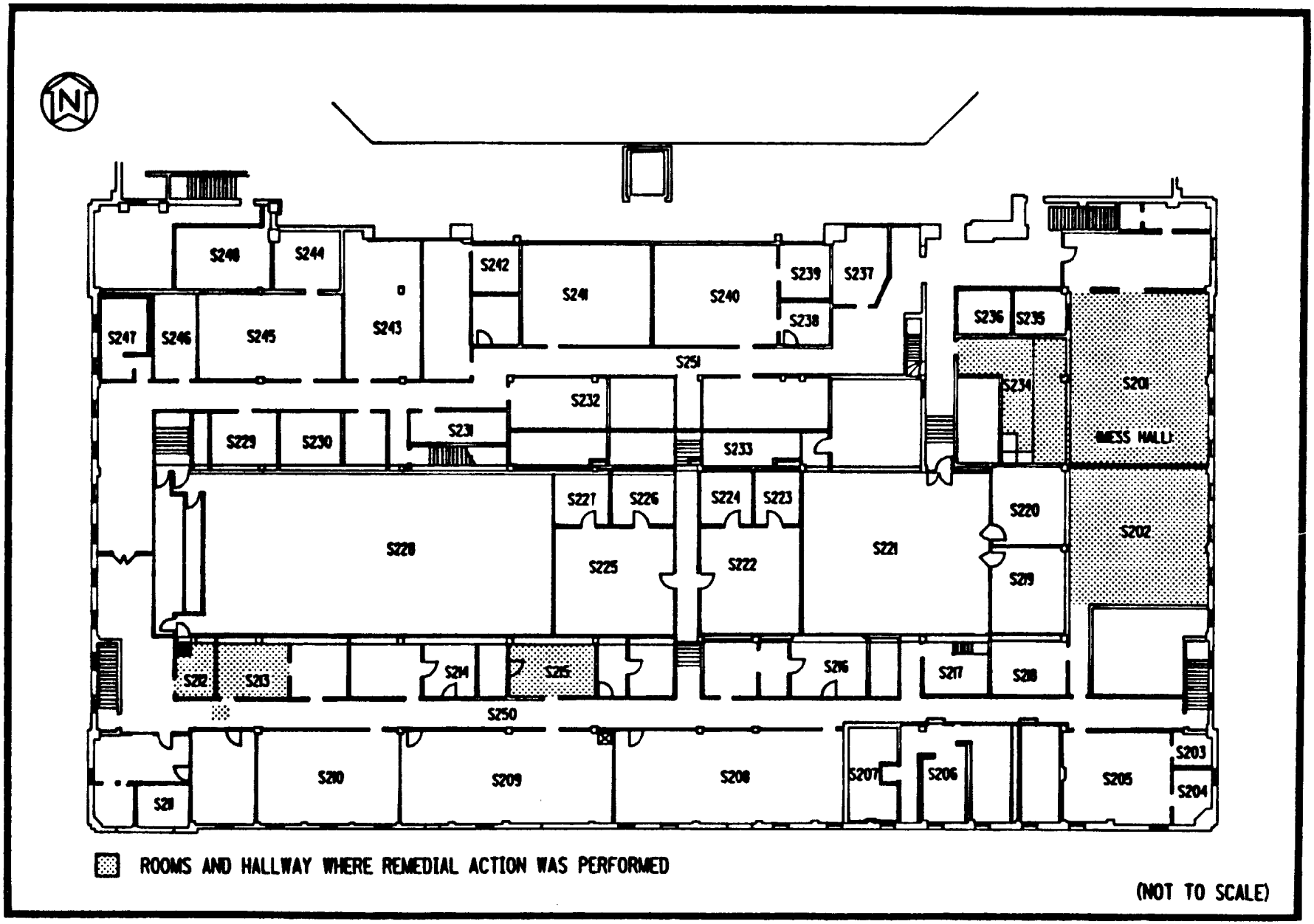

FIGURE 3-2 THE SECOND FLOOR OF THE SOUTH HEADHOUSE

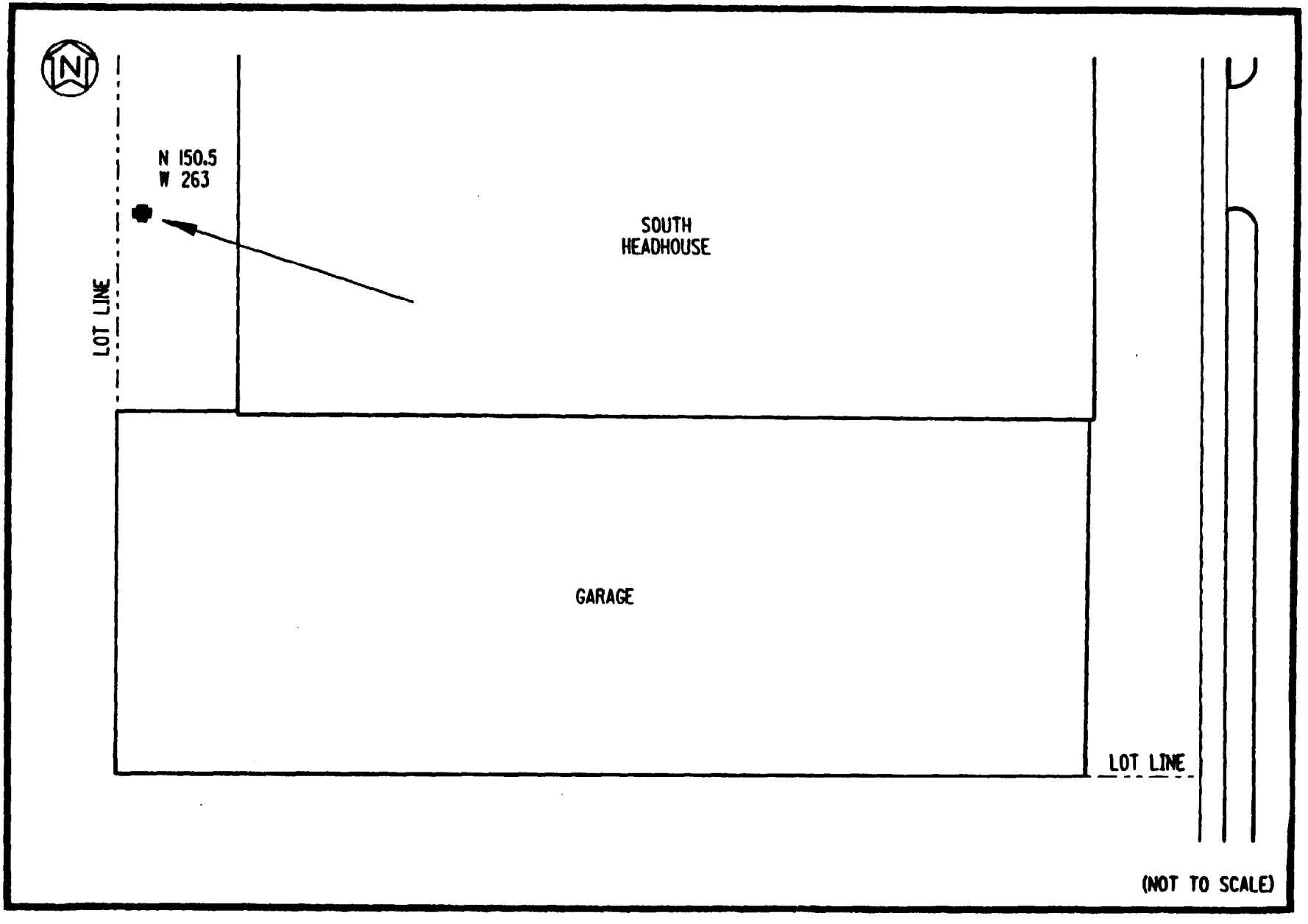

FIGURE 3-3 AREA WHERE REMEDIAL ACTION WAS PERFORMED OUTSIDE THE BUILDING

[1,7] N19W9808.DGN JKL

The second type of remedial action was the decontamination of surfaces with fixed contamination by sanding, grinding, or scabbling the areas of contamination. It was necessary to cut the concrete along a joint or a crack to remove all residual contamination in some places. These activities were conducted in Rooms 1, 1A, 1E, 5, 5B, S201, S202, S212, S213, S215, and S250.

The third type of remedial action involved the removal of contaminated sludges. These sludges contained mixed waste and had a very low ignition temperature (72°F). The decontamination process required several steps. First, the sludges were removed from the six catch basins using a non-sparking shovel. Then the catch basin walls were sandblasted to remove all contamination adhering to the walls. Finally, a high-pressure, low-volume water pipe cleaning system was used to decontaminate all pipes extending from each catch basin. A portion of the main pipe between Catch Basins 3 and 4 could not be decontaminated with the pipe cleaning system and was removed and disposed of.

The fourth type of remedial action conducted at the site was the removal of contaminated soil by shovel. This activity was conducted at the location outside the building and between Catch Basins 3 and 4 (where the main pipe was removed) as required.

Waste from all these remedial action activities was placed in 55-gal steel drums for disposal. All the water generated from the remedial action activities was also placed in drums and temporarily stored on-site.

3.2 CONTAMINATION CONTROL DURING REMEDIAL ACTION

During remedial action operations, measures were taken to prevent the spread of contamination and to keep exposure rates as low as possible for the building occupants, including the remedial action workers. Measures were also taken to monitor airborne radioactivity resulting primarily from dust and to limit personnel exposure to organic vapors from the sludges.

The following contamination control measures were implemented during remedial action at the National Guard Armory:

- All sanding, scabbling, grinding, or cutting was done in a containment box, a cardboard or plywood box with a plastic top that permitted the operator to use the proper equipment. The top also had an opening for the hose of the high-efficiency filtered exhaust vacuum, which was used primarily for dust control.

- All personnel working around an operation that could produce dust or organic vapors wore respiratory protection. For dusty operations, a full-face respirator was used, and for operations involving organic vapors, supplied air was used.

- In Room 1, where large amounts of removable contamination were present and the possibility of organic vapors existed, a control area was established. The room was isolated from the rest of the armory by a partition made of sheets of plastic. This controlled area served as the only access and egress from the contaminated area, and all personnel and equipment leaving this area were checked for contamination. Parts of Room 1 were subdivided, as needed, to allow the work to progress.

Continuous air sampling was performed at several points within the building to ensure that these contamination control measures were successful.

4.0 POST-REMEDIAL ACTION MEASUREMENTS

Post-remedial action measurements were taken in all areas where remedial action was performed. These areas include the catch basin system, rooms in which remedial action was conducted, and the area outside the building where contaminated soil was removed. These measurements consisted primarily of direct alpha and beta-gamma readings. The direct beta-gamma readings are reported to the nearest 0.01 mrad/h. Wipes were used when direct readings indicated that an area exceeded guidelines for removable contamination, and soil samples were taken in areas where soil was excavated or disturbed.

In the tables at the end of this section, use of the "less than" (<) notation in reporting results indicates that the radionuclide was not present in concentrations that are quantitative with the instruments and techniques used. The less than value represents the lower bound of the quantitative capacity of the instrument and technique used and is based on various factors, including the volume, size, and weight of the sample; the type of detector used; the counting time, and the background count rate. The actual concentration of the radionuclide is less than the value indicated. In addition, since radioactive decay is a random process, a correlation between the rate of disintegration and a given radionuclide concentration cannot be precisely established. For this reason, the exact concentration of the radionuclide cannot be determined. As such, each value that can be quantitatively determined has an associated uncertainty term ($\pm$), which represents the amount by which the actual concentration can be expected to differ from the value given in the table. The uncertainty term has an associated confidence level of 95 percent.

All the beta-gamma measurements are reported without instrument background levels having been subtracted. All these measurements were taken with portable handheld instruments. Background measurements recorded with such instruments can vary from room to room because of the use of different instruments in the various

rooms, the occurrence of small changes in the response of the instrument (i.e., new batteries), and small day-to-day changes in the ambient background. Slight variations between background measurements for different rooms can result from these factors.

The average background concentrations measured in the surface soil at the five background locations were less than detectable for uranium-238, 1.0 pCi/g for radium-226, and 1.2 pCi/g for thorium-232 (Ref. 1).

The following subsections describe in more detail the methods of sampling performed in each area and the results of the sampling. Figures and tables for these areas are grouped at the end of this section.

4.1 THE CATCH BASIN SYSTEM

The part of the catch basin system where remedial action was performed consists of six interior catch basins connected by a cast iron main line with a 6-in. interior diameter. No contamination had been found in Catch Basin 7 (the exterior manhole). Figure 4-1 shows the catch basin configuration and indicates the position of the main line. Several 4-in. lateral pipes are connected to each catch basin. These lateral pipes at one time serviced floor drains in Rooms 1 and 5; however, at some point in the past, the lateral pipes were filled with grout, and the floor drain openings were covered. Except for a small section, each lateral pipe is filled with grout. An additional 4-in. lateral joined the main line between Catch Basins 3 and 4. This lateral serviced a floor drain in Room 5B that had been covered over. The remainder of the catch basin system consists of three grease traps connected to Catch Basin 6.

Post-remedial action measurements were taken inside all of the catch basins except Catch Basin 3, which was removed and replaced. Measurements consisted of direct alpha and beta-gamma readings. Figure 4-2 shows the measurement locations; the average, maximum,

and minimum readings for each wall and the floor are presented in Table 4-1. In addition to these direct readings, the entire inside surface of each catch basin was scanned to ensure that the surface readings were below DOE guidelines.

After Catch Basin 3 was removed, soil samples were collected to verify that the soil around and underneath the catch basin had not become contaminated. Analysis results of these samples (Table 4-2) indicate that the soil was uncontaminated.

Post-remedial action measurements were taken inside the main line between all the catch basins, except for part of a section between Catch Basins 3 and 4, which was removed and replaced. Direct beta-gamma measurements were taken at 6-in. intervals along the length of the line with the probe face oriented in four different directions (up, down, right, and left). The average, maximum, and minimum beta-gamma values found along the line between adjacent catch basins are presented in Table 4-3. All measurements taken along the main line averaged less than 0.2 mrad/h/m^2. In the area where the main line was removed between Catch Basins 3 and 4 (Figure 4-1), four composite soil samples were taken to verify that the soil had not become contaminated during remedial action. Results of the analysis of these samples are presented in Table 4-4.

The main line between Catch Basins 3 and 4 is connected to a small lateral line (4-in. inner diameter) originating from a floor drain in Room 5B. This section of pipe was examined at both the connection to the main line and at the floor drain. The floor drain was removed to examine this pipe at the floor drain end. No contamination was found at either end of this line.

Post-remedial action measurements were taken inside the laterals connected to the catch basins except for those connected to Catch Basins 1 and 6. Measurements were not taken in these laterals, because the grout used to seal the floor drains had also closed off the openings inside Catch Basin 1, and no contamination had been found in Catch Basin 6.

Readings were taken at 6-in. intervals with the probe face oriented in two different directions (up and down). The average, maximum, and minimum beta-gamma values for each lateral are presented in Table 4-5.

Measurements taken inside the grease traps indicated that no contamination was present; therefore, no remedial action was performed.

4.2 ROOMS WHERE REMEDIAL ACTION WAS PERFORMED

Remedial action was performed in 12 rooms and one hallway. All remedial action consisted of decontaminating sections of walls, floors, and the ceiling in the various rooms. The following subsections describe in more detail the post-remedial measurements performed in each room.

4.2.1 Room 1

In Room 1, remedial action was performed to decontaminate the ceiling, portions of the floor, portions of the walls, and sections of three columns in the room. Post-remedial action measurements included both direct alpha and beta-gamma readings.

A total of 2,576 direct alpha and beta-gamma readings were taken on the honeycomb section ceiling in Room 1, which covers nine bays (Figure 4-3). The average, maximum, and minimum readings for each bay were calculated by averaging the measurements from all the sections in each respective bay (Table 4-6). In addition to the large number of direct readings taken, the entire ceiling was scanned for both alpha and beta-gamma activity to ensure that no hot spots remained. Areas in which contact readings indicated concentrations in excess of guidelines for removable contamination were wiped to ensure that the activity was not removable. The removable alpha activity concentrations measured with the wipes ranged from 3 to 132 dpm (guidelines are presented in Table 2-1).

All the wipes had concentrations below DOE guidelines for removable activity on surfaces.

Remedial action was performed on portions of the floors in Room 1 to clean small spots along cracks and in areas where uranium ore had been stored (Figures 4-4 through 4-9). The entire floor was checked to ensure that all contamination in excess of guidelines had been removed from the spots on the floor and that the floor had not become contaminated during the remedial action performed on the catch basin system. Post-remedial action measurements of the floor of Room 1 consisted of 3,438 direct alpha and beta-gamma measurements. The average, maximum, and minimum alpha activity readings were 45, 331, and 22 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings were 0.03, 0.13, and 0.02 mrad/h, respectively. (Background, 0.02 mrad/h, has not been subtracted.)

Remedial action was performed on several very small areas on Columns 1, 2, and 3 on the east side of Room 1 and on the upper surface of Column 3 from 17 ft above the floor to the ceiling (Figures 4-10 through 4-12). Post-remedial measurements taken on the columns consisted of direct alpha and beta-gamma readings. The average, maximum, and minimum alpha activity readings for Column 1 were 22, 101, and 18 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings for Column 1 were 0.03, 0.10, and 0.02 mrad/h, respectively. For Column 2, the average, maximum, and minimum alpha activity readings were 19, 35, and 18 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings for Column 2 were 0.03, 0.04, and 0.02 mrad/h, respectively. For Column 3, the average, maximum, and minimum alpha activity readings were all 18 dpm/100 cm^2. The average, maximum, and minimum beta-gamma levels for Column 3 were 0.03, 0.03, and 0.02 mrad/h, respectively. (Background, 0.03 mrad/h, has not been subtracted.)

4.2.2 Room 1A

Two areas on the floor in Room 1A required remedial action (Figure 4-13). Post-remedial action measurements in this room consisted of direct alpha and beta-gamma readings. The entire floor was surveyed to ensure that all areas of contamination on the floor had been removed during remedial action. The average, maximum, and minimum alpha activity readings were 69, 153, and 20 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings in Room 1A were 0.03, 0.08, and 0.03 mrad/h, respectively. (Background, 0.02 mrad/h, has not been subtracted.)

4.2.3 Room 1D

The remedial action carried out in Room 1D consisted of removing part of the 6-in. main line between Catch Basins 3 and 4. Remedial action performed on the catch basin system is discussed in Section 4.1.

4.2.4 Room 1E

Two areas on the floor in Room 1E required remedial action (Figure 4-9). Post-remedial action measurements taken in this room consisted of direct alpha and beta-gamma readings. The entire floor was surveyed to ensure that all contaminated areas on the floor were removed during remedial action. The average, maximum, and minimum alpha activity readings were 32, 108, and 25 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings in Room 1E were 0.03, 0.06, and 0.02 mrad/h, respectively. (Background, 0.02 mrad/h, has not been subtracted.)

4.2.5 Room 5

Three areas on the floor in Room 5 required remedial action (Figures 4-14 and 4-15). Post-remedial action measurements for these areas consisted of direct alpha and beta-gamma measurements. The results of all alpha measurements taken in this room were

indistinguishable from background count rates. Similarly, all but one of the beta-gamma readings were indistinguishable from background level. The one beta-gamma reading that differed from background level was 0.05 mrad/h. (Background, 0.03 mrad/h, has not been subtracted.)

4.2.6 Room 5B

Several small areas on the floor and walls in Room 5B required remedial action (Figure 4-15). The post-remedial action measurements taken in this room consisted of direct alpha and beta-gamma readings. The average, maximum, and minimum alpha and beta-gamma activity readings for each wall are reported in Table 4-7. Room 5B also contained a floor drain that was connected to the catch basin system. The drain was removed, and the connecting pipe was checked for contamination. All of the measurements taken were below guidelines.

4.2.7 Rooms S201 and S202

Four areas on the floor in Rooms S201 and S202 required remedial action (Figure 4-16). Area I covered approximately 54 ft^2 (5 m^2), Area II covered approximately 2.6 ft^2 (0.24 m^2), Area III covered approximately 4.0 ft^2 (0.37 m^2), and Area IV covered approximately 7.6 ft^2 (0.7 m^2). Post-remedial action measurements taken in these areas consisted of direct alpha and beta-gamma readings. The average, maximum, and minimum alpha and beta-gamma readings for each area are presented in Table 4-8.

4.2.8 Room S212

Three areas in Room S212 required remedial action (Figure 4-17). The floor in this room is not all on the same level: the northeast corner of the floor is recessed approximately 15 in. (38 cm) below the level of the main floor. Areas I and II are on the main floor level and are very small areas [both less than 1.1 ft^2 (0.1 m^2)]. The third area where remedial action was performed

extends from the main floor level into the recessed area. The average, maximum, and minimum alpha and beta-gamma readings for these areas are presented in Table 4-9. Data for the area that covers two floor levels are provided separately for Area III, the area on the level of the main floor; the west and south walls, which extend from the main floor down into the recessed floor; and the area with the recessed floor. All these measurements were direct contact readings and are below DOE guidelines.

4.2.9 Room S213

Two small areas of contamination on the north wall in Room S213 required remedial action (Figure 4-18). Post-remedial action measurements were taken on the 6-ft by 3-ft (2-m by 1-m) section of the wall where the two contaminated areas had been, to verify that all contamination in excess of guidelines had been removed. Post-remedial action measurements consisted of direct alpha and beta-gamma readings. The average, maximum, and minimum alpha activity readings were 45, 206, and 24 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings were 0.04, 0.05 and 0.02 mrad/h, respectively. (Background, 0.02 mrad/h, has not been subtracted.)

4.2.10 Hallway outside Room S213

A small area on the floor in the hallway outside Room S213, approximately 3.2 ft^2 (0.3 m^2), required remedial action (Figure 4-19). Post-remedial action measurements taken in this area consisted of direct alpha and beta-gamma readings. Results of this survey indicated an average alpha activity of less than 26 dpm/100 cm^2 and an average beta-gamma reading of 0.03 mrad/h. (Background, 0.02 mrad/h, has not been subtracted from this average.)

4.2.11 Room S215

One area of contamination on the floor of the southeast corner of Room S215 required remedial action (Figure 4-20). Post-remedial

action measurements were taken over a 43-ft^2 (4-m^2) area where the contaminated area had been, to verify that all contamination had been removed. Post-remedial action measurements consisted of direct alpha and beta-gamma readings. The average, maximum, and minimum alpha activity readings were 11, 33, and 5 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings were 0.03, 0.06, and 0.01 mrad/h, respectively. (Background, 0.03 mrad/h, has not been subtracted.)

4.2.12 Room S234

A rectangular area of contamination on the floor in Room S234 required remedial action (Figure 4-21). Post-remedial action measurements taken in this area consisted of direct alpha and beta-gamma readings. The average, maximum, and minimum alpha activity readings were 34, 71, and 20 dpm/100 cm^2, respectively. The average, maximum, and minimum beta-gamma level readings were 0.03, 0.03, and 0.02 mrad/h, respectively. (Background, 0.02 mrad/h, has not been subtracted).

4.3 OUTSIDE AREA

One area outside the west wall of Room 1 was found to be contaminated with radium-226 during the characterization survey. The radium-226 contamination is believed to have originated from a radium dial found buried in the center of the area where remedial action was performed (Figure 3-3). Because the area was small, approximately 51 ft^2 (4.7 m^2) and 12 in. (30 cm) deep, it was decontaminated as part of the characterization survey. Analysis results of post-remedial action soil samples from this area indicated average, maximum, and minimum concentrations (including background) of 0.7, 0.8, and 0.6 pCi/g for radium-226, respectively. All soil samples indicated uranium-238 concentrations at background level.

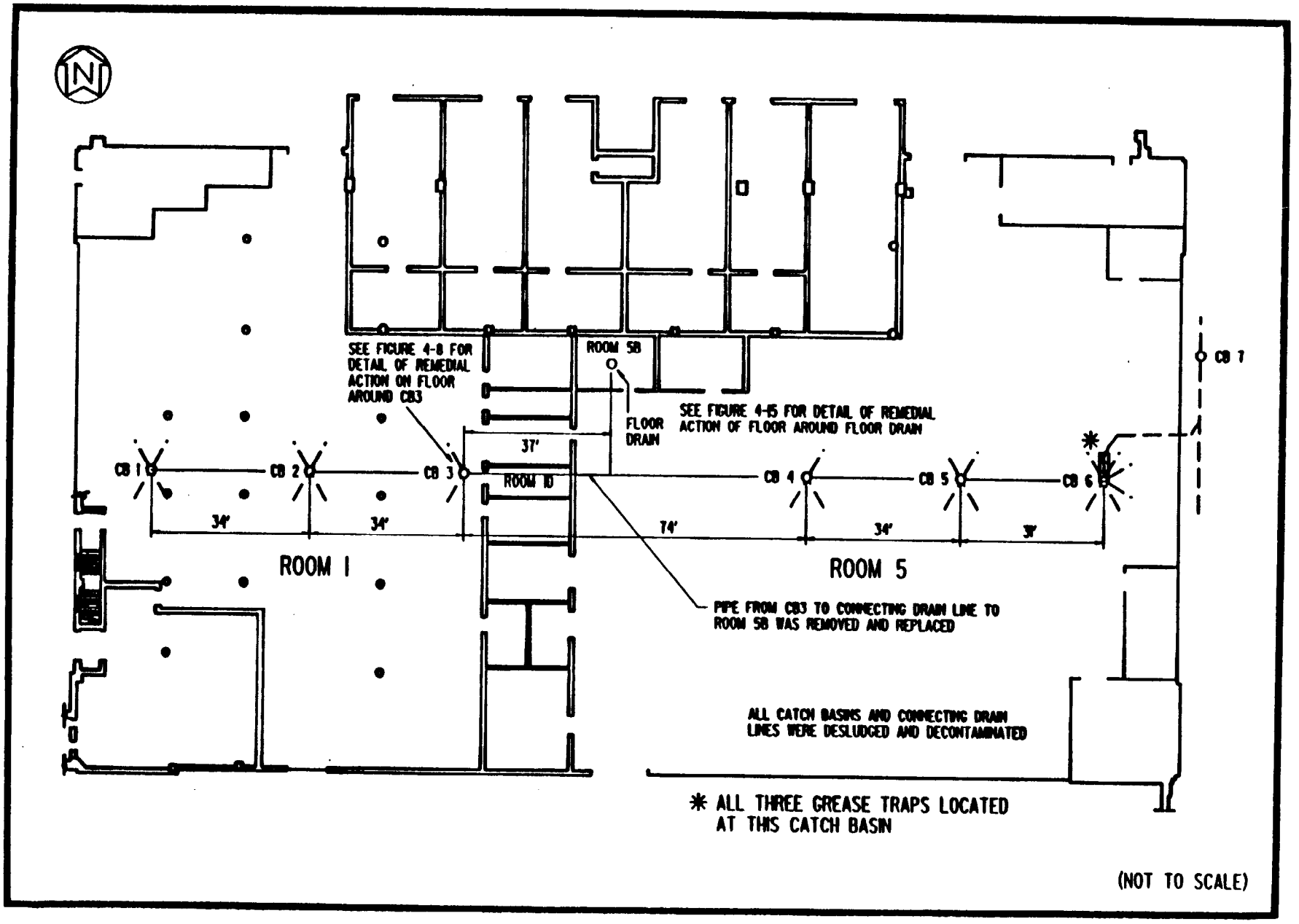

FIGURE 4-1 THE CATCH BASIN SYSTEM ON THE FIRST FLOOR OF THE SOUTH HEADHOUSE

CRA: (42,7) N19W9811.DGN JKL

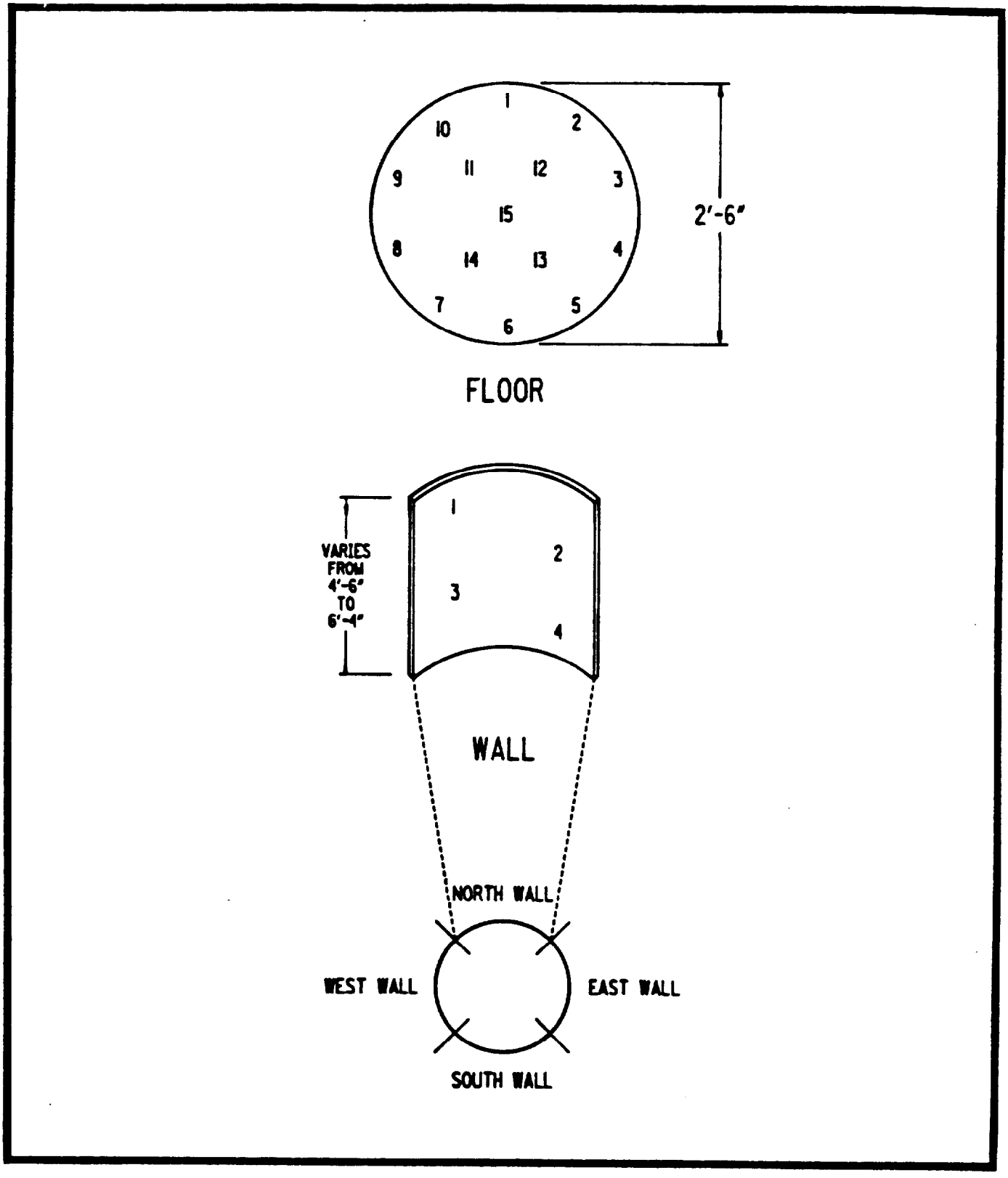

FIGURE 4-2 LOCATIONS WHERE RADIOLOGICAL MEASUREMENTS WERE TYPICALLY TAKEN IN A CATCH BASIN

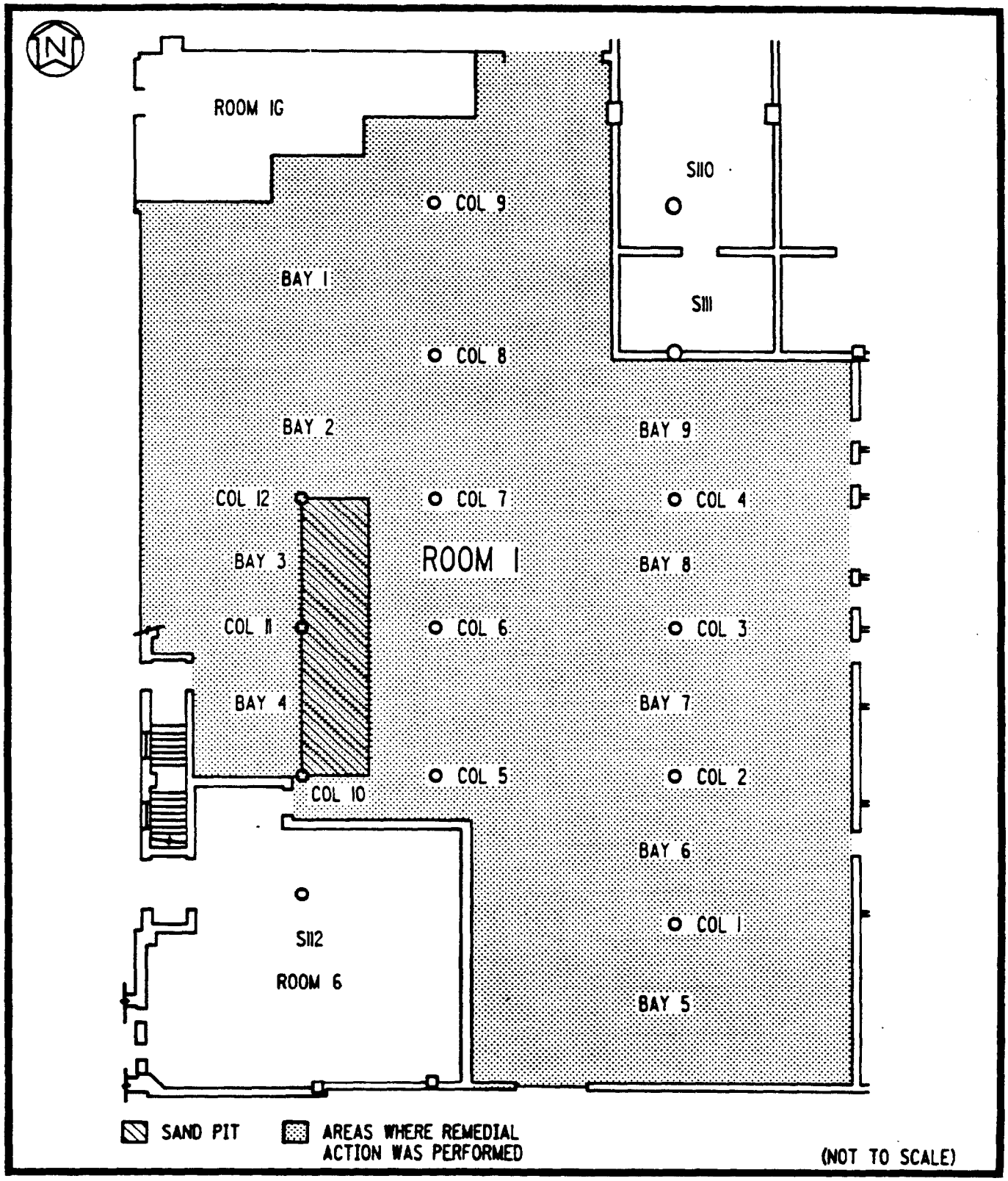

FIGURE 4-3 NINE-BAY CEILING IN ROOM 1 ON THE FIRST FLOOR OF THE SOUTH HEADHOUSE

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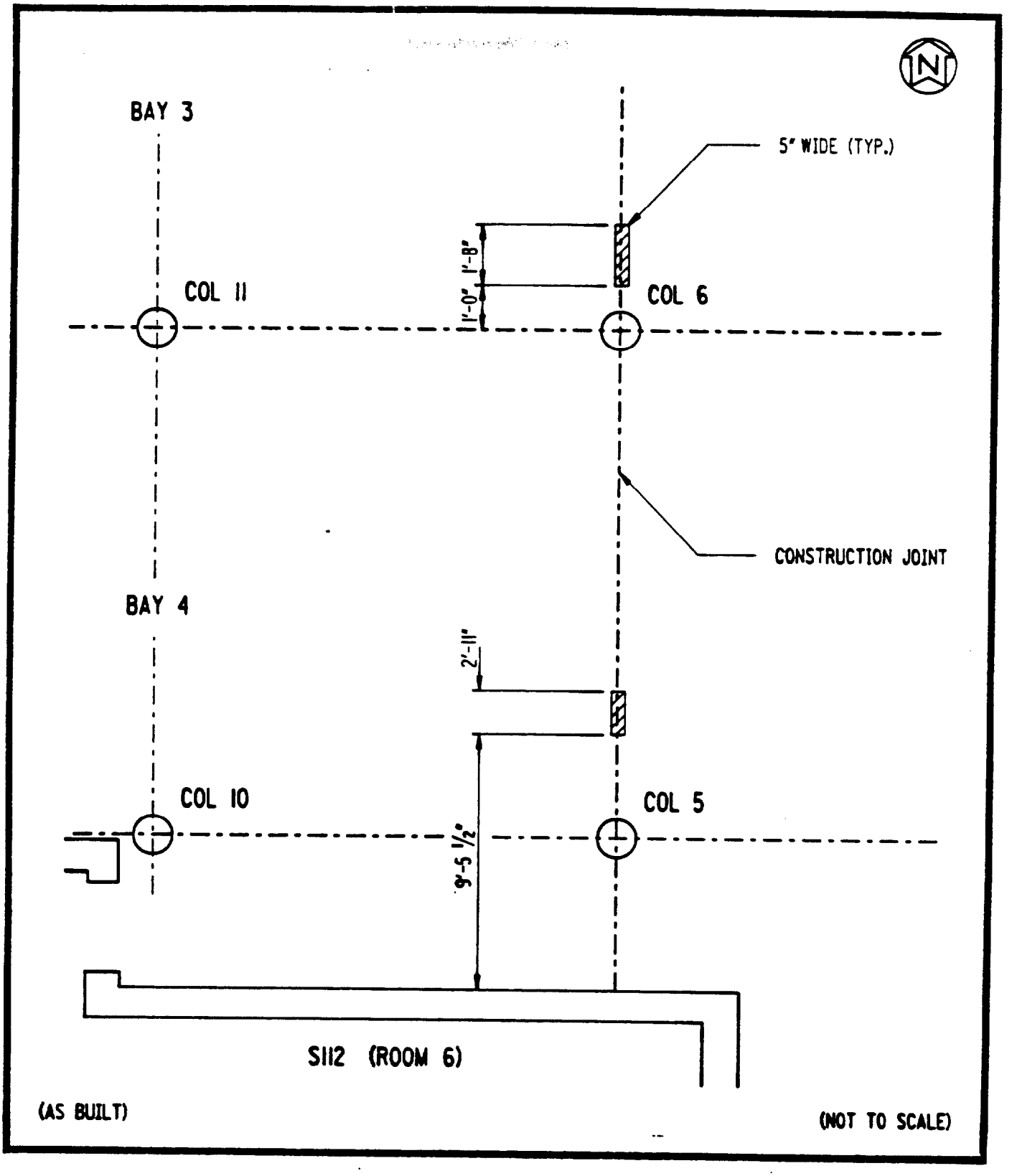


FIGURE 4-4 ROOM 1—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAYS 3 AND 4

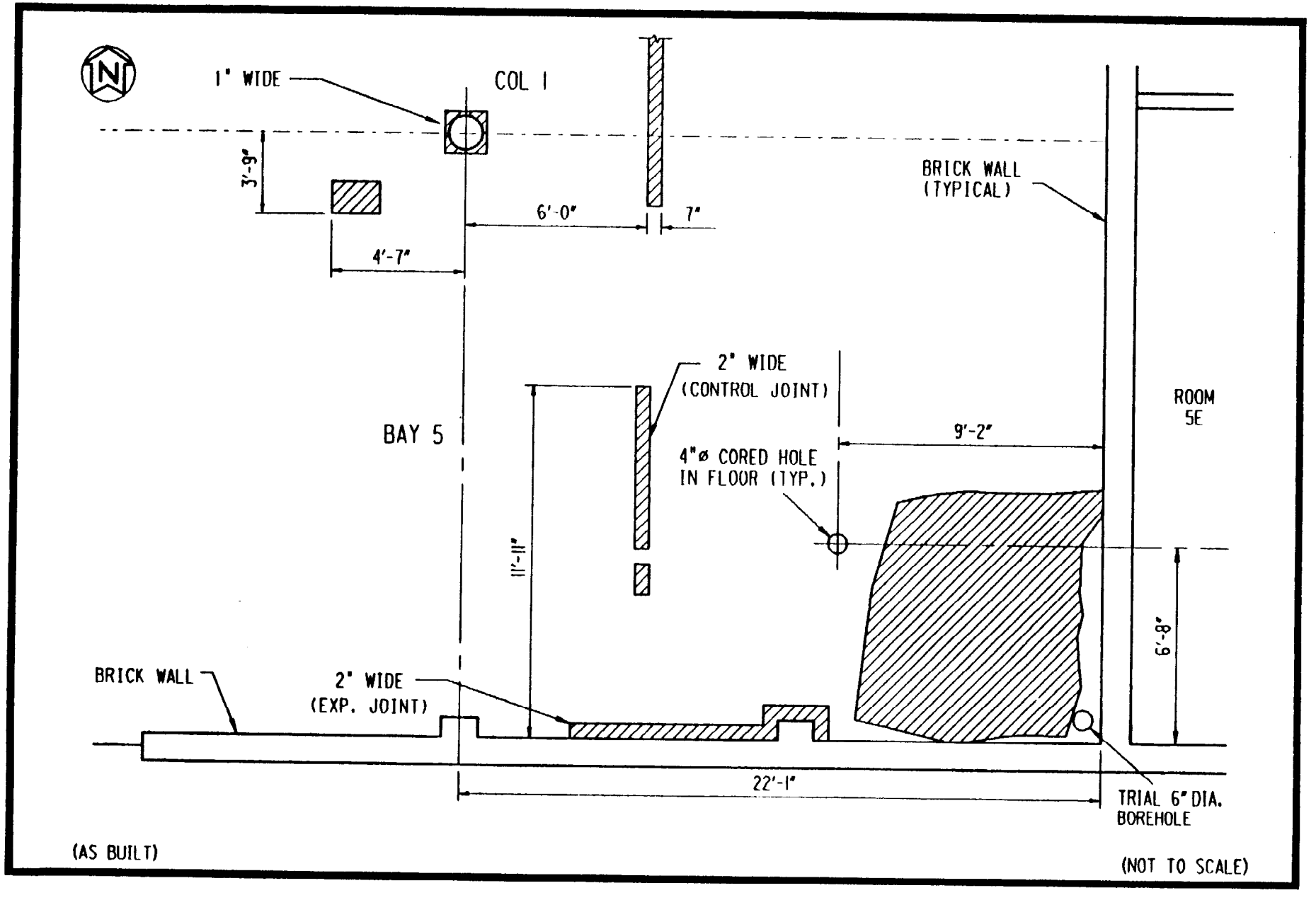
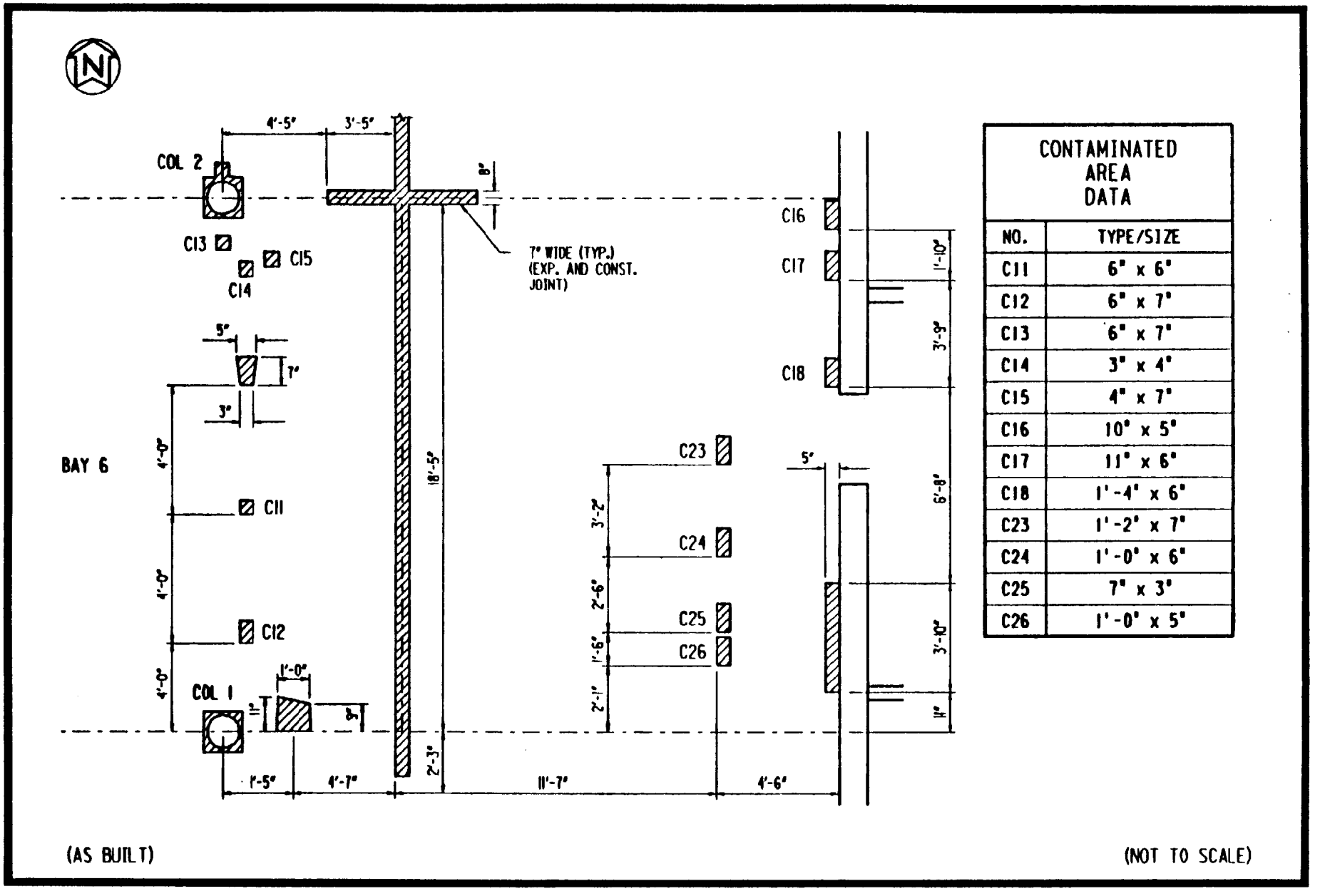


FIGURE 4-5 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 5



CONTAMINATED AREA DATA	
NO.	TYPE/SIZE
C11	6" x 6"
C12	6" x 7"
C13	6" x 7"
C14	3" x 4"
C15	4" x 7"
C16	10" x 5"
C17	11" x 6"
C18	1'-4" x 6"
C23	1'-2" x 7"
C24	1'-0" x 6"
C25	7" x 3"
C26	1'-0" x 5"

FIGURE 4-6 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 6

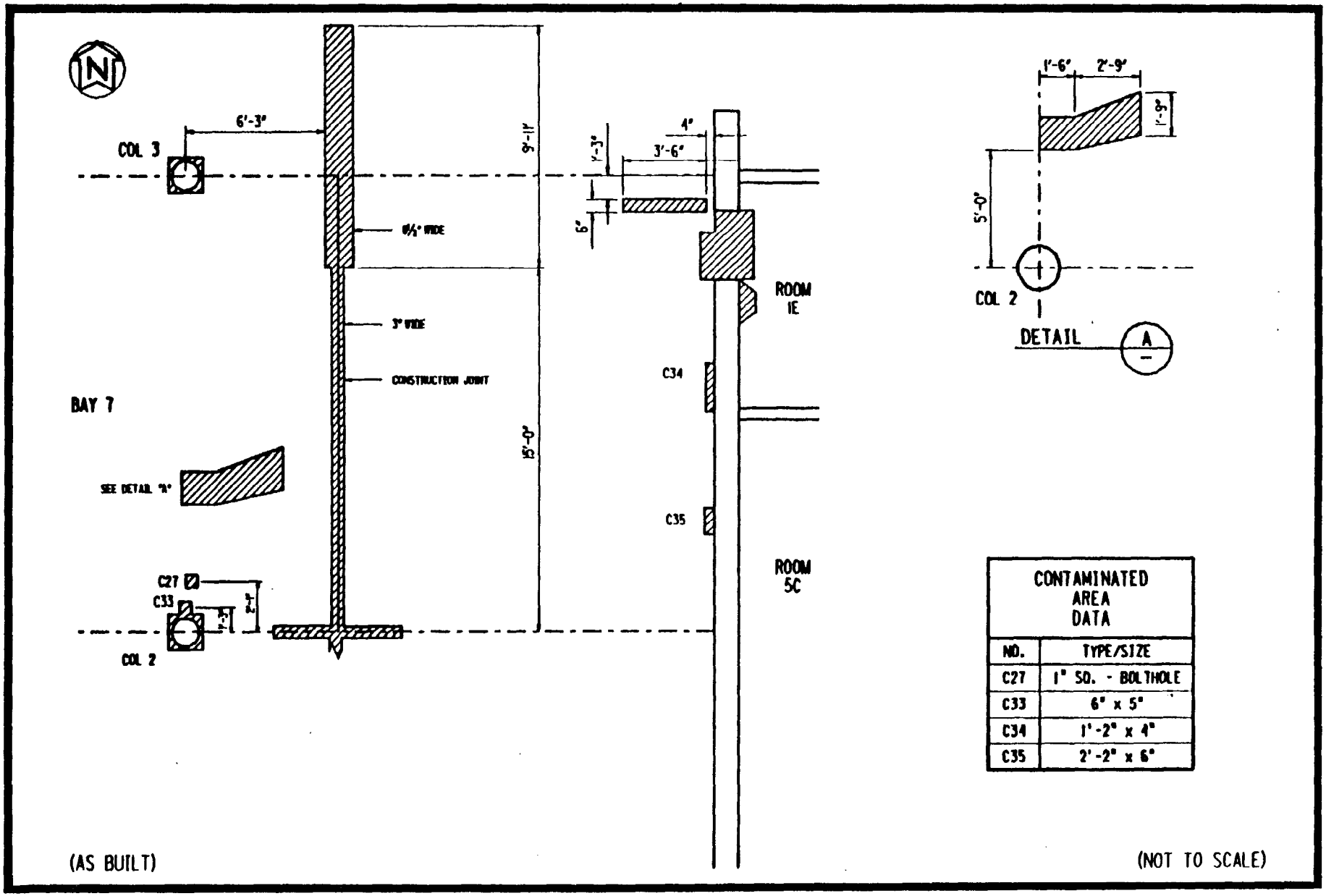


FIGURE 4-7 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 7

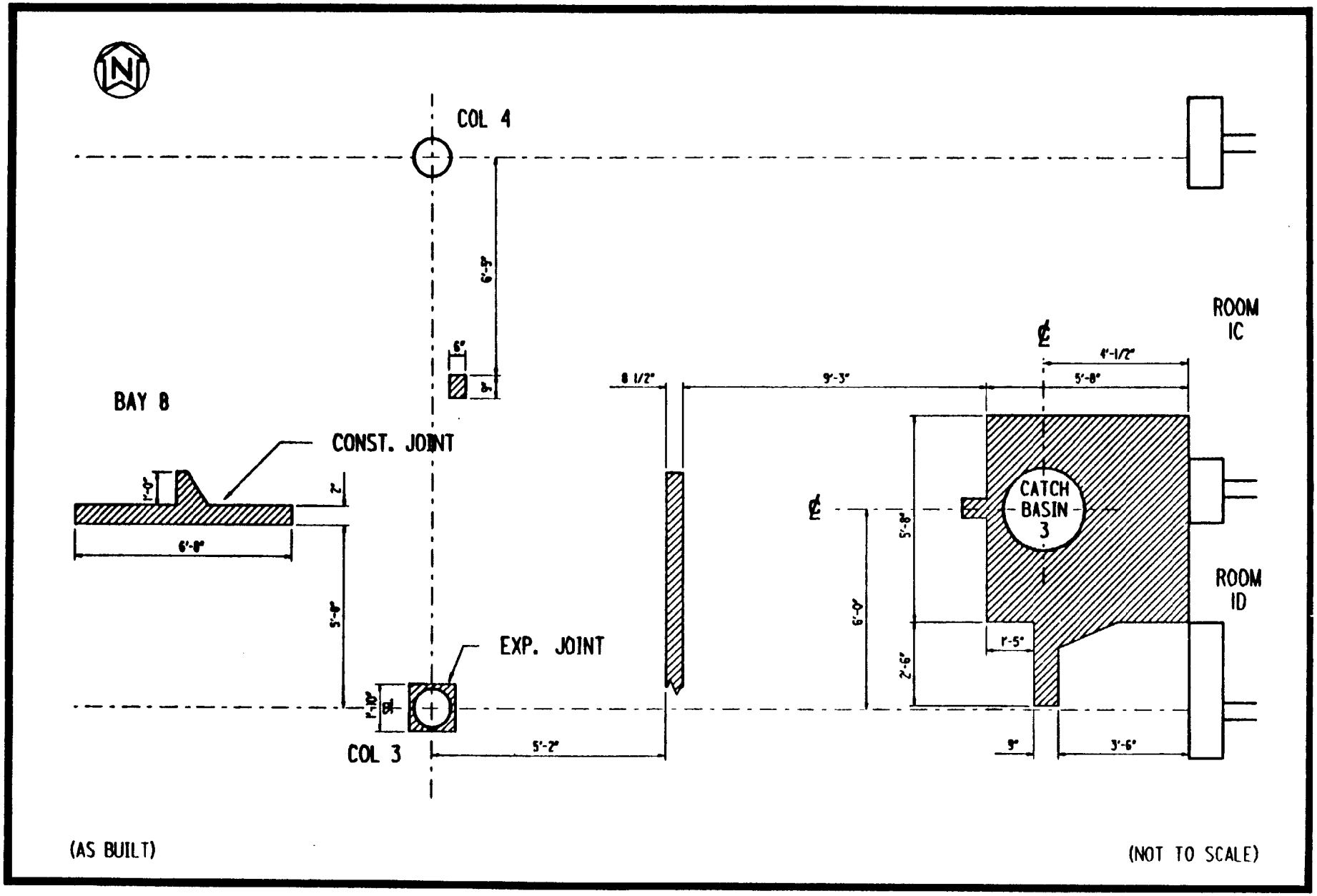


FIGURE 4-8 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 8

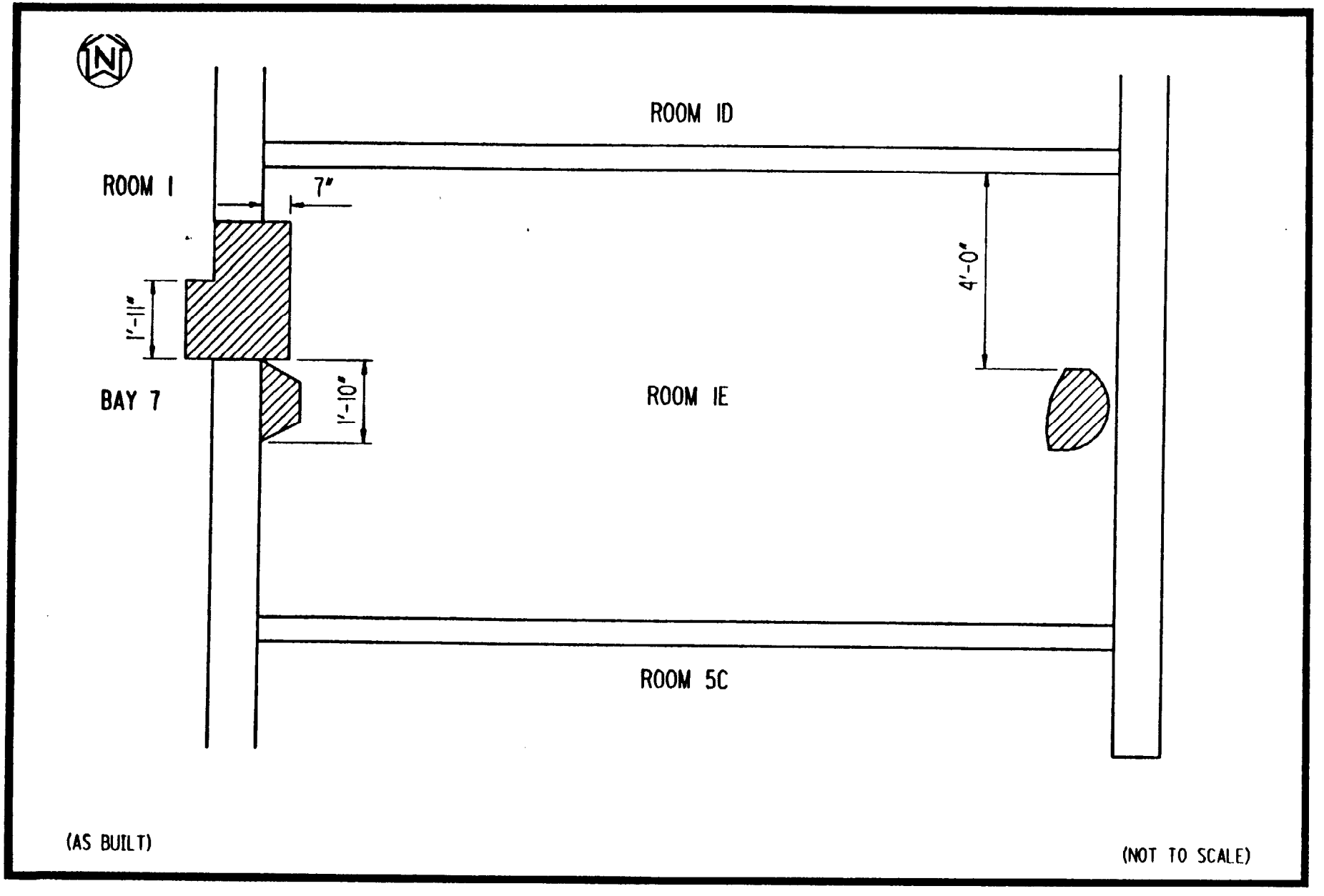


FIGURE 4-9 ROOMS 1 AND 1E — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

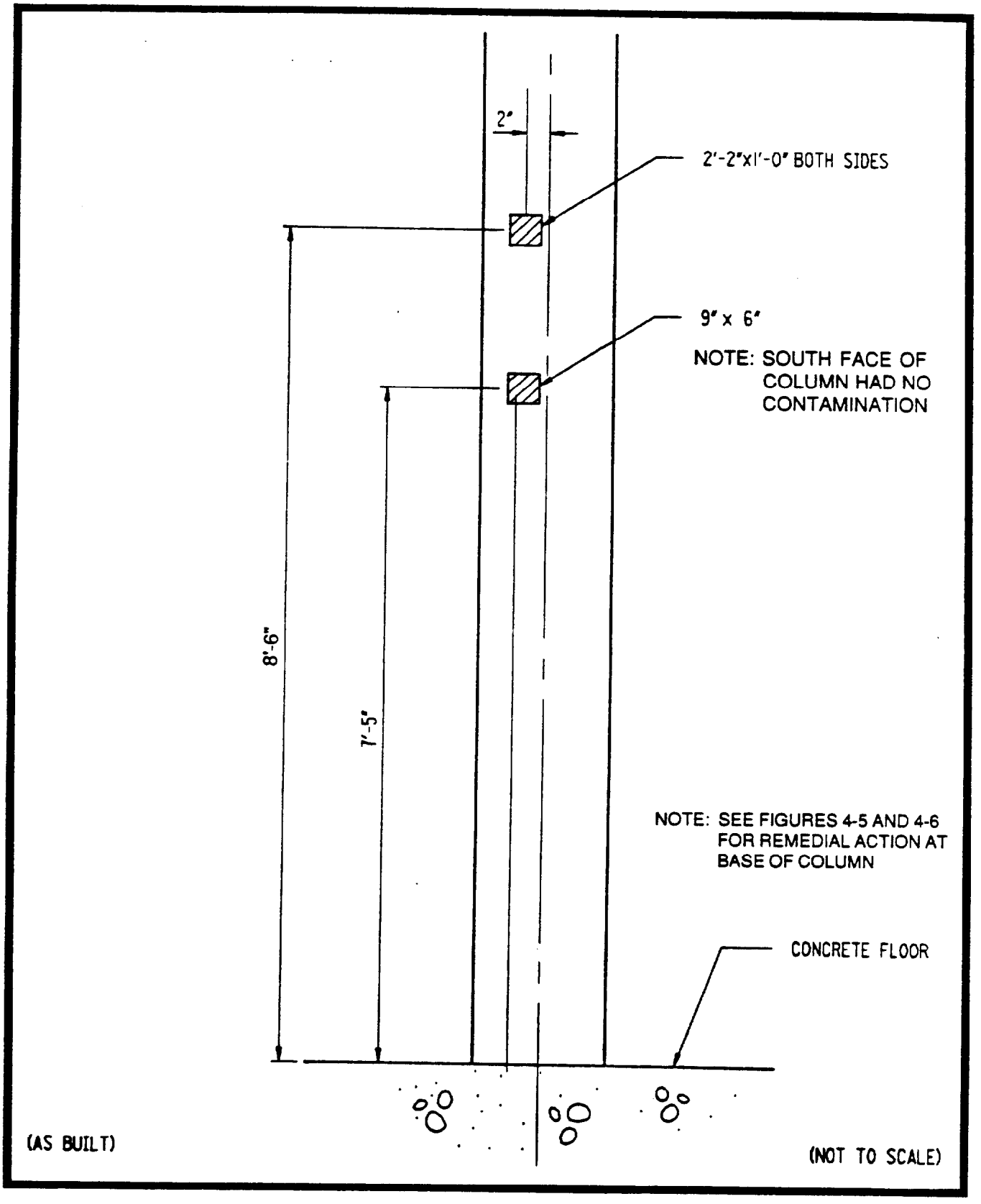


FIGURE 4-10 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH FACE OF COLUMN 1

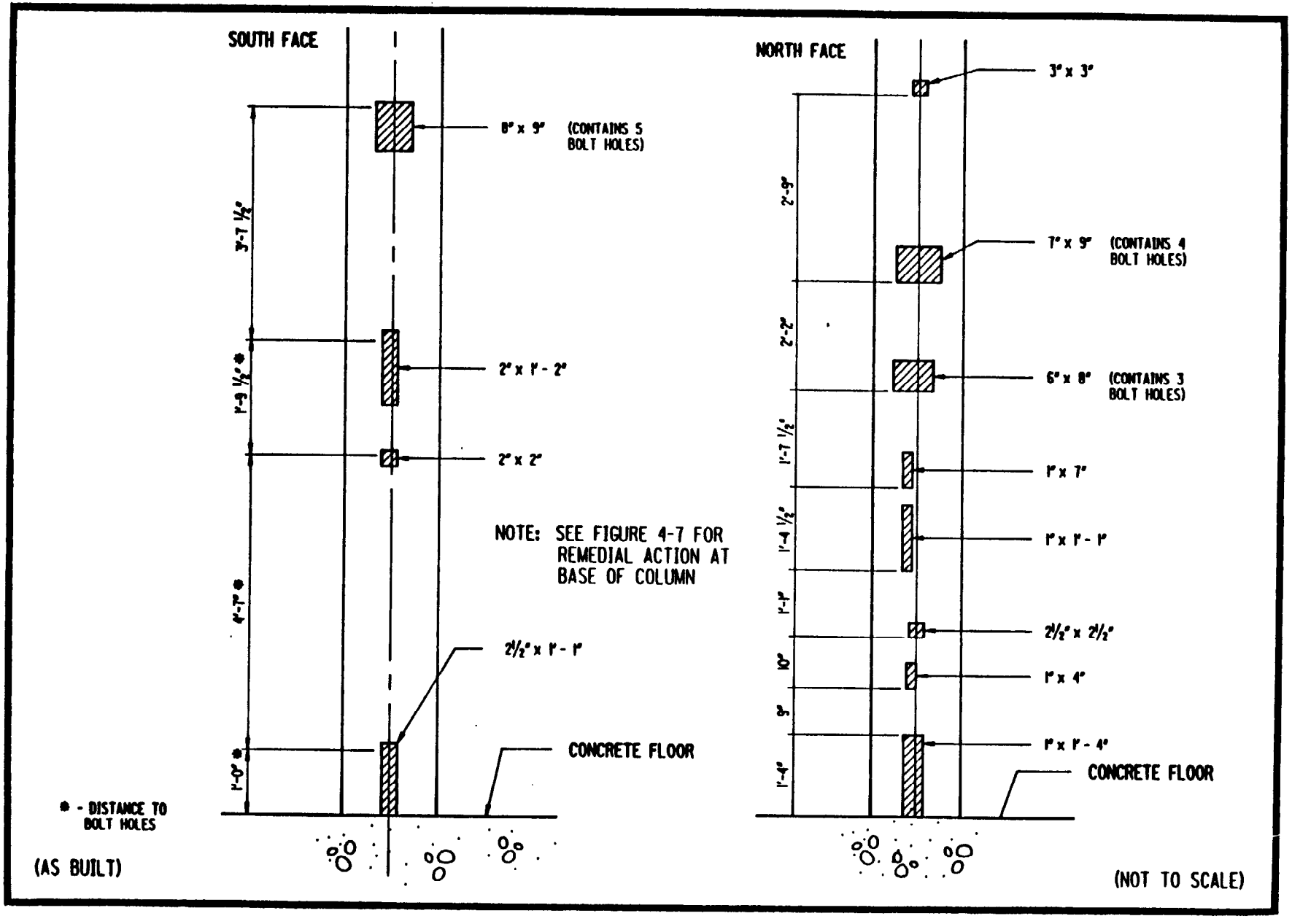


FIGURE 4-11 ROOM 1—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH AND SOUTH FACES OF COLUMN 2

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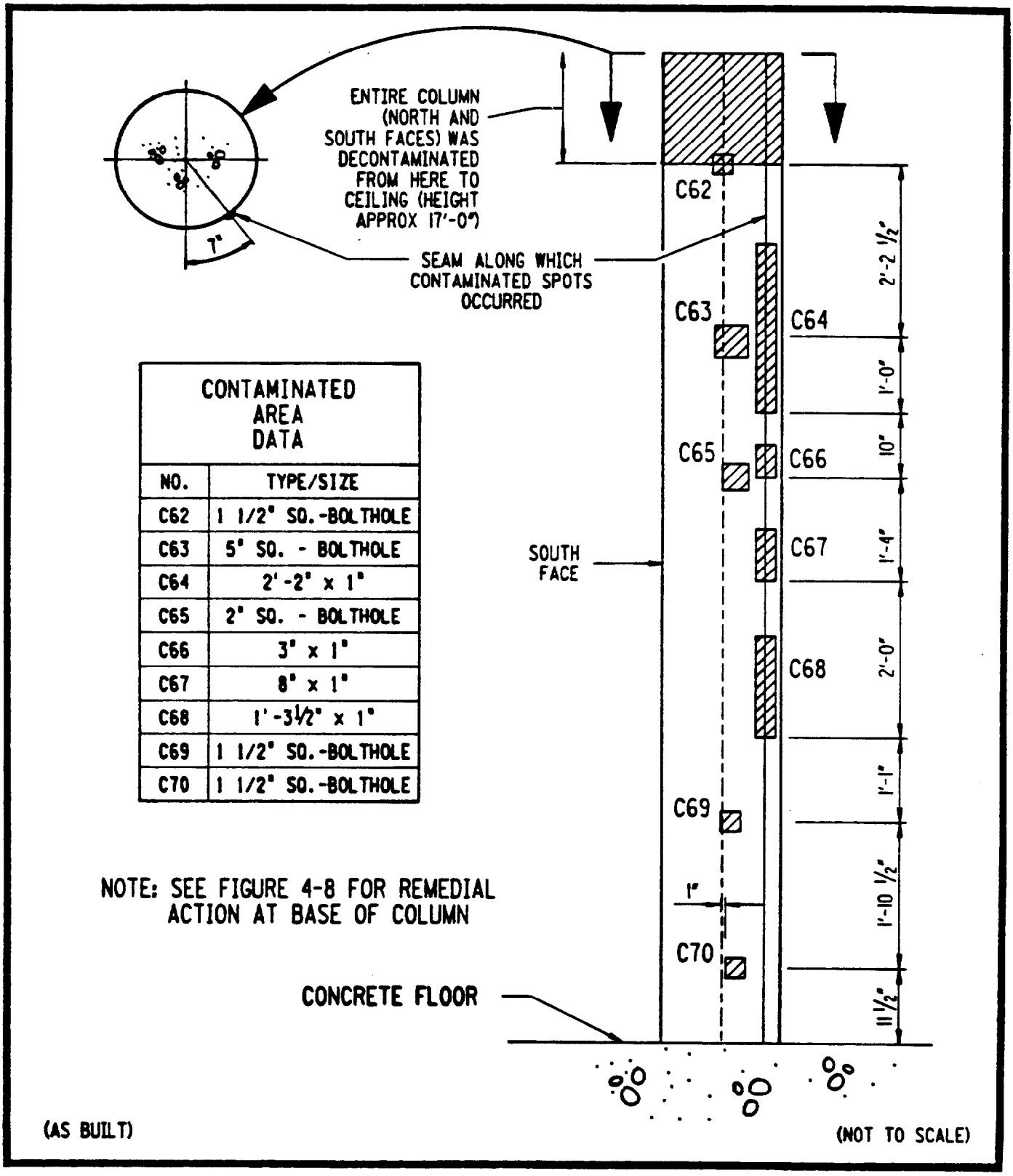

CONTAMINATED AREA DATA	
NO.	TYPE/SIZE
C62	1 1/2" SQ.-BOLTHOLE
C63	5" SQ. - BOLTHOLE
C64	2'-2" x 1"
C65	2" SQ. - BOLTHOLE
C66	3" x 1"
C67	8" x 1"
C68	1'-3½" x 1"
C69	1 1/2" SQ.-BOLTHOLE
C70	1 1/2" SQ.-BOLTHOLE

FIGURE 4-12 ROOM 1—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH AND SOUTH FACES OF COLUMN 3

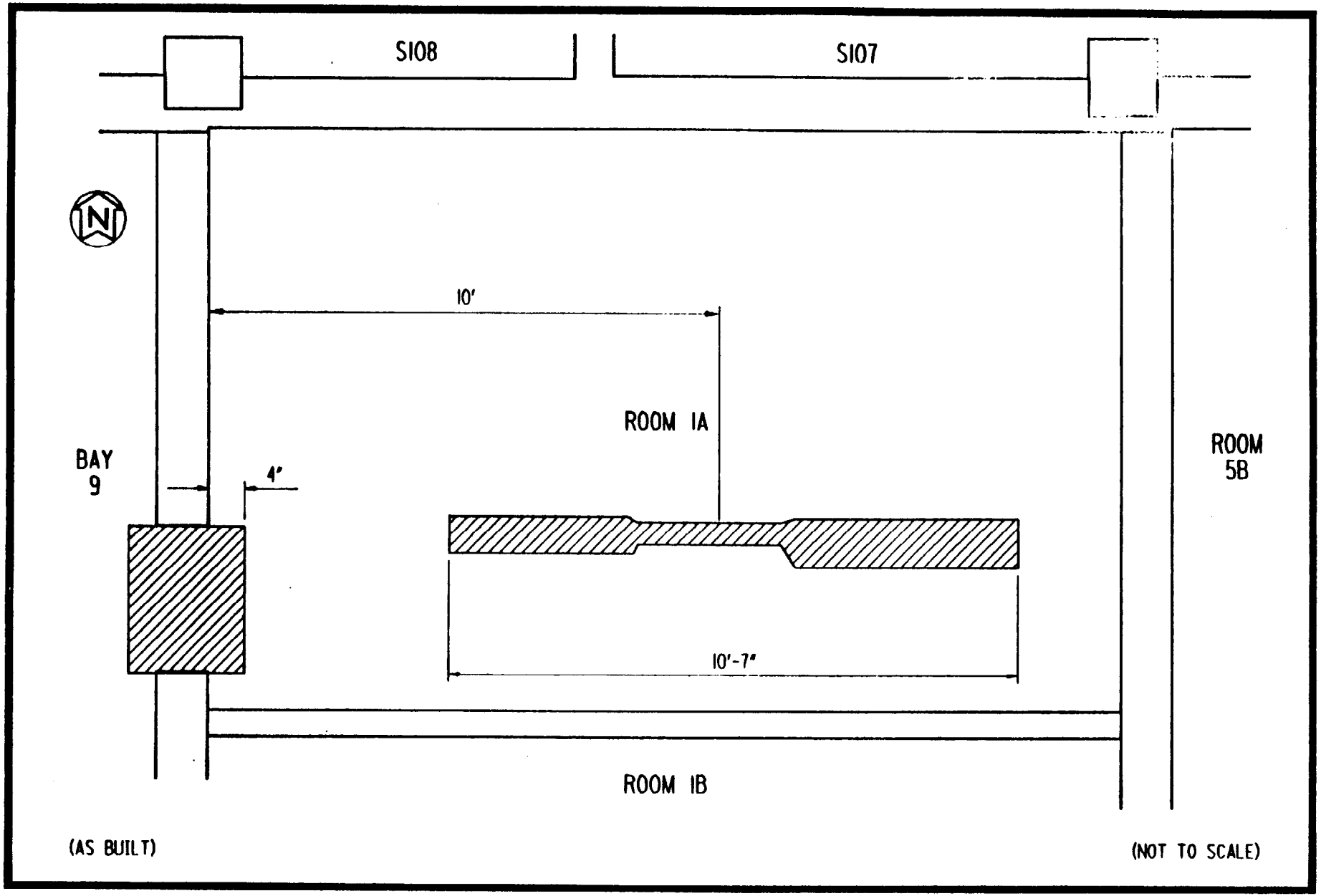

FIGURE 4-13 ROOM 1A — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

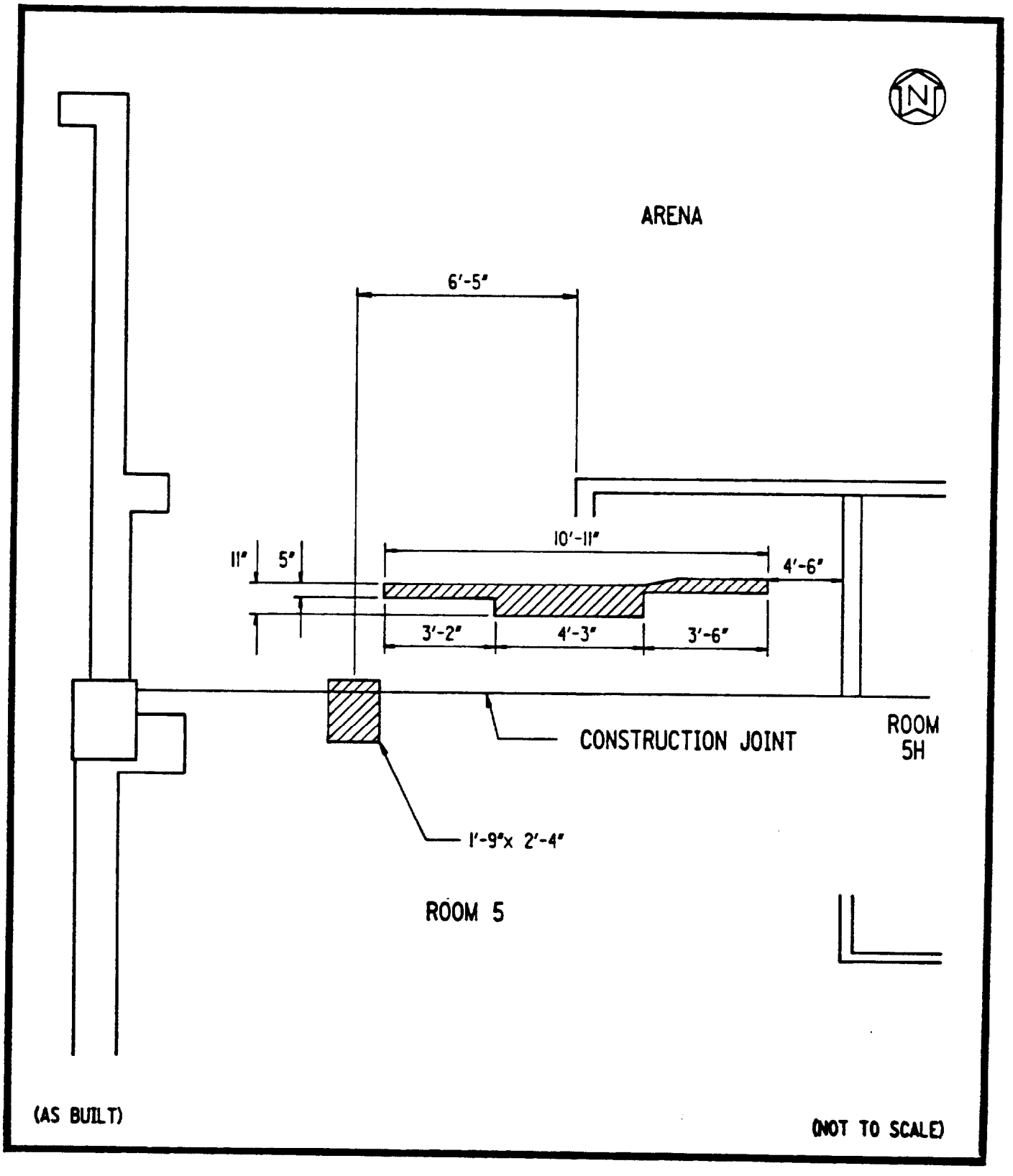

FIGURE 4-14 ROOM 5—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR NEAR THE ARENA

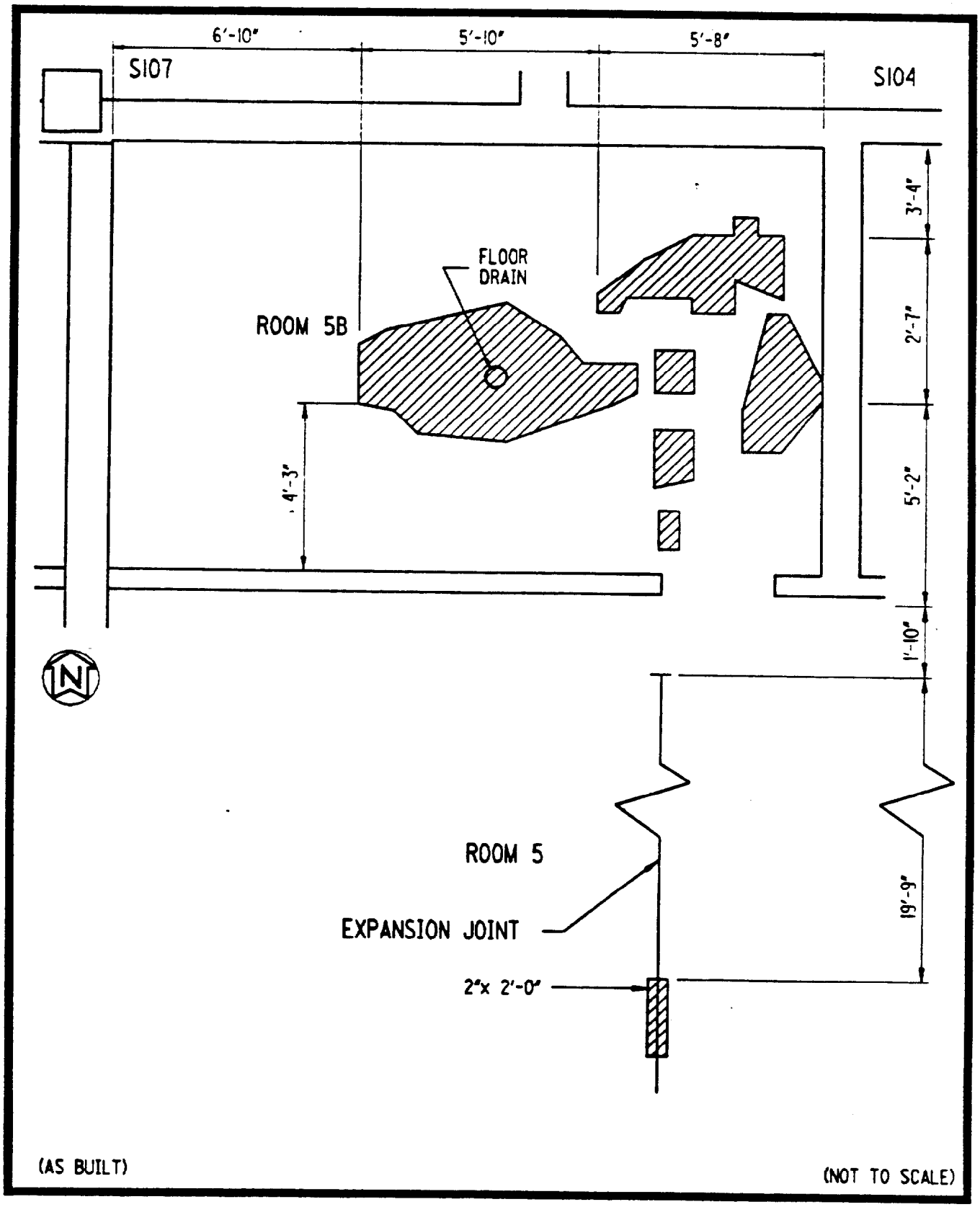

FIGURE 4-15 ROOMS 5 AND 5B — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

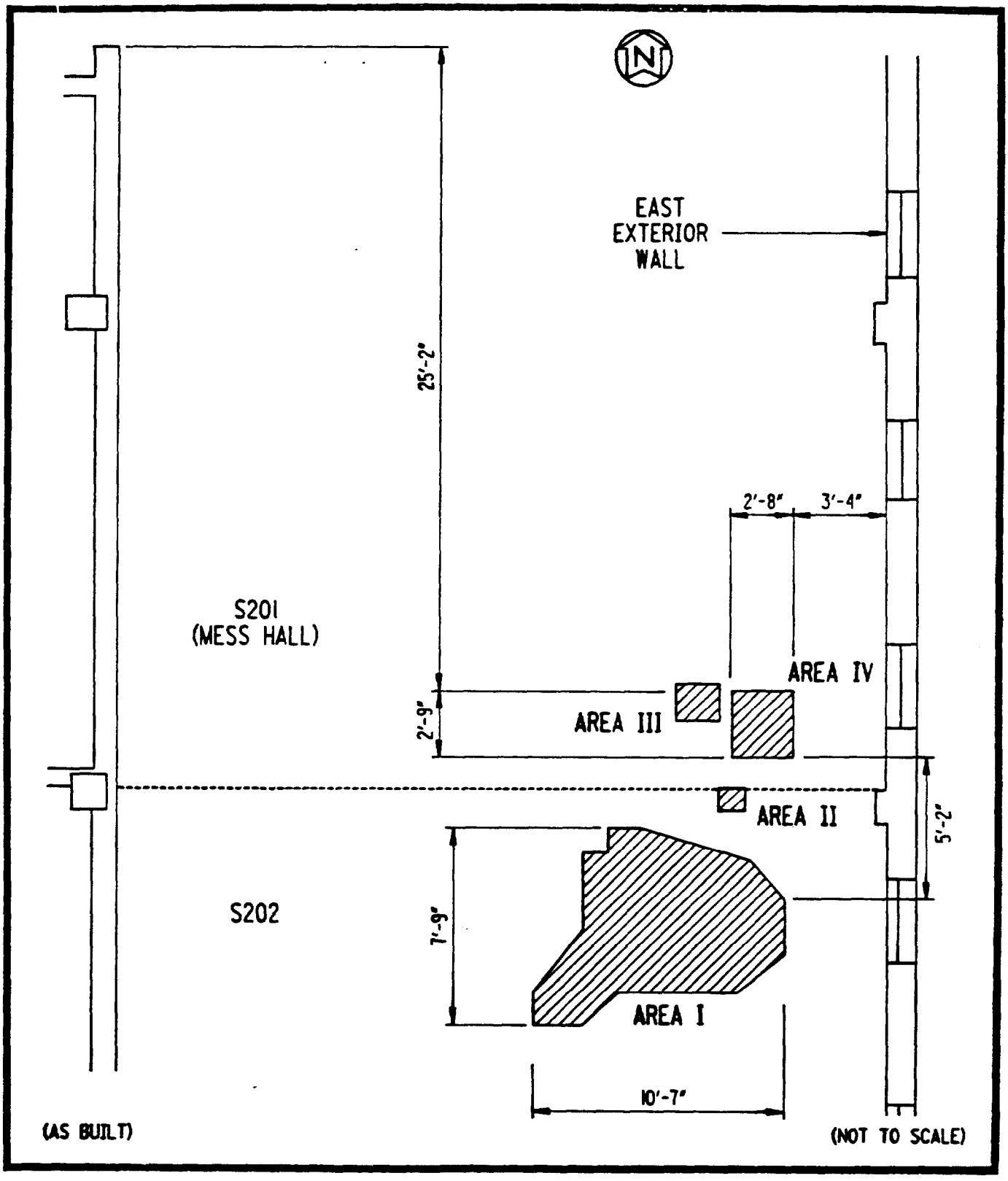

FIGURE 4-16 ROOMS S201 AND S202—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

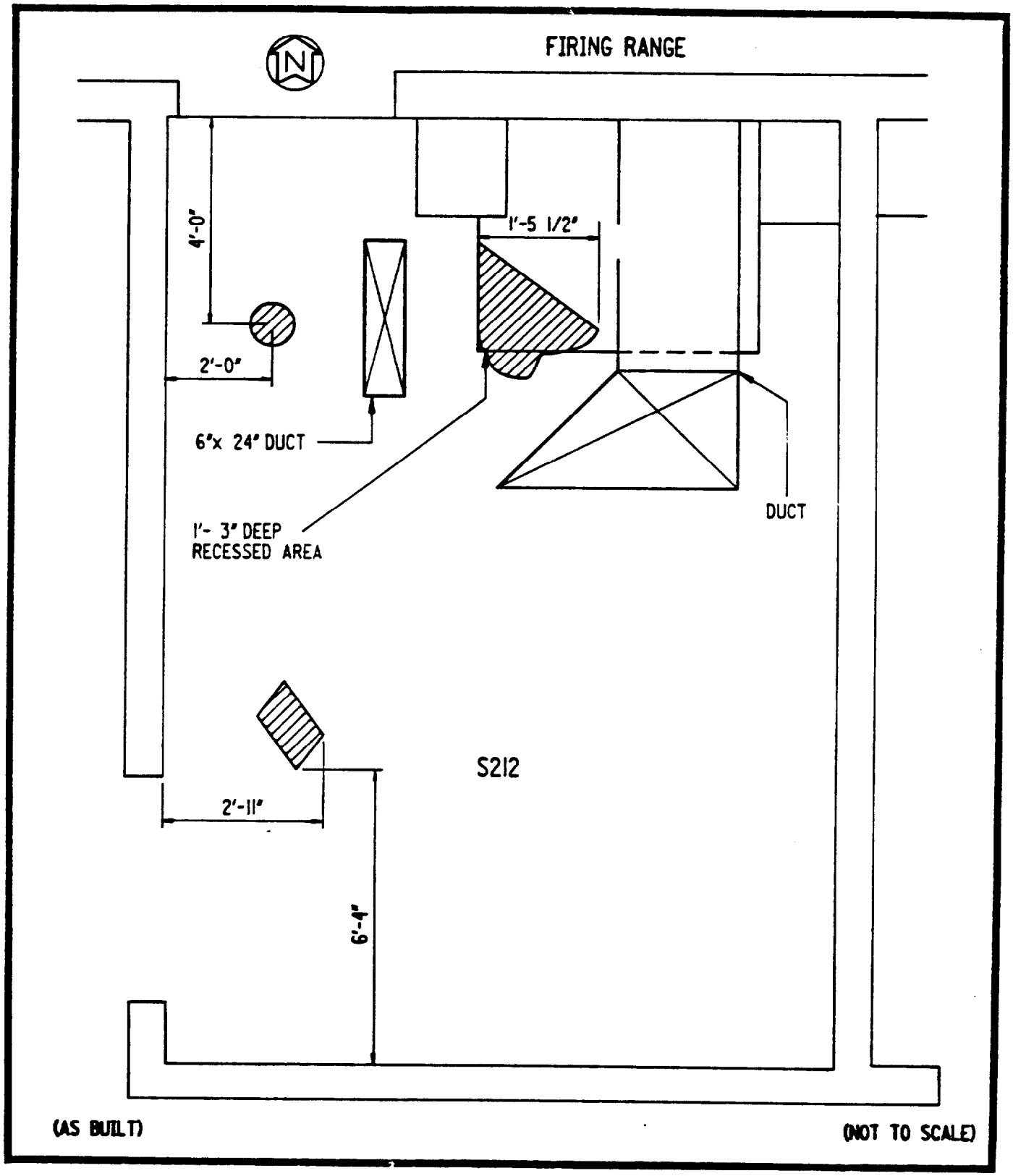

FIGURE 4-17 ROOM S212—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE MAIN FLOOR AND THE RECESSED FLOOR

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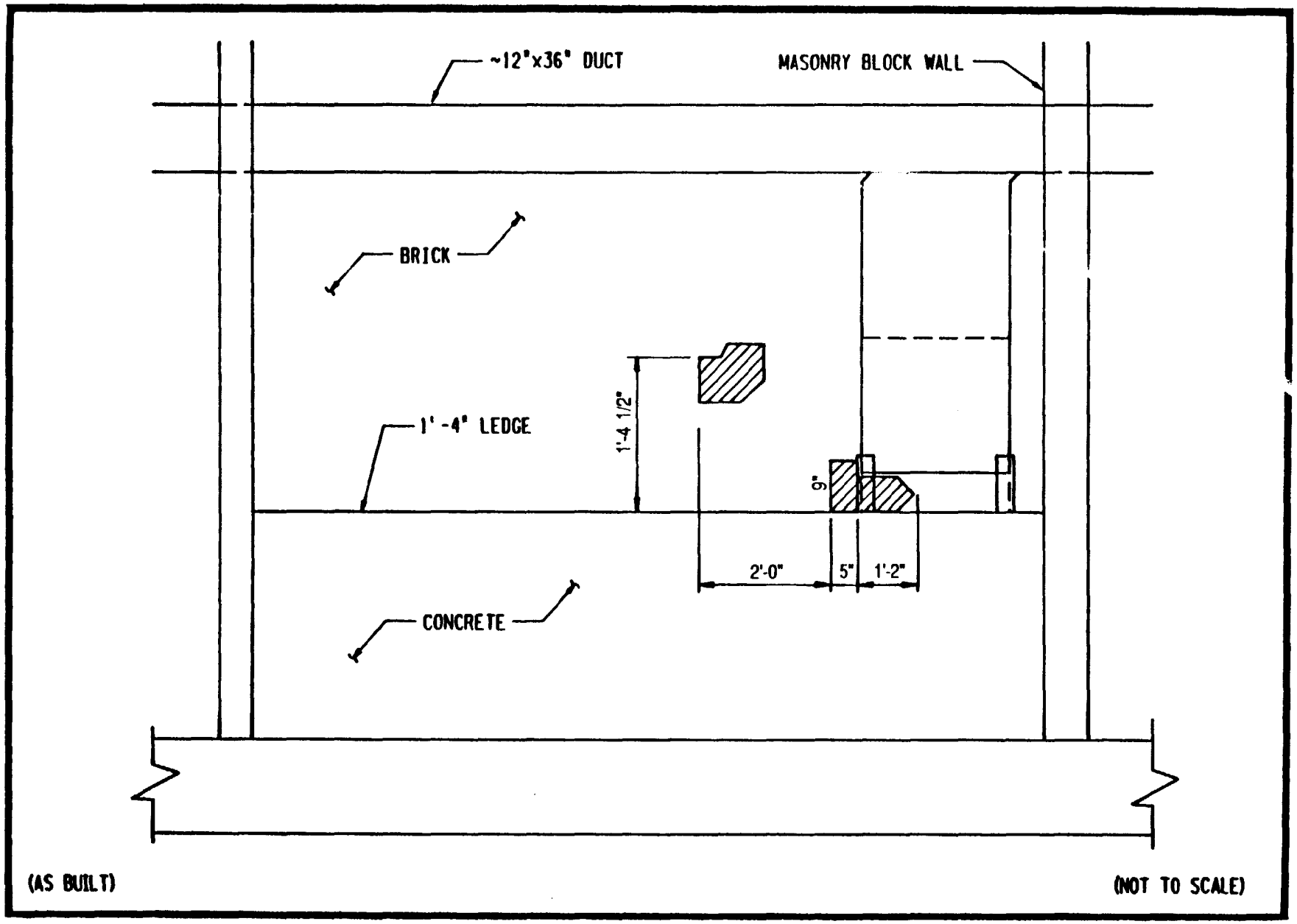


FIGURE 4-18 ROOM S213—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH WALL

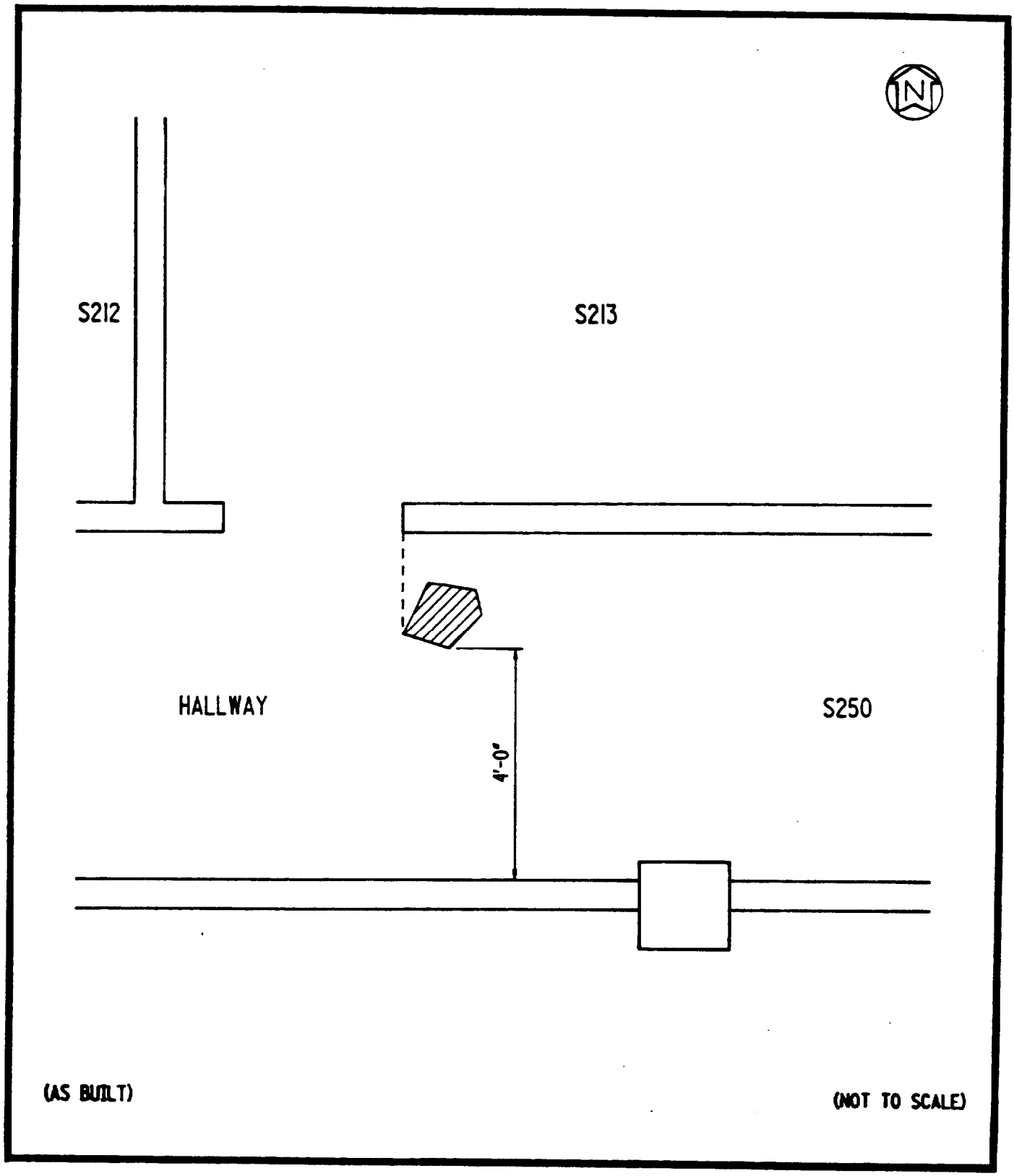


FIGURE 4-19 HALLWAY OUTSIDE ROOM S213—AREA WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

GRB: [42,7] N1979812.DGN JKL

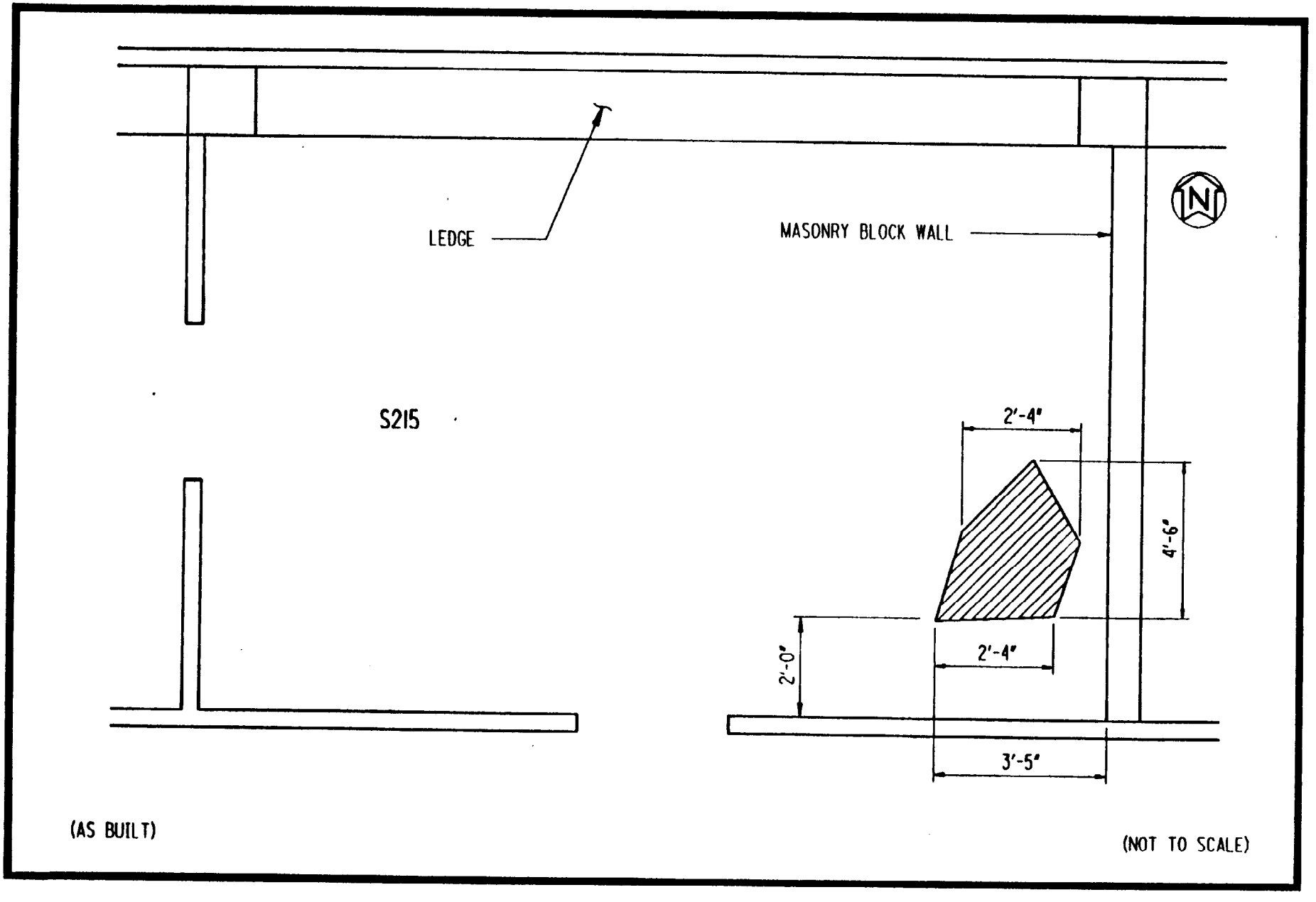


FIGURE 4-20 ROOM S215 — AREA WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

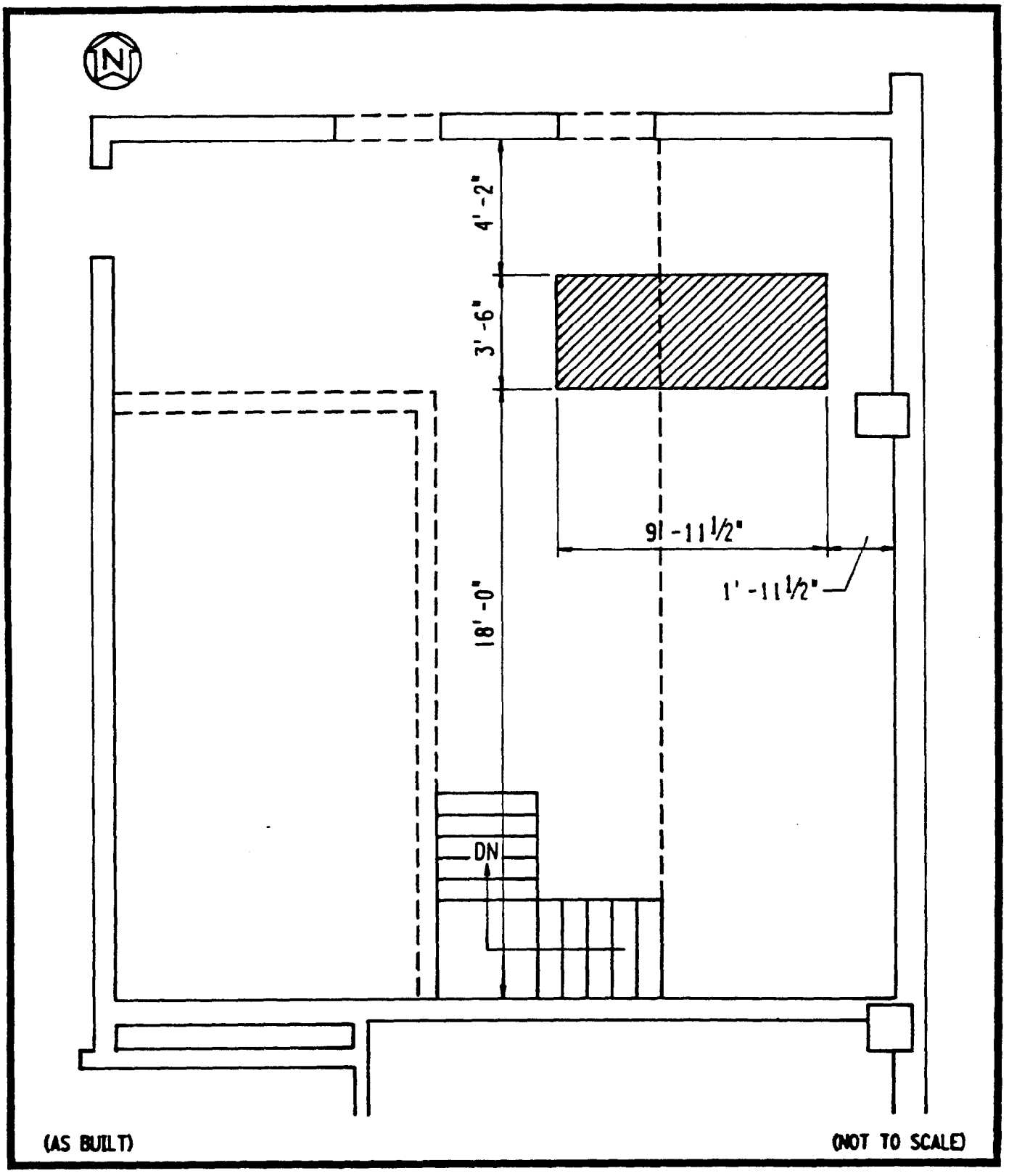


FIGURE 4-21 ROOM S234—AREA WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

TABLE 4-1

RESULTS OF RADIOLOGICAL SURVEY OF THE CATCH BASINS IN THE CATCH BASIN SYSTEM

CATCH BASIN 1

	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
North Wall	68	98	<36	<0.20+	N/A	N/A
East Wall	43	62	<36	<0.20+	N/A	N/A
South Wall	39	49	<36	<0.20+	N/A	N/A
West Wall	40	49	<36	<0.20+	N/A	N/A
Floor	51	123	<36	<0.03	0.05	<0.03

CATCH BASIN 2

	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
North Wall	88	191	<36	0.04	0.05	0.03
East Wall	63	110	<36	0.06	0.07	0.04
South Wall	120	294	41	0.06	0.12	0.05
West Wall	115	260	<36	0.06	0.09	0.03
Floor	69	99	<36	0.06	0.14	<0.03

TABLE 4-1

(Continued)

CATCH BASIN 4

	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
North Wall	34	45	<30	0.03	0.04	<0.03
East Wall	100	294	<30	0.06	0.13	<0.03
South Wall	38	45	<30	0.04	0.04	0.03
West Wall	81	121	45	0.06	0.12	<0.03
Floor	48	99	<30	0.04	0.06	0.03

CATCH BASIN 5

	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
North Wall	76	164	<34	0.04	0.05	0.02
East Wall	44	69	<34	0.04	0.04	0.02
South Wall	74	101	<34	0.04	0.05	0.02
West Wall	110	164	69	0.06	0.08	0.02
Floor	47	111	<34	0.10	0.13	0.04

TABLE 4-1

(Continued)

CATCH BASIN 6

	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
North Wall	41	52	<37	<0.20+	N/A	N/A
East Wall	37	41	<37	<0.20+	N/A	N/A
South Wall	41	52	<37	<0.20+	N/A	N/A
West Wall	55	109	<37	<0.20+	N/A	N/A
Floor	44	64	<37	<0.06+	0.07	0.04

*Background, 0.02 mrad/h, has not been subtracted.

+Area was checked only to ensure that guidelines were met.

TABLE 4-2

RADIONUCLIDE CONCENTRATIONS IN SOIL SAMPLES

TAKEN UNDER CATCH BASIN 3

Sample Location	Concentration (pCi/g)*		
	Uranium-238	Radium-226	Thorium-232
Northwest Corner of Catch Basin 3	<5	0.8	1.2
Northeast Corner of Catch Basin 3	<10	1.1	1.1
Southwest Corner of Catch Basin 3	<6	1.9	2.0
Southeast Corner of Catch Basin 3	<4	0.7	<1

*Samples were counted wet; background level has not been subtracted.

TABLE 4-3

BETA-GAMMA VALUES FOR THE MAIN LINE

IN THE CATCH BASIN SYSTEM

Line	Background (mrad/h)	Average[a] (mrad/h)	Maximum[a] (mrad/h)	Minimum[a] (mrad/h)
Catch Basin 1 to Catch Basin 2	0.07	0.16	0.26	0.04
Catch Basin 2 to Catch Basin 3	0.06	0.16	0.38	0.10
Catch Basin 3 to Catch Basin 4	0.10	0.28	0.93	0.13
Catch Basin 4 to Catch Basin 5	0.07	0.16	0.59	0.08
Catch Basin 5 to Catch Basin 6	0.06	0.10	0.12	0.07

[a]Background has not been subtracted.

TABLE 4-4

RADIONUCLIDE CONCENTRATIONS IN COMPOSITE SOIL SAMPLES TAKEN UNDER THE MAIN LINE BETWEEN CATCH BASINS 3 AND 4

Sample Location	Concentration (pCi/g)*		
	Uranium-238	Radium-226	Thorium-232
0 to 10 ft east of Catch Basin 3	<5	0.5	0.7
10 to 20 ft east of Catch Basin 3	<8	0.9	1.1
20 to 30 ft east of Catch Basin 3	<6	0.7	0.7
30 to 37 ft east of Catch Basin 3	<14	1.2	1.3

*Samples were counted wet; background level has not been subtracted.

TABLE 4-5

BETA-GAMMA VALUES FOR THE LATERALS CONNECTED TO THE BASIN SYSTEM

Location	Average (mrad/h)	Maximum (mrad/h)	Minimum (mrad/h)
Catch Basin 1	N/A	N/A	N/A
Catch Basin 2			
Northwest lateral	0.06	0.13	0.03
Southwest lateral	0.05	0.14	0.03
Southeast lateral	0.07	0.10	0.03
Northeast lateral	0.06	0.07	0.03
Catch Basin 3			
Northeast lateral	0.04	0.09	0.03
Southeast lateral	0.04	0.10	0.02
Catch Basin 4			
Northeast lateral	0.04	0.07	0.03
Southwest lateral	0.04	0.07	0.03
Southeast lateral	0.04	0.09	0.03
Catch Basin 5			
Northwest lateral	0.04	0.04	0.03
Northeast lateral	0.04	0.04	0.02
Southeast lateral	0.04	0.05	0.03
Catch Basin 6	N/A	N/A	N/A

Average background, 0.03 mrad/h, has not been subtracted.

TABLE 4-6

SUMMARY OF THE RADIOLOGICAL CONDITION OF THE CEILING IN ROOM 1

Bay	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
1	32	189	23	0.02	0.04	0.01
2	68	204	33	0.02	0.03	0.02
3A	196	352	23	0.03	0.03	0.01
3B	30	139	25	0.02	0.03	0.01
4A	156	723	30	0.03	0.04	0.02
4B	45	720	30	0.02	0.03	0.01
5	94	522	30	0.02	0.05	0.01
6	220	879	29	0.03	0.19	0.01
7	354	1551	33	0.04	0.14	0.02
8	376	2228	76	0.03	0.07	0.02
9	68	209	26	0.02	0.03	0.01
Sand Pit	76	122	22	0.04	0.09	0.02

*Average background; 0.02 mrad/h, has not been subtracted.

TABLE 4-7

POST-REMEDIAL ACTION MEASUREMENTS FOR ROOM 5B

Location	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
South Wall	40	96	<26	0.03	0.06	0.01
West Wall	52	128	<26	0.03	0.04	0.02
North Wall	52	257	<26	0.04	0.06	0.03
East Wall	32	54	<26	0.04	0.05	0.03
Floor	26	32	<26	0.03	0.06	0.02

*Average background, 0.02 mrad/h, has not been subtracted.

TABLE 4-8

POST-REMEDIAL ACTION MEASUREMENTS FOR ROOMS S201 AND S202

Location	Alpha Activity (dpm/100 cm^2)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Area I	35	54	<35	0.03	0.08	0.02
Area II	35	43	<35	0.04	0.09	0.02
Area III	35	43	<35	0.04	0.08	0.02
Area IV	35	43	<35	0.04	0.09	0.02

*Average background, 0.02 mrad/h, has not been subtracted.

TABLE 4-9

POST-REMEDIAL ACTION MEASUREMENTS FOR ROOM S212

Location	Alpha Activity ($dpm/100\ cm^2$)			Beta-Gamma Activity (mrad/h)*		
	Average	Maximum	Minimum	Average	Maximum	Minimum
Area I	23	23	<23	0.03	0.04	0.03
Area II	28	39	<23	0.04	0.05	0.03
Area III	95	161	<29	0.05	0.09	0.03
West Wall	88	262	<29	0.02	0.03	0.02
South Wall	73	139	<29	0.02	0.03	0.02
Recessed Floor	95	217	<29	0.05	0.09	0.03

*Average background, 0.02 mrad/h, has not been subtracted.

5.0 POST-REMEDIAL ACTION STATUS

All the measurements taken after the removal of radioactive materials indicate that no areas of radioactive contamination remain in which concentrations exceed DOE guidelines. An independent assessment of the remedial action conducted at the National Guard Armory, Chicago, Illinois, was performed by Oak Ridge Associated Universities (ORAU) under the Radiological Site Assessment Program. The assessment verified BNI data supporting the adequacy of remedial action and confirmed that radiological conditions at the armory are in compliance with DOE remedial action guidelines (Ref. 5).

On the basis of the data collected, the National Guard Armory site conforms to all applicable DOE radiological guidelines established for release of this site for unrestricted use.

All remedial action was completed. Nineteen barrels of mixed waste were stored in a secured area inside the NGA facility pending permanent disposal.

REFERENCES

1. Bechtel National, Inc. Radiological and Limited Chemical Characterization Report for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-179, Oak Ridge, TN, January 1988.

2. Argonne National Laboratory. Radiological Survey of the National Guard Armory at Washington Park, 52nd Street and Cottage Grove Avenue, DOE/EV-0005/22 (ANL-OHS/HP-83-100), Chicago, IL, January 1983.

3. Argonne National Laboratory. Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987.

4. U.S. Department of Energy. U.S. Department of Energy Guidelines for Residual Radioactive Material at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites, Revision 2, March 1987.

5. Letter, James D. Berger, Oak Ridge Associated Universities, to James J. Fiore, U.S. Department of Energy. "Verification of Remedial Actions of the National Guard Armory, Chicago, Illinois," June 30, 1987.

Alpha-emitting - See radiation.

Background Radiation - Background radiation refers to naturally occurring radiation emitted from either cosmic (e.g., from the sun) or terrestrial (e.g., from the earth) sources. Exposure to this type of radiation is unavoidable, and its level varies greatly depending on geographic location. For example, New Jersey typically receives 100 millirem (mrem) per year, Colorado receives about 300 mrem/yr, and some areas in South America receive up to 7000 mrem/yr. Naturally occurring terrestrial radionuclides include uranium, radium, potassium, thorium, etc. (see definition of radionuclide below). These dose levels do not include the concentrations of naturally occurring radon inside buildings.

Beta-gamma-emitting - See radiation.

Centimeter - A centimeter (cm) is a metric unit of measurement for length; 1 inch is equal to 2.54 cm; 1 foot is equal to approximately 30 cm.

Contamination - Contamination is used generally to mean a concentration of one or more radioactive materials that exceeds naturally occurring levels. Contamination may or may not exceed the DOE cleanup guidelines.

Counts per minute - A count is the unit of measurement registered by a radiation detection instrument when radiation imparts its energy within the sensitive range of the detector probe. The number of counts registered per minute can be related to the number of disintegrations per minute occurring from a radioactive material. See the definition of disintegrations per minute.

Disintegrations per minute - Disintegrations per minute (dpm) is the measurement indicating the amount of radiation being released from a substance per minute. See the definition of picocurie.

Dose - Dose as used in this report is actually dose equivalent and is used to relate absorbed dose (mrad) to an effect on the body. Dose is measured in mrem. For the purpose of comparison, a dose of 500,000 mrem to the whole body within a short time causes death in 50 percent of the people who receive it; a dose of 5,000,000 mrem may be delivered to a cancerous tumor during radiation treatment; normal background radiation results in an annual dose of about 100 mrem; DOE radiation protection standards limit the dose to members of the general public to 100 mrem/yr above background levels; living in a brick house typically results in a dose of about 75 mrem/yr above the background level.

Exposure rate - Exposure rate is the rate at which radiation imparts energy to the air. Exposure is typically measured in microroentgens (uR), and exposure rate is typically expressed as uR/h. The dose to the whole body can be approximated by multiplying the exposure rate by the number of hours of exposure. For example, if an individual were exposed to gamma radiation at a rate of 20 uR/h for 168 hours per week (continuous exposure) for 52 weeks per year, the whole-body dose would be 170 mrem.

Gamma Radiation - See radiation.

Gram - A gram (g) is a metric unit of weight. There are 454 g in 1 pound, and 28 g in 1 ounce.

Meter - A meter (m) is a metric unit of length; 1 m is equal to approximately 39 inches.

Microcurie - A microcurie is 1,000,000 picocuries (see picocuries for additional explanation).

Microroentgen - A microroentgen (uR) is a unit used to measure radiation exposure. For further information, see the definition of exposure rate.

Milliliter - A milliliter (ml) is a unit of measure for volume. There are 3785 ml in 1 gallon.

Millirad - The millirad (mrad) is used to indicate the amount of energy imparted by radiation to a unit of mass. An absorbed dose rate is expressed in terms of mrad per hour (mrad/h).

Millirem - The millirem (mrem) is the unit used to measure radiation dose to man. The DOE dose limit is 100 mrem above background radiation levels within any one-year period for members of the general public. Naturally occurring radioactive substances in the ground result in a yearly exposure of about 100 mrem to each member of the population. To date, no difference can be detected in the health of population groups exposed to 100 mrem/yr above background and in the health of groups who are not exposed.

Picocurie - A picocurie (pCi) is the unit of measure for radioactivity, just as an ounce is a unit to measure weight. A measurement of 1 pCi means that one radioactive particle is released on the average of every 27 seconds.

Radium-226 - Radium-226 is a naturally occurring radioactive material that spontaneously emits alpha radiation.

Radiation - There are three primary types of radiation: alpha, beta, and gamma. Alpha radiation travels less than an inch in air before it stops. Alpha radiation cannot penetrate the outer layer of skin on the body. Beta radiation can penetrate the outer layers of skin, but cannot reach the internal organs of the body. Gamma radiation is the most penetrating type and can usually reach the internal organs.

Radionuclide - Radioactive elements are also referred to as radionuclides. For example, uranium-235 is a radionuclide, uranium-238 is another, thorium-232 another, and so on.

Remedial Action - Remedial action is a general term used to mean "cleanup of contamination that exceeds DOE guidelines." It refers to any action required so that a property can be released for unrestricted use as uncontaminated. In practice, this may mean removing grass and soil, cutting trees, removing asphalt, etc. Remedial action also includes restoring remediated properties to their original conditions, to the extent that this is possible.

Uranium - Uranium is a naturally occurring, radioactive element. The principal use of uranium when refined is for the production of fuel for nuclear reactors. Uranium in its natural form is not suitable for use as a fuel source.

Working Level - Working level (WL) is a unit of measurement for the amount energy expended in air by radon or its radioactive decay products. The term was derived to measure radon progeny concentrations to which uranium miners were exposed.

Exhibit II (7) - Interim Verification Letters to Property Owners and Verification Statements and Reports

The verification statement and the verification report for the subject site are referenced below and are included in this section.

Page

Letter, J.D. Berger, Oak Ridge Associated Universities, to J.J. Fiore, U.S. Department of Energy. "Verification of Remedial Actions of the National Guard Armory, Chicago, Illinois," June 30, 1987. II-383

Oak Ridge Associated Universities. Verification of Remedial Action -- Illinois National Guard Armory, Chicago, Illinois, Oak Ridge, TN, February 1988. II-384

Oak Ridge
Associated
Universities

Post Office Box 117
Oak Ridge, Tennessee 37831-0117

Manpower Education,
Research, and Training
Division

June 30, 1987

Mr. James J. Fiore, Director
Division of Facility and Site
Decommissioning Projects
Office of Nuclear Energy
U.S. Department of Energy
Washington, DC 20545

Subject: VERIFICATION OF REMEDIAL ACTIONS AT THE NATIONAL GUARD ARMORY, CHICAGO, ILLINOIS

Dear Mr. Fiore:

Oak Ridge Associated Universities (ORAU) has completed independent verification activities at the National Guard Armory, Chicago, Illinois. Based on the results of document reviews and independent site surveys it is ORAU's opinion that the remedial actions have been effective in meeting the Department of Energy's radiological guidelines established for that property. A report, describing the verification activities and findings, is being prepared.

If I can be of further assistance, please contact me at FTS 626-3305.

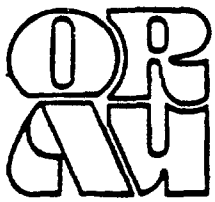
Sincerely,

James D. Berger

James D. Berger, Manager
Radiological Site Assessment Program

JDB:mec

cc: A. Wallo, DOE/NE
S. Ahrends, DOE/ORO/TSD
L. Clark, DOE/ORO/TSD
G. Hovey, BNI
W. Borden, BNI
C. Leichtweis, BNI



Prepared by
Oak Ridge Associated Universities

Prepared for
Facility and Site Decommissioning Projects
U.S. Department of Energy

VERIFICATION OF REMEDIAL ACTION ILLINOIS NATIONAL GUARD ARMORY CHICAGO, ILLINOIS

J. D. BERGER

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

FINAL REPORT
FEBRUARY 1988

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VERIFICATION OF REMEDIAL ACTION ILLINOIS NATIONAL GUARD ARMORY CHICAGO, ILLINOIS

Prepared by

J. D. Berger

Radiological Site Assessment Program
Manpower, Education, Research, and Training Division
Oak Ridge Associated Universities
Oak Ridge, Tennessee 37831-0117

Project Staff

R. D. Condra
M. R. Dunsmore
D. A. Gibson
F. T. Lange
G. L. Murphy
J. L. Payne
E. A. Powell
D. R. Styers*
C. F. Weaver
S. A. Wical

Prepared for

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FINAL REPORT

February 1988

This report is based on work performed under contract number DE-AC05-760R00033 with the U.S. Department of Energy.

*Currently with ASG, Oak Ridge, TN.

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VERIFICATION
OF
REMEDIAL ACTION
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

INTRODUCTION

Beginning in March 1942, the Illinois National Guard Armory at Washington Park, 52nd Street and Cottage Grove Avenue, Chicago, Illinois (Figure 1), was used by the Manhattan Engineer District (MED) and it's successor, the Atomic Energy Commission (AEC), for the storage and processing of uranium metal. In 1951, the AEC terminated use of the facility, and the property was returned to the State of Illinois. Decontamination, including removal of soil from the arena floor, was apparently performed at the time that MED/AEC activities were completed; however, no records, documenting the decontamination efforts and resulting radiological conditions, can be located.

During 1977 and 1978, Argonne National Laboratory conducted a radiological survey of the Armory. Findings identified some areas of residual contamination. The primary radioactive contaminant in the Armory was processed natural uranium, with minimal amounts of associated decay products (i.e., thorium-230 and radium-226).[1] Although contamination was generally limited to relatively small areas and the direct radiation levels resulting from the contamination were quite low, the levels of surface contamination exceeded the DOE guidelines.[2] As a result of these findings, the Illinois National Guard Armory was included in the Department of Energy's (DOE) Formerly Utilized Sites Remedial Action Program (FUSRAP).

In early 1987, Bechtel National, Inc. (BNI), the Project Management Contractor for FUSRAP, conducted additional characterization surveys, where necessary, to more accurately define the boundaries of the contamination. Results of the BNI survey were in good agreement with the earlier survey conducted by Argonne National Laboratory.[3] A work plan was prepared by BNI[4], and, during the period April through June 1987, remedial action was performed to remove or reduce radiologial contamination at the Illinois National Guard Armory.

Followup survey results, presented in the BNI post-remedial action report, indicate that the remedial actions were successful in meeting the DOE guidelines.[5]

It is the policy of DOE to perform independent verifications of the effectiveness of remedial actions conducted within FUSRAP. The Radiological Site Assessment Program of Oak Ridge Associated Universities (ORAU) was designated by DOE as the organization responsible for this task at the Illinois National Guard Armory site. During the period remedial actions were being conducted, ORAU representatives performed independent measurements and sampling at this site. In addition, documents describing the project were reviewed, and selected samples were analyzed for comparison with BNI's results. This report describes the procedures and findings of these verification activities.

PROCEDURES

Objectives

The objectives of the verification were to confirm that the surveys, sampling, and analyses conducted prior to, during, and following remedial action and associated project documentation provide an accurate and complete description of the condition of the property and, thereby, confirm that remedial actions have been effective in meeting established criteria.

Procedures

General Approach

1. Radiological survey reports, work plans, and the post-remedial action report (references 1, 3-5) were reviewed. Data were evaluated to assure that areas exceeding current DOE guidelines were identified and had undergone remedial action. Post-remedial action radionuclide concentrations, surface contamination levels, and direct radiation levels were compared to guidelines, and the post-remedial action report and data were reviewed for general thoroughness and accuracy.

2. Nine of 16 soil samples, collected by BNI during the post-remedial action survey, were obtained from BNI and independently analyzed for U-238, by the ORAU laboratory, to confirm the accuracy of BNI analyses. Twelve of 40 smear samples, collected by BNI during the post-remedial action survey, were also obtained and analyzed for gross alpha and gross beta levels.

3. Survey teams from ORAU visited the site and performed visual inspections and limited independent gamma scans, exposure rate measurements, surface contamination measurements, and soil sampling on representative portions of both remediated and non-remediated areas. Dates of these independent surveys were April 28 to May 5, 1987; May 10 to 20, 1987; and June 16 to 25, 1987. Survey procedures are described in a plan[6], prepared by ORAU and submitted to DOE's Office of Nuclear Energy; these procedures are described below.

Facility Survey

General

Independent radiological surveys were performed on almost 100% of the remediated areas. In addition, about 10% of the non-remediated rooms throughout the Armory were selected at random for surface scans and contamination measurements. Figures 2 thru 8 indicate those areas included in the ORAU surveys.

Reference Grids

In Rooms 1 and 5 of the South Head House, a 2 m x 2 m grid (Figures 9 and 10) was established on the floor and lower walls (up to 2 m) around remediated areas. Upper walls and ceilings of these areas were not gridded; survey locations on these areas were referenced to other grids or building features.

One meter grids were established on the floor of Rooms 5A and S201/202 (Figures 11 and 12) and surrounding remediated areas of greater than 1 m^2 in other rooms of the Armory.

Remediated areas of less than 1 m^2 and non-remediated rooms or areas were not gridded; measurements were referenced to building features.

Surface Scans

The floor and lower walls in areas selected for verification were surface scanned using NaI(Tl) gamma scintillation detectors, ZnS alpha detectors, and "pancake" GM beta-gamma detectors. Where surface areas and conditions permitted, floor scans for alpha and beta contamination were conducted with a gas-proportional floor monitor. Upper wall and overhead surface scanning on ledges, beams, piping, fixtures, equipment, and ductwork was conducted using hand held alpha and beta-gamma detectors. Elevated areas were marked for additional measurements.

Measurement of Surface Contamination Levels

In gridded areas, measurements of total alpha and beta-gamma contamination were performed in randomly selected grid blocks. A total of 140 grid-block surveys were performed (Figures 9 to 12); these consisted of measurements at the block center and at four points, midway between the center and block corners. Smears for removable alpha and beta contamination were performed at the location in each grid block, where the highest direct beta-gamma reading was obtained.

In ungridded areas, total and removable contamination levels were measured at random single point locations on the floors, walls, ceilings, and miscellaneous overhead objects. A total of 101 single-point measurements were performed at locations of remedial action; 305 single-point measurements were performed in 39 non-remediated rooms, throughout the Armory building (Figures 4 to 8).

Exposure Rate Measurements

Gamma exposure rate measurements, were peformed at one meter above the floor, throughout the building. Gamma scintillation detectors, cross-calibrated onsite with a pressurized ion chamber, were used for these

measurements. The background exposure rate was established, using the pressurized ionization chamber, in areas that were not radiologically contaminated but of similiar construction material.

Catch Basin Drain System

Inside surfaces of catch basins 1, 2, 4, 5, and 6 were scanned using alpha, beta-gamma, and gamma detectors. Measurements of total beta-gamma surface contamination were performed on the catch basin walls and bottoms and on interior piping surfaces. Gamma and beta-gamma scans were performed in the main piping between all basins, in lateral drain lines entering the catch basins, and in the lateral lines connecting Room 5A and the piping section between catch basins 3 and 4.

Excavated sections along the main piping between catch basins 3 and 4, and the area where catch basin 3 was removed, were gamma scanned. Soil samples were collected from 13 locations along the piping; 16 samples were collected from the catch basin 3 excavation (Figures 13 and 14).

Outdoor Survey

Gridding

A 10 m grid was established outside the south portion of the building. This grid is shown on Figure 15.

Surface Scans

Walkover surface scans, using portable NaI(Tl) gamma scintillation detectors attached to portable ratemeters, were conducted at 1-2 meter intervals over the gridded area, to identify locations of elevated contact gamma radiation.

Exposure Rate Measurements

Gamma exposure rates were measured at the surface and at 1 meter above the surface, at grid block centers, using gamma scintillation detectors.

Conversion to exposure rates in microroentgens per hour (μR/h) were made by onsite cross calibration of the NaI(Tl) detectors with a pressurized ionization chamber (PIC).

Soil Sampling

Surface (0-15 cm) soil samples were collected from the center of each grid block.

Sample Analysis and Interpretation of Results

Smears for the determination of removable contamination were counted for gross alpha and gross beta activity. Soils were analyzed by gamma spectroscopy for uranium-238 and other identifiable photopeaks. Major analytical equipment used in support of this survey is listed in Appendix A; Appendix B describes the measurement and analytical procedures.

Findings of the inspections and radiological surveys were compared with the post-remedial action report and the established Illinois National Guard Armory guidelines (Appendix C).

FINDINGS AND RESULTS

Document Review

Review of the ANL and BNI characterization reports indicated that the major areas of contamination were identified by both surveys. These major areas were surfaces in Rooms 1 and 5 and the catch basin system servicing these two rooms. Other locations identified by both organizations were Rooms 1E, 5B, S201/202 (messhall), S213, S212, and S250 (the 2nd floor corridor). In addition to the locations identified by ANL, BNI also found small areas of contamination in Rooms 1A, S215, and S234. It should be noted that in the time period between the ANL and BNI surveys numerous changes in room partitioning have taken place; also, the room numbering identification sytem has been changed throughout the facility. (Throughout this verification report, the current room identification numbers are used. For comparison of current and past room layout and identification, the reader should consult references 1, 3, and 5.)

Review of characterization and interim remedial action data indicated that decisions regarding requirements for remediation were appropriate. Visual inspections confirmed that identified areas were remediated to the extent described in the post-remedial action report. Data presented in the post-remedial action report demonstrate that the remedial actions were effective in meeting the established cleanup guidelines at all identified locations.

Confirmatory Sample Analyses

Table 1 presents the results of gamma spectrometry analyses, performed by ORAU and BNI, for 9 soil samples from the remediated areas. For the primary radionuclide of concern, U-238, data are in agreement within their respective 99% confidence intervals for 8 of the 9 samples. It should be noted that most of the samples contained U-238 concentrations near or below the detection limits of the analytical procedures. Therefore these concentration values have relatively large uncertainty values associated with them. In addition, BNI analyzed the samples in an unprocessed form (not dried or ground), and, because the levels were well below the guideline values, BNI did not have the samples reanalyzed after processing. ORAU analyses were on processed samples; direct comparison of results is therefore not technically correct. The one sample for which the analytical results of the 2 laboratories differed by greater than the 99% confidence intervals was sample 258. The BNI analysis indicated 38 ± 14 pCi/g; the ORAU measurement was 18.1 ± 2.1 pCi/g. Although this difference has not been explained, it is important to emphasize that all measurements on these samples by both laboratories were well within the guideline soil concentration of 150 pCi/g.

Results of the confirmatory analyses on 12 smear samples are also presented in Table 1. Gross alpha results on all of these samples indicated agreement within the 99% confidence intervals. As with the soil samples, most of these smears contained radioactivity levels below or near the detection sensitivities of the procedures and consequently have relatively large uncertainty values. BNI did not measure gross beta levels on these smears; however, ORAU measurements of the gross beta levels indicated that most of these, too, were very low. All smears measured by ORAU and BNI were well below the DOE surface contamination guideline level of 5000 dpm/100 cm^2,

averaged over 1 m^2, for both alpha and beta radiations associated with uranium contamination. On the basis of these findings, it is ORAU's opinion that the BNI data are accurate, within the statistical limitations of the analytical procedures and adequately represent the radiological status of the site.

Verification Surveys

Remediated Areas

Surface scans of remediated areas identified small sites of residual contamination exceeding guidelines at several locations in Rooms 5B (floor, walls, and drain), S201/202 (floor), and S212 (sump). These were brought to the attention of the remedial-action contractor. Further decontamination of these areas was performed immediately and followup scans by ORAU verified the effectiveness of the additional cleanup actions. Scans of other remediated areas indicated no areas of residual surface contamination in excess of guidelines.

The results of contamination measurements on remediated surface areas are summarized in Table 2. Total alpha levels ranged from <30 to 990 dpm/100 cm^2, beta-gamma levels ranged from <560 to 8000 dpm/100 cm^2. All locations exceeding 5000 dpm/100 cm^2 beta-gamma were small isolated spots and averaging over adjacent 1 m^2 areas resulted in levels below the 5000 dpm/100 cm^2 guideline. None of these locations exceeded the limit of 15000 dpm for maximum contamination levels averaged over a 100 cm^2 area. The maximum beta-gamma level of 8000 dpm/100 cm^2 is equivalent to a surface dose rate of approximately 0.19 mrad/h, which is within the guideline values of 0.20 mrad/h, average, and 1.0 mrad/h, maximum. Removable surface contamination ranges were <3 to 19 alpha dpm/100 cm^2 and <6 to 23 beta dpm/100 cm^2.

Scans of catch basins 1, 2, 4, 5, and 6 and remaining piping indicated no locations of gross residual contamination in excess of DOE guidelines. Surface contamination measurements in the catch basins are summarized in Table 3. Total beta-gamma levels ranged from <620 to 14770 dpm/100 cm^2. The porous, rough, and dirt and oil coated condition of the catch basin and piping surfaces prevented meaningful alpha contamination measurements. Although small areas of the surfaces in these drainage and collection systems are above

5000 dpm/100 cm^2, the average contamination levels were below that guideline value. In addition, the individual isolated spots, when averaged over 100 cm^2, were within the maximum guideline level of 15000 dpm/100 cm^2. Beta-gamma dose rates satisfied the criteria of 1.0 mrad/h, maximum, and 0.2 mrad/h, average.

Uranium 238 concentrations in samples of soil from the excavated area of catch basin 3 and trenches, where piping was removed, are presented in Table 4. The highest U-238 concentration was 13.4 ± 2.0 pCi/g from the bottom of the catch basin 3 excavation. This is well within the guideline of 150 pCi/g. For comparision, the background concentration of U-238 in samples, collected by ORAU from the vicinity of the Armory, ranged from <1.1 to 2.5 pCi/g.

Non-remediated Areas

Surface scans and contamination measurements in randomly selected non-remediated areas indicated that all of these areas satisfy the DOE guidelines. Results of the measurements in these rooms are presented in Table 5. Total alpha contamination levels ranged from <30 to 140 dpm/100 cm^2; total beta-gamma levels ranged from <600 to 5400 dpm/100 cm^2. Highest levels were located on the floor of the 2nd floor corridor (area S250) in the South Head House. Detectable contamination was limited to small (<100 cm^2) isolated areas. The contamination levels at these locations are within the 15000 dpm/100 cm^2 guideline for maximum concentrations, averaged over areas of 100 cm^2. Also, averaging the detectable contamination over surface areas of 1 m^2 results in levels well below the 5000 dpm/100 cm^2 guideline value for such areas. Removable levels of alpha and beta contamination were <3 to 5 dpm/100 cm^2 and <6 to 52 dpm/100 cm^2, respectively.

In addition to the surveys of 39 non-remediated rooms, scans for alpha and beta-gamma contamination were performed on portions of the arena floor and on the floors of the aisles on all sides of the arena floor. No areas of residual contamination were identfied by these scans.

Exposure Rates

Table 6 summarizes gamma exposure rates, measured throughout the Armory. Measurements ranged from 8 to 16 μR/h. Levels were slightly higher in small

rooms on the first floor of the South Head House, probably due, in part, to natural activity in concrete material and storage of instruments with luminous dials (Ra-226) in this general area. All levels are well within the DOE guideline of 20 μR/h above background. Background exposure rates, measured in the vicinity of the Armory by ORAU, averaged approximately 8 μR/h; inside the concrete Armory structure the background exposure rates averaged approximately 11 μR/h.

Outdoor Survey

Surface scans did not identify any locations of significantly elevated gamma radiation in the gridded area outside the south portion of the Armory. Exposure rates over this area ranged from 8 to 11 μR/h, with an average of approximately 9 μR/h (Table 7), which is comparable to the average background level of 8 μR/h. Concentrations of uranium-238 in soil samples from this area are also presented in Table 7. The maximum concentration of U-238 in these samples was 16.5 ± 2.1 pCi/g, which is well within the site specific guideline value of 150 pCi/g. No other radionuclides were present in these samples at concentrations higher than those naturally occurring in surface soil from this area.

CONCLUSIONS

During April to June 1987, Oak Ridge Associated Universities' Radiological Site Assessment Program performed independent activities to verify the adequacy of remedial actions at the Illinois National Guard Armory and the accuracy of documentation supporting the remedial actions. The verification activities included document review, confirmatory laboratory analyses, and independent direct measurements and sampling analysis. Based on the results and findings of these activities it is ORAU's opinion that the remedial action has been effective in satisfying the established DOE criteria. It is also ORAU's opinion that the documentation supporting the remedial action process is adequate and accurate. A verification letter, indicating these opinions, was provided to DOE in June 1987.[7]

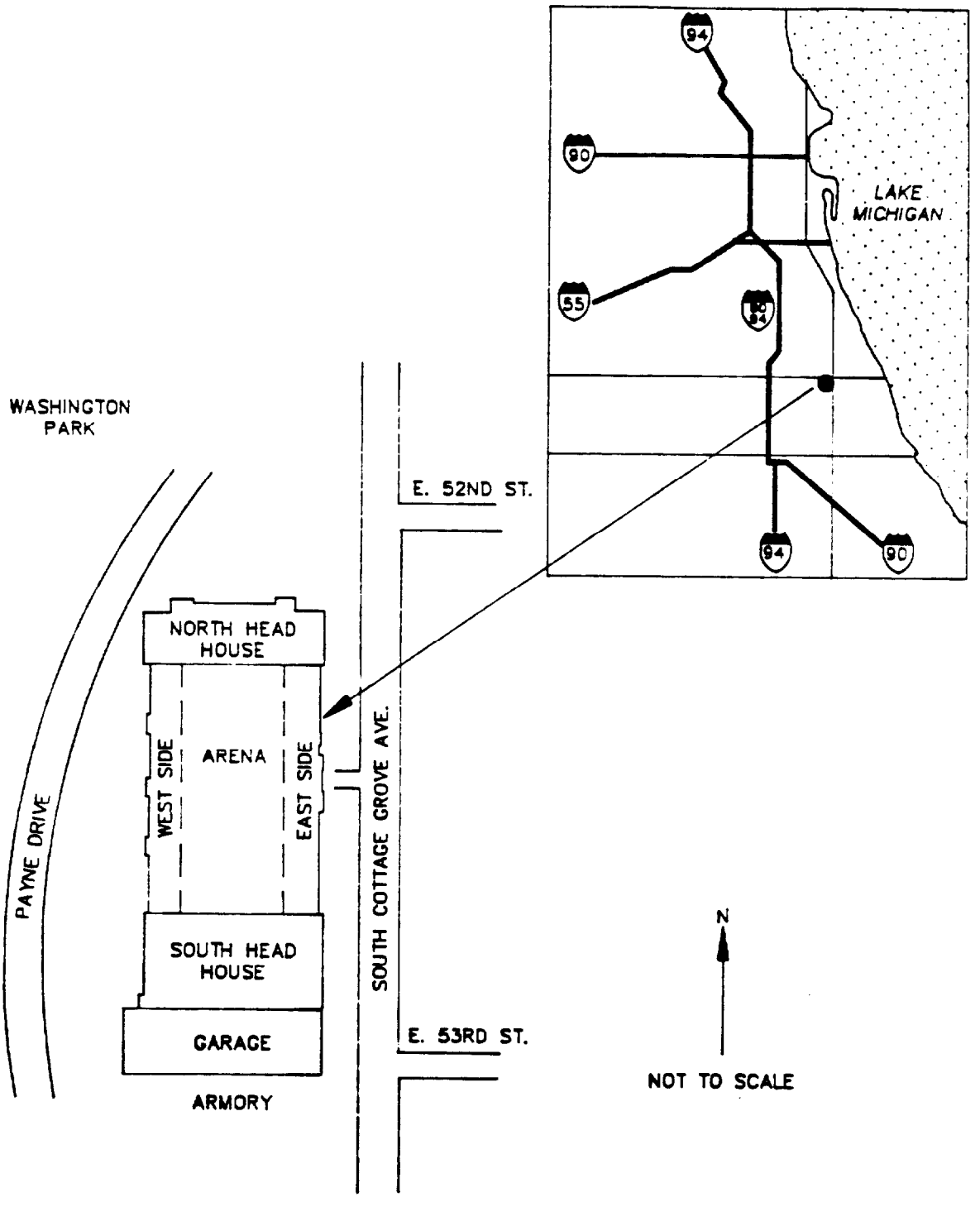

FIGURE 1: Chicago Area, Indicating the Location of the Illinois National Guard Armory

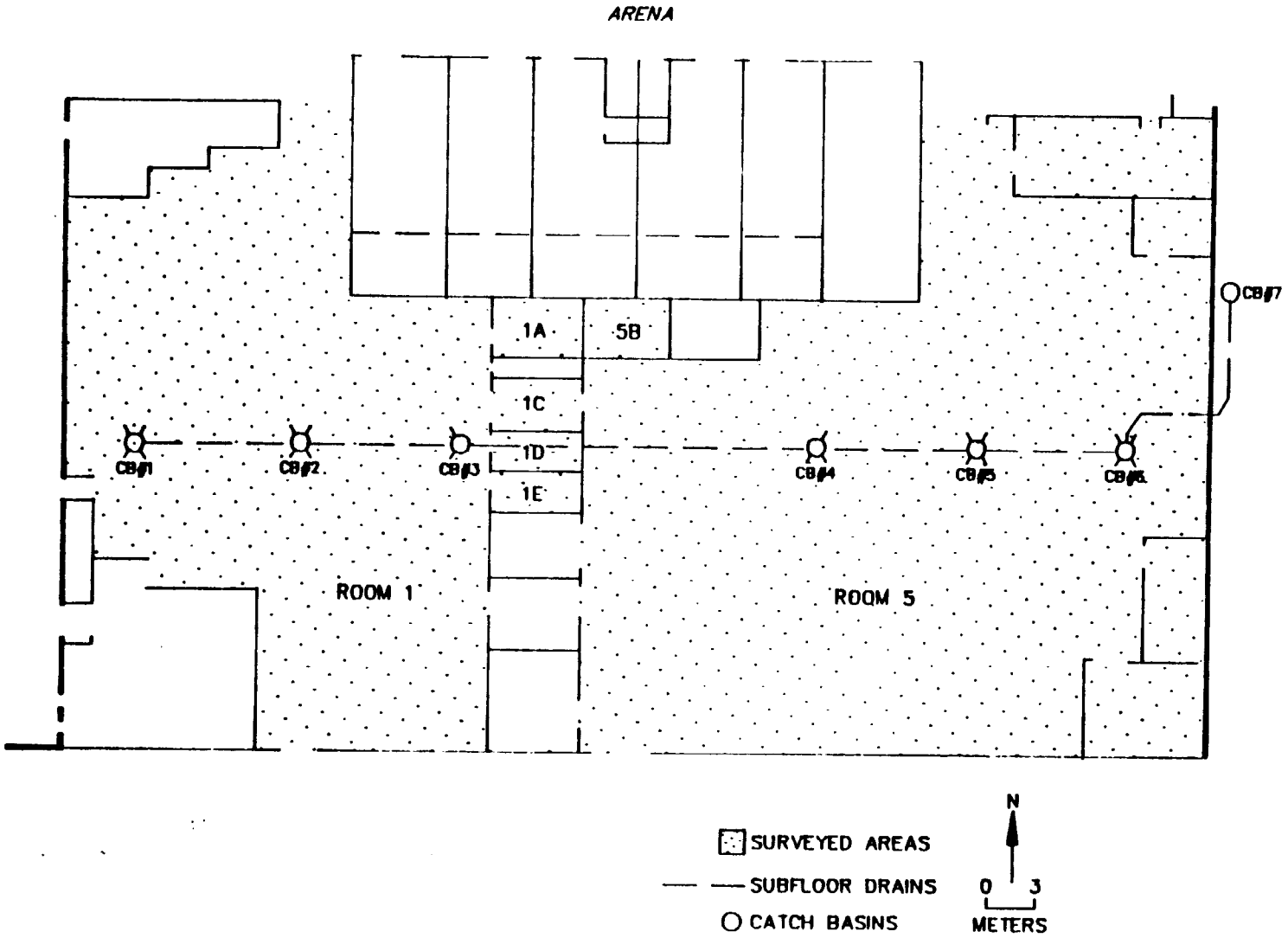

FIGURE 2: Locations of Remediated Areas on the First Level of the South Head House, Surveyed by the IVC

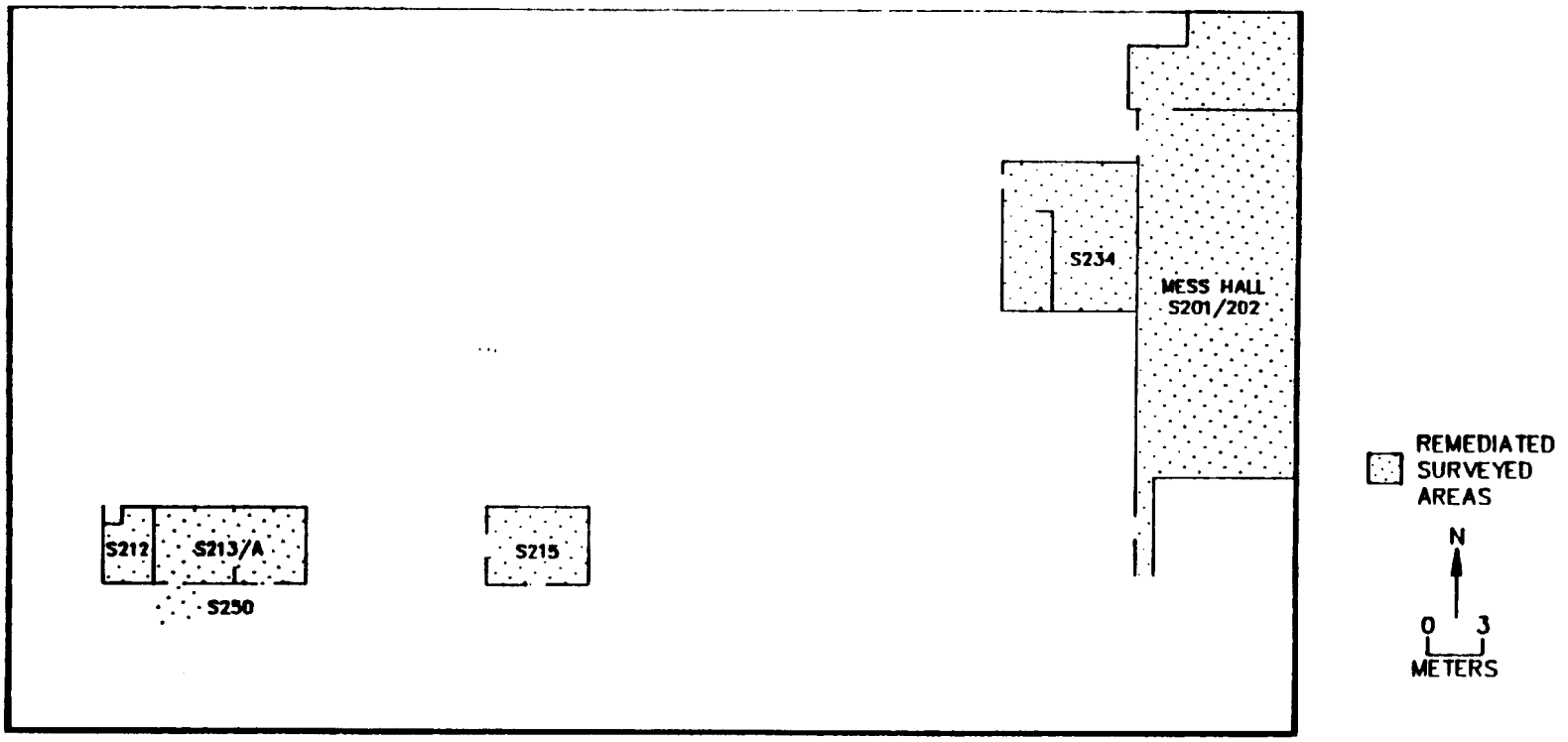

FIGURE 3: Locations of Remediated Areas on the Second Level of the South Head House, Surveyed by the IVC

NGA21

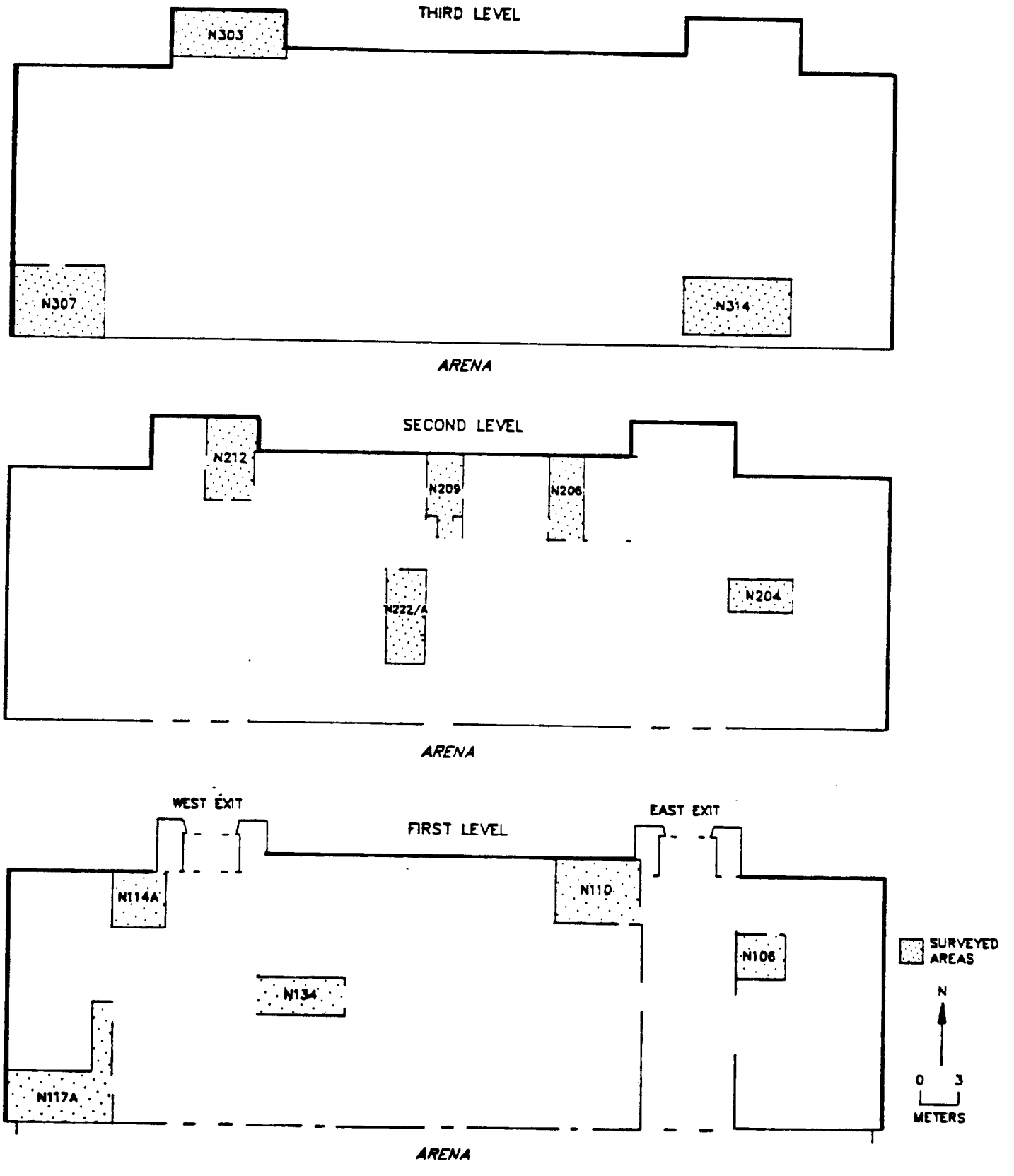

FIGURE 4: Non-remediated Areas of the North Head House, Randomly Selected for Survey

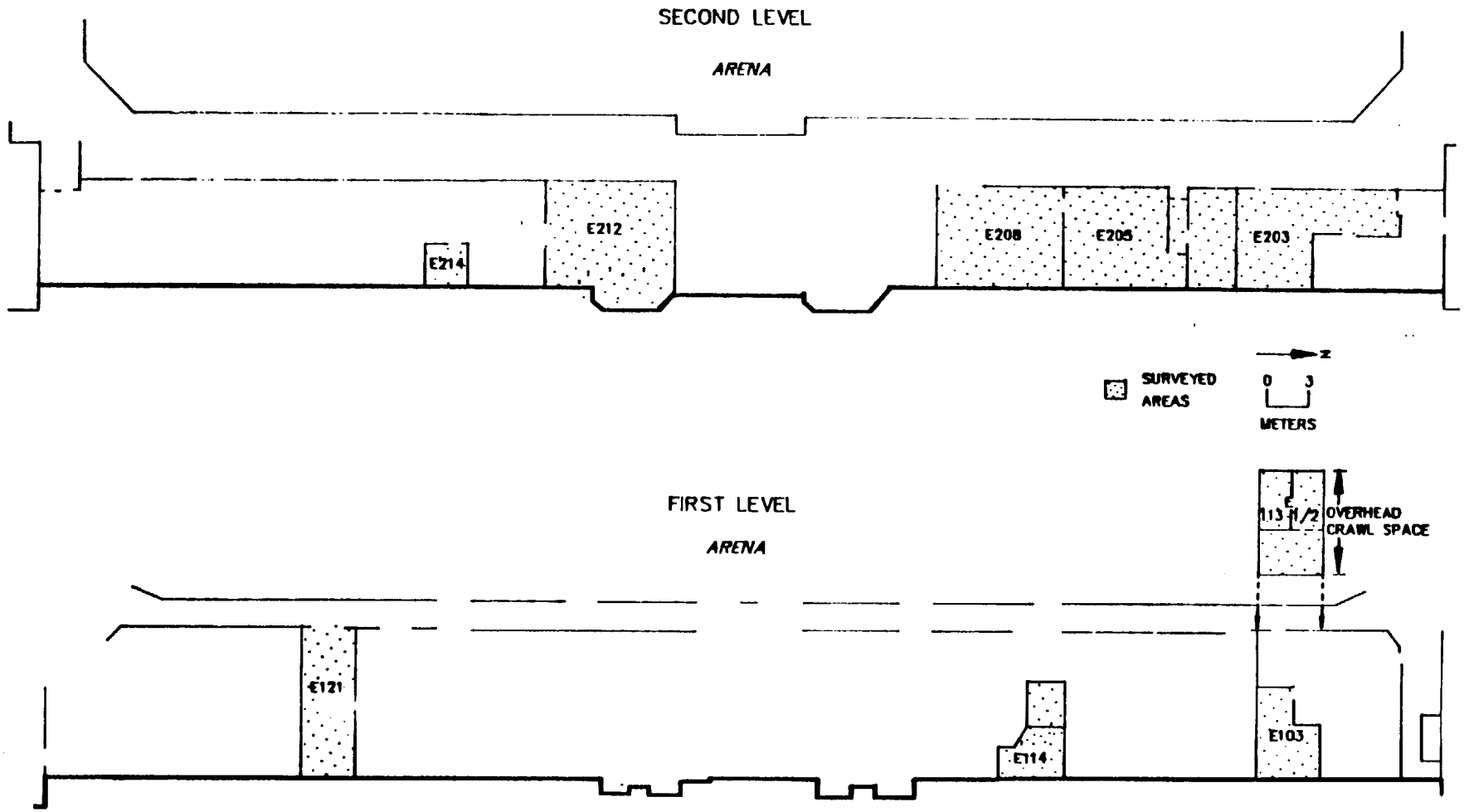

FIGURE 5: Non-remediated Areas of the East Wing, Randomly Selected for Survey

NGA10a

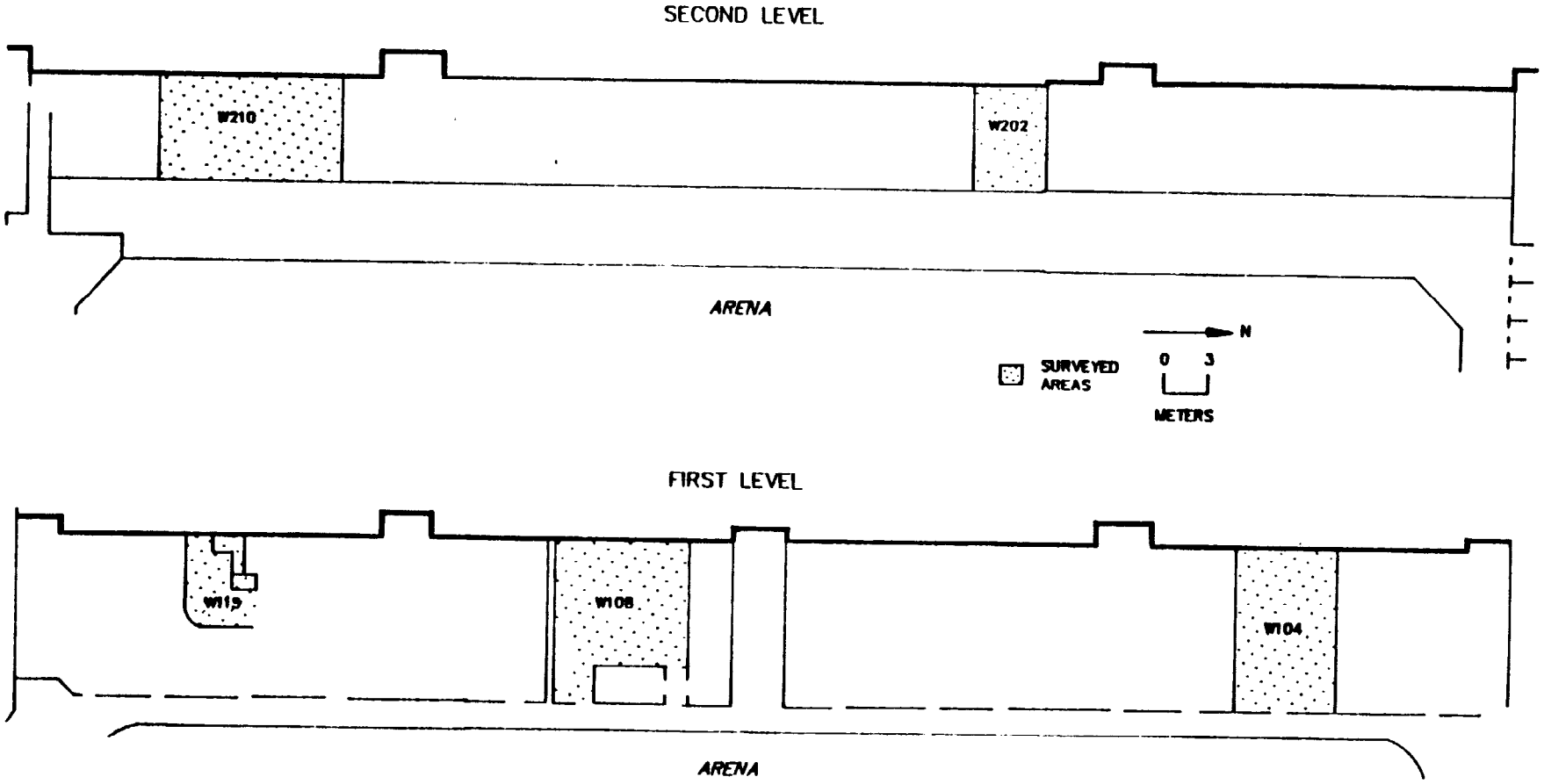

FIGURE 6: Non-remediated Areas of the West Wing, Randomly Selected for Survey

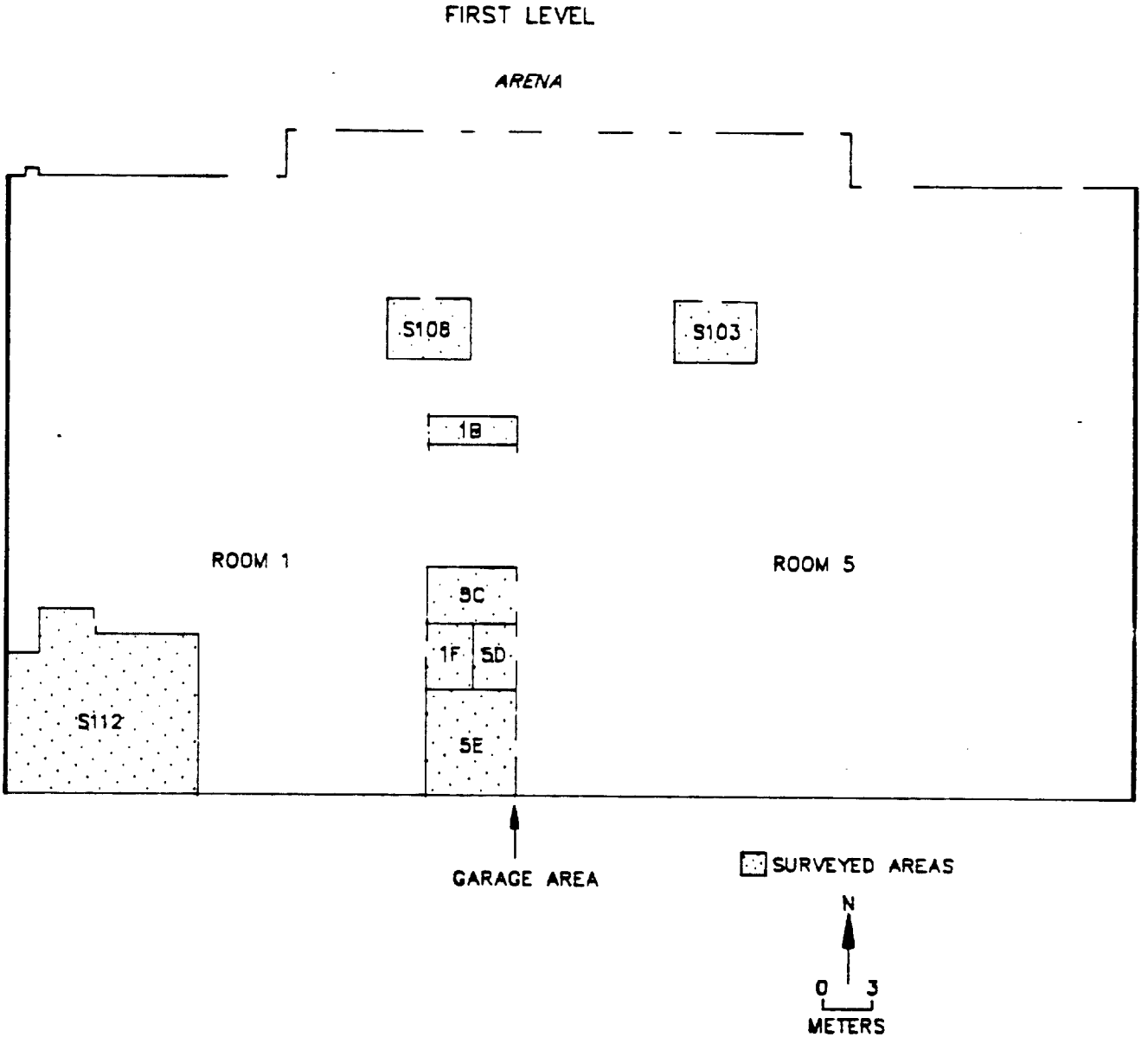

FIGURE 7: Non-remediated Areas of South Head House (First Level), Selected for Survey

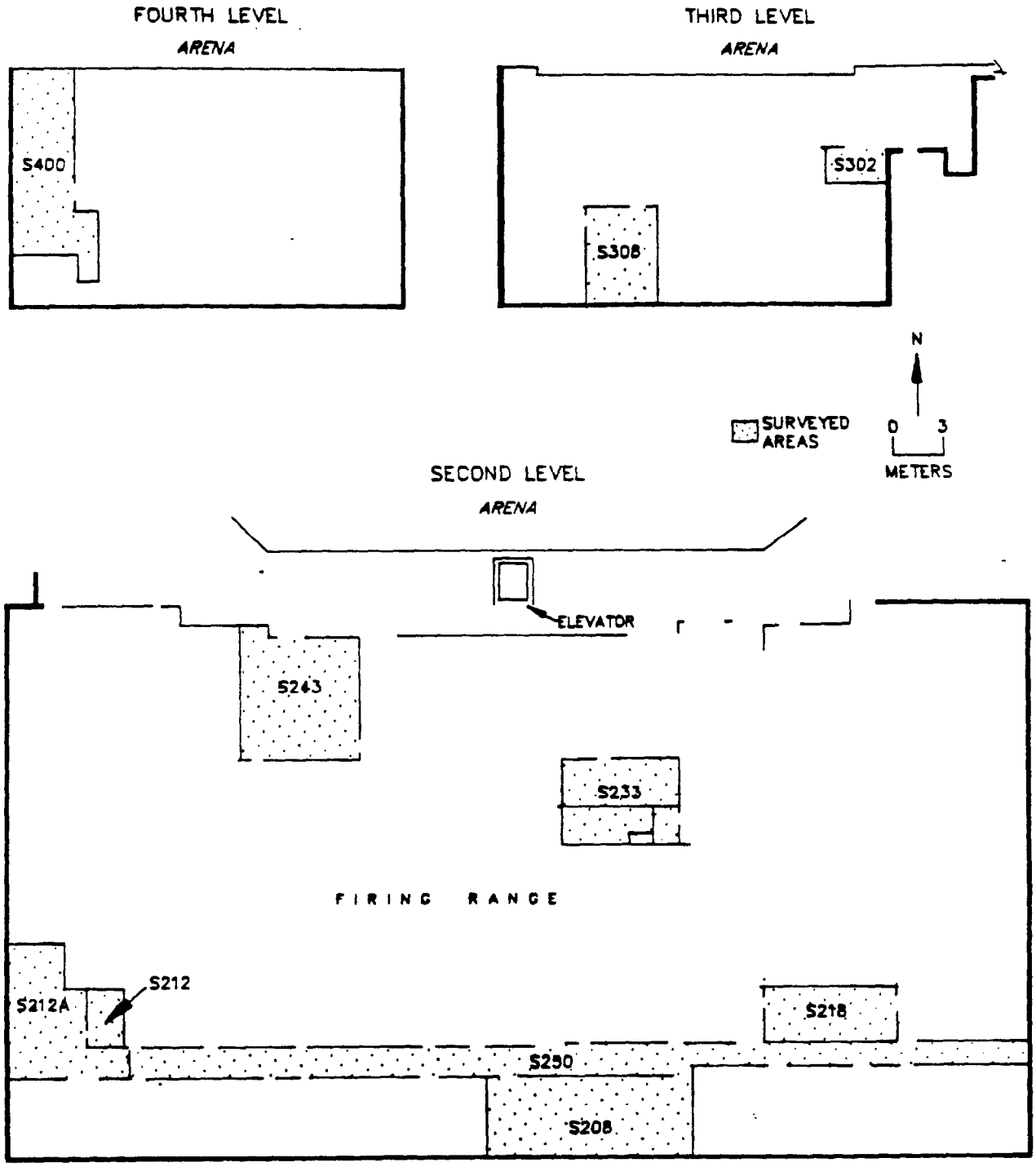

FIGURE 8: Non-remediated Areas of the South Head House, (Second, Third, and Fourth Levels) Randomly Selected for Survey

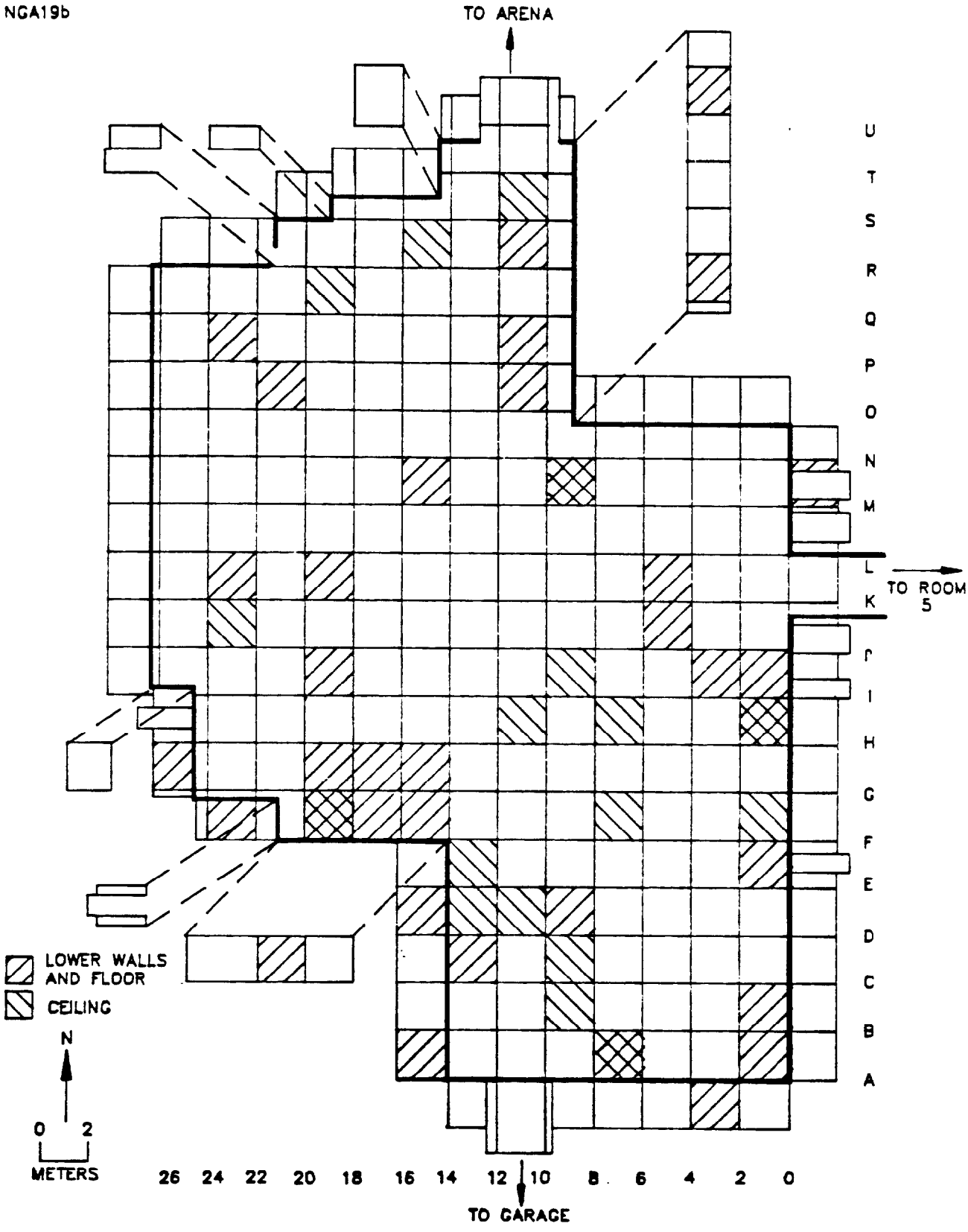

FIGURE 9: Grid System in Room 1 of the South Head House, Indicating Areas Selected for Surface Contamination Measurements

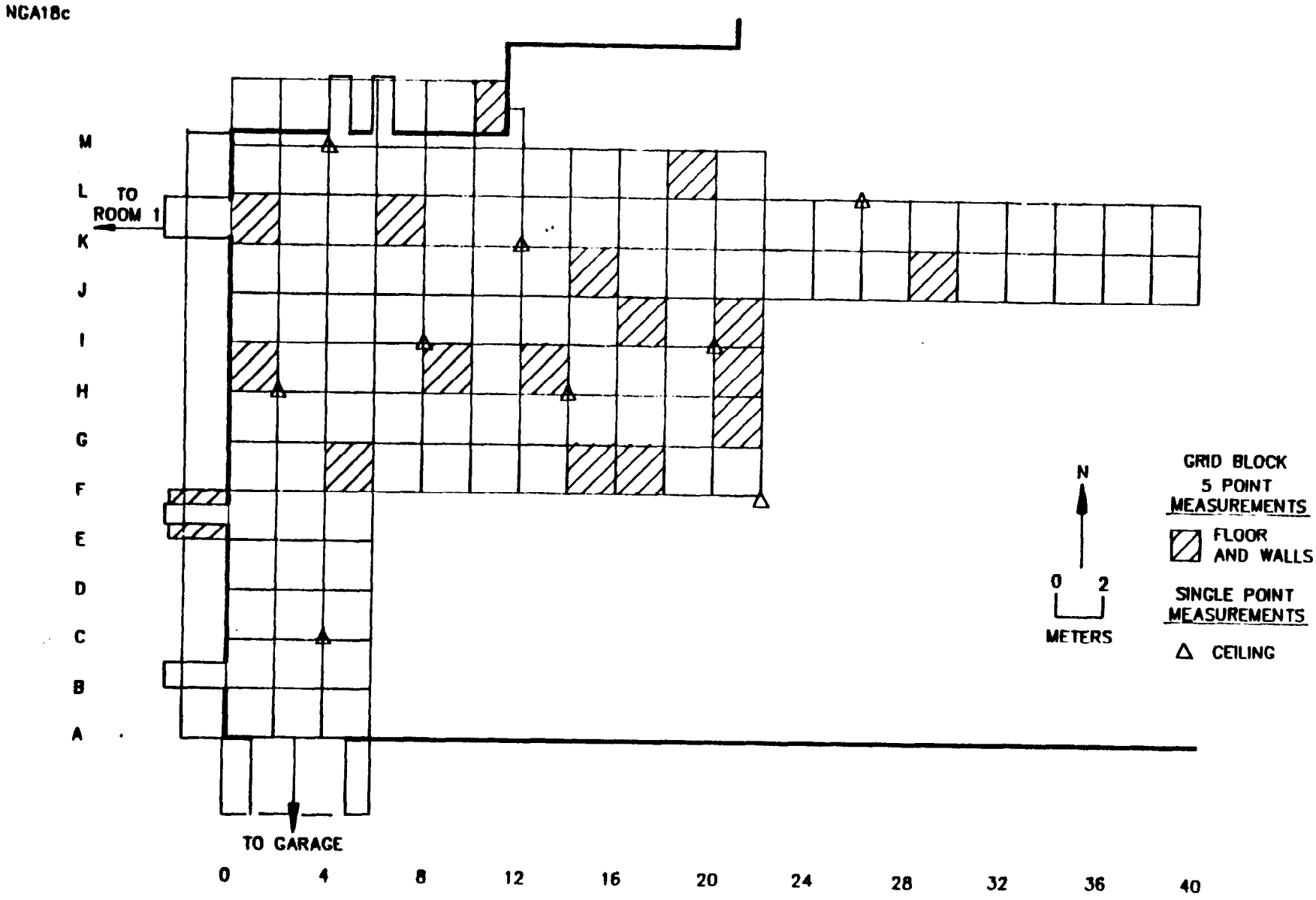

FIGURE 10: Grid System in Room 5 of the South Head House, Indicating Areas Selected for Surface Contamination Measurements

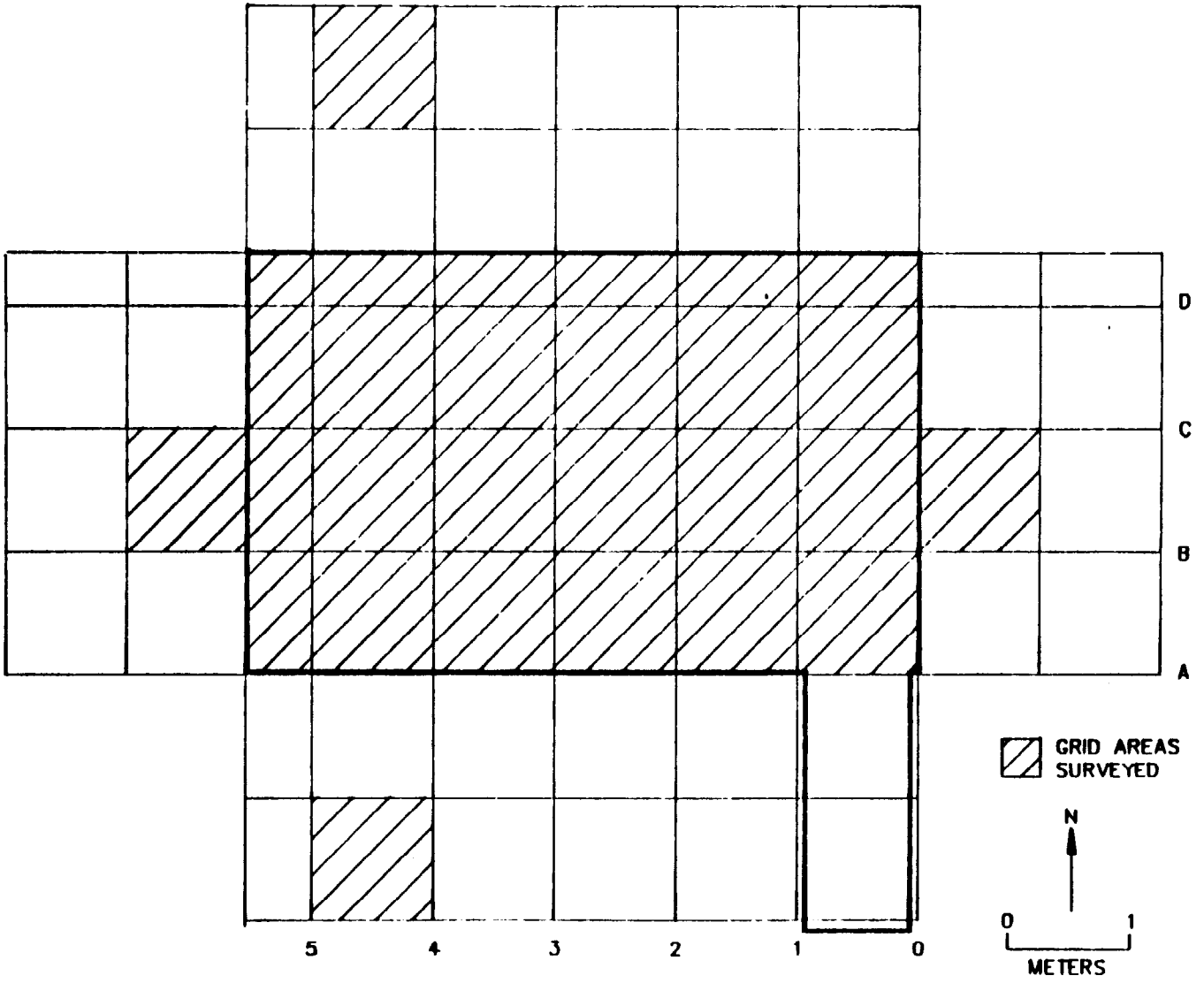

FIGURE 11: Reference Grid Established in Room 5B, Indicating Grid Blocks Surveyed

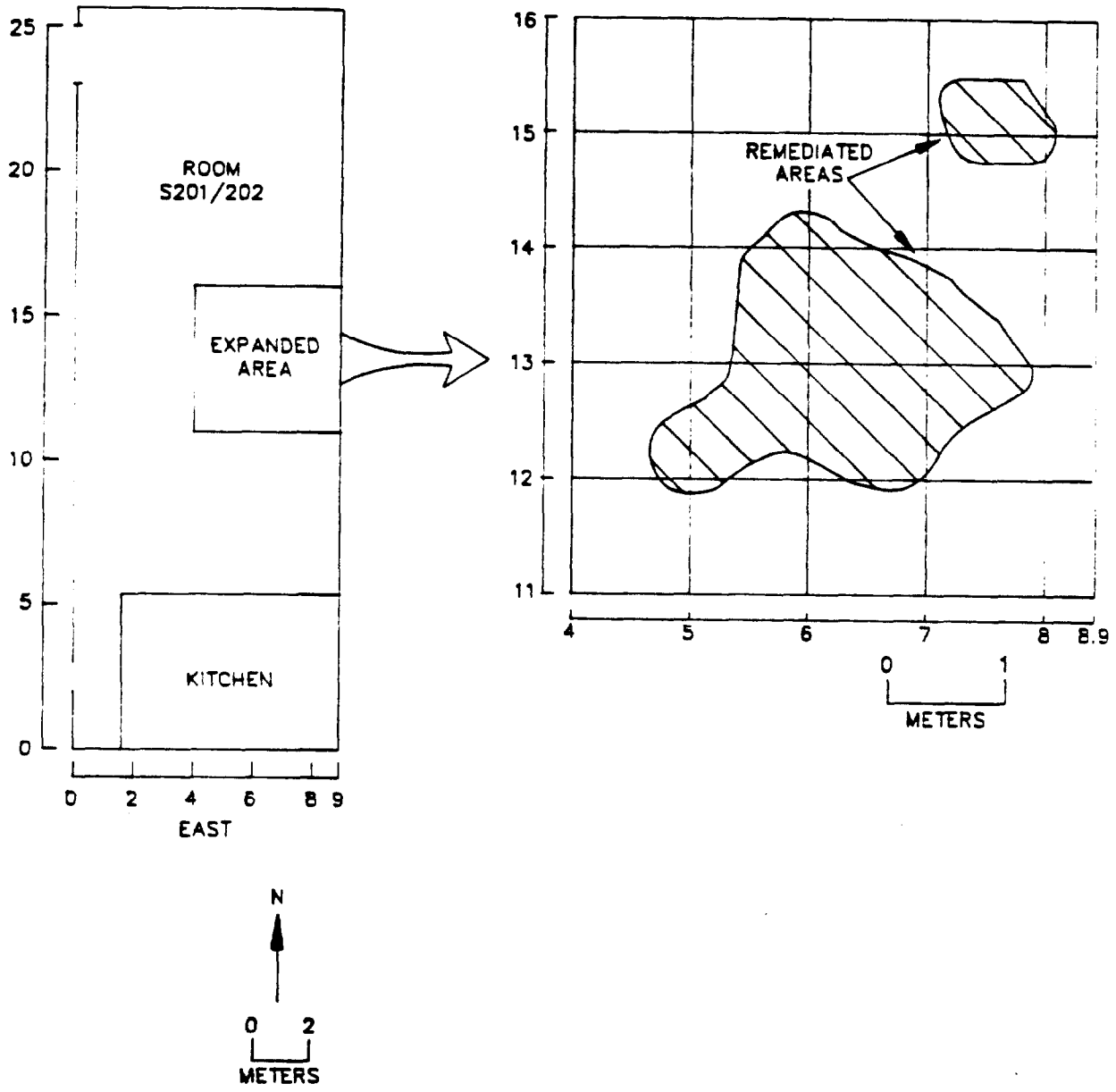

FIGURE 12: Room S201/202 Indicating Remediated Area and Grid System Established for Survey Reference

NGA17a

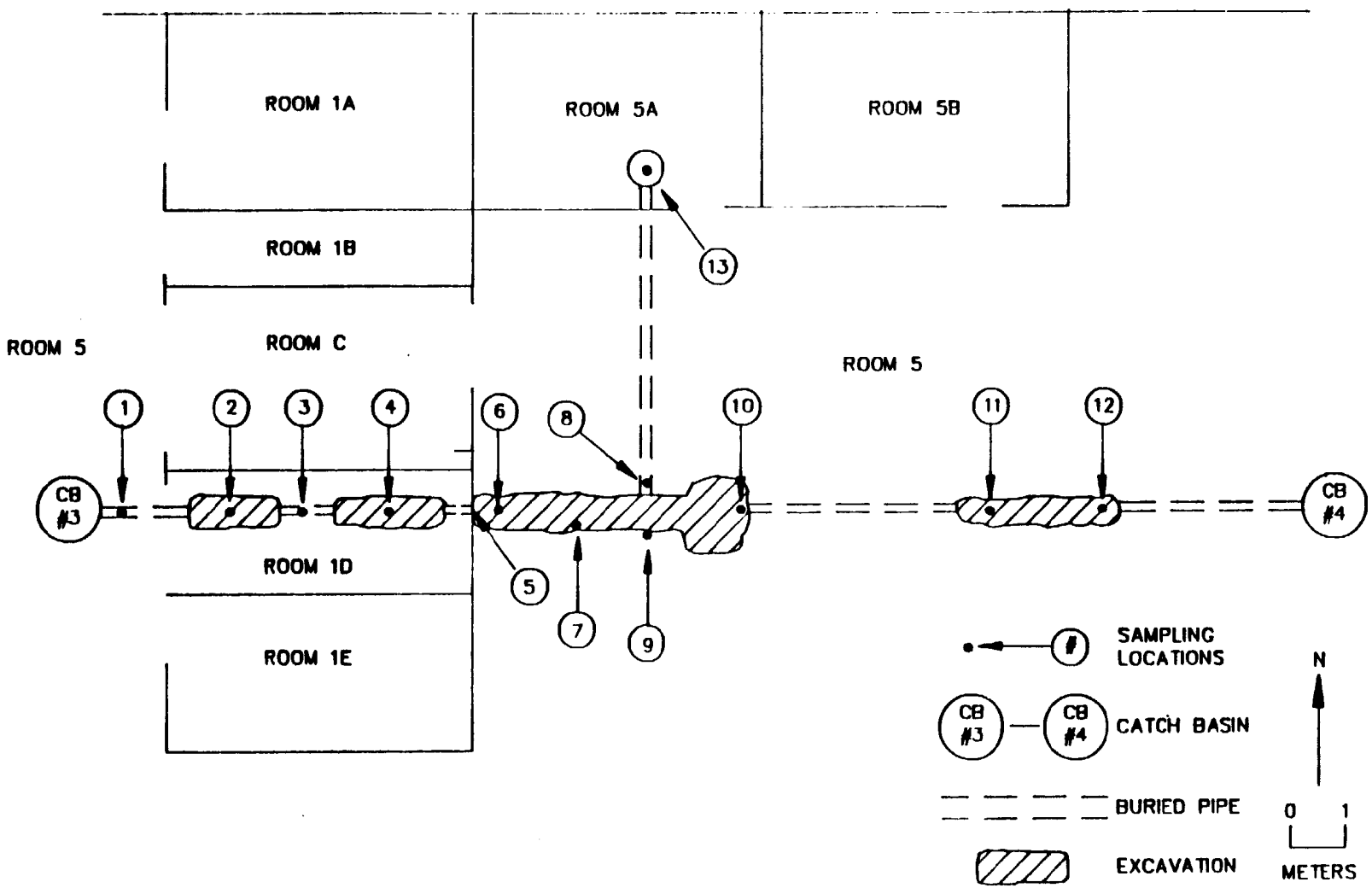

FIGURE 13: Locations of Samples from Excavations Between Catch Basins #3 and #4

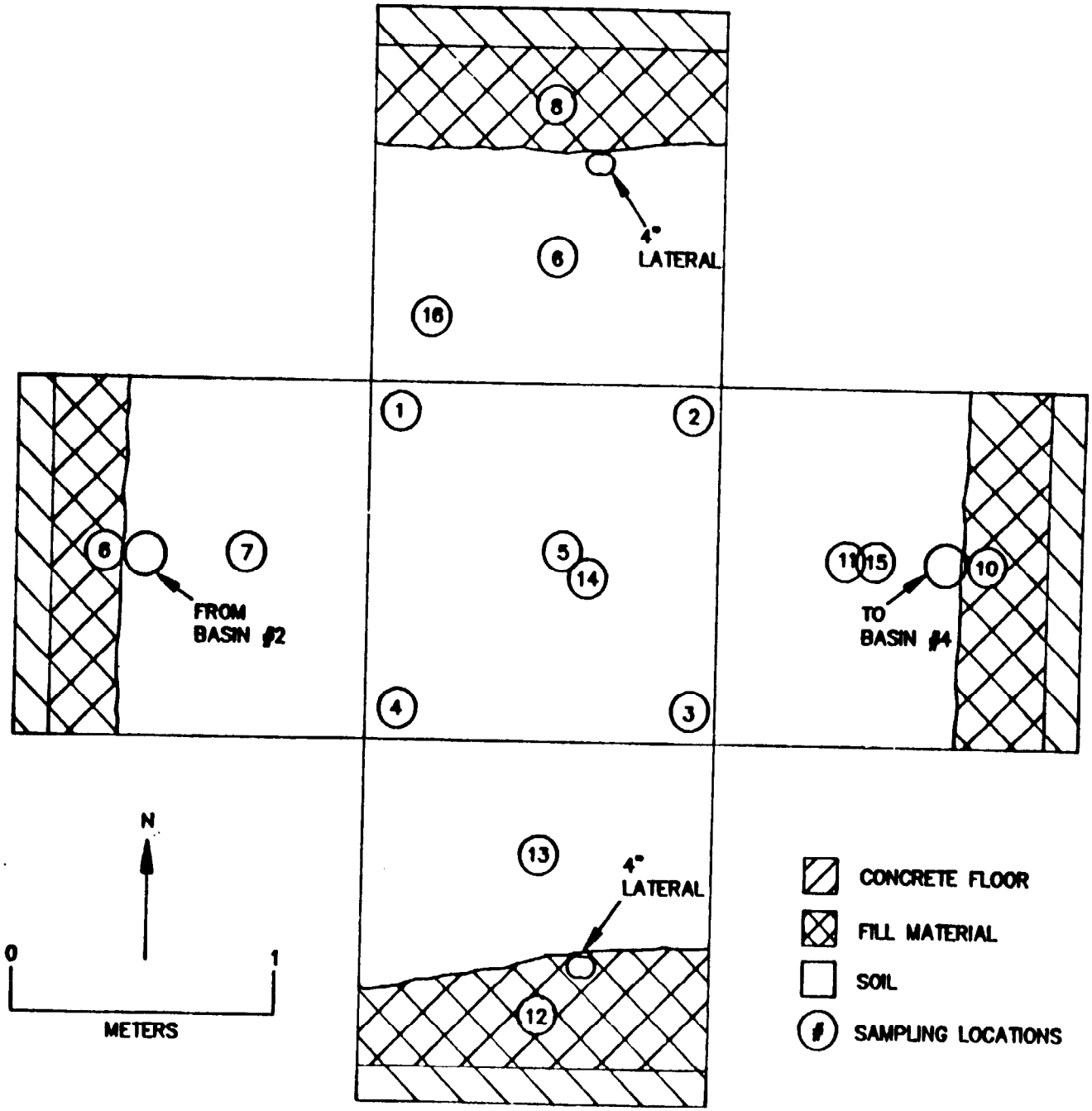

FIGURE 14: Locations of Soil Samples in Excavated Catch Basin #3 Area

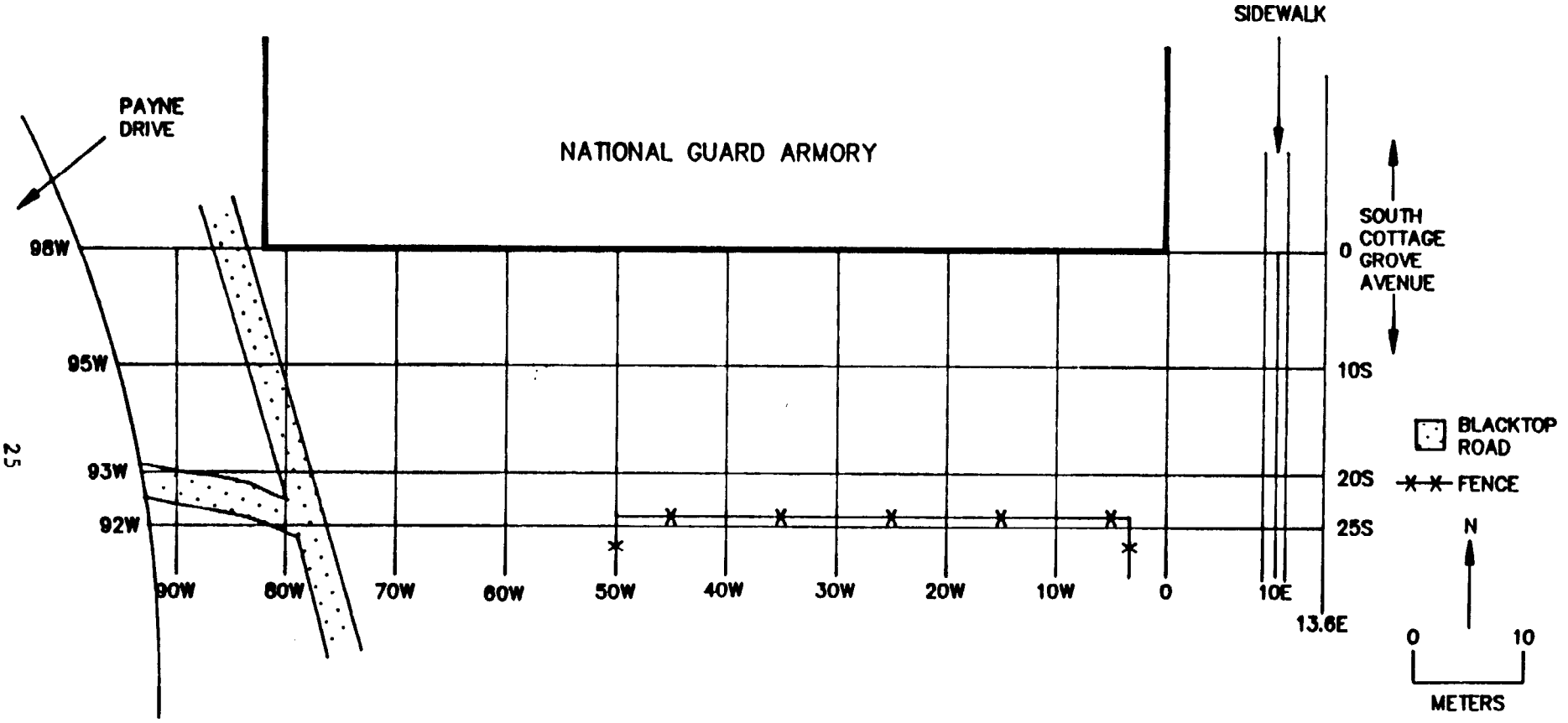

FIGURE 15: Exterior Grid System Established at South End of National Guard Armory Facility

TABLE 1

RESULTS OF CONFIRMATORY ANALYSES
ON SOIL AND SMEAR SAMPLES
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Sample[a]		Analysis By	Concentration U-238 (pCi/g)	Gross alpha (dpm/100 cm^2)	Gross beta (dpm/100 cm^2)
SOIL					
244	Catch Basin 3, NW Corner	BNI	<5	--[c]	--
		ORAU	3.0 ± 0.9[b]	--	--
247	Catch Basin 3, SE Corner	BNI	<4	--	--
		ORAU	0.7 ± 0.9	--	--
251	Excavation Between Catch Basin 3 & 4	BNI	<6	--	--
		ORAU	0.9 ± 1.5	--	--
252	Excavation Between Catch Basin 3 & 4	BNI	<14	--	--
		ORAU	<0.5	--	--
254	Excavation Between Catch Basin 3 & 4	BNI	8 ± 9	--	--
		ORAU	1.3 ± 1.2	--	--
257	Composite, Barrel "G"	BNI	11 ± 9	--	--
		ORAU	9.5 ± 2.4	--	--
258	Composite, Barrel "H"	BNI	38 ± 14	--	--
		ORAU	18.1 ± 2.1	--	--
279	Excavation	BNI	<8	--	--
		ORAU	2.4 ± 1.4	--	--
281	Drain, Room 5B	BNI	<6	--	--
		ORAU	2.1 ± 2.2	--	--

TABLE 1 (Continued)

RESULTS OF CONFIRMATORY ANALYSES
ON SOIL AND SMEAR SAMPLES
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Sample[a]	Analysis By	Concentration		
		U-238 (pCi/g)	Gross alpha (dpm/100 cm^2)	Gross beta (dpm/100 cm^2)
SMEAR				
996	BNI	--	5 ± 12	--
	ORAU	--	<4	<9
998	BNI	--	8 ± 15	--
	ORAU	--	16 ± 17	15 ± 12
999	BNI	--	5 ± 12	--
	ORAU	--	10 ± 12	19 ± 14
1003	BNI	--	5 ± 12	--
	ORAU	--	<4	13 ± 11
1008	BNI	--	8 ± 15	--
	ORAU	--	7 ± 11	<9
1010	BNI	--	10 ± 17	--
	ORAU	--	<4	13 ± 11
1013	BNI	--	<2	--
	ORAU	--	<4	<8
1015	BNI	--	36 ± 30	--
	ORAU	--	21 ± 18	31 ± 17
1020	BNI	--	10 ± 17	--
	ORAU	--	5 ± 9	15 ± 12

TABLE 1 (Continued)

RESULTS OF CONFIRMATORY ANALYSES
ON SOIL AND SMEAR SAMPLES
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Sample[a]	Analysis By	Concentration		
		U-238 (pCi/g)	Gross alpha (dpm/100 cm^2)	Gross beta (dpm/100 cm^2)
SMEAR				
1022	BNI	--	<2	--
	ORAU	--	<4	<9
1028	BNI	--	13 ± 16	--
	ORAU	--	<4	<9
1032	BNI	--	132 ± 57	--
	ORAU	--	110 ± 45	136 ± 39

[a]Sample identification as obtained from TMA/Eberline analytical report forms.
[b]Uncertainties represent the 99% confidence limits based only on counting statistics.
[c]Dash indicates analysis was not performed

TABLE 2

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and[a] Area	Number of Grid Blocks or Locations Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)			
		Highest Grid Block Avg.	Range of Measurements	Highest Grid Block Avg.	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)
Room 1							
Floors/L. Walls[b]	36	190	<32 - 540	2,500	<600 - 8,000	<3 - 7	<6 - 14
U. Walls/Ceilings[b]	18	620	<30 - 990	1,400	<570 - 2,600	<3 - 19	<6 - 23
Room 1A							
Floors/L. Walls[b]	4	280	<30 - 470	1,600	<600 - 2,000	<3	<6 - 7
U. Walls/Ceilings	0	N/A[d]	N/A	N/A	N/A	N/A	N/A
Room 1B							
Floors/L. Walls[c]	5	N/A	<30 - 91	N/A	<600 - 1,500	<3	<6
U. Walls/Ceiling	0	N/A	N/A	N/A	N/A	N/A	N/A
Room 1D							
Floors/L. Walls[c]	5	N/A	<30 - 39	N/A	<600 - 1,500	<3	<6
U.Walls/Ceilings[c]	1	N/A	<30	N/A	<600	<3	<6
Room 1E							
Floors/L. Walls[b]	6	32	<30 - 39	1,100	<600 - 1,700	<3	<6
U.Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
Room 1F							
Floors/L. Walls[c]	6	N/A	<30 - 39	N/A	<600 - 880	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A

TABLE 2 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Grid Blocks or Locations Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)			
		Highest Grid Block Avg.	Range of Measurements	Highest Grid Block Avg.	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)
Room 5							
Floors/L. Walls[b]	17	50	<21 - 110	970	<600 - 1,700	<3	<6 - 7
U. Walls/Ceilings[c]	10	N/A	<30 - 110	N/A	<570 - 770	<3	<6
Room 5A							
Floors/L. Walls[b]	28	49	<30 - 125	2,300	<620 - 7,600	<3 - 5	<6 - 18
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
Room 5C							
Floors/L. Walls[c]	6	N/A	<30 - 39	N/A	<600 - 690	<3	<6
U. Walls/Ceiling	0	N/A	N/A	N/A	N/A	N/A	N/A
Room 5D							
Floors/L. Walls[c]	7	N/A	<30 - 39	N/A	<600 - 690	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
Room 5E							
Floors/L. Walls[c]	6	N/A	<30 - 39	N/A	<570	<3 - 7	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
Room 5201/202							
Floors/L. Walls[b]	31	94	<35 - 350	3,000	<560 - 7,800	<3 - 5	<6 - 15
U. Walls/Ceilings[c]	12	N/A	<39 - 98	N/A	<630 - 690	<3	<6 - 7

TABLE 2 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Grid Blocks or Locations Surveyed	TOTAL CONTAMINATION				REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm^2)		Beta-Gamma (dpm/100 cm^2)			
		Highest Grid Block Avg.	Range of Measurements	Highest Grid Block Avg.	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)
Room S212							
Floors/L. Walls[c]	6	N/A	<30 - 320	N/A	<620 - 6,300	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A	N/A	N/A
Room S213/A							
Floors/L. Walls[c]	12	N/A	<35 - 88	N/A	<630 - 7,000	<3	<6
U. Walls/Ceilings[c]	4	N/A	<35 - 53	N/A	<630	<3	<6
Room S215							
Floors/L. Walls[c]	7	N/A	<35 - 88	N/A	<630	<3	<6 - 9
U. Walls/Ceilings[c]	2	N/A	<35 - 53	N/A	<630	<3	<6 - 7
Room S234							
Floors/L. Walls[c]	6	N/A	<35 - 53	N/A	<630 - 1,100	<3	<6 - 7
U. Walls/Ceilings[c]	6	N/A	<35 - 71	N/A	<630	<3	<6 - 8

[a]Refer to Figures 2, 3, 9, 10, 11, and 12.
[b]Five-point measurements in grid blocks.
[c]Single-point measurements.
[d]N/A = Not applicable.

TABLE 3

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN CATCH BASINS AND PIPING
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Location	Beta-Gamma Contamination Levels	
	(dpm/100 cm^2)	(mrad/h)
Catch Basin #1		
walls	<620	<0.01
bottom	<620	<0.01
piping	<620 - 2030	<0.01 - 0.04
Catch Basin #2		
walls	1000	0.20
bottom	1750 - 14770	0.04 - 0.30
piping	<620 - 10640	<0.01 - 0.22
Catch Basin #4		
walls	<620 - 11270	<0.01 - 0.23
bottom	<620	<0.01
piping	<620 - 14350	<0.01 - 0.30
Catch Basin #5		
walls	<620 - 4130	<0.01 - 0.08
bottom	1440 - 5250	0.03 - 0.11
piping	<620 - 12040	<0.01 - 0.25
Catch Basin #6		
walls	<620 - 6650	<0.01 - 0.14
bottom	<620	<0.01
piping	1120 - 1750	0.02 - 0.04

TABLE 4

URANIUM 238 CONCENTRATIONS IN
SOIL SAMPLES FROM EXCAVATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Location	U-238 Concentration (pCi/g)[a]
Catch Basin 3[b]	
1	3.9 ± 0.8[c]
2	7.7 ± 1.3
3	3.8 ± 0.7
4	4.8 ± 0.9
5	13.4 ± 2.0
6	4.2 ± 2.8
7	10.6 ± 1.4
8	4.8 ± 1.6
9	5.1 ± 1.3
10	0.8 ± 1.5
11	1.5 ± 0.6
12	1.7 ± 1.2
13	11.9 ± 1.3
14	2.4 ± 1.5
15	3.1 ± 1.2
16	0.9 ± 0.9

TABLE 4 (Continued)

URANIUM 238 CONCENTRATIONS IN
SOIL SAMPLES FROM EXCAVATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Location	U-238 Concentration (pCi/g)
Piping Trenchs[d]	
1	1.1 ± 1.2
2	<0.8
3	0.7 ± 0.8
4	<0.7
5	<0.9
6	0.5 ± 0.9
7	<1.1
8	<0.6
9	1.4 ± 1.5
10	<0.6
11	<0.8
12	<0.4
13	3.1 ± 1.2

[a]Data includes background level.
[b]Refer to Figure 14.
[c]Uncertainties are 95% confidence levels based only on counting statistics; additional analytical uncertainties of ± 6 to 10% have not been propagated in these data.
[d]Refer to Figure 13.

TABLE 5

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and[a] Area	Number of Measurements	TOTAL CONTAMINATION: Alpha (dpm/100 cm^2) Range of Measurements	TOTAL CONTAMINATION: Beta-Gamma (dpm/100 cm^2) Range of Measurements	REMOVABLE CONTAMINATION: Alpha Range (dpm/100 cm^2)	REMOVABLE CONTAMINATION: Beta Range (dpm/100 cm^2)
NORTH HEAD HOUSE					
Room N106					
Floors/L. Walls	5	<35	<630	<3	<6
U. Walls/Ceilings	1	<35	<630	<3	<6
Room N110					
Floors/L. Walls	7	<35 - 120	<630	<3	<6 - 10
U. Walls/Ceilings	1	<35	<630	<3	<6
Room N114A					
Floors/L. Walls	5	<35 - 71	<630	<3	<6
U. Walls/Ceiling	1	<35	<630	<3	<6
Room N117A					
Floors/L. Walls	6	<39	<630	<3	<6 - 14
U. Walls/Ceilings	1	58	750	<3	<6
Room N134					
Floors/L. Walls	5	<35 - 53	<630 - 1,200	<3	<6 - 7
U. Walls/Ceilings	1	<35	<630	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm^2)	Beta-Gamma (dpm/100 cm^2)		
		Range of Measurements	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)
Room N204					
Floors/L. Walls	5	<35	<630	<3	<6
U. Walls/Ceilings	1	<35	<630	<3	<6
Room N206					
Floors/L. Walls	5	<35 - 71	<630	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6
Room N209					
Floors/L. Walls	5	<35	<630	<3	<6
U. Walls/Ceilings	1	<35	<630	<3	<6
Room N212					
Floors/L. Walls	5	<35 - 53	<630	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6
Room N222/A					
Floors/L. Walls	5	<35 - 53	<630	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION: Alpha (dpm/100 cm^2) Range of Measurements	TOTAL CONTAMINATION: Beta-Gamma (dpm/100 cm^2) Range of Measurements	REMOVABLE CONTAMINATION: Alpha Range (dpm/100 cm^2)	REMOVABLE CONTAMINATION: Beta Range (dpm/100 cm^2)
Room N303					
Floors/L. Walls	5	<35	<630 - 1,500	<3	<6
U. Walls/Ceilings	1	53	1,100	<3	<6
Room N307					
Floors/L. Walls	5	<35	<630 - 750	<3	<6
U. Walls/Ceilings	1	53	<630	<3	<6
Room N314					
Floors/L. Walls	6	<35 - 53	<630 - 1,100	<3	<6 - 8
U. Walls/Ceilings	0	N/A[b]	N/A	N/A	N/A

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm^2)	Beta-Gamma (dpm/100 cm^2)		
		Range of Measurements	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)
EAST WING					
Room E103					
Floors/L. Walls	3	<30 - 39	<620	<3	<6 - 7
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
Room E113 1/2					
Floors/L. Walls	5	<30 - 74	<620 - 2,200	<3	<6
U. Walls/Ceilings	1	<30	<620	<3	<6
Room E114					
Floors/L. Walls	5	<30 - 39	<620 - 1,000	<3	<6
U. Walls/Ceiling	1	<39	<620	<3	<6
Room E121					
Floors/L. Walls	8	<30 - 56	<620 - 2,100	<3	<6 - 52
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
Room E203					
Floors/L. Walls	3	<30	<620 - 1,900	<3	<6 - 8
U. Walls/Ceilings	1	<30	<620	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION		REMOVABLE CONTAMINATION	
		Alpha (dpm/100 cm^2)	Beta-Gamma (dpm/100 cm^2)		
		Range of Measurements	Range of Measurements	Alpha Range (dpm/100 cm^2)	Beta Range (dpm/100 cm^2)
Room E205					
Floors/L. Walls	8	<30 - 56	<620 - 760	<3	<6
U. Walls/Ceilings	2	<30 - 74	<620	<3	<6
Room E208					
Floors/L. Walls	6	<30 - 56	<620 - 1,700	<3	<6 - 8
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
Room E212					
Floors/L. Walls	7	<30 - 74	<620 - 1,700	<3	<6
U. Walls/Ceilings	1	<30	<620	<3	<6
Room E214					
Floors/L. Walls	5	<30 - 39	<620	<3	<6
U. Walls/Ceiling	1	<30	<620	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION Alpha (dpm/100 cm^2) Range of Measurements	TOTAL CONTAMINATION Beta-Gamma (dpm/100 cm^2) Range of Measurements	REMOVABLE CONTAMINATION Alpha Range (dpm/100 cm^2)	REMOVABLE CONTAMINATION Beta Range (dpm/100 cm^2)
WEST WING					
Room W104					
Floors/L. Walls	11	<30 - 74	<620 - 1,800	<3	<6 - 8
U. Walls/Ceilings	2	56 - 74	970 - 1,700	<3	<6
Room W108					
Floors/L. Walls	9	<30 - 39	<620 - 1,200	<3	<6
U. Walls/Ceilings	2	39 - 56	<620	<3 - 5	<6
Room W115					
Floors/L. Walls	6	<30	<620 - 900	<3	<6
U. Walls/Ceiling	1	<30	<620	<3	<6
Room W202					
Floors/L. Walls	8	<30 - 56	<620 - 1,400	<3	<6
U. Walls/Ceilings	2	<30 - 74	<620	<3	<6 - 13
Room W210					
Floors/L. Walls	8	<30	<620 - 2,000	<3 - 5	<6 - 10
U. Walls/Ceilings	2	<30 - 39	<620	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION: Alpha (dpm/100 cm^2) Range of Measurements	TOTAL CONTAMINATION: Beta-Gamma (dpm/100 cm^2) Range of Measurements	REMOVABLE CONTAMINATION: Alpha Range (dpm/100 cm^2)	REMOVABLE CONTAMINATION: Beta Range (dpm/100 cm^2)
SOUTH HEAD HOUSE					
Room S103					
Floors/L. Walls	5	<30	<600	<3	<6 - 8
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
Room S108					
Floors/L. Walls	4	<30 - 91	<600 - 620	<3	<6 - 9
U. Walls/Ceilings	1	<30	<600	<3	<6
Room S112					
Floors/L. Walls	9	<30 - 39	<600 - 1,900	<3	<6
U. Walls/Ceiling	0	N/A	N/A	N/A	N/A
Room S208					
Floors/L. Walls	10	<30 - 39	<620 - 630	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
Room S121A					
Floors/L. Walls	10	<30 - 56	<620 - 2,000	<3	<6 - 8
U. Walls/Ceilings	1	<30	<620	<3	<6

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION: Alpha (dpm/100 cm^2) Range of Measurements	TOTAL CONTAMINATION: Beta-Gamma (dpm/100 cm^2) Range of Measurements	REMOVABLE CONTAMINATION: Alpha Range (dpm/100 cm^2)	REMOVABLE CONTAMINATION: Beta Range (dpm/100 cm^2)
Room S218					
Floors/L. Walls	6	<30 - 56	<620	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
Room S233					
Floors/L. Walls	16	<30 - 56	<620 - 1,700	<3	<6 - 8
U. Walls/Ceilings	3	<30 - 39	<620	<3	<6
RoomS243					
Floors/L. Walls	8	<30 - 74	<620 - 1,200	<3	<6 - 7
U. Walls/Ceilings	1	<30	<620	<3	<6
Room S250					
Floors/L. Walls	15	<39 - 97	<630 - 5,400	<3 - 5	<6 - 8
U. Walls/Ceilings	7	<39 - 140	<630	<3	<6 - 18
Room S302					
Floors/L. Walls	4	<30 - 74	<600 - 620	<3	<6 - 7
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A

TABLE 5 (Continued)

SUMMARY OF SURFACE CONTAMINATION MEASUREMENTS
IN NON-REMEDIATED AREAS
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Room and Area	Number of Measurements	TOTAL CONTAMINATION: Alpha (dpm/100 cm^2) Range of Measurements	TOTAL CONTAMINATION: Beta-Gamma (dpm/100 cm^2) Range of Measurements	REMOVABLE CONTAMINATION: Alpha Range (dpm/100 cm^2)	REMOVABLE CONTAMINATION: Beta Range (dpm/100 cm^2)
Room S308					
Floors/L. Walls	7	<30 - 56	<600 - 1,100	<3	<6
U. Walls/Ceilings	0	N/A	N/A	N/A	N/A
Room S400					
Floors/L. Walls	8	<30 - 39	<600	<3	<6 - 19
U. Walls/Ceilings	1	<30	<600	<3	<6

[a]Refer to Figures 4 to 8.
[b]N/A = Not applicable.

TABLE 6

SUMMARY OF EXPOSURE RATE MEASUREMENTS
THROUGHOUT ARMORY BUILDING
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Location	Number of Rooms	Exposure Rates at 1 m above Floor[a] (μR/h)
North Head House		
First Level	5	8 - 13
Second Level	5	9 - 13
Third Level	3	11 - 13
East Wing		
First Level	4	9 - 11
Second Level	5	9 - 10
West Wing		
First Level	3	10 - 11
Second Level	2	10
South Head House		
First Level	15	9 - 16
Second Level	1	8 - 13
Third Level	2	10 - 11
Fourth Level	1	10
Arena	N/A	8 - 13

[a]Data includes average background level of about 11 μR/h.

TABLE 7

DIRECT RADIATION LEVELS AND URANIUM-238 CONCENTRATIONS MEASURED
AT GRID BLOCK CENTERS - SOUTH OF ARMORY
ILLINOIS NATIONAL GUARD ARMORY
CHICAGO, ILLINOIS

Location[a]	Gamma Exposure Rates (μR/h)[b]		U-238 Concentration[b] (pCi/g)
	1 m above surface	surface contact	
5S, 12E	10	10	<0.8
5E	10	10	12.5 ± 4.3[c]
5W	9	10	2.8 ± 0.8
15W	11	10	2.7 ± 1.7
25W	11	10	<1.3
35W	10	10	1.6 ± 0.8
45W	11	10	2.9 ± 1.3
55W	9	9	<1.4
65W	9	9	4.0 ± 1.0
75W	9	9	4.6 ± 1.5
85W	8	8	<0.9
93W	9	9	16.5 ± 2.1
15S, 12E	10	10	<0.9
5E	9	9	<1.3
5W	9	9	2.9 ± 1.1
15W	8	9	<0.8
25W	9	9	<1.2
35W	8	9	2.7 ± 1.1
45W	9	9	2.0 ± 2.0
55W	10	9	4.6 ± 1.5
65W	10	10	3.0 ± 2.0
75W	8	8	8.5 ± 3.6
85W	9	9	16.1 ± 3.6
93W	8	8	<1.4
22S, 12E	11	9	2.4 ± 1.2
5E	9	9	2.7 ± 1.7
5W	9	8	<1.1
15W	8	8	3.2 ± 1.1
25W	8	9	5.0 ± 1.3
35W	9	9	<1.1
45W	8	8	0.7 ± 0.7
55W	8	9	4.0 ± 1.7
65W	9	9	<1.0
75W	9	9	3.7 ± 0.8
85W	9	9	[d]
91W	8	8	[d]

[a]Refer to Figure 15.
[b]Data include background levels.
[c]Uncertainties are 95% confidence levels, based only on counting statistics; additional analytical uncertainties of ± 6 to 10% have not been propogated in these data.
[d]No sample obtained.

REFERENCES

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2. U.S. Department of Energy, "U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites," Rev. 2, March 1987.

3. Betchel National, Inc., Radiological and Limited Chemical Characaterization for the National Guard Armory, Chicago, Illinois, DOE/OR/20722-179, Oak Ridge, TN, January 1988.

4. Betchel National, Inc., Work Plan for Remedial Action at National Guard Armory, Chicago, Illinois, FUSRAP: 119-00-IG-02, Oak Ridge, TN, April 1987.

5. Betchel National, Inc., Post Remedial Action Report for the National Guard Armory, DOE/OR/20722-184, Oak Ridge, TN, February 1988.

6. Oak Ridge Associated Universities, "Proposed Verification Survey Plan, Illinois National Guard Armory Site, Chicago, Illinois, Oak Ridge, TN, April 1987.

7. Letter from J.D. Berger (ORAU), to J.J. Fiore (DOE/NE), "Verification of Remedial Actions at the National Guard Armory, Chicago, Illinois," Oak Ridge, TN, June 30, 1987.

8. Argonne National Laboratory, Derivation of a Uranium Residual Radioactivity Guideline for the National Guard Armory in Chicago, Illinois, Chicago, IL, May 1987. (BNI CCN 047186)

APPENDIX A

MAJOR SURVEY AND ANALYTICAL EQUIPMENT

APPENDIX A

Major Survey 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 on 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
(Eberline, Santa Fe, NM)

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

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

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

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

Victoreen Beta-Gamma "Pancake" Detector
Model 489-110
(Victoreen, 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)

Ge(Li) Detector
Model LGCC2220SD, 23% Efficiency
(Princeton Gamma-Tech, Princeton, NJ)

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

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

used in conjunction with:
Lead Shield Model G-16
(Gamma Products, Palos Hills, IL)

High Purity Germanium Coaxial Well Detector
Model GWL-110210-PWS-S, 23% Efficiency
(EG&G ORTEC, Oak Ridge, TN)

used in conjuction 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
ND66/680 System
(Nuclear Data, Schaumburg, IL)

APPENDIX B

MEASUREMENT AND ANALYTICAL PROCEDURES

APPENDIX B

Measurement and Analytical Procedures

Alpha and Beta-gamma Measurements

Measurements of total alpha radiation levels 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 (dpm/100 cm^2) by dividing the net rate by the 4π efficiency and correcting for the active area of the detector. Effective window areas were 59 cm^2 for the ZnS detectors and 15 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 40 cpm for the G-M detectors.

Surface Scans

Surface scans in the facility were performed by passing the probes slowly over the surface. The distance between the probe and the surface was maintained at a minimum - nominally about 1 cm. 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 is 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 2220 scaler/ratemeter.

Exposure Rate Measurement

Walkover surface scans and measurements of gamma exposure rates were performed using Eberline Model PRM-6 portable ratemeters with Victoreen Model 489-55 gamma scintillation probes, containing 3.2 cm x 3.8 cm NaI(Tl) scintillation probes. Count rates were converted to exposure rates (μR/h) by onsite cross-calibration with a Reuter-Stokes Model RSS-111 pressurized ionization chamber (PIC).

Removable Contamination Measurements

Smear measurements were performed using numbered filter paper disks, 47 mm in diameter. Smears were sealed in labeled envelopes with the location and other pertinent information recorded. The smears were returned to Oak Ridge and evaluated using a low-background alpha-beta proportional system.

Soil Sample Analysis

Gamma Spectrometry

The soil sample was 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 weight was determined and the sample counted using 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. The 0.094 MeV energy peak from Th-234 used for determination of the U-238 concentration (secular equilbrium was assumed). The spectra were also reviewed for the presence of other radionuclides.

Uncertainties and Detection Limits

The uncertainties associated with the analytical data presented in the tables of this report, represent the 95% (2σ) 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 capability of the measurement procedure. Because of variations in backgrounds and in Compton contributions from other radionuclides in the samples, the detection sensitivities for specific radionuclides may differ from sample to sample and instrument to instrument. Additional uncertainties of ± 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 the following manuals, developed specifically for the Oak Ridge Associated Universities' Radiological Site Assessment Program: "Survey Procedures Manual", Revision 3, May 1987; "Laboratory Procedures Manual", Revision 3, May 1987 and "Quality Assurance Manual", Revision 1, June 1987.

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

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

APPENDIX C

CRITERIA APPLICABLE TO THE ILLINOIS NATIONAL GUARD ARMORY

APPENDIX C

Criteria Applicable to the Illinois National Guard Armory

The Department of Energy's radiological criteria for remedial action are presented in the "U.S. Department of Energy Guidelines for Residual Radioactivity at Formerly Utilized Sites Remedial Action Program and Remote Surplus Facilities Management Program Sites" Revision 2, March 1987.[2] The portions of those guidelines applicable to the site are:

1. Building Surfaces

   a. Total uranium surface contamination of 5,000 α dpm/100 cm^2 averaged over an area not exceeding 1 m^2, with a maximum of 15,000 α dpm/100 cm^2 in areas of not more than 100 cm^2.

   b. Removable uranium contamination of 1,000 α dpm/100 cm^2.

   c. 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 mg/cm^2 of total absorber.

2. Direct Radiation

   External direct gamma radiation levels should be such that, under reasonable conditions of site use and occupancy, an individual would not receive a dose equivalent in excess of 100 mrem/y above background.

A site specific uranium concentration guide for soil was developed for the Armory site by Argonne National Laboratory.[8] This guideline is 150 pCi/g of U-238 per gram of dry soil (approximately 300 pCi/g of total U per gram of soil, based on equal activities of U-238 and U-234, i.e., naturally occuring abundancies).

Exhibit II (8) - State, County, and Local Comments on Remedial Action

The State of Illinois was kept fully informed of all DOE activities in connection with remedial action performed at the NGA. Communication was maintained with the Illinois Department of Nuclear Safety during the development of a site-specific remedial action guideline for uranium in soil.

Exhibit II (9) - Restrictions

There are no radiologically based restrictions on use of the subject site following the completion of remedial action under FUSRAP.

Exhibit II (10) - Federal Register Notice

This section contains the text of the Federal Register notice that was approved by DOE for publication in the Federal Register. It documents the certification that the subject property has no radiological restrictions on its use.

6450-01

DEPARTMENT OF ENERGY

OFFICE OF NUCLEAR ENERGY

Certification of the Radiological Condition of the National Guard Armory in Chicago, Illinois

AGENCY: Office of Remedial Action and Waste Technology, Department of Energy

ACTION: Notice of Certification

SUMMARY: The Department of Energy has completed radiological surveys and taken remedial action to decontaminate the National Guard Armory in Chicago, Illinois. The site was found to contain quantities of radioactive material remaining from wartime activities conducted at the site by the Manhattan Engineer District/Atomic Energy Commission.

FOR FURTHER INFORMATION CONTACT:

James J. Fiore
Division of Facility and Site Decommissioning Projects
Office of Remedial Action and Waste Technology
U.S. Department of Energy
Washington, D.C. 20545

(301) 353-5272

SUPPLEMENTARY INFORMATION:

The Department of Energy (DOE), Office of Nuclear Energy, Office of Remedial Action and Waste Technology, Division of Facility and Site Decommissioning Projects, has implemented a remedial action project at the National Guard Armory (NGA) in the Chicago, Illinois area as part of the Formerly Utilized Sites Remedial Action Program (FUSRAP), which was initiated by the United States Government in 1974 to identify, clean up, or otherwise control sites where residual radioactive material (exceeding current guidelines) remains from the early years of the nation's atomic energy program or from commercial operations causing conditions that Congress has mandated DOE to remedy.

The NGA was used beginning in March 1942 by the Manhattan project when space shortages occurred at the University of Chicago. The Atomic Energy Commission (AEC), which succeeded the MED, ceased use of the NGA in 1951.

Available information indicates that the NGA was utilized to store and process uranium metal. The building was the shipping and central procurement location for the Metallurgical Laboratory in 1943, and records indicate that uranium metal stock was received and temporarily stored at the NGA in 1944.

Apparently, the armory storeroom was used to store grinding wastes and uranium shavings, because one of the uranium fires in the armory occurred in the northeast corner of this room.

In 1987, the subject property was decontaminated. The post-remedial action survey has demonstrated and DOE has certified that radiological conditions at the affected property are consistent with applicable criteria and that use of the property presents no radiological hazard to the general public or to site occupants. These findings are supported by the DOE Certification Docket for the Remedial Action Performed at National Guard Armory in Chicago, Illinois from April 1987 to June 1987. Accordingly, this property is released from the Formerly Utilized Sites Remedial Action Program.

The certification docket will be available for review between 9:00 a.m. and 4:00 p.m., Monday through Friday (except on Federal holidays), in the Department of Energy Public Reading room located in Room 1E-190 of the Forrestal Building, 1000 Independence Avenue, SW, Washington, D.C. The certification docket will also be available in the Public Document Room, U.S. Department of Energy, Chicago Operations Office, 9800 S. Cass Avenue, Argonne, Illinois; and in the Public Document Room, U.S. Department of Energy, Oak Ridge Operations Office, Federal Building, Oak Ridge, Tennessee.

The Department of Energy, through the Oak Ridge Operations Office, Technical Services Division, has issued the following statement:

STATEMENT OF CERTIFICATION: NATIONAL GUARD ARMORY
IN CHICAGO, ILLINOIS

The Oak Ridge Operations Office, Technical Services Division, has reviewed the radiological data obtained following the remedial action at the subject property. Based on this review, DOE has certified that the property is in compliance with all applicable decontamination criteria and standards. This certification of compliance provides assurance that use of the property will result in no radiological exposure above applicable criteria and standards to members of the general public or to occupants of the site. Accordingly, the National Guard Armory property is released from the Formerly Utilized Sites Remedial Action Program.

J.E. Baublitz

Dated: 2/17/89

J.E. Baublitz, Acting Director
Office of Remedial Action
and Waste Technology
Office of Nuclear Energy
U.S. Department of Energy

Exhibit II (11) - Approved Certification Statement

The following statement documents the certification of the subject property.

DOE F 1325.8
(12-84)

United States Government | Department of Energy

memorandum

DATE: FEB 16 1989

REPLY TO ATTN OF: NE-23: Fiore

SUBJECT: Recommendation for Certification of Remedial Action Performed at the National Guard Armory Site in Chicago, Illinois.

TO: J.E. Baublitz, Acting Director
Office of Remedial Action and Waste Technology, NE-20

I am attaching for your signature the Federal Register Notice for the National Guard Armory site in Chicago, Illinois. Also attached is the signed Statement of Certification for this property.

The National Guard Armory was used by the Manhattan Engineer District (MED) to conduct operations beginning in 1942, when adequate space was no longer available at the University of Chicago. By 1951, the Atomic Energy Commission (AEC), successor to the MED, had ceased use of the National Guard Armory. During the MED/AEC era, the site was used for storage of uranium metal stock, uranium shavings, and grinding wastes.

Based on a review of all documents related to this property, we have concluded that it should be certified as being in compliance with criteria and standards established for the National Guard Armory remedial action project. These criteria were established in accordance with DOE guidelines and orders, consistent with other appropriate Nuclear Regulatory Commission and Environmental Protection Agency guidelines, to protect public health and the environment.

The Division of Facility and Site Decommissioning Projects has provided the attached docket to effect the certification of the subject property.

Following your approval of the certification, this office or the Oak Ridge Operations Office will notify interested state and local agencies, the public, local land offices, and the specific property owner of the certification action by correspondence and local newspaper announcements, as appropriate. The documents transmitted with the Statement of Certification and the Federal Register Notice will be compiled in final docket form by the Division of Facility and Site Decommissioning Projects for retention in accordance with DOE Order 1324.2 (Disposal Schedule 25).

J. Fiore

James J. Fiore, Director
Division of Facility and Site
Decommissioning Projects
Office of Nuclear Energy
U.S. Department of Energy

Attachments:
As Stated

STATEMENT OF CERTIFICATION: NATIONAL GUARD ARMORY SITE
IN CHICAGO, ILLINOIS

The U.S. Department of Energy, Oak Ridge Operations Office, Technical Services Division, has reviewed and analyzed the radiological data obtained following remedial action at the National Guard Armory, which was contaminated by uranium materials stored there during the Manhattan Engineer District/Atomic Energy Commission era. Based on this analysis of all data collected, the Department of Energy certifies that the National Guard Armory is in compliance with Department of Energy decontamination criteria and standards developed to protect health, safety, and the environment.

This certification of compliance provides assurance that use of the property will result in no radiological exposure above applicable criteria and standards to members of the general public or to site occupants.

By: _____ Date: 1/31/89

P.J. Gross, Director
Technical Services Division
Oak Ridge Operations Office
U.S. Department of Energy

Exhibit III *Diagrams of the Remedial Action at the National Guard Armory in Chicago, Illinois*

EXHIBIT III

DIAGRAMS OF THE REMEDIAL ACTION

PERFORMED AT THE NATIONAL GUARD ARMORY

IN CHICAGO, ILLINOIS

FROM APRIL 1987 TO JUNE 1987

The figures on the following pages are taken from the post-remedial action report and indicate the areas where remedial action was performed at the NGA.

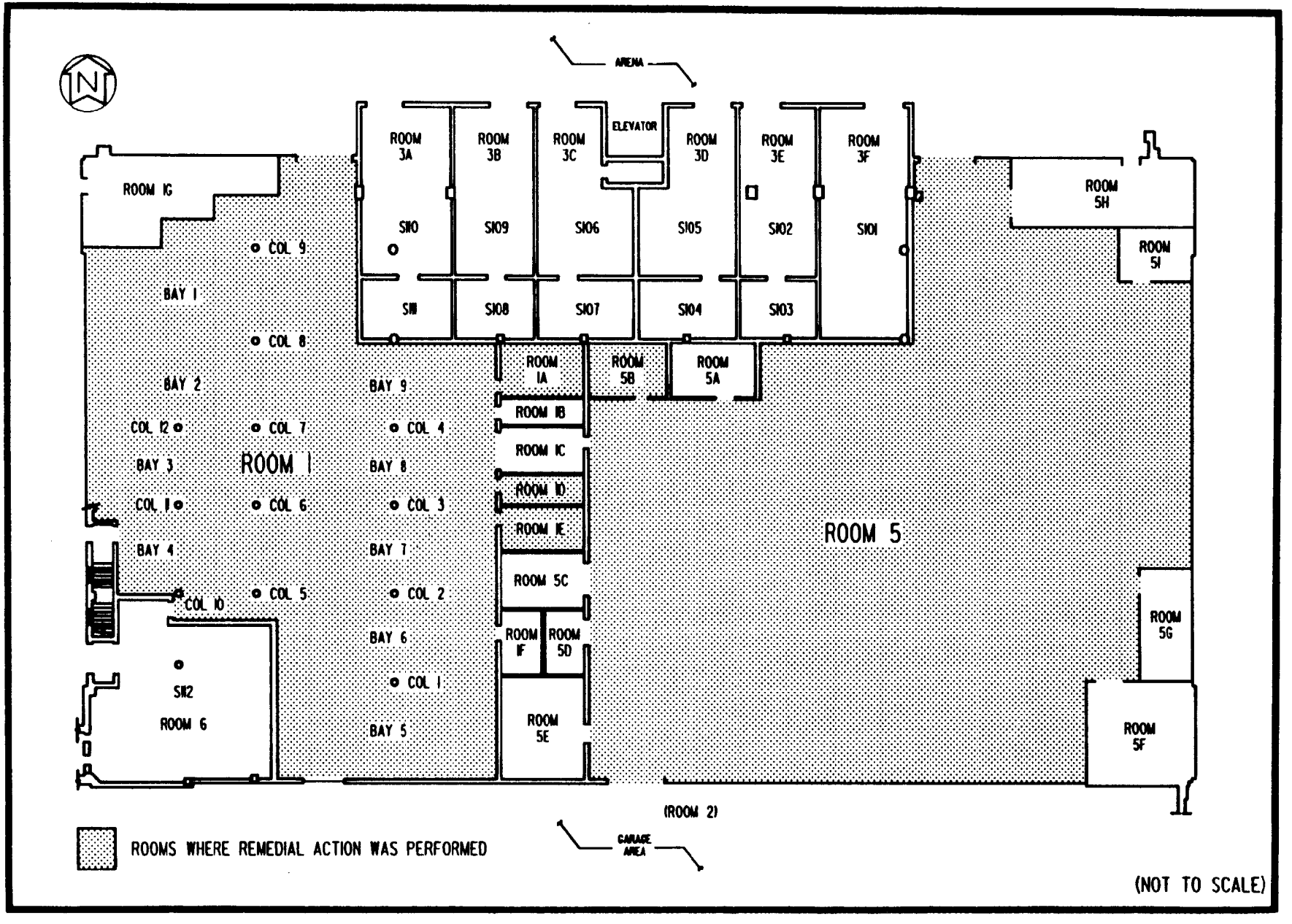


FIGURE 1 THE FIRST FLOOR OF THE SOUTH HEADHOUSE

DGN: [42,7] NI9W9806.DGN JKL

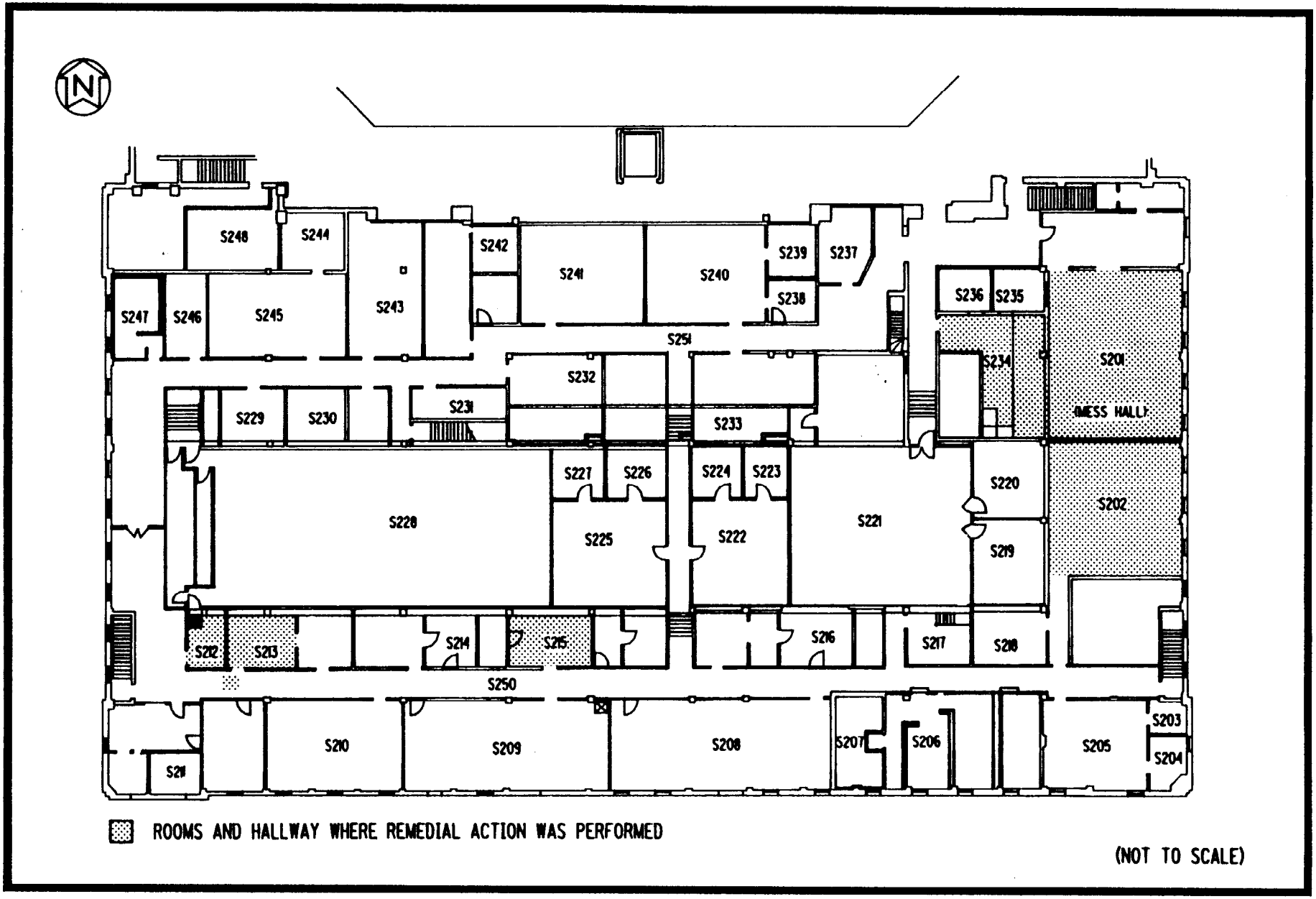


FIGURE 2 THE SECOND FLOOR OF THE SOUTH HEADHOUSE

M19W9807.DGN JKL

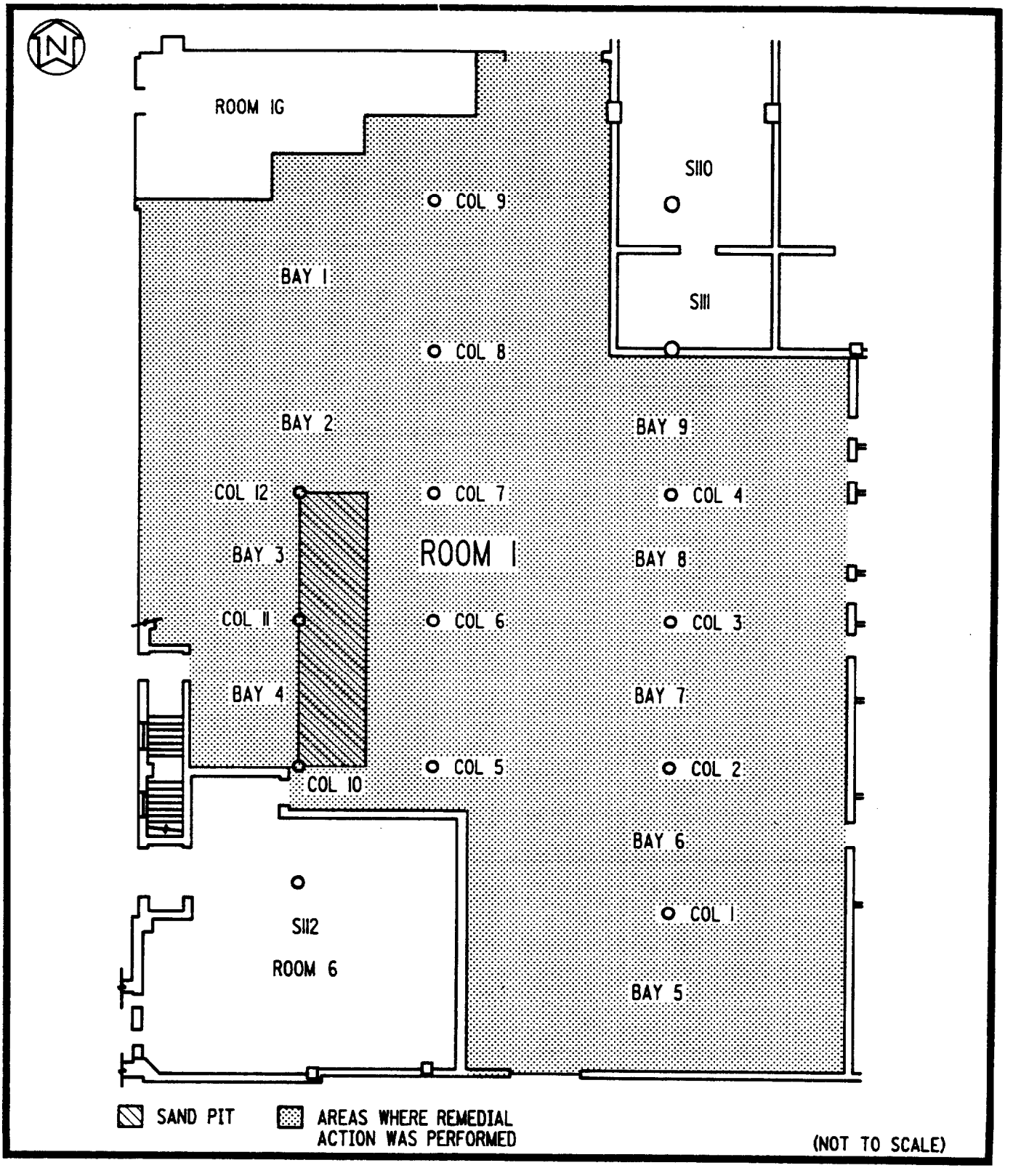


FIGURE 3 NINE-BAY CEILING IN ROOM 1 ON THE FIRST FLOOR OF THE SOUTH HEADHOUSE

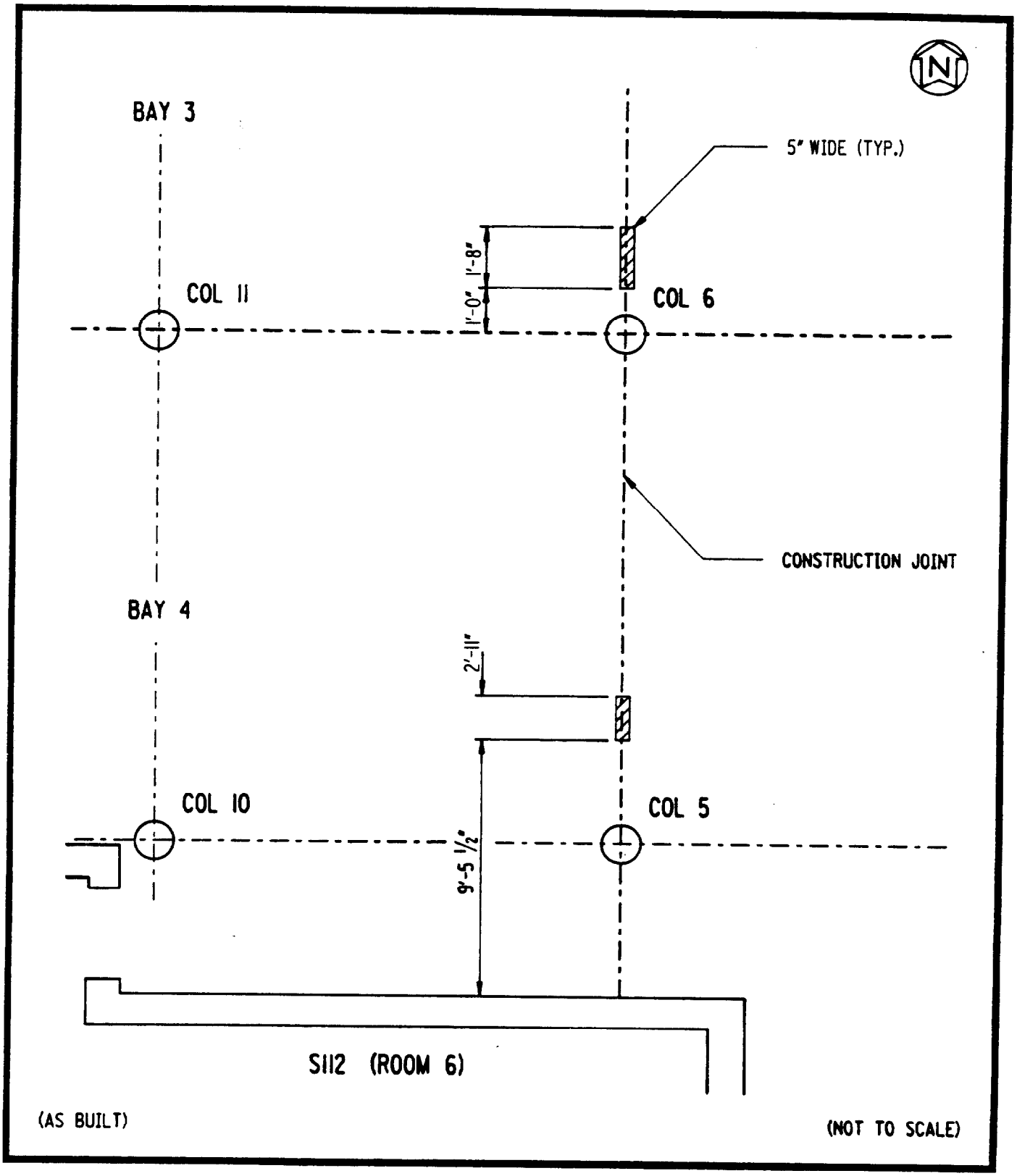


FIGURE 4 ROOM 1—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAYS 3 AND 4

9: [66,42] N19W981.DGN JKL

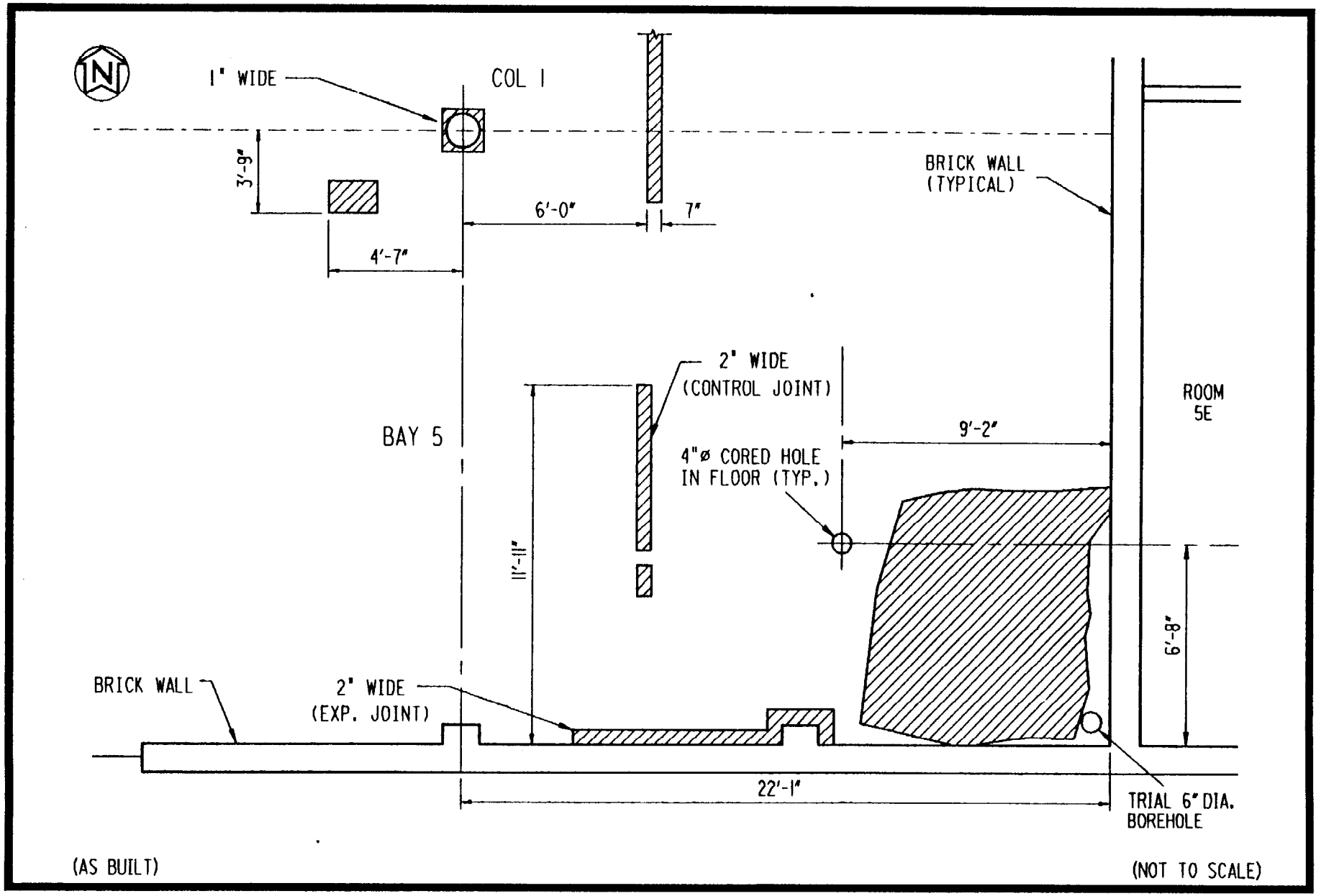
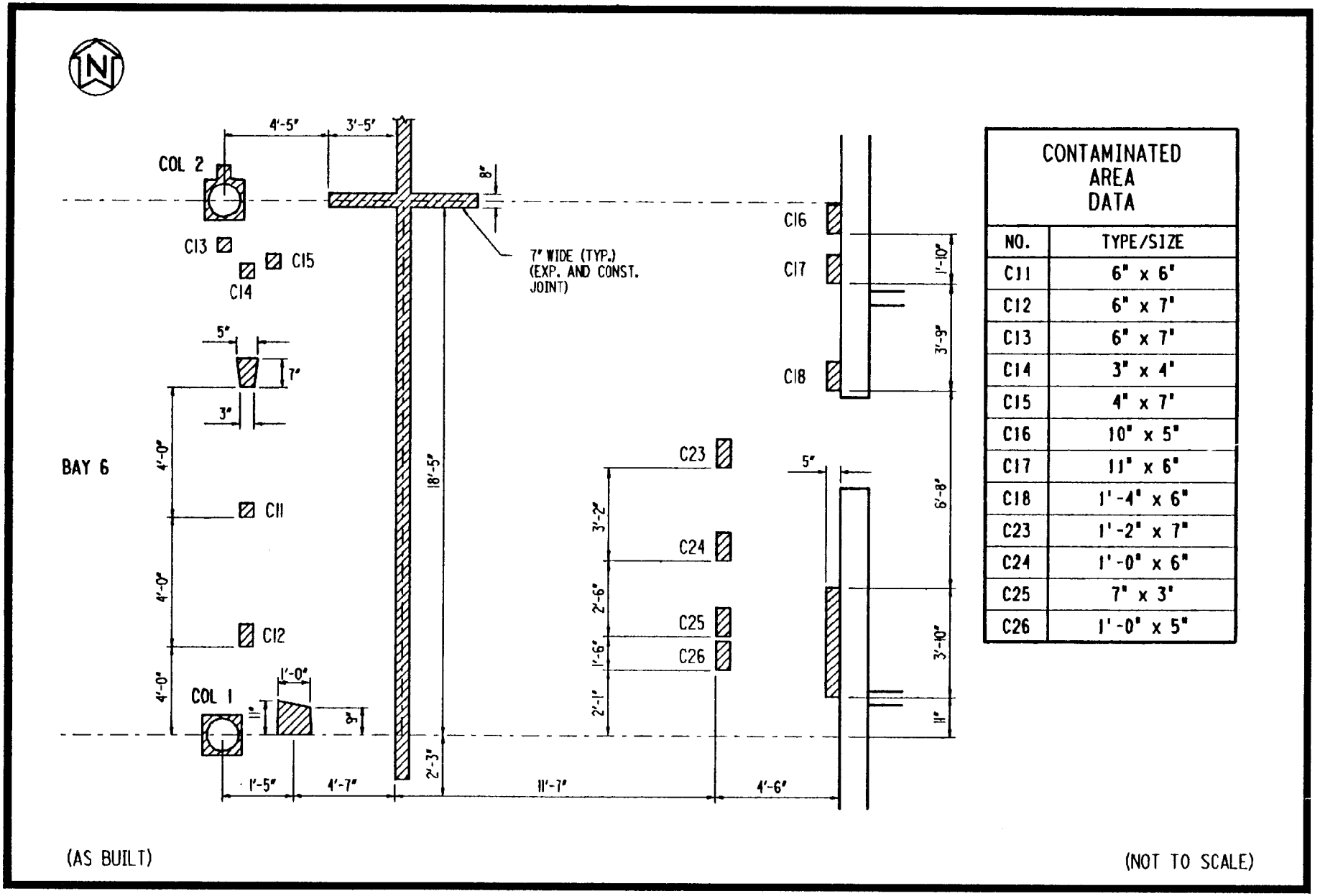


FIGURE 5 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 5



CONTAMINATED AREA DATA	
NO.	TYPE/SIZE
C11	6" x 6"
C12	6" x 7"
C13	6" x 7"
C14	3" x 4"
C15	4" x 7"
C16	10" x 5"
C17	11" x 6"
C18	1'-4" x 6"
C23	1'-2" x 7"
C24	1'-0" x 6"
C25	7" x 3"
C26	1'-0" x 5"

FIGURE 6 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 6

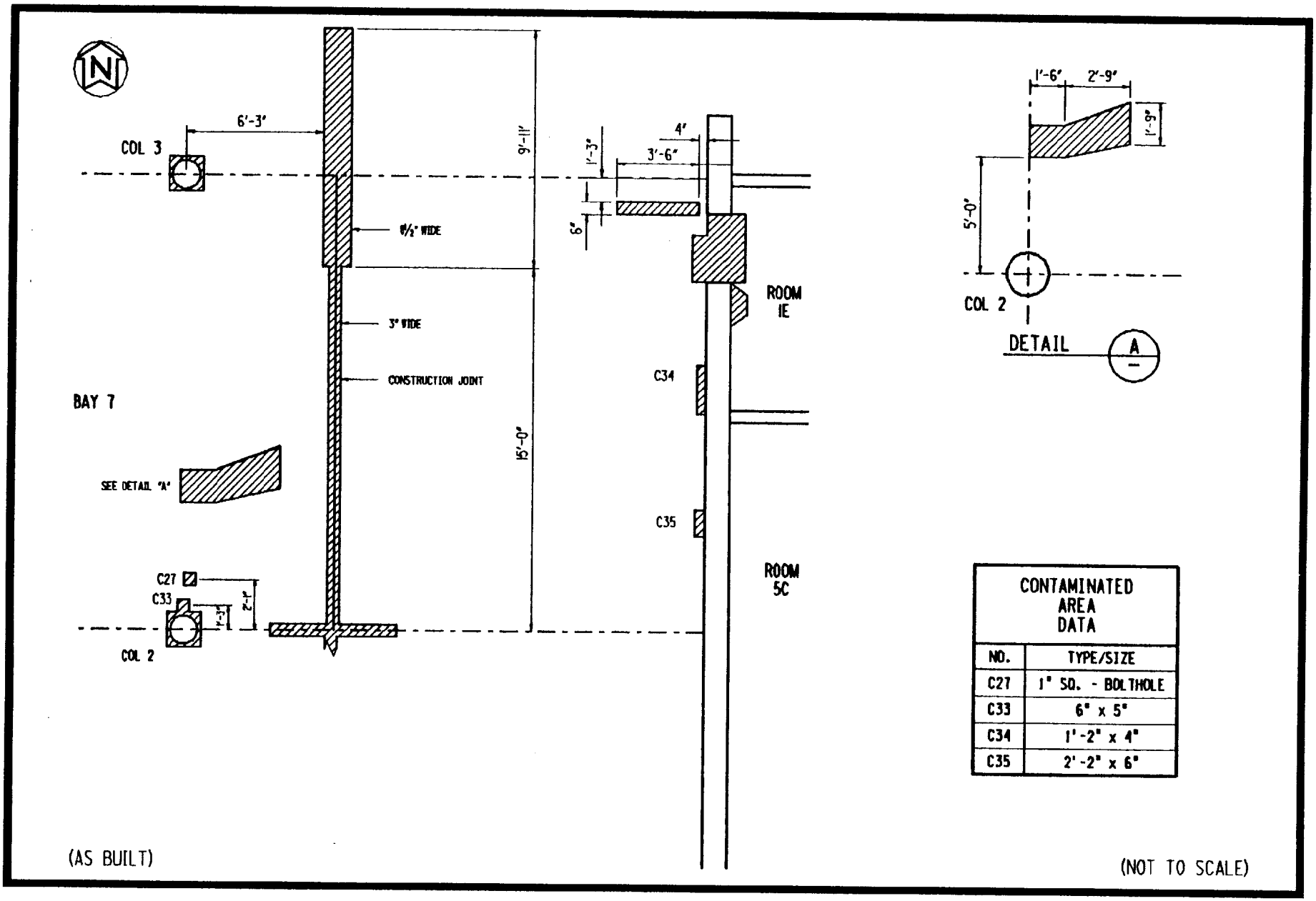


FIGURE 7 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 7

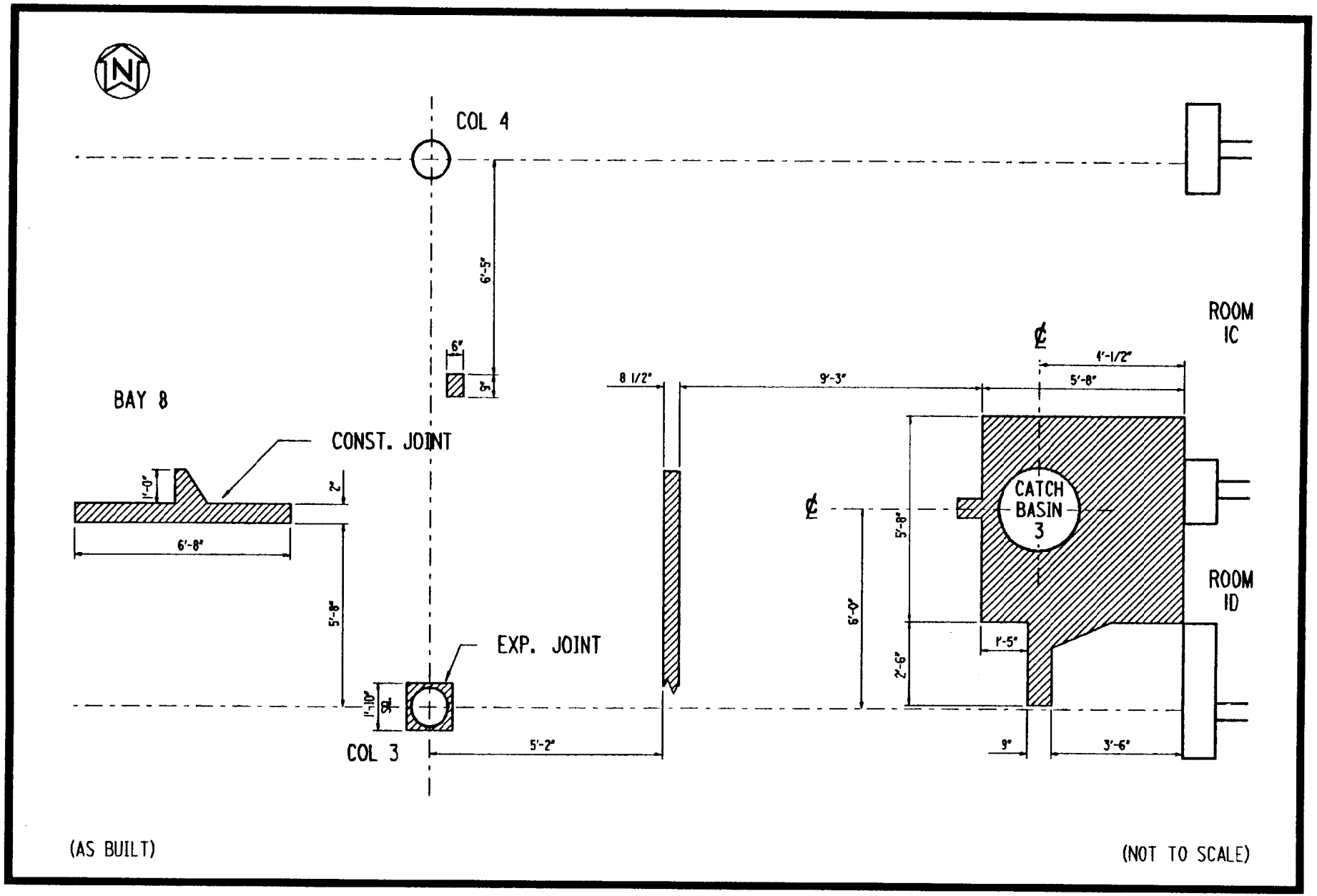


FIGURE 8 ROOM 1 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR IN BAY 8

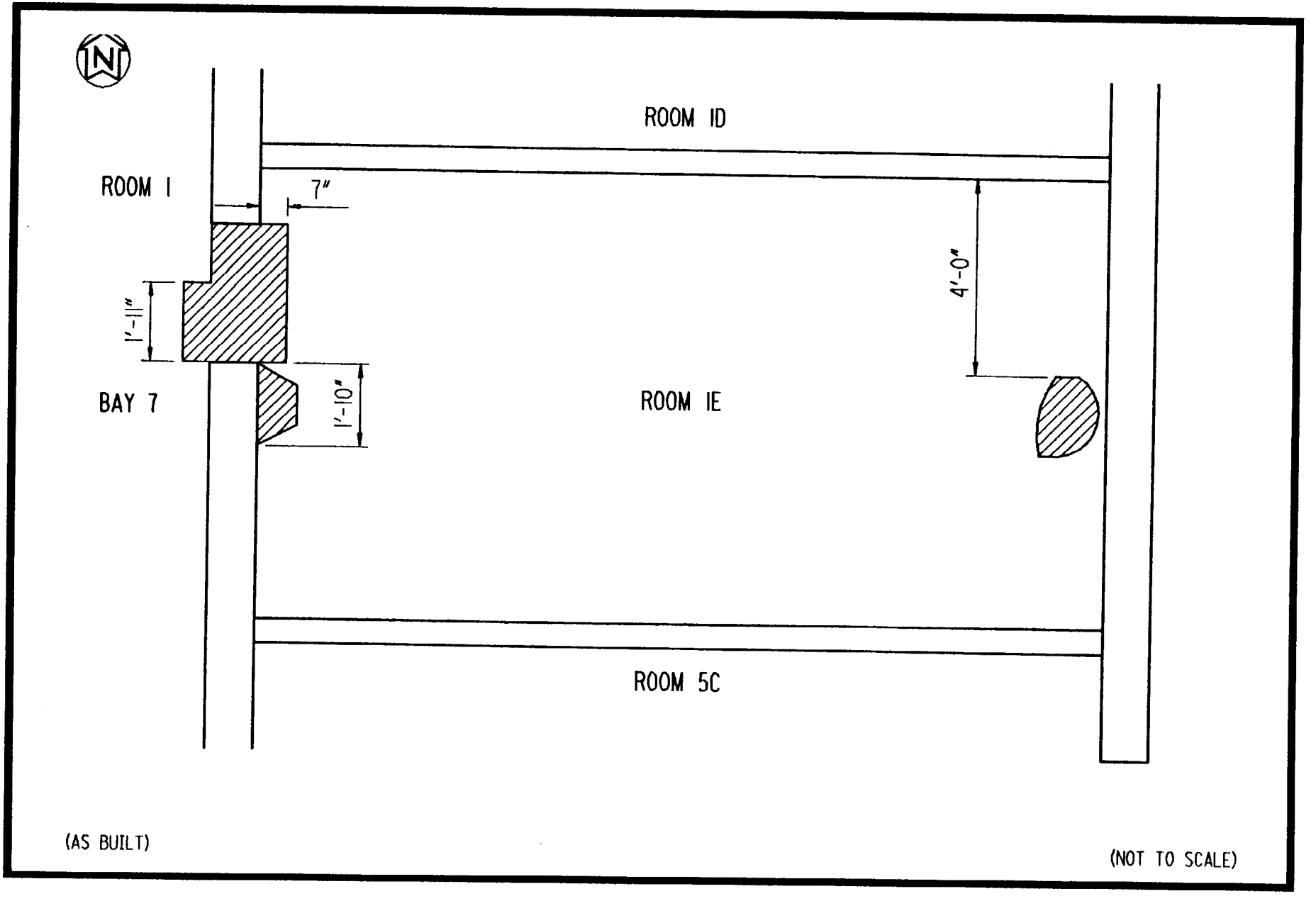


FIGURE 9 ROOMS 1 AND 1E — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

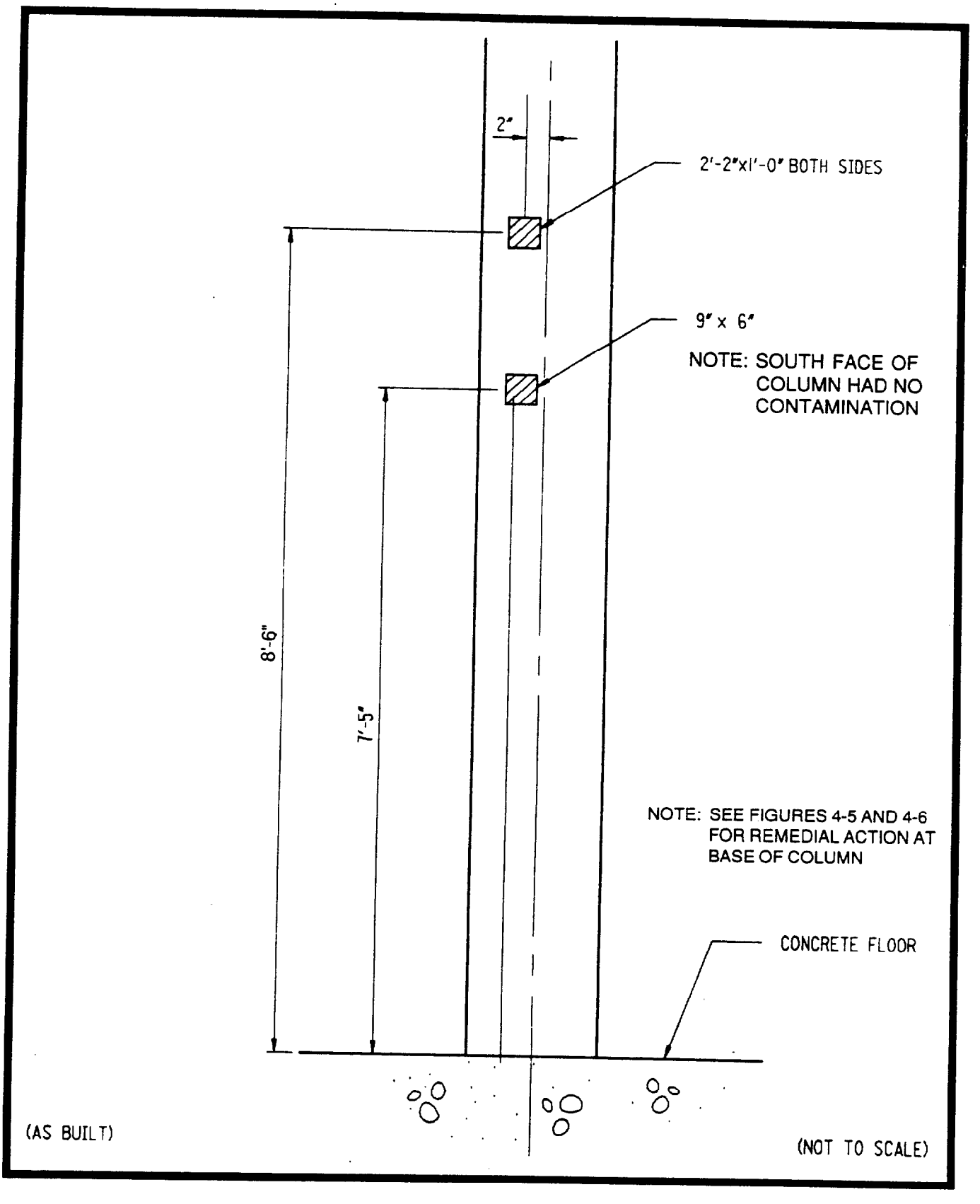


FIGURE 10 ROOM 1—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH FACE OF COLUMN 1

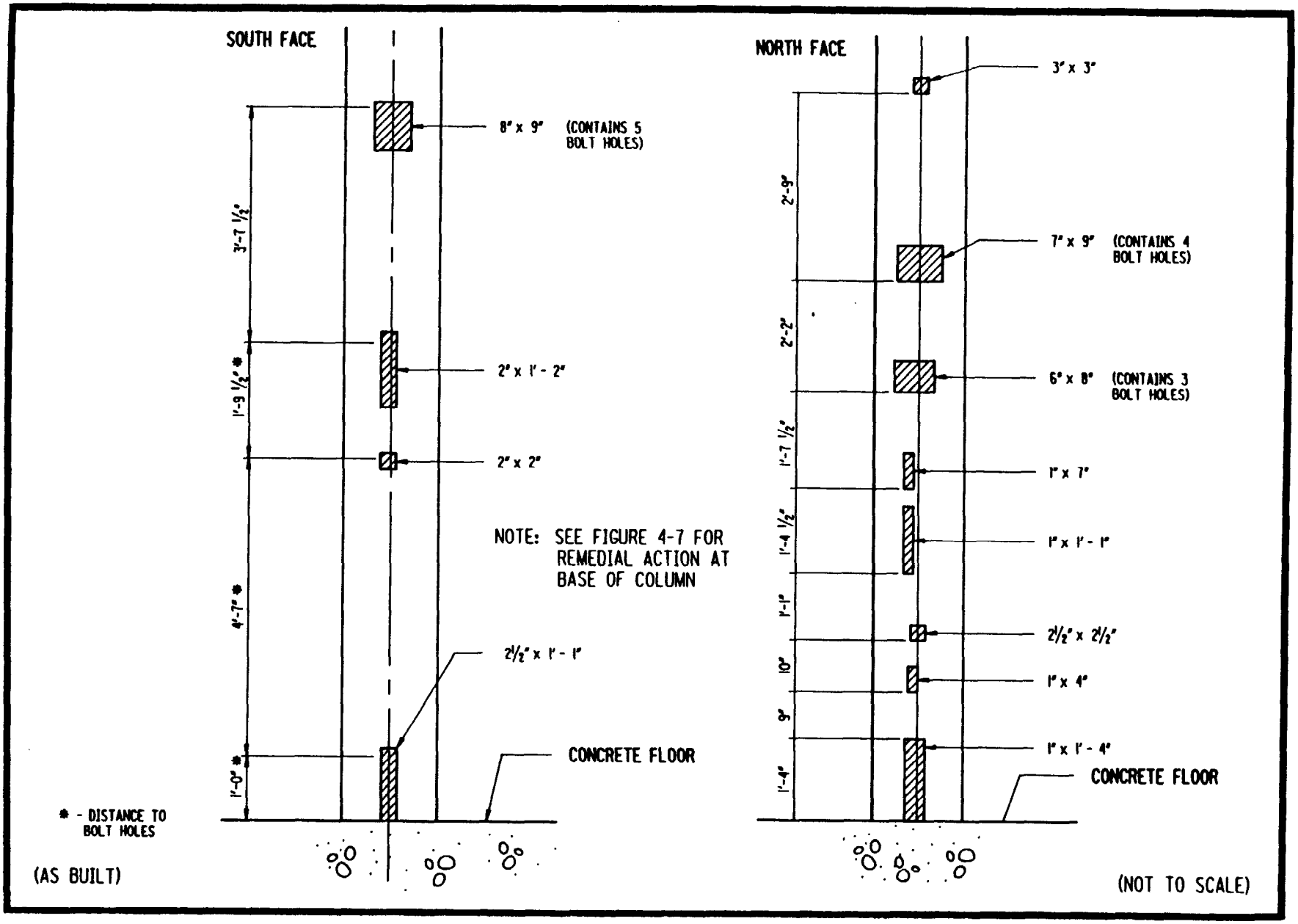
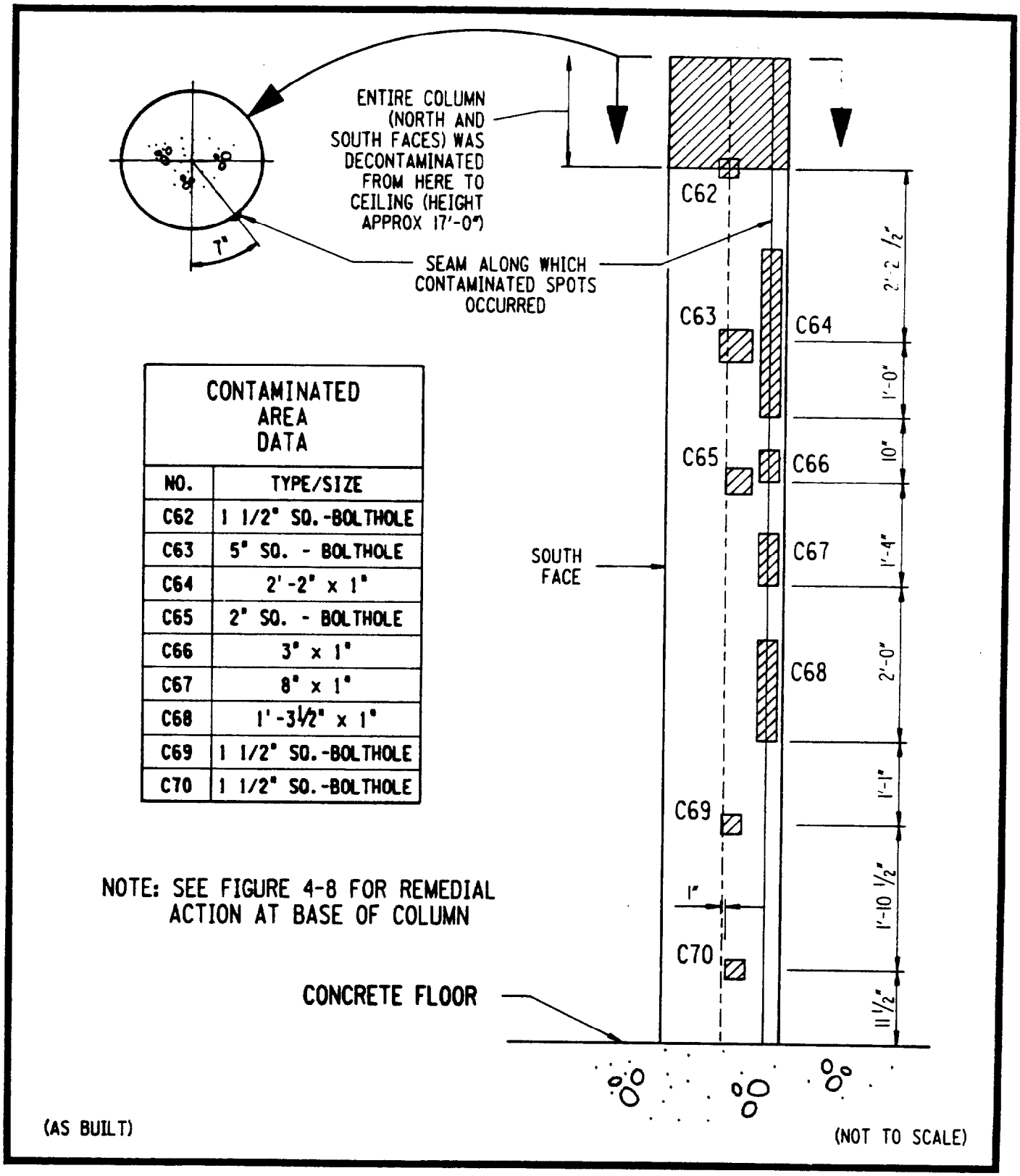


FIGURE 11 ROOM 1—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH AND SOUTH FACES OF COLUMN 2

GRA: (42,7) N19W9811.DGN JKL



CONTAMINATED AREA DATA	
NO.	TYPE/SIZE
C62	1 1/2" SQ.-BOLTHOLE
C63	5" SQ. - BOLTHOLE
C64	2'-2" x 1"
C65	2" SQ. - BOLTHOLE
C66	3" x 1"
C67	8" x 1"
C68	1'-3½" x 1"
C69	1 1/2" SQ.-BOLTHOLE
C70	1 1/2" SQ.-BOLTHOLE

FIGURE 12 ROOM 1—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH AND SOUTH FACES OF COLUMN 3

CRB: [66,42] NI9W981L.DGN JKL

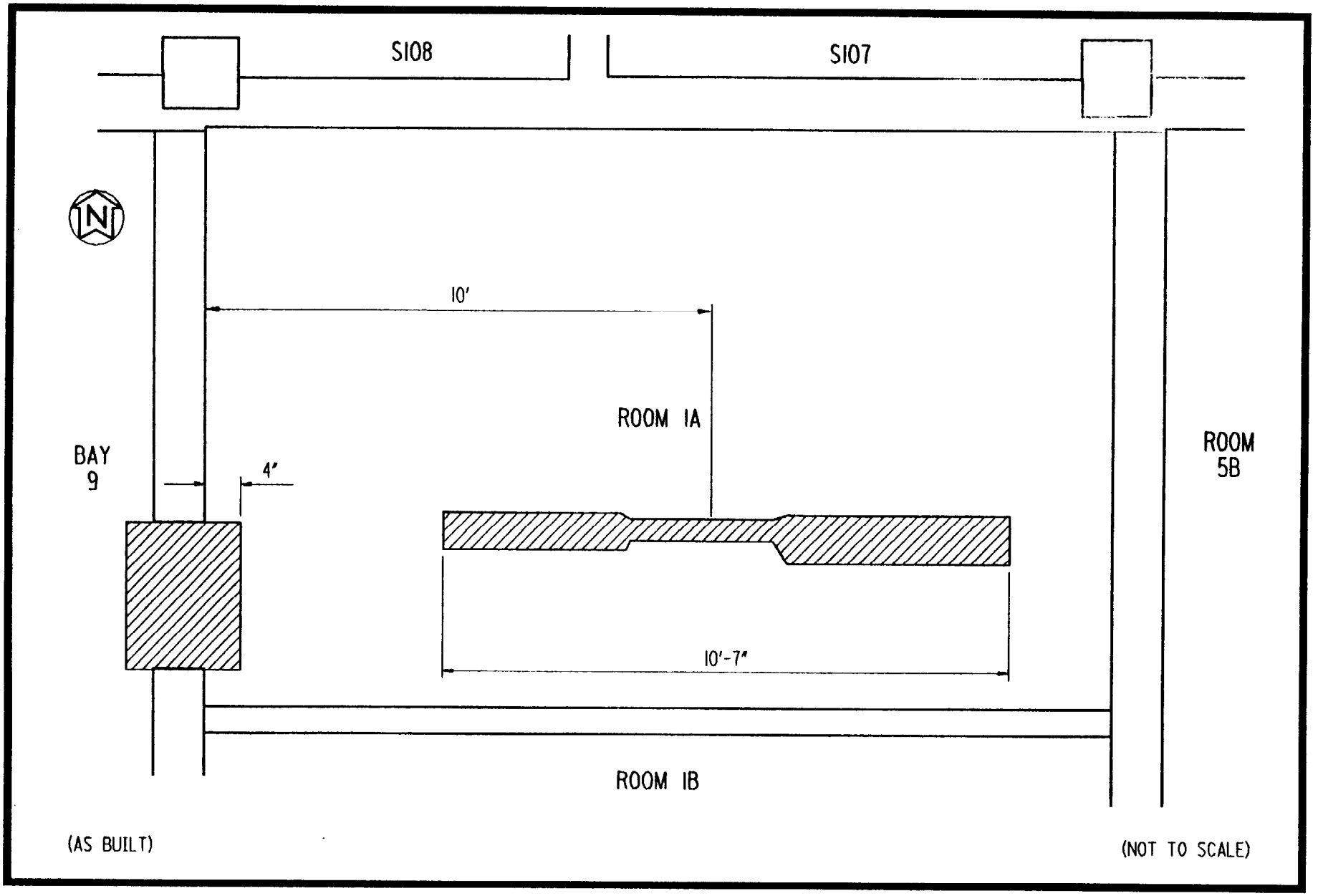


FIGURE 13 ROOM 1A — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

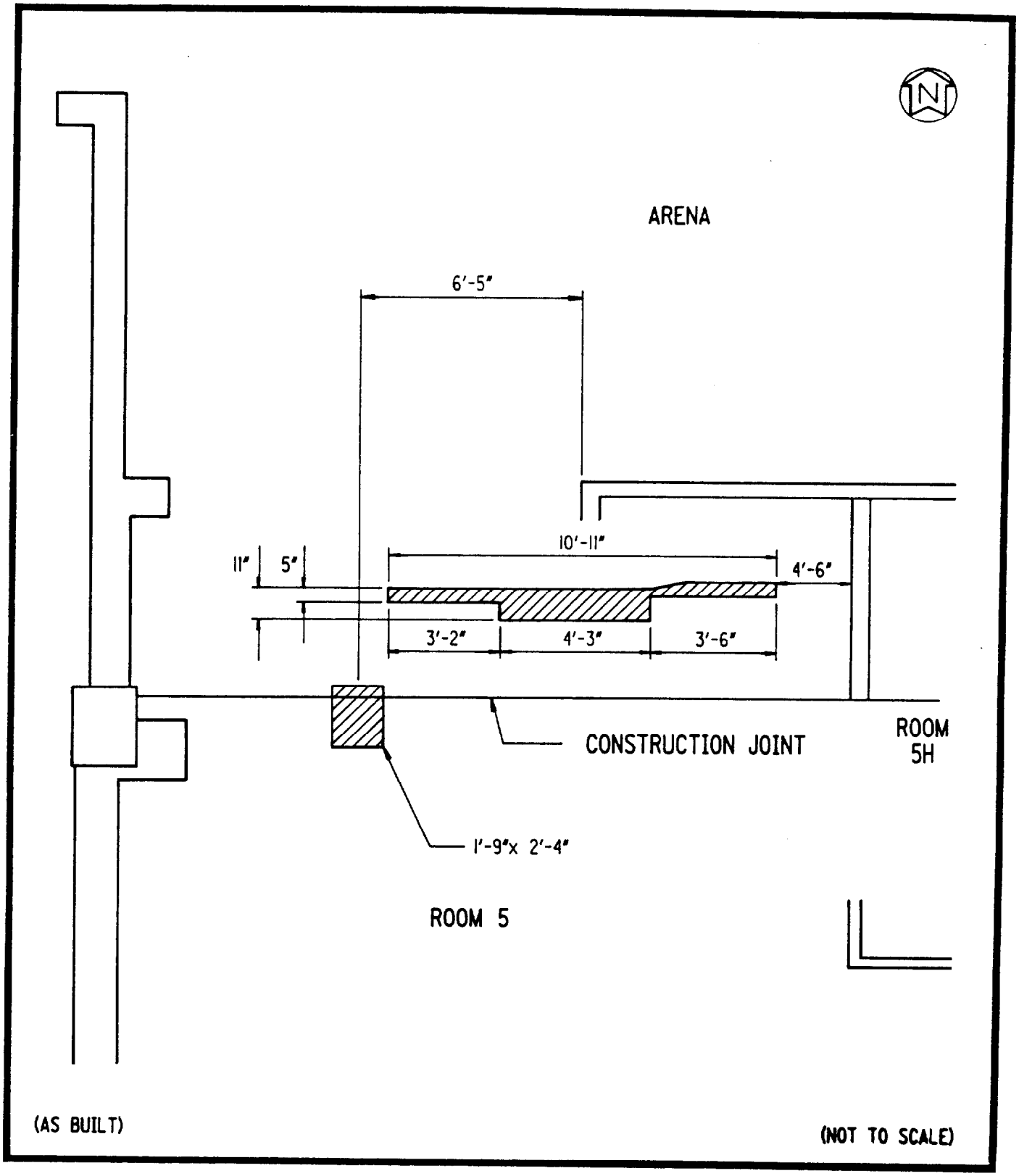


FIGURE 14 ROOM 5—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR NEAR THE ARENA

GRB: [66,42] NI9W981LDGN JKL

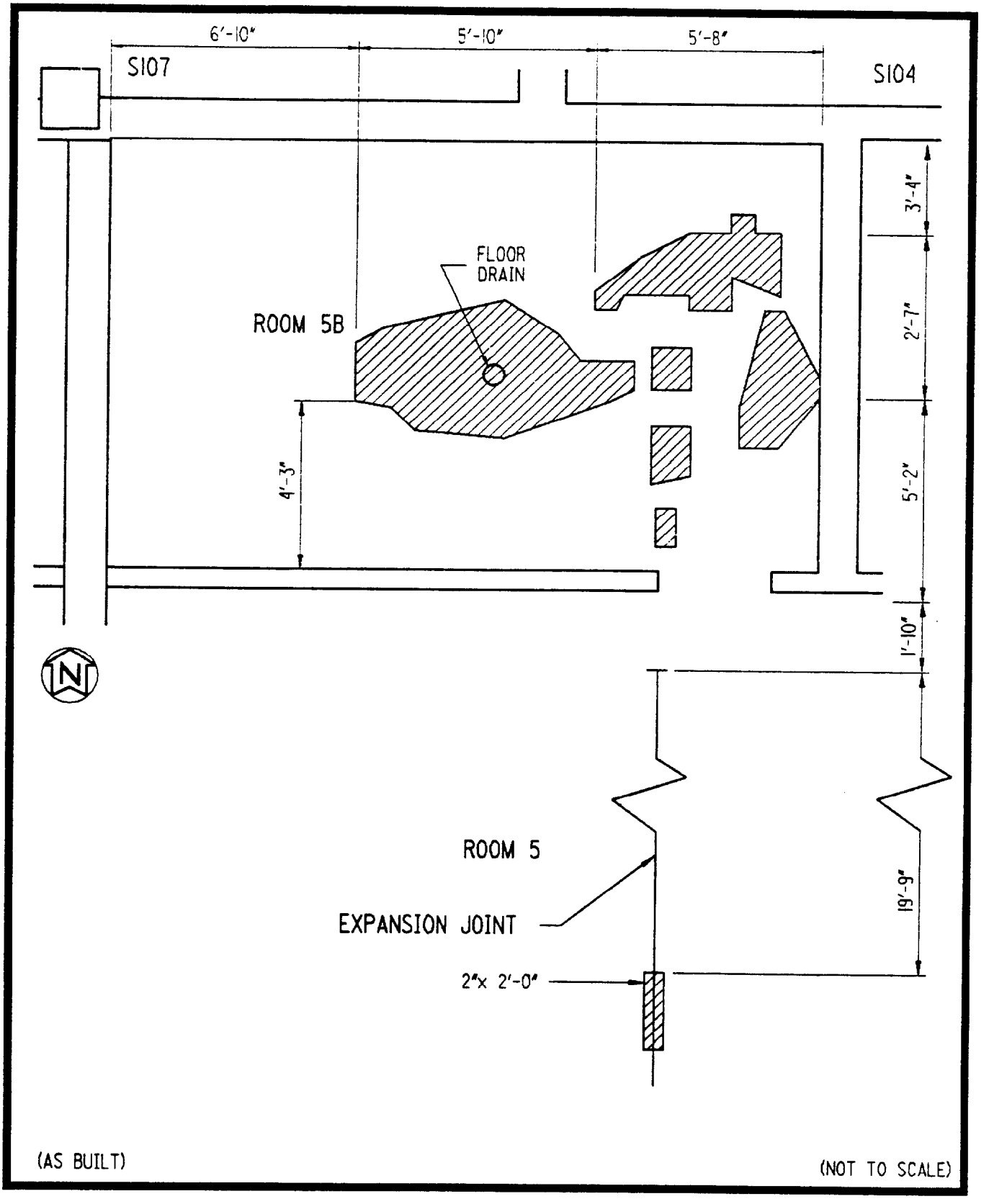


FIGURE 15 ROOMS 5 AND 5B — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

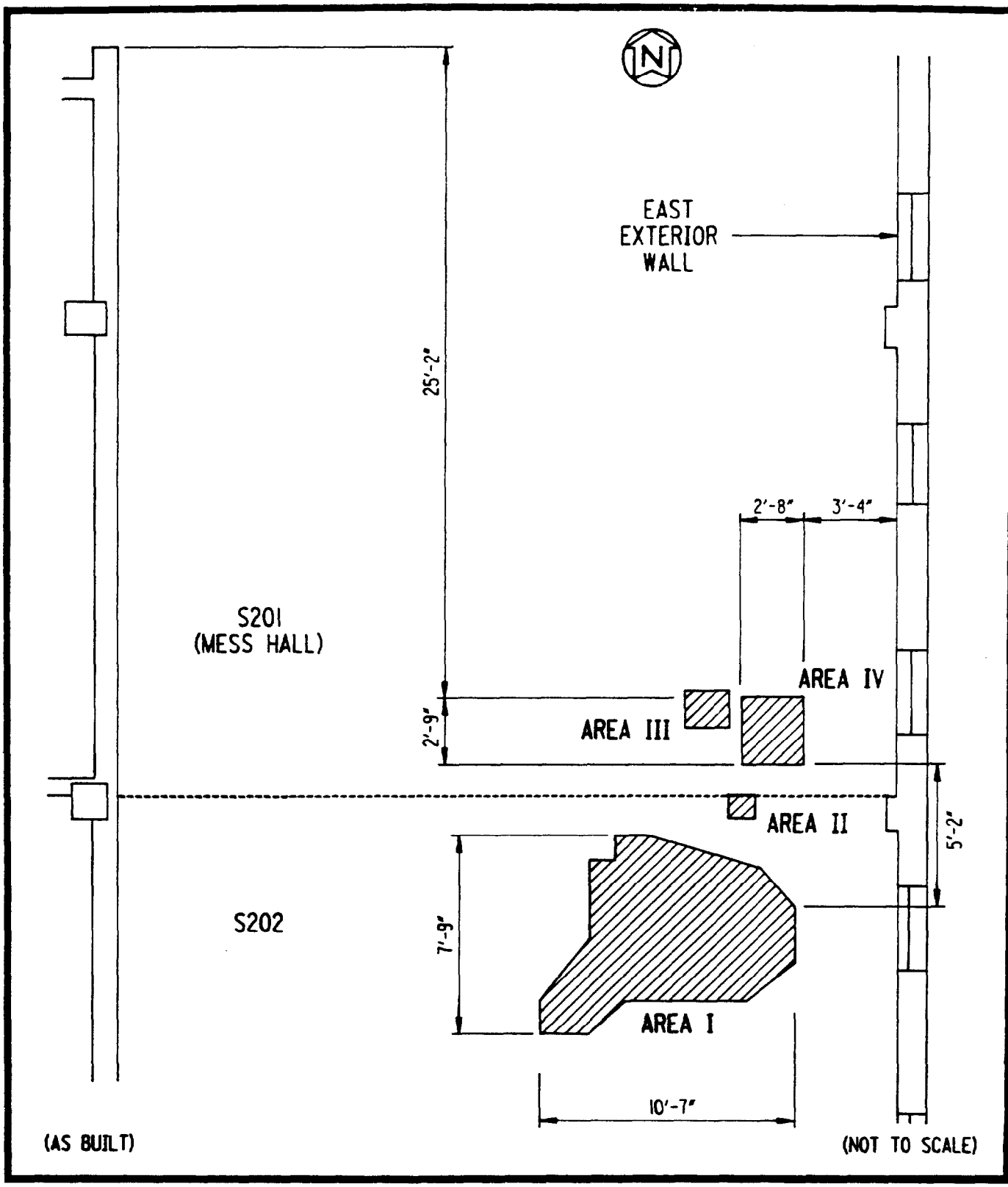


FIGURE 16 ROOMS S201 AND S202—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

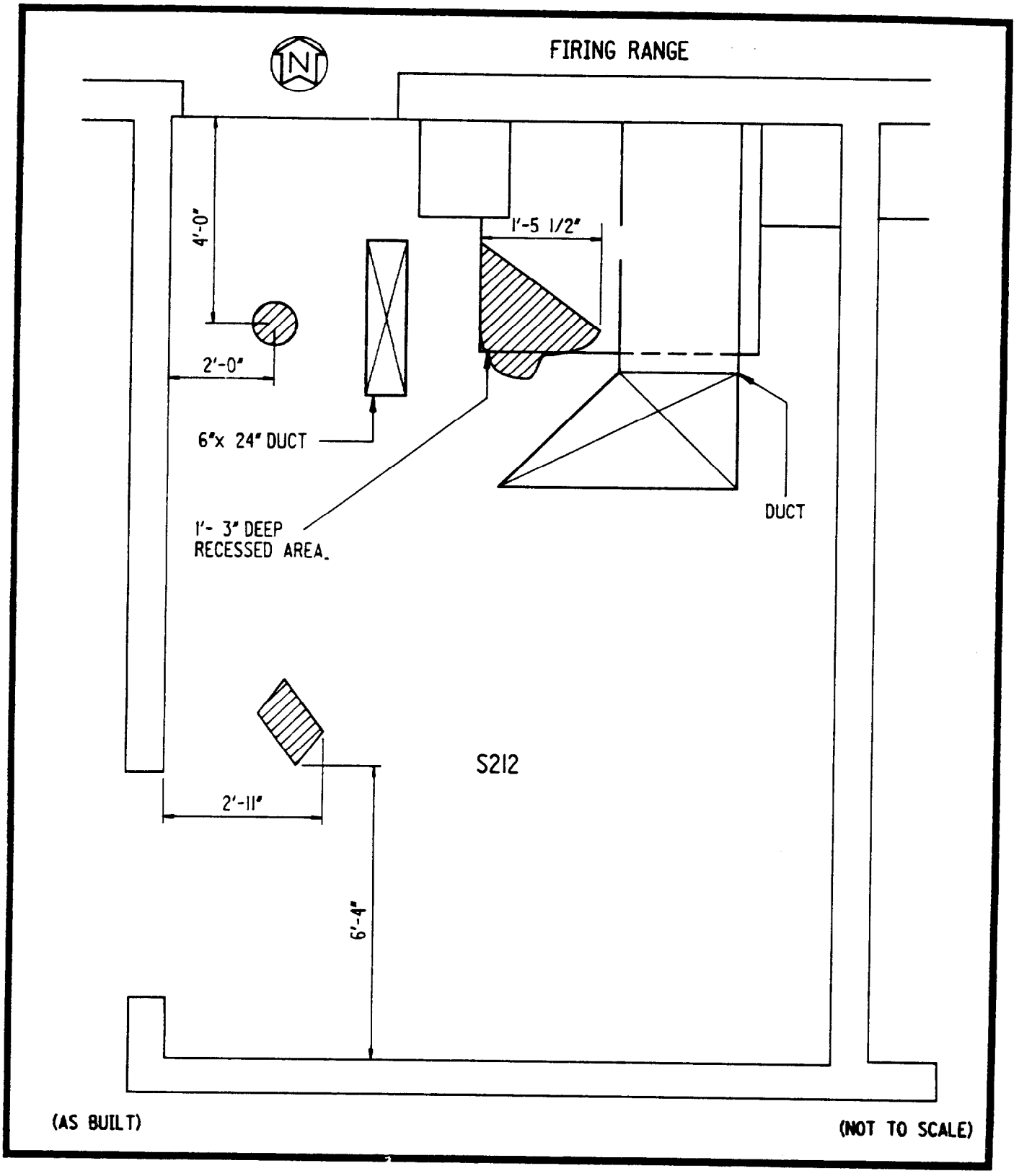


FIGURE 17 ROOM S212—AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE MAIN FLOOR AND THE RECESSED FLOOR

Plot: [42,7] N19T9812.DGN JKL

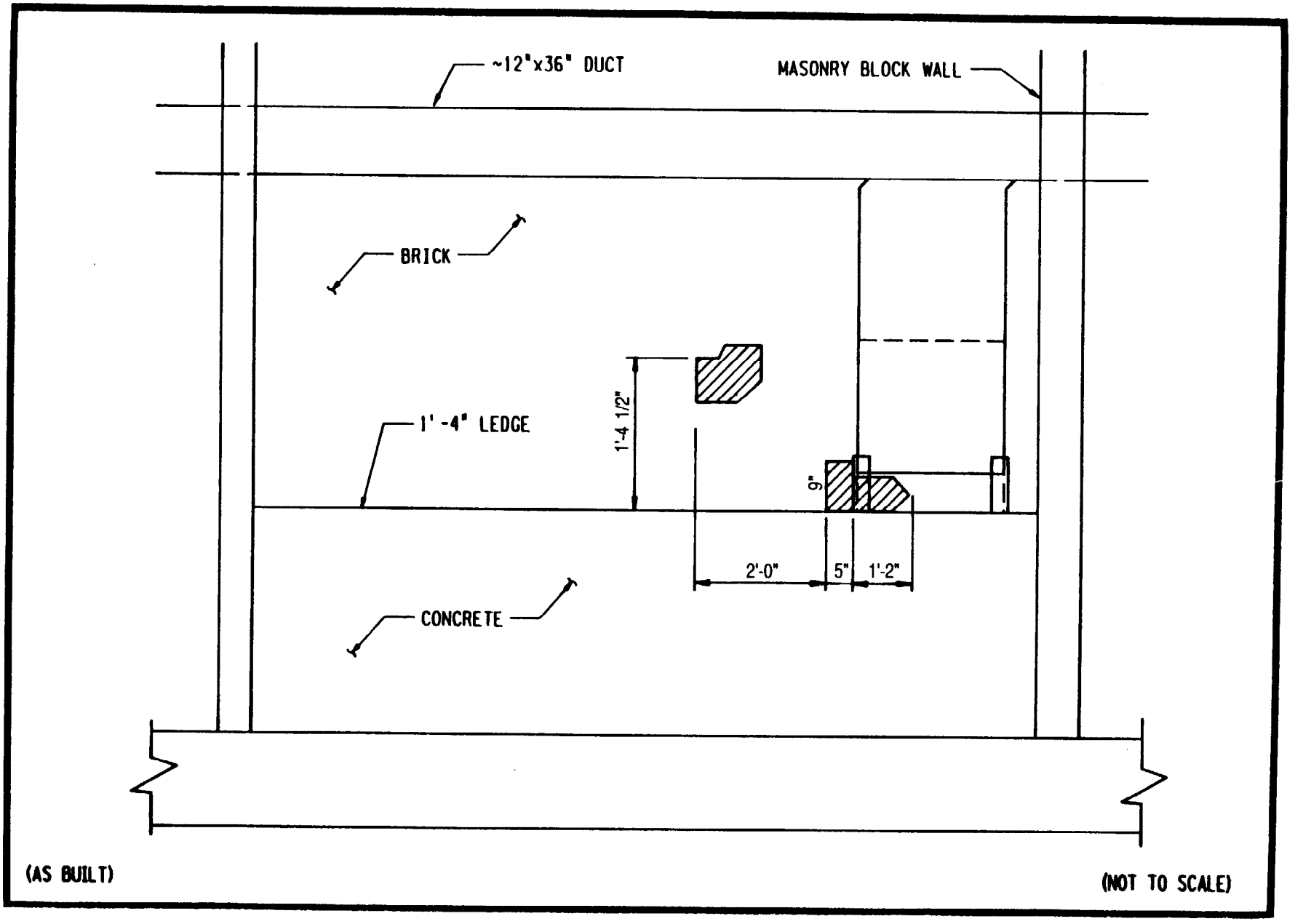


FIGURE 18 ROOM S213 — AREAS WHERE REMEDIAL ACTION WAS PERFORMED ON THE NORTH WALL

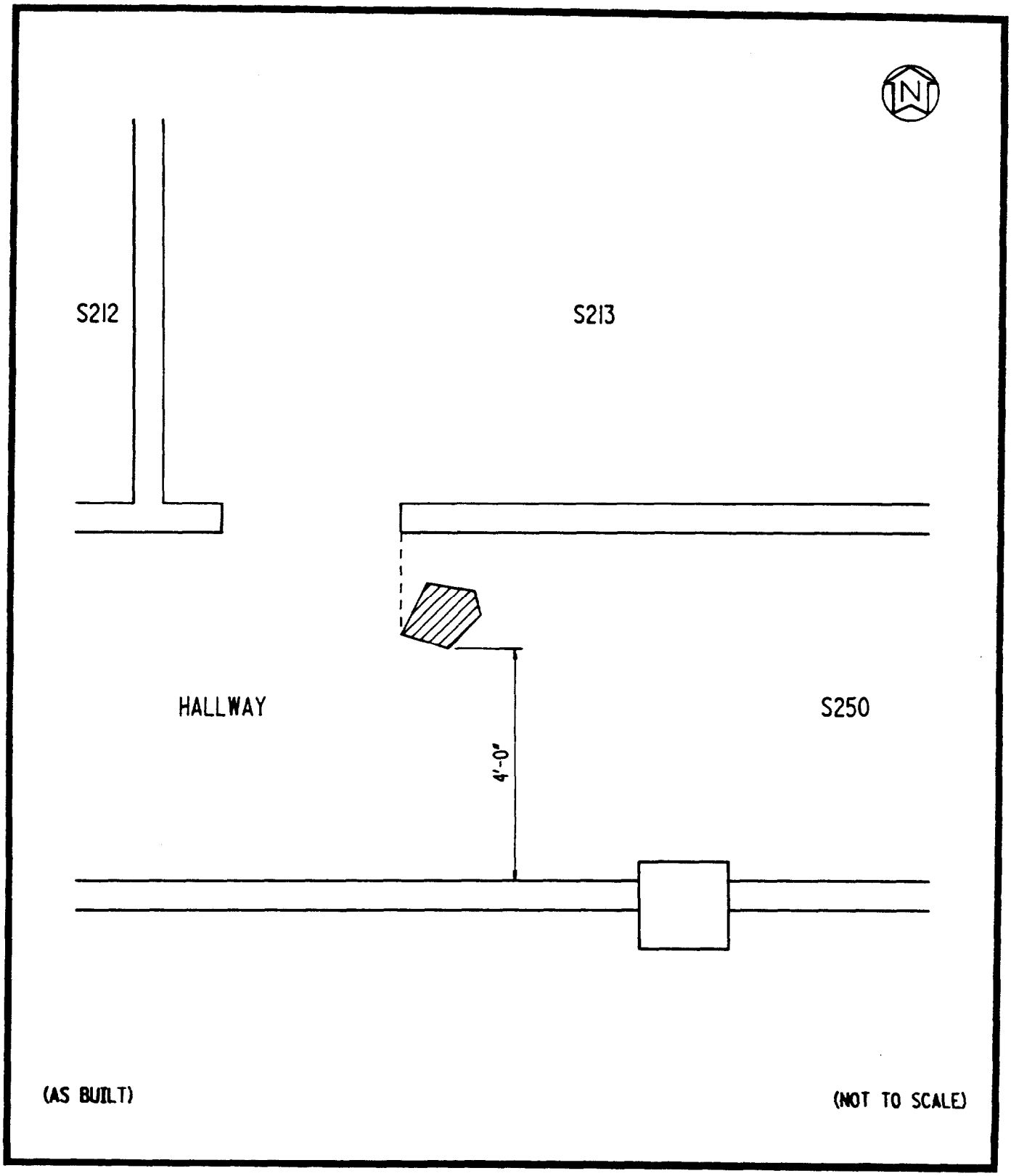


FIGURE 19 HALLWAY OUTSIDE ROOM S213—AREA WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

GRL. .42,TJ N19W9812.DGN JKL

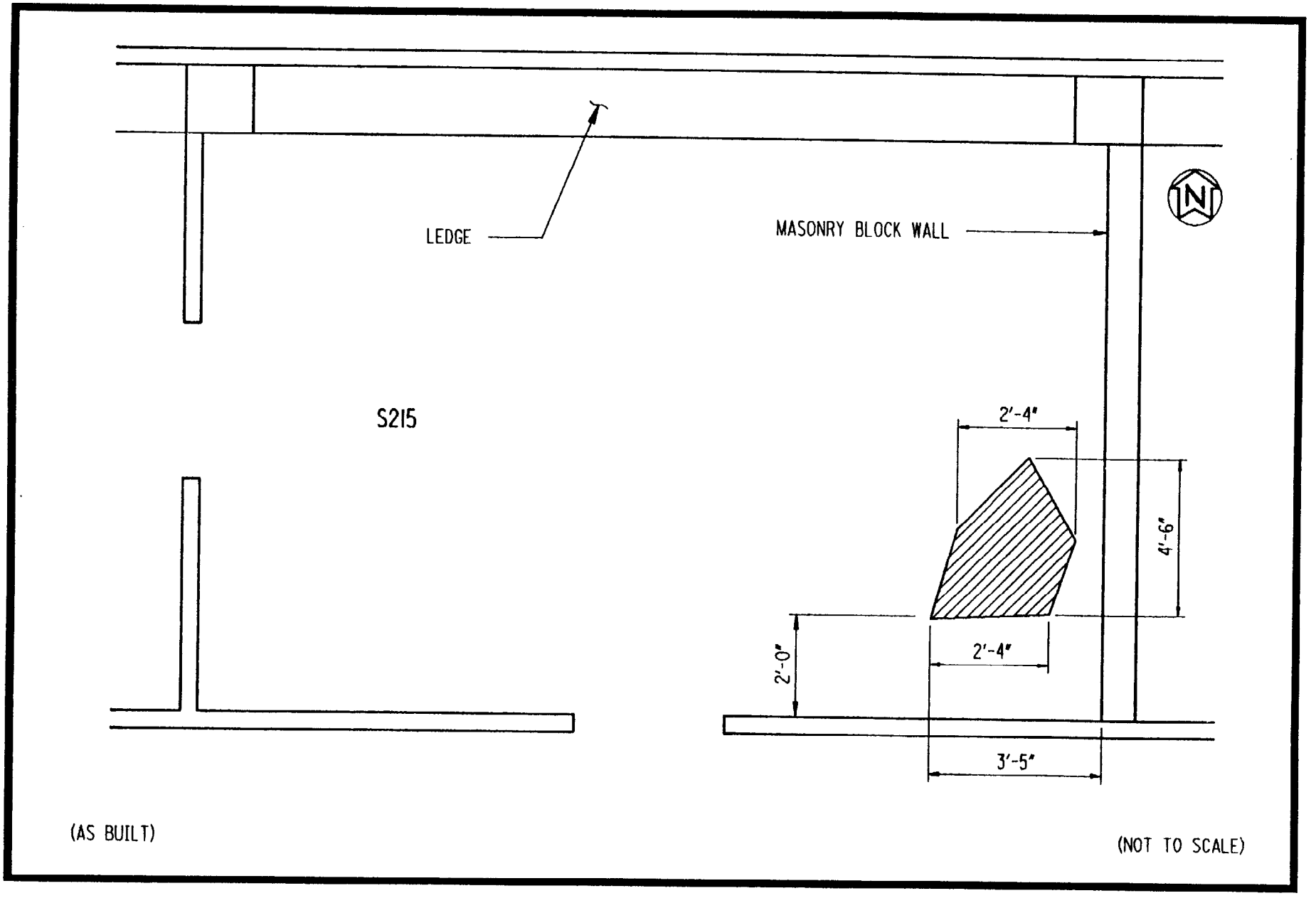


FIGURE 20 ROOM S215 — AREA WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

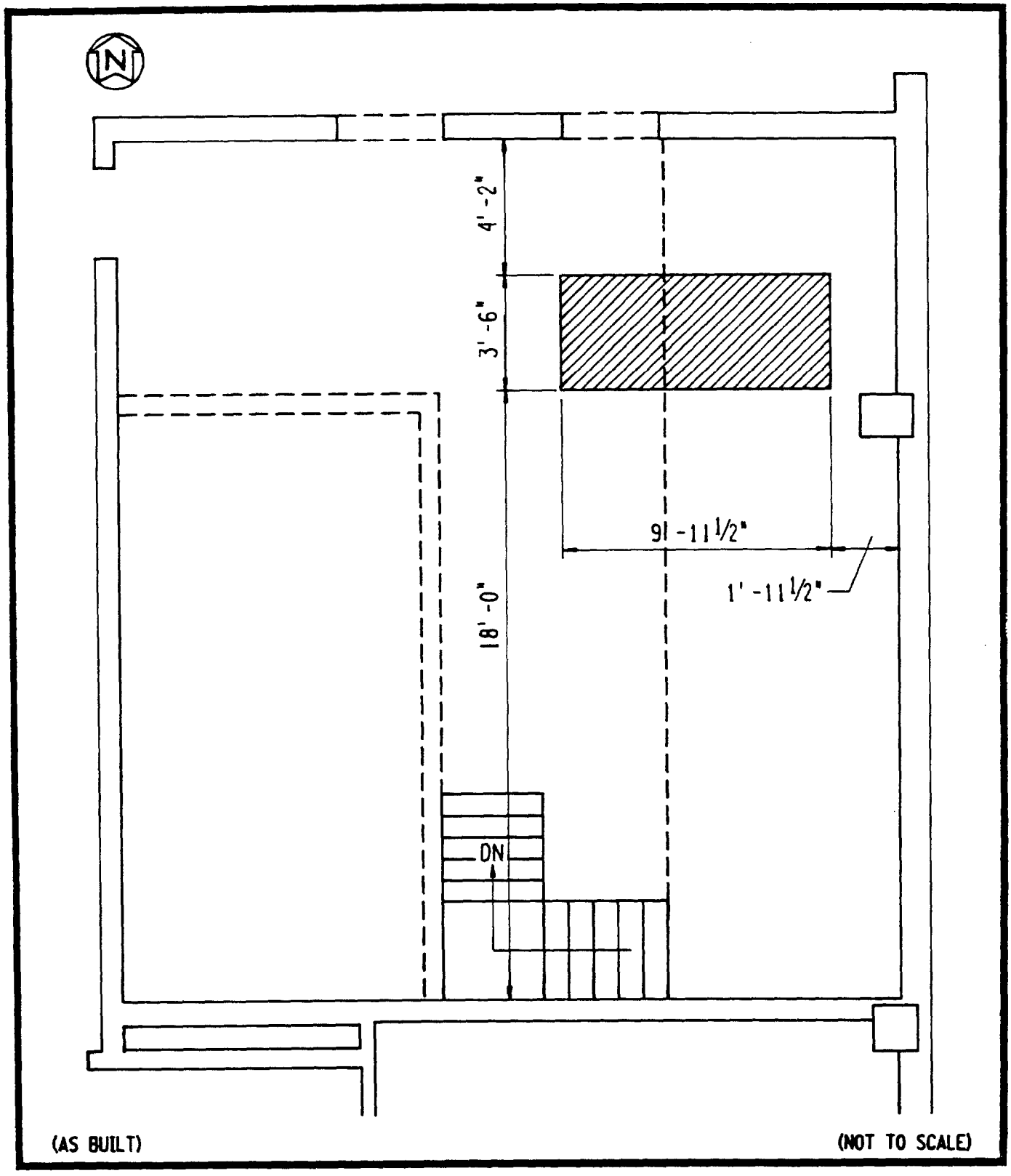


FIGURE 21 ROOM S234—AREA WHERE REMEDIAL ACTION WAS PERFORMED ON THE FLOOR

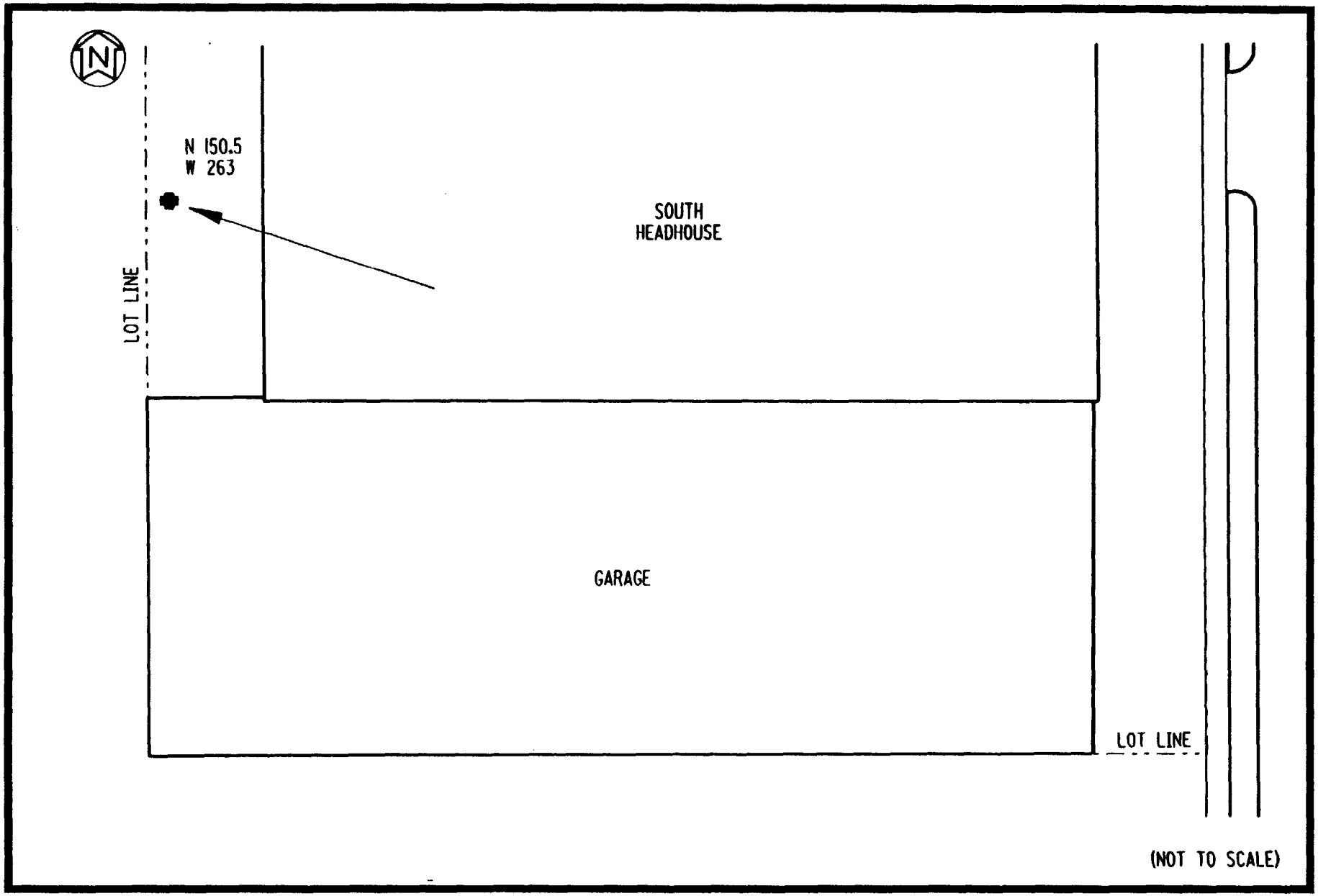


FIGURE 22 AREA WHERE REMEDIAL ACTION WAS PERFORMED OUTSIDE THE BUILDING