DECONTAMINATION AND DECOMMISSIONING

OF

BUILDING C - PHASE I

AT

LYNCHBURG RESEARCH CENTER

LYNCHBURG, VIRGINIA

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1.0 INTRODUCTION

1.1 Statement of the Problem

The Babcock & Wilcox Company (B&W), a wholly owned subsidiary of Mc Dermott International, Inc., holds NRC License SNM-778 (1) to conduct operations involving SNM at its Lynchburg Research Center (LRC) near Lynchburg, Virginia. Under this license, research and development on thoria, urania, and plutonia nuclear fuels were performed in Building C at the LRC.

A corporate decision was made in 1982 to discontinue R&D activties with radioactive materials in Building C. B&W, in ceasing licensed activities in Building C, is complying with a valid license requirement as stated in Appendix F to SNM-778 to provide for decontamination of this building to protect the environment and the general public from exposure to levels of radioactivity in excess of those permissible. Decontamination means the removal or reduction of radioactivity from buildings, walls, floors,and equipment and of radioactively contaminated soil from around and beneath buildings.

A decommissioning plan for Building C was submitted to the NRC for information purposes. (2) Decommissioning means action taken that results in the facility or a portion thereof being released for unrestricted use and termination of control of License SNM-778 for the facility or portion thereof by the NRC and includes the act of decontamination. The decommissioning plan divided work into three phases with a different section of the building being decontaminated in each phase. This report addresses the decontamination performed in Phase I.

1.2 Statement of the Objective

The objective of the decommissioning project is to decontaminate Building C in a responsible and safe manner so as to enable release of the facility for unrestricted use and from licensed control. To assure adequate standards of quality are maintained in achieving this objective, work is performed according to QA Plan No. 82008L. (3) The decontamination includes the interior and exterior surfaces of Building C and the underlying soil. Table F-1 in Reference 1 establishes numerical limits for surface contamination within the facility. Additional numerical limits for external exposure and soil remaining under Building C are contained in Reference 4. B&W used these limits as minimum goals to achieve during decontamination, but followed the principle of reducing contamination to ALARA levels (As Low As Reasonably Achievable). The objective will be achieved in three sequential phases as described in Reference 2.

1.3 Organization of this Report

This report contains seven sections that describe the decommissioning work performed during Phase I of the Building C pro-

ject. Following this introductory section, a physical description of the site and Building C is provided. Information is provided in Section 3 about the decontamination and decommissioning operations themselves. The fourth section contains descriptions of the survey design and survey procedures used to determine residual radioactivity in and under the building. Sections 5 and 6 provide the results and data interpretation of the surveys. The final section lists the documents referenced in this report.

2.0 IDENTIFICATION OF PREMISES

2.1 Site Description

The Lynchburg Research Center (LRC) is located on the James River about 4 miles east of Lynchburg, Virginia. The site lies within Campbell County and borders on Amherst County. Of the 525 acres at this location, only 13.6 acres are utilized by the LRC. Other major B&W facilities on the site are the Naval Nuclear Fuels Division and the Commercial Nuclear Fuels Plant. Figure 2-1 shows the site property boundary and the locations of the separate facilities on the site.

The LRC is a highly integrated facility built to develop, test, and examine nuclear reactor cores and to develop overall nuclear fuel cycles. The location of Building C is shown in Figure 2-2 relative to the other buildings comprising the LRC

2.2 Building C Physical Description

The existing structure known as Building C is the result of several additions to a small laboratory completed in 1962 (see Fig. 2-3). Building C is a single story building of concrete block construction with outside dimensions of 225 feet by 174 feet at its greatest width. There is a small basement under one of the laboratories. The building contains about 24,000 square feet of laboratory, office, and support space. There were approximately 10,250 square feet in the laboratories which had suitable bench-scale and pilot plant equipment, ventilation, and personnel protection equipment for the handling of radioactive materials. There was sufficient office space to house up to 38 technical, support, and supervisory personnel. The building also contains two vaults formerly used for storage of SNM, a boiler room containing a boiler and a chilled water supply system, and a laundry. There was a large storeroom that served the entire LRC. Finally, the building contains a fan room with associated air stack that serves adjacent Building B as well as Building C.

2.3 Definition of Phase I

Decontamination of Building C will be completed in three phases. Phase I includes laboratories on the western end of the building where projects were performed with thorium, plutonium, and uranium solutions and powders. Phase II includes laboratories on the eastern end of the building where projects were performed with plutonium and uranium oxide powders. (External drain lines between Building C and the Liquid Waste Building are included in Phase II.) Phase III includes two laboratories in the center of the building that were used primarily for analytical chemistry projects on plutonium fuels. The Fan Room and Laundry are also included in Phase III. Phase I includes about 10,000 square feet; Phase II, about 6,000 square feet; and Phase III about 8,000 square feet. Figure 2-4 shows the areas included in each phase. No area beyond the walls and roof of Building C are included in this decommissioning project.

Phase I includes former Laboratories 25 (Health Physics Office), 26 (Technician's Office), 27, 43, 44, 50, 51, 52, 53, and 54. Also included are the offices and hallway along the front of the building that used to be part of Labs 43, 44, and 50; the western portion of Hallway 23; and the region marked as Old Central Stores. The interior walls, ceilings, and floors as well as the underlying soil are considered to be included in Phase I.

Physically surrounded by Phase I, but not included in Phase I, are the Fan Room and the Laundry Room. The exhaust fans still provide ventilation for all of Building C (both decontaminated and non-decontaminated areas). The Laundry is still used for clothing from controlled areas.

2.4 History of Operations in Phase I

The first experiments performed in the original building were bench-scale experiments converting thorium nitrate to thorium oxide. An expansion in 1964 added pilot scale equipment for preparation of thorium - U-233 nuclear fuel by a sol-gel process. Thorium fuel R&D was conducted in Laboratories 43, 44, 50, 53, and 54 and existing offices that used to be part of Laboratories 43, 44, and 50.

R&D with plutonium-bearing fuels was initiated in new laboratories added in 1965. A major building expansion was completed in 1968 to permit work on the FFTF Program. Experiments with plutonium nitrate solutions were conducted in gloveboxes installed in Laboratories 43, 44, 50, 53, and 54 and existing offices that used to be part of Laboratories 43, 44, and 50. (Laboratory 25 has been used as the Health Physics Office; Laboratory 26, Technician's Office; and Laboratory 27, glovebox construction prior to it's conversion to an analytical chemistry laboratory for non-plutonium materials.)

Uranium fuel projects were initiated in laboratories that were vacated at the conclusion of the FFTF Program. These projects included work with uranium nitrate and uranium fluoride solutions and uranium fluoride, uranium chloride, and uranium oxide powders. Uranium fuel R&D was performed in Laboratories 27, 43, 44, 50, 53, and 54.

A limited amount of beta-gamma contaminated material has been brought into the Phase I area. Samples of beta-gamma materials were occasionally analyzed in Laboratory 27 and the waste was solidified and placed in waste drums for disposal rather than being poured into the Building C drain system. Sealed containers of beta-gamma contaminated materials from reactor sites were stored in the rear of Old Central Store.

FIGURE 2-1. BABCOCK & WILCOX PROPERTY — MOUNT ATHOS

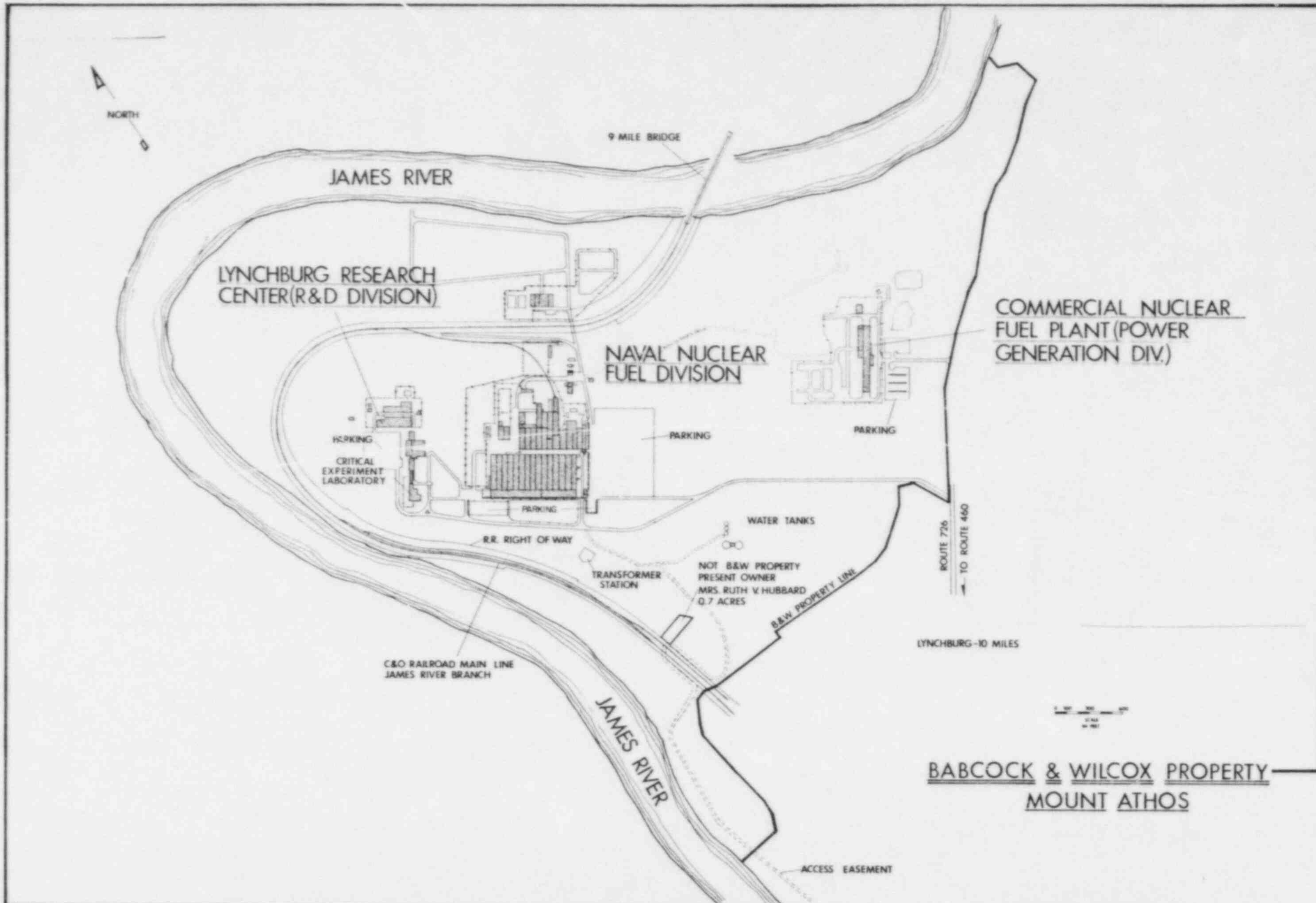


FIGURE 2-2. LYNCHBURG RESEARCH CENTER PLAN OF BUILDINGS

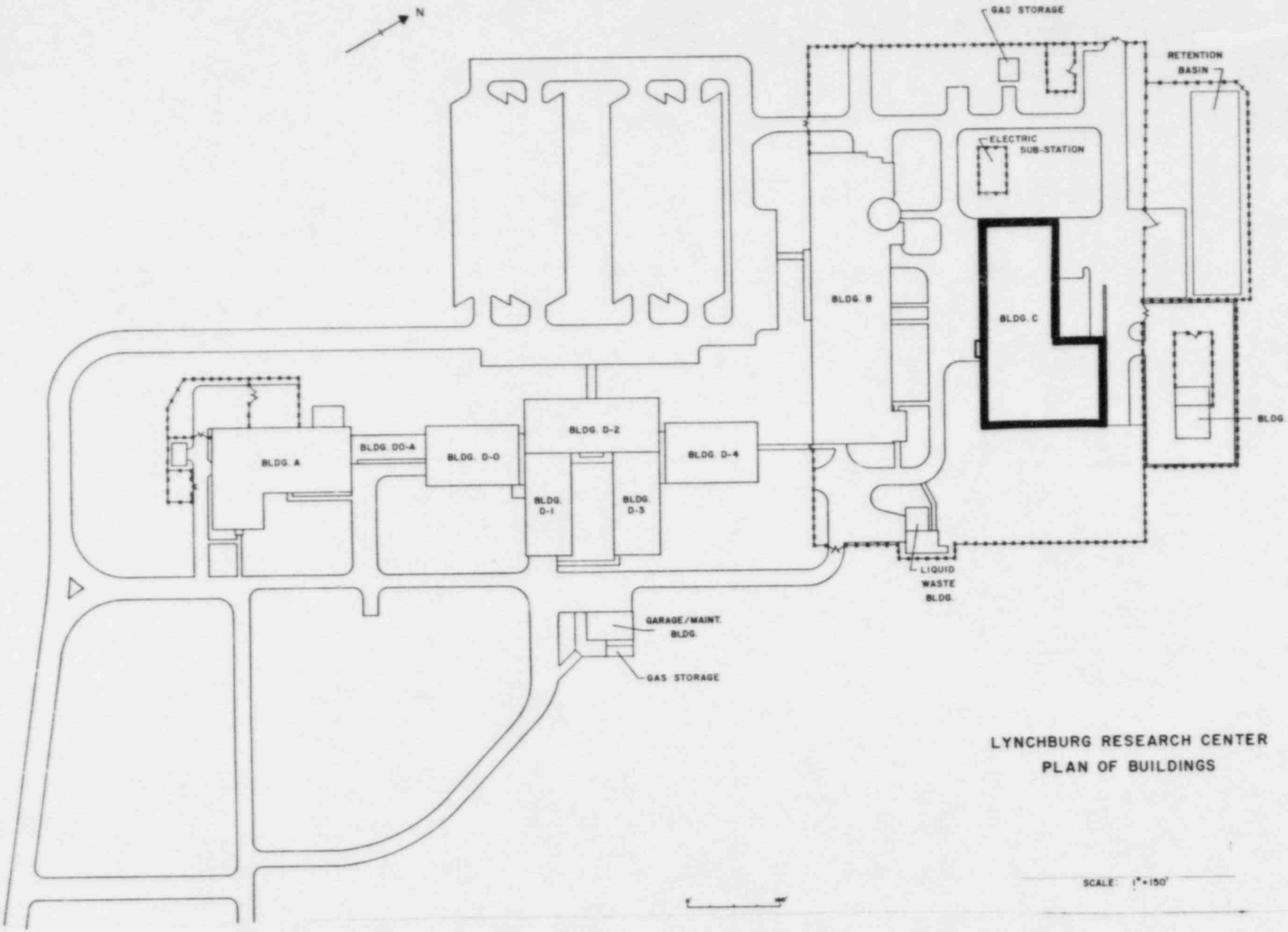


FIGURE 2-3. BUILDING C CONSTRUCTION HISTORY

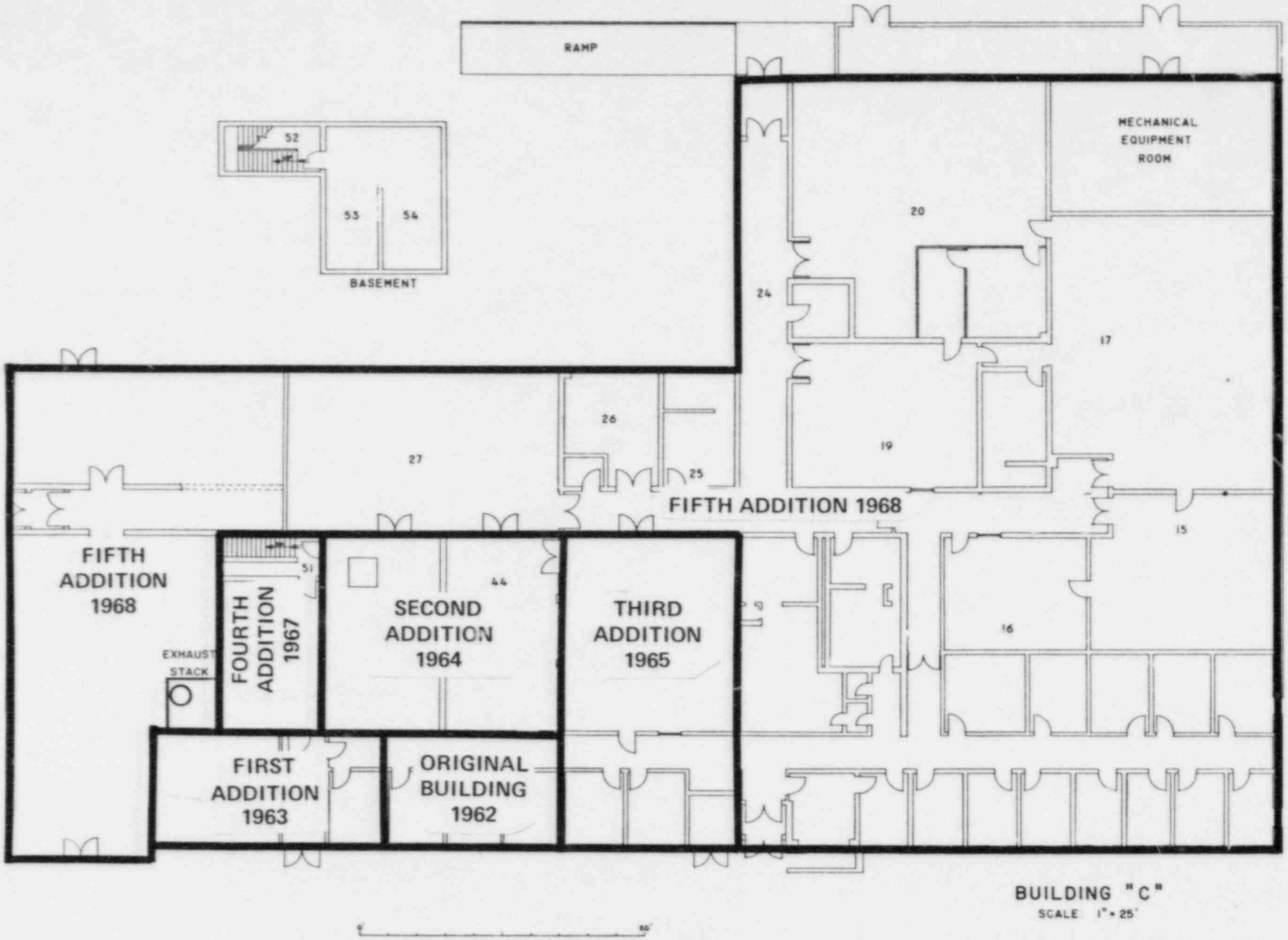
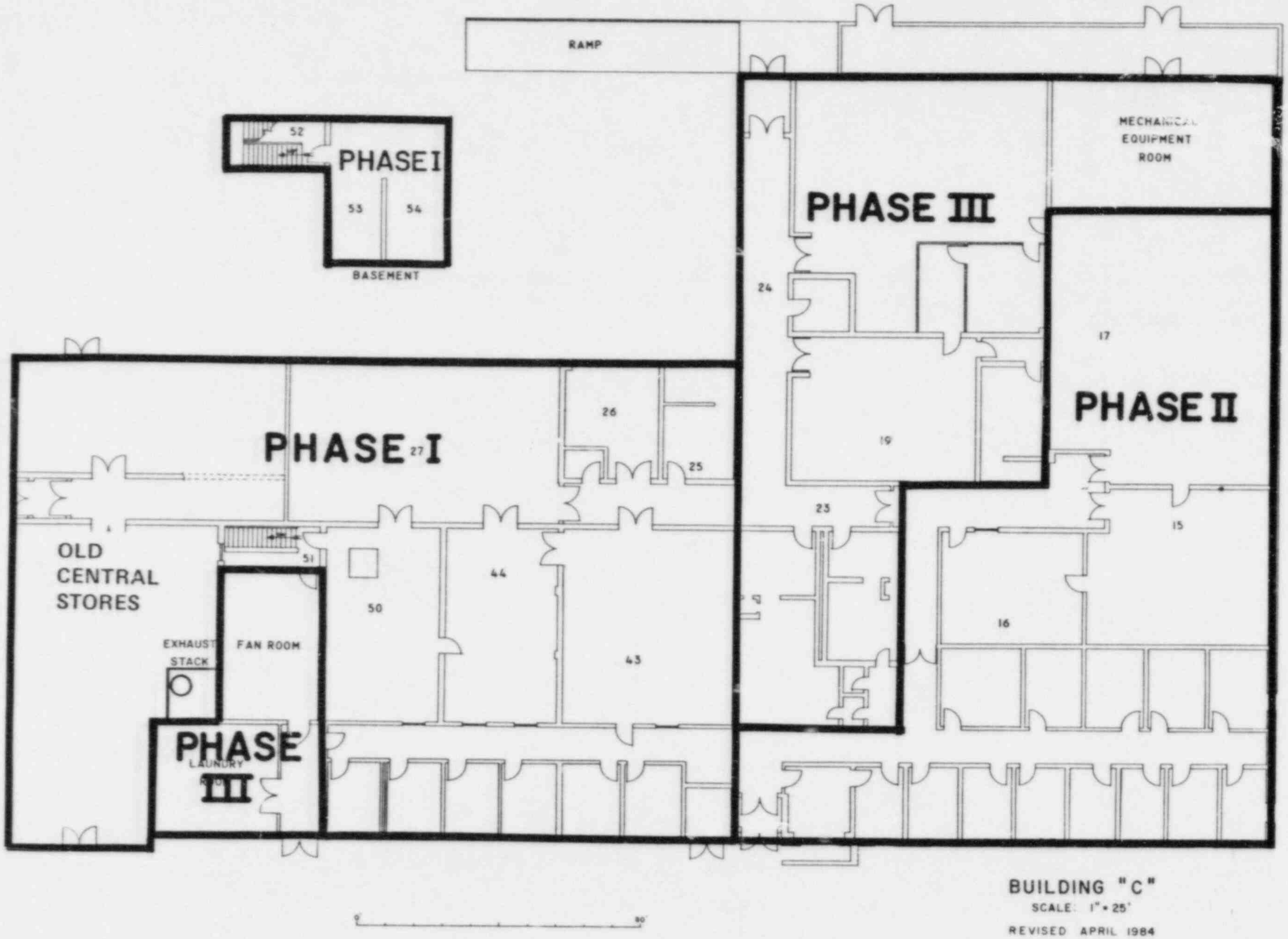


FIGURE 2-4. BUILDING C FLOOR PLAN WITH PHASE BOUNDARIES



3.0 DECONTAMINATION OPERATIONS

The Phase I area of Building C was used for a broad range of R&D projects with thorium, plutonium, and uranium solutions and powders. The general procedure for decontamination operations performed in Phase I consisted of (a) removing all SNM, equipment and supplies, (b) removing service and utility lines that would not be needed during decontamination, (c) decontaminating surfaces in the rooms, (d) removing drain lines, (e) excavating underlying soil, and (f) disposing of contaminated waste. Surveying for radioactivity was conducted during and after decontamination. A successfully decontaminated area was isolated from other areas still being decontaminated in order to prevent recontamination. The decontamination operations were performed by skilled and unskilled laborers, lab technicians, and health physics technicians and professionals trained in approved decontamination procedures and surveying and analytical procedures. The survey equipment and procedures are described in Section 4.0.

3.1 Preparation of Rooms for Decontamination

All accountable SNM was removed from the Phase I area. Equipment and supplies in each room in Phase I were surveyed for contamination prior to removal from Building C. The equipment and supplies were released for unrestricted use if the surface contamination levels were below the limits specified in Table 4-1. If the survey showed contamination at or above permissible limits, the material was decontaminated to meet the limits before removal or was disposed of as contaminated waste. In some cases, equipment was disassembled and contaminated portions were removed and disposed of as contaminated waste.

3.2 Decontamination of Pipe and Duct

Service lines (compressed air, chilled water, vacuum, etc.), electrical conduit, and HVAC (heating, ventilation, and air conditioning) ducts were removed if they would have interfered with the comprehensive survey of laboratory surfaces. Paint and coatings were removed from these pipes and ducts. Dismantled, cleaned pipes were surveyed for radioactivity and released as clean scrap if the limits specified in Table 4-1 were met. Pipes that exceeded these limits were disposed of as contaminated waste. Dismantled, clean HVAC ducts were also surveyed for radioactive contamination and all were reinstalled because they met the limits specified in Table 4-1.

Filters, filter housings, and branch ducts in the box off-gas system serving Phase I were removed. Filters and filter housings in the room off-gas system serving Phase I were removed. Paint and coatings were removed from the ducts and filter housings. Cleaned duct and housings were surveyed for radioactivity and released as clean scrap if the surface activity levels were below the limits specified in Table 4-1. If the survey showed activity above these limits, the materials were disposed of as contaminated waste. The box off-gas and room off-gas headers were surveyed in place. (These headers are suspended from the ceiling and did not interfere with the

survey of room's surfaces.) All filters were disposed of as contaminated waste.

3.3 Decontamination of Room Surfaces

Paint, floor tile, and tile cement were removed from most walls, ceilings, and floors in the Phase I area. Removal was necessary because the walls and ceilings had been repainted and new floor tile had been installed as laboratories were converted to other uses. Potential existed for alpha contamination to be hidden under the new paint and floor tile. The paint was removed to expose either the base surface or the original layer of paint that had been applied prior to introduction of licensed material into a room. (The paint was not removed from the walls of Lab 27 because it was the original coat.) Paint was not removed from walls that had been erected after cessation of activities with SNM. (These were primarily walls in the front offices.) Paint was not removed from walls in rooms from which SNM had been excluded. (SNM was not handled in Labs 25 or 26 or Old Central Stores. Non-nuclear operations have been resumed in Old Central Stores.) Floor tile and tile cement were removed to expose the concrete floor surface. Paint chips, floor tile, sand and other wastes generated in the surface cleaning processes were placed in 55-gallon waste drums. Samples were obtained from each drum for analysis by gamma spectroscopy. These analyses were used to determine the ultimate disposal of a drum's contents. Drums that satisfy the criteria shown in Table 4-2 are being retained at the LRC for unrestricted disposal after the verification survey has been completed by the NRC. Drums that exceed these criteria have been shipped to an NRC licensed disposal site.

Walls, ceilings, and floors were thoroughly surveyed for alpha radioactivity. When contaminated areas were found, walls were decontaminated by removing portions of cinder block and floors were decontaminated by chipping up portions of the concrete floor. These areas were resurveyed and the iterative process of chipping and surveying was continued until release limits were met. These removed materials were disposed of as contaminated waste.

Two areas, Lab 44 and Labs 50 - 54, were released for uncontrolled access, but were later returned to controlled area status. It was learned that Lab 44 was being inadvertently entered as a controlled area to change an area film dosimeter. When this area was resurveyed for release, contamination was found under the original coat of epoxy paint on the floor and in the surface of the concrete. The levels were below release limits, but decontamination was performed to meet ALARA conditions. Contaminated soil was discovered under Lab 50 after it had been released for uncontrolled access. The connecting Labs 50 - 54 were used as a controlled area until excavation was complete and then were resurveyed for release. Contamination was found in the concrete floor in Lab 53 where a drainage sump had been filled with concrete. (This was not known during the first release survey and was not found.) The concrete plug was chipped out and the surrounding floor was decontaminated to meet release limits.

3.4 Drain Line Removal

Hot and cold drain lines were installed under the floor of Building C. A diagram of the hot drain system is shown in Figure 3-1. The floor was removed from above each hot drain line after the bare concrete floor had been surveyed and released. This uncontaminated concrete rubble was disposed of as clean land fill. The soil was removed from above each hot drain line and placed in 55-gallon drums. Samples were obtained from each drum for analysis by gamma spectroscopy. These analyses were used to determine the ultimate disposal of a drum's contents. Drums that satisfy the criteria shown in Table 4-2 are being retained at the LRC for unrestricted disposal after the verification survey has been completed by the NRC. Drums that exceed these criteria have been shipped to an NRC licensed disposal site.

Each hot drain line was cut into sections, removed, and surveyed. If the surface activity was less than the limits specified in Table 4-1, the pipe was released as clean scrap. Otherwise, the pipe was decontaminated to meet the limits or was disposed of as contaminated waste.

All cold drain lines were surveyed for smearable alpha radioactivity. No contamination was found, therefore, these lines were not removed. (Experience in Phase II indicates that pulling a smear cloth through the line is a reliable method to identify radioactivity. A contaminated drain line was found by this method in Phase II.)

3.5 Soil Excavation

Samples were taken of the soil lying under the drain line after the pipe was removed. If analyses showed the radioactivity to be below the limits specified in Table 4-2, temporary flooring was installed to isolate the pipe trench. If the activity exceeded these limits, core samples were taken to determine the extent of the contamination and then further excavation was performed. Soil removal from a given area was continued until soil samples taken from the surface of the excavation showed the radioactivity to be below the limits listed in Table 4-2. Figure 3-2 shows the location of the excavations. Excavated soil was placed in 55-gallon drums. Samples were obtained from each drum for analysis by gamma spectroscopy. These analyses were used to determine the ultimate disposal of a drum's contents. Drums that satisfy the criteria shown in Table 4-2 are being retained at the LRC for unrestricted disposal after the verification survey has been completed by the NRC. Drums that exceed these criteria have been shipped to an NRC licensed disposal site.

3.6 Waste Disposal

As stated above, Phase I contaminated materials (equipment, pipes, ducts, off-gas filters, filter housings, paint chips, floor tile, concrete chips, soil, etc.) were placed in 55-gallon drums for shipment to a licensed disposal facility in accordance with applic-

able requirements as described in References 5, 6, and 7. Uncontaminated paint chips, floor tile, cinder blocks, and sand were also placed in 55-gallon drums and are being retained at the LRC for unrestricted disposal after the verification survey has been completed by the NRC.

FIGURE 3-1. BUILDING C — PHASE I HOT DRAIN SYSTEM

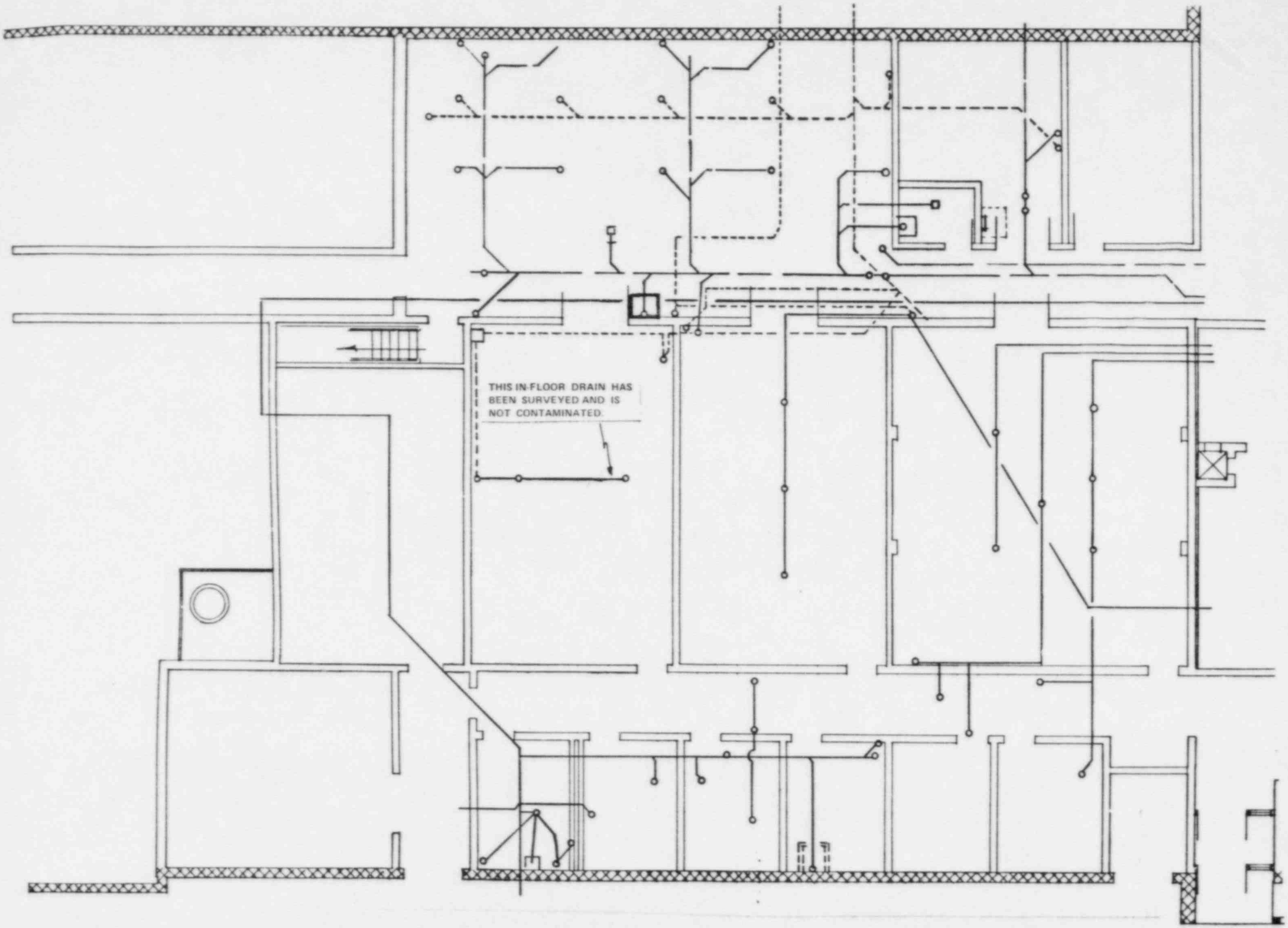
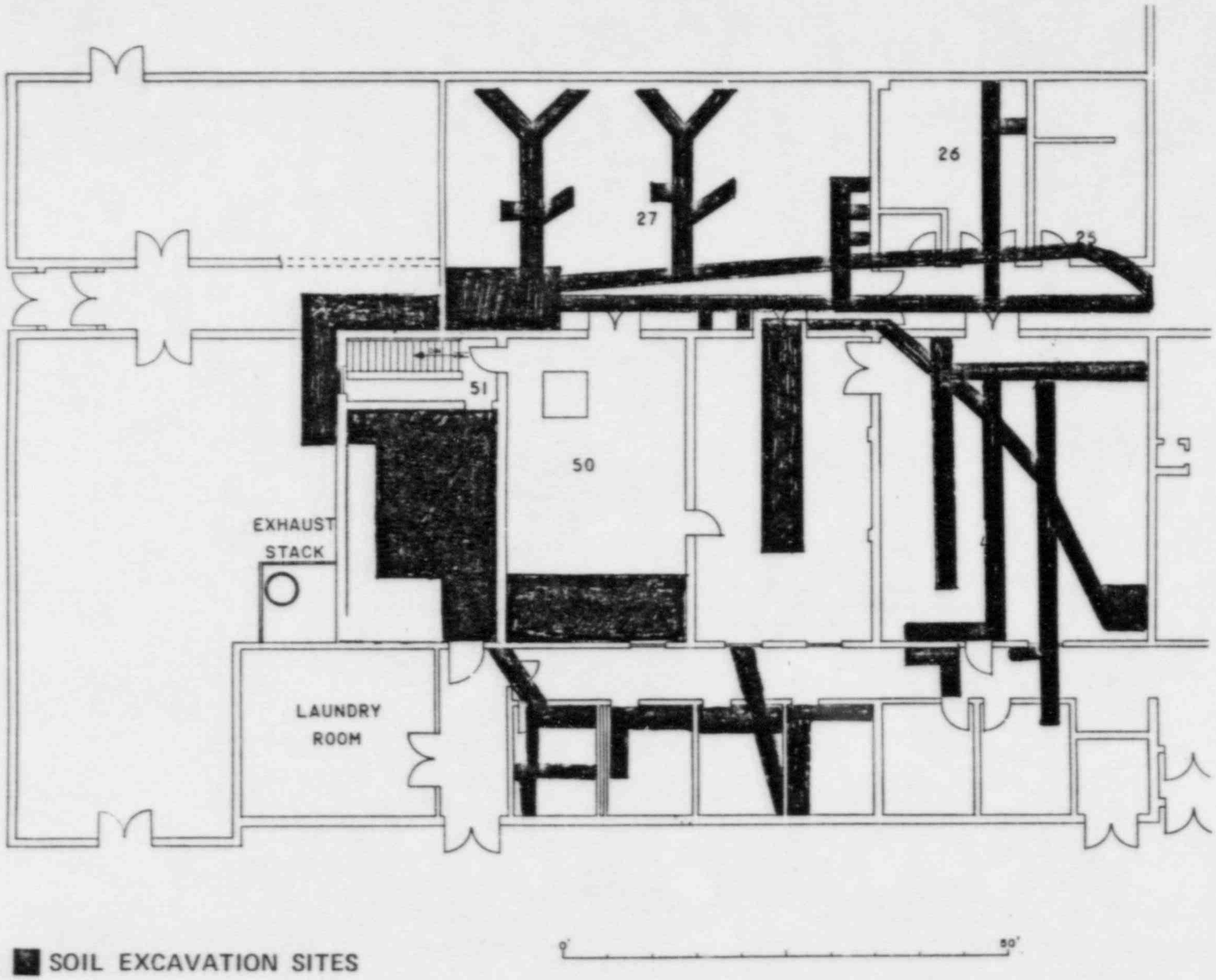


FIGURE 3-2. PHASE 1 EXCAVATION LOCATIONS



4.0 SURVEY DESIGN AND PROCEDURES

R&D projects performed in Phase I involved the use of plutonium, thorium and uranium. The isotopes of these three elements are primarily alpha emitters, but many of their daughters are gamma emitters. The survey plan was based upon inspecting surfaces primarily for alpha contamination and analyzing granular materials (soil, paint chips, etc.) for gamma contamination. Sampling was planned according to NUREG/CR-2082 (8) to assure that no area remained in Phase I that contained radioactivity above release limits established by the NRC. The effect of naturally occurring thorium and uranium at the LRC site was also taken into account during planning and surveying.

4.1 Applicable Release Limits

The release limits applicable to Phase I surfaces were obtained from Table F-1 and Annex C of Reference 1. These limits are reproduced in Table 4-1. The limits for transuranics are the most restrictive in this table and were selected for application to Phase I. These limits can be corrected for local naturally occurring thorium and uranium. From previous background measurement experience within buildings at LRC, it was concluded that the small natural background surface alpha and beta-gamma activity from thorium and uranium and their daughters would not significantly affect the decontamination effort required to achieve the release limits. Therefore, the surface decontamination work for Phase I was based on the conservative use of gross alpha and beta-gamma residual activity to satisfy the surface release limits of Table 4-1 for unrestricted use.

Release limits for Phase I soil are provided in Reference 3 and are listed in Table 4-2. These limits were applied to soil remaining under Building C and to excavated soil. These limits can be corrected for the naturally occurring thorium and uranium. Plans were made to correct the measured analyses for soil samples below the limits, but not to correct measured analyses that were at or above the limit. The correction would have little effect on analyses above the limit and would add confidence that an ALARA condition was achieved. A new set of background soil samples would be needed to obtain data for application to this project. (These soil release limits were also applied to drums of other granular materials; i. e., paint chips, sand, concrete chips, and floor tile.) (It was recognized that additional release limits might be needed for Co-60, Cs-137, and U-233. A decision was made to review soil sample analysis data for evidence of these isotopes before requesting limits. The collected data are presented in Section 5.0 and are discussed and evaluated in Section 6.0. There does not appear to be a need for release limits for these three isotopes.)

The release limit for external beta-gamma exposure is given in Reference 2 and is included in Table 4-2. This limit can be corrected for local background activity. It was concluded that the beta-gamma activity from natural thorium and uranium and their daughters would not significantly affect survey results, but external beta-gamma activity from the Hot Cells and Building J would have to be

taken into account. (The Hot Cells are located near the south-west corner of Building B and contain high-level beta-gamma materials. Located toward the north-east behind Building C, Building J is used for storage of high-level beta-gamma waste.) A survey in and around Building C for external beta-gamma activity would be needed to obtain data for application to this project.

4.2 Survey Design

4.2.1 Surface Survey Design

Most of the laboratories in Phase I had been used for experiments with all three elements of interest - plutonium, uranium, and thorium. Each Phase I laboratory had been cleaned and repainted more than once so there was a possibility that contamination existed beneath the paint and floor tile. Prudence dictated stripping walls, floors, and ceilings to the original surface to expose potential contamination for identification. The surface surveys were designed with these items in mind.

The laboratory surfaces (walls, floors, and ceilings) that had existed during experimental work with plutonium, thorium, and uranium had to be identified. Materials that could interfere with a comprehensive survey for surface contamination had to be removed. Paint, floor tile, and tile cement had to be removed from these surfaces to expose the original surface. (Paint did not need to be removed from walls that had been erected after cessation of activities with SNM or from walls in areas from which SNM had been excluded.) A rectangular grid was designed for use on walls, floors, and surfaces with each grid block containing slightly less than one square meter. The dimensions of the grid block were determined by the size of the probe to be used for direct alpha survey. An example of a grid configuration is shown in Figure 4-1.

A comprehensive direct alpha survey was planned to include 100% of each grid block and alpha smears were planned for each of the grid blocks. This comprehensive method was chosen for the alpha surveys because the history of usage, leaks, and spills of SNM within specific laboratories was uncertain. The direct and indirect (smear) alpha surveys would be conducted immediately after removal of surface coatings to identify areas that would require further decontamination. When the alpha surveys showed acceptable results, other types of surveys would be conducted. Beta smears and direct beta and direct gamma surveys were planned for each of 242 randomly selected floor grid blocks in the Phase I area. This statistical method was chosen for beta-gamma surveys because of the low potential for beta-gamma contamination in Building C. Since the floor was the most likely place to have been contaminated in case of a spill, only floor grid blocks were selected for the beta-gamma surveys.

4.2.2 External Gamma Survey Design

External gamma surveys were planned for each of the 242 randomly selected floor grid blocks in the Phase I area. This

represents 30% of the floor grid blocks. This statistical method was chosen to establish background levels for comparison with direct gamma surveys taken on the same basis.

4.2.3 Soil Survey Design

Four separate types of soil surveys were foreseen. One would be for soil excavated from under the floor and placed in drums. Another would be for soil samples from the face of an excavation. A third would be to determine the extent of contamination identified by the excavation face samples. The fourth would be to establish the concentrations of naturally radioactive isotopes in the site's soil. The same analytical procedure could be used for each type, but sampling methods would differ. Since the SNM isotopes are primarily alpha emitters and a large number of samples was expected, gamma analyses were planned based upon known daughters of plutonium, thorium, and uranium. A sampling method was planned for excavated soil that would obtain a uniform quantity of soil for analysis as each drum was filled. (This method was also planned for use with other granular materials; e. g., paint chips, concrete chips, and floor tile.) A sampling method was planned to obtain samples from the surface of the excavation that would result in a uniform quantity of soil for analysis from gridded areas of the excavation. Core samples were planned to define contaminated soil boundaries and to obtain samples of background soil at this site.

The sampling plan was based on the assumption that the only source for soil contamination would be the hot drainline system. The only other pathway for contaminants to enter the soil under the building would be through the concrete floor. This type of contamination would be found on and in the floor itself during surface surveys and could be tracked if it did appear. (No evidence was found that contamination penetrated through the concrete into the soil.)

4.3 Survey Instruments

The instruments used for survey and analysis in Phase I are standard models routinely used by the nuclear industry for this type of work. The instruments were calibrated in accordance with applicable LRC Technical Procedures using National Bureau of Standards traceable sources with the exception of the direct gamma survey instrument.

4.3.1 Surface Survey Instruments

Each surface survey instrument has a lower limit of detection for the radiation being measured. This is the lowest level of non-zero activity that it can register. These limits are defined in the following sections.

4.3.1.1 Direct Alpha Survey Instruments

Eberline Model PAC-4G or Model PAC-4G-3 Gas Proportional Survey Meters were used for making direct alpha surveys with two different size probes. The probes consisted of either a Model AC-23A 335 sq. cm. Flat Plate Probe or a Model FM-3G 445 sq. cm. Floor Monitor Probe. Calibration was performed according to Technical Procedure LRC-TP-51 using NBS traceable alpha sources. The lower limit of detection for the PAC-4G for alpha detection was 30 dpm/100 sq. cm.

4.3.1.2 Direct Beta Survey Instrument

Separate Eberline PAC-4G instruments similar to those described above were used for making direct beta surveys. Calibration was performed according to Technical Procedure LRC-TP-51 using NBS traceable beta sources. The lower limit of detection for the PAC-4G for beta detection was 300 dpm/100 sq. cm.

4.3.1.3 Alpha and Beta Smear Survey Instruments

Either an NMC Model PC-5 Proportional Counter or an ORT-S-1 Gas Proportional Smear Counter was used to count alpha and beta smears. The former is calibrated using Technical Procedure LRC-TP-162 and the latter using Technical Procedure LRC-TP-190. Calibration was done with NBS traceable alpha and beta sources as appropriate. The background level for the smear counters was 0.1 dpm alpha/ 100 sq. cm. and 300 dpm beta/100 sq. cm.

4.3.1.4 Direct Gamma Survey Instrument

A Geiger-Muller (GM) Survey Meter was used for the direct gamma survey. Instrument calibration was performed according to LRC-TP-50, but the NBS certificate for the calibration source can not be located. A new source has been obtained and a new calibration will be performed. The lower limit of detection for the GM meter was about 0.05 mR/hr.

4.3.2 External Gamma Survey Instruments

The Geiger-Muller (GM) Survey Meter described above was also used for the external gamma survey.

A Model RS-111 Reuter-Stokes Environmental Radiation Monitor was also used to measure gamma radiation due to external sources. These measurements were taken both inside and outside Building C. This monitor was calibrated by the manufacturer with NBS traceable sources. The lower limit of detection for the RS-111 was 1 uR/hr.

4.3.3 Soil Survey Instrument

A Nuclear Data Corporation high-resolution gamma-ray spectroscopy system using HPGe detectors was used to nondestruc-

tively analyze soil samples. This system is standardized according to Technical Procedure LRC-TP-210.

This spectroscopy system was used to examine a gamma spectrum from about 50 keV to about 2 MeV. Am-241, plutonium, thorium, and uranium concentrations were measured by analysis of gamma-ray energies within this range. The Am-241 concentration was determined directly from it's 59.54-keV peak. The plutonium concentration was calculated by multiplying the Am-241 concentration by an experimetally determined factor. (The Pu-239 concentration was directly measured at 375.02 and 413.69-keV in samples containing nCi/g quantities of Pu-239. These values were compared with Am-241 concentrations in the same samples to develop the factor.) The Th-232 concentration was determined indirectly from it's Pb-212 daughter's 238.60-keV peak. The uranium concentration was determined directly from the 185.72-keV peak for U-235. (A correction was made for the 186.18-keV peak for Ra-226.) Other gamma-ray peaks were evaluated for radionuclides such as Co-60, Cs-137, and U-232 as needed.

4.4 Survey Procedures

A list of the procedures used for this project is provided in Table 4.3. These procedures were prepared in accordance with QA Plan No. 82008L (8).

4.4.1 Surface and External Gamma Surveys

Surface surveys were conducted according to Technical Procedure LRC-TP-183. The major steps in this procedure are summarized below.

(1) Mark the surface with 1 sq. m. grid blocks. Sketch the grid on a data sheet and label each block.

(2) Perform a direct alpha survey with a properly calibrated PAC-4G. Make sequential measurements in a grid block until the entire block has been surveyed. Record the location and count on a log sheet.

(3) Take a random 100 sq. cm. smear in each grid block. Count the smears for alpha activity in a properly calibrated proportional counter. Record the location and count on a data sheet.

(4) In a randomly selected grid block on the floor, conduct a direct gamma survey, a direct beta survey, and a beta smear survey. Using a properly calibrated GM meter, locate the point in the grid block with the maximum gamma level. Perform a direct gamma survey at this point with a properly calibrated G-M meter. Perform a direct beta survey at the maximum gamma point in each block with a properly calibrated PAC-4G meter. Record the location and maximum gamma, direct gammma, and direct beta counts on a data sheet.

(5) Take a 100 sq. cm. smear at the maximum gamma point in each block. Count the smears for beta activity in a properly calibrated proportional counter. Record the location and count on a data sheet.

4.4.2 Soil Surveys

All soil samples (whether from drums, excavations, or cores) were prepared for analysis using Technical Procedure LRC-TP-208 and were analyzed according to Technical Procedure LRC-TP-210. Each sample was dried, screened, and placed into a container for analysis by gamma spectroscopy. Soil standards were prepared using Technical Procedure LRC-TP-267.

Varying methods were used to obtain soil samples according to their source. These methods are described below. All samples were placed in labelled containers.

Sampling, sample preparation, and sample analysis information and data were recorded on route sheets that followed the sample from the time it was taken through the time it was analyzed.

4.4.2.1 Excavated Soil

Technical Procedure LRC-TP-206 describes three techniques for taking samples of excavated soil. These are all commonly used sampling techniques. (9) These three techniques allow sampling as the drum is filled or after it has been filled.

(1) Six to eight grab samples can be taken as a drum is filled to form a 4-liter sample. The multiple samples are obtained to create a composite sample representative of the drum's contents. (This method was also used with other granular materials besides soil; i. e., paint chips, sand, concrete chips, and floor tile.)

(2) A 4-liter sample can be scooped from the entire length of a filled drum as it is laying on its side.

(3) A sampling thief can be used to obtain a 4-liter sample from a filled drum standing upright.

4.4.2.2 Excavation Survey

Technical Procedure LRC-TP-197 describes two techniques for collecting soil samples in excavated areas.

(1) A 4-liter sample can be scooped from the bottom of a trench (no longer than 20 feet) from which a drainline has just been removed to create a sample representative.

(2) A 4-liter sample can be scooped from the surface of a trench to create a sample representative of about 10 square feet.

4.4.2.3 Building C Core Samples

Technical Procedure LRC-TP-207 describes the method for taking exploratory cores in the vicinity of contaminated soil to guide further excavation efforts. A core sampler is used that collects a 4-liter sample per foot of depth.

4.4.2.4 Background Soil Core Samples

Technical Procedure LRC-TP-207 also describes the method of taking background soil cores external to Building C.

TABLE 4-1. ACCEPTABLE SURFACE CONTAMINATION LEVELS

Nuclides[a]	Average[b,c,f]	Maximum[b,d,f]	Removable[b,e,f]
U-nat, U-235, U-238, and associated decay products	5,000 dpm α/100 cm^2	15,000 dpm α/100 cm^2	1,000 dpm α/100 cm^2
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100 dpm/100 cm^2	300 dpm/100 cm^2	20 dpm/100 cm^2
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000 dpm/100 cm^2	3,000 dpm/100 cm^2	200 dpm/100 cm^2
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5,000 dpm $\beta\gamma$/100 cm^2	15,000 dpm $\beta\gamma$/100 cm^2	1,000 dpm $\beta\gamma$/100 cm^2

a Where surface contamination by both alpha- and beta-gamma emitting nuclides exists, the limits established for alpha and beta-gamma-emitting nuclides should apply independently.

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

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

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

e The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of know 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/hr at 1 cm and 1.0 mrad/hr at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

TABLE 4.2

BUILDING C SOIL RELEASE LIMITS
AND
BUILDING C EXTERNAL BETA-GAMMA EXPOSURE LIMIT *

Contaminant	Maximum Acceptable Limit For Unrestricted Use **
Natural Thorium (Th-232 + Th-228) with daughters present and in equilibrium	10 pCi/g soil ***
Natural Uranium (U-238 + U-234) with daughters present and in equilibrium	10 pCi/g soil
Depleted Uranium or Natural Uranium that has been separated from its daughters, soluble or insoluble	35 pCi/g soil
Enriched Uranium Soluble or insoluble	30 pCi/g soil
Plutonium (Y) or (W) compounds	25 pCi/g soil
Americium-241 (W) compounds	30 pCi/g soil
External Beta-Gamma Exposure Rate	10uR/hr

* These limits are above background levels.

** The individual soil limits given in this table apply to each element if it exists by itself. When they occur as a mixture, the sum of the ratios of the elemental concentrations versus their limits must be less than 1. Thus, for Phase I,

$$(Am\text{-}241/30) + (Pu/25) + (Th\text{-}232/5) + (U/30) < 1$$

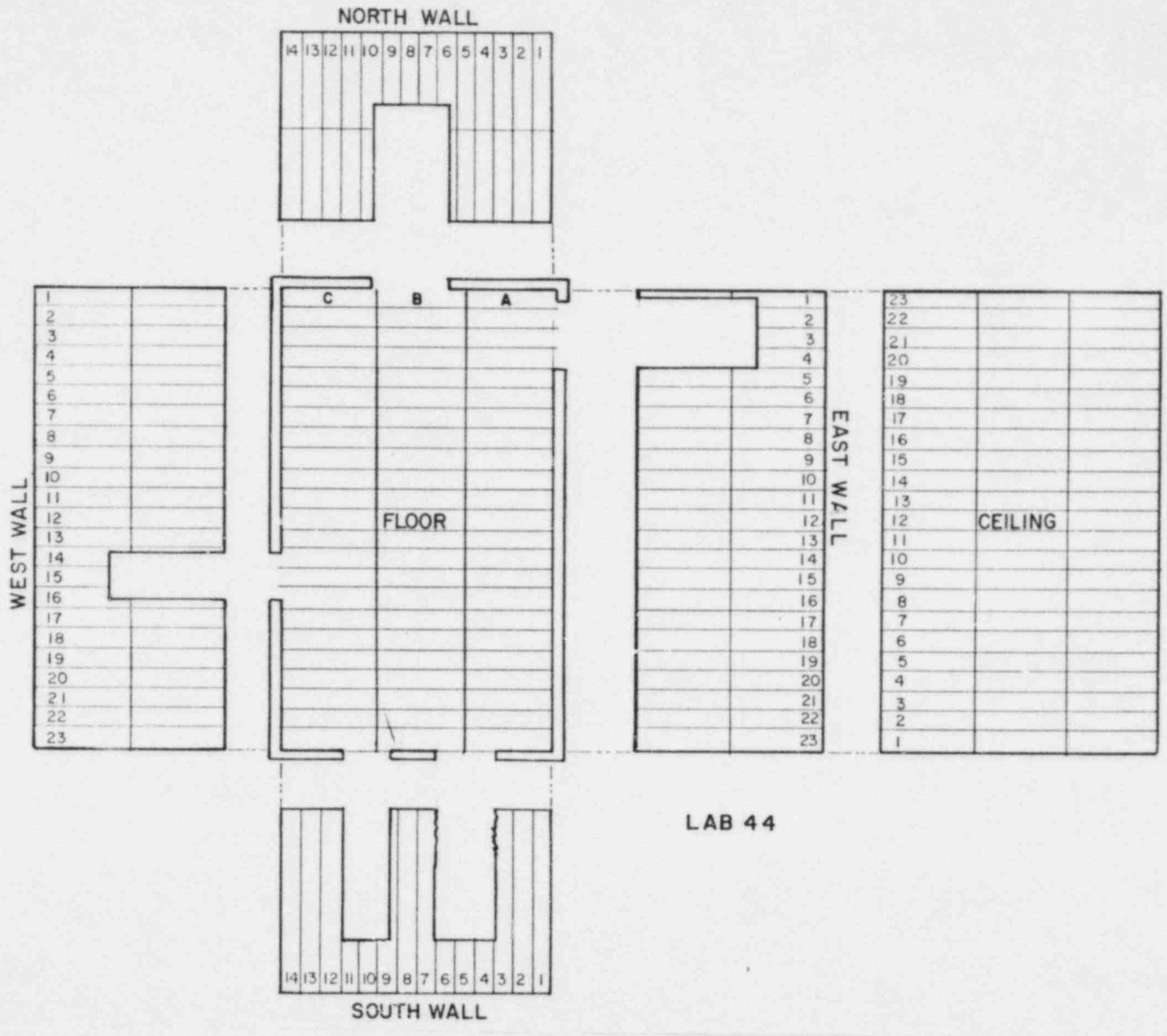
*** A limit of 5 pCi Th-232/g soil has been adopted for this project.

TABLE 4.3

LRC TECHNICAL PROCEDURES
USED FOR
BUILDING C DECOMMISSIONING OPERATIONS

LRC-TP-50	CALIBRATION PROCEDURE FOR EBERLINE G-M COUNTER
LRC-TP-51	CALIBRATION PROCEDURE FOR PAC-4G GAS PROPORTIONAL COUNTER
LRC-TP-95	RESPIRATORY PROTECTION PROGRAM
LRC-TP-162	CALIBRATION AND OPERATING PROCEDURE FOR NMC PC-5 PROPORTIONAL COUNTER
LRC-TP-183	SURVEY OF DECONTAMINATED LABORATORY AND OFFICES IN BUILDING C FOR FIXED AND SMEARABLE CONTAMINATION
LRC-TP-190	CALIBRATION PROCEDURE FOR BUILDING C PROPORTIONAL SMEAR COUNTER
LRC-TP-197	BUILDING C SOIL SAMPLING PROCEDURE
LRC-TP-206	PLUTONIUM DECONTAMINATION PROJECT DRUM SAMPLING PROCEDURE
LRC-TP-207	BUILDING C SOIL CORE SAMPLING PROCEDURE
LRC-TP-208	PREPARATION OF SOIL SAMPLES
LRC-TP-210	ANALYSIS OF RADIONUCLIDES IN SOIL BY GAMMA RAY SPECTROSCOPY
LRC-TP-236	OPERATING INSTRUCTIONS FOR USE OF 3M BRAND WHITECAP HELMET MODEL W-5005
LRC-TP-237	PREPARATION OF WASTE SHIPMENTS TO THE U. S. ECOLOGY SITE IN WASHINGTON
LRC-TP-267	PREPARATION OF SOIL STANDARDS

FIGURE 4-1. TYPICAL SURFACE GRID ARRANGEMENT



5.0 PHASE I SURVEY RESULTS

Building C was used primarily for R&D projects with thorium, plutonium, and uranium. Since these are all alpha emitters and only limited information was available about specific usage in the laboratories, comprehensive surveys for direct and smearable alpha contamination were conducted on the surfaces of the Phase I area in Building C. Only limited amounts of beta-gamma materials had ever entered Building C, so beta-gamma surveys were conducted on a limited number of randomly selected floor grid blocks. A survey was perform-ed to establish gamma radiation levels due to sources external to Building C. The data for these surveys and analyses are described below. All data are contained in the Building C Decommissioning files.

5.1 Surface Surveys

5.1.1 Initial Surface Surveys

Each room was cleaned (SNM and equipment were removed, non-essential service pipe and duct were removed, and paint and floor tile were stripped) and an initial survey was performed to determine direct and smearable alpha radiation levels on the room's surfaces. Tables 5-1 through 5-3 provide summaries of these initial surface survey results.

The lower limit of detection for the direct alpha survey was 30 dpm/100 sq. cm. As Table 5-1 shows, 3,987 of the 4,339 grids or 92% were at this level and another 281 grids or 6% were below or met the release limit of 100 dpm/100 sq. cm. About 75% of these 281 grids were on the floors with the other 25% on the walls. No contamination was found on the ceilings. About 2% or 71 grids exceeded the release limit for direct alpha radiation. About 70% of these grids were on the walls with the other 30% on the floors. (The data from the pit skew this percentage because 46 of the 71 grids were pit-wall grids.) Using the ALARA concept, additional decontamination was performed on the 352 grids that were above the lower limit of detection.

Table 5-2 summarizes the 61,458 direct alpha readings that were obtained during the initial surface survey. Ninety five per cent or 58,421 of these readings were at the lower limit of detection and 2,887 or about 5% were below 300 dpm/100 sq. cm. Less than 1% or 150 readings were above 300 dpm/100 sq. cm. with the highest reading being 9,000 dpm/100 sq. cm.

No smearable alpha radioactivity above 10 dpm/100 sq. cm. was detected. The background reading for the smear counter was 0.1 dpm/100 sq. cm. As shown in Table 5-3, 3,561 of the 4,339 smears or 82% were at this level. Of the remainder, 651 or 15% were between 1 and 5 dpm/100 sq. cm. and the remaining 3% or 127 readings were between 6 and 10 dpm/100 sq. cm. Alpha smears were taken at random locations in the front part of Old Central Stores, but no direct surveys for alpha radioactivity were performed since radioactive materials were not handled in this area. No activity was found.

5.1.2 Release Surface Surveys

Decontamination was performed in those 352 areas identified in the original alpha survey as being above the limit of detection. Some areas were more difficult to decontaminate than others. Removal of 1/16 -1/4 inch of the concrete surface was adequate in most areas, but as much as 5 inches of concrete had to be chipped up in Lab 53. It was also necessary to remove epoxy paint from the floor in Lab 43 to complete decontamination (even though the floor was painted prior to the use of SNM in this laboratory). Tables 5-4 and 5-5 provide summaries of the release survey results.

Table 5-4 gives a summary of the release direct alpha surface survey data. The data show that all grid blocks are below the release criterion of an average value of 100 dpm/100 sq. cm. with no grid block exceeding an average of 70 dpm/100 sq. cm. About 95% of the grids averaging over 30 dpm/100 sq. cm. were on the floor. The data summarized in Table 5-5 show that no single reading exceeded 150 dpm/100 sq. cm. Over 97% of the grid blocks and over 99% of the individual readings had readings at the lower limit of detection of 30 dpm/100 sq. cm.

In the course of data reduction, the raw direct alpha survey data were summarized in terms of range, mean, standard deviation, variance, and other simple statistics as needed for estimating population parameters. Normal distribution statistics were used as all sample sizes were greater than 100. Sample means were used as the least biased estimate of the unknown population mean. Confidence limits were set up on the sample mean to assess the significance or degree of confidence that can be placed on such a value. As shown in Table 5-6 (which summarizes the data from Tables 5-4 and 5-5), we can be 99.7% confident that the population mean lies between 30.38 and 30.06 dpm/100 sq. cm. in the case of the grids and between 30.24 and 30.14 dpm/100 sq. cm. in the case of the individual readings. The 99.7% confidence limit is based on the formula

$$UCL = x(mean) + (z)(\sigma)/\sqrt{N}$$

$$LCL = x(mean) - (z)(\sigma)/\sqrt{N}$$

where $z = 3.0$

UCL = Upper Confidence Limit

LCL = Lower Confidence Limit

The data obtained during the original alpha smear survey and shown in Table 5-3 are being used for the release alpha smear survey. Precautions were taken during decontamination to prevent the spread of contaminated dust and routine large area smears have shown no trace of smearable alpha activity in the Phase I portion of Building C. No grid had smearable alpha activity greater than 50 percent of the allowable limit of 20 dpm/100 sq.cm. The alpha smear survey data were statistically analyzed in the same manner as the direct

alpha survey data. Table 5-6 contains these results.

Surveys for direct beta, smearable beta, and direct gamma activity were made in randomly selected floor grid blocks. The results are shown in Table 5-7. A survey for direct gamma was performed in each of 242 floor grids out of a total of 780 in Phase I. A gamma radiation reading was taken 1 meter from the floor and another reading was taken less than 1 cm from the floor at the same spot. Both readings were equal in all 242 cases indicating no residual gamma contamination was present. (All 484 readings were 0.04 or 0.05 mR/hr. This is the lower limit of detection for the GM meter.) Surveys were performed for direct beta and smearable beta activity at the same 242 spots. As shown in Table 5-7, the beta activity averaged 300 dpm/100 sq. cm., well below the limit of 5,000 dpm/100 sq. cm. for fixed beta activity and the limit of 1,000 dpm/100 sq. cm. for smearable beta activity. (One reading for smearable beta activity was 360 dpm/100 sq. cm. The other 241 readings were all 300 dpm/100 sq. cm. which is the background level for the beta smear instrument.)

5.1.3 External Gamma Radiation Survey

A survey was conducted in and around Phase I to measure the gamma radiation levels due to external sources. Figure 5-1 shows the results of this survey. The data show that the Hot Cells in Building B and the high-level waste stored in Building J are the external sources that establish the background gamma radiation inside Phase I of Building C. The data also support the gamma survey data shown in Table 5-7.

5.2 Release Soil Survey

Samples were taken from drums of soil excavated from under Building C and samples were taken from the face of the excavations. Samples of site background soil were also taken. The data are presented in Tables 5-8 through 5-10 for each type of material. These data are discussed below.

5.2.1 Background Soil Survey

Core samples were taken at each foot of depth from three holes 15 feet deep and from 31 holes 2 feet deep to provide 107 samples of background soil. These samples were analyzed for Am-241, Th-232, Pu, and U. The results are summarized in Table 5-8. The results for Am-241 and plutonium represent the lower limits of detection for gamma analyses. These data are being reported here, but do not actually indicate the presense of Am or Pu, but indicate an upper limit for the values if they were present. The values for uranium and thorium have been used to correct excavation and drum samples for local naturally occurring concentrations of these elements.

5.2.2 Excavation Release Survey

The data are summarized in Table 5-9 for the excavation release soil survey. The results for Am-241 and plutonium represent 76 samples in which Am-241 was detected and 203 samples where Am-241 was reported at the lower limit of detection. The analyses for thorium and uranium indicate only background concentrations for these two elements remain in the excavation under Phase I and identify the relatively uniform concentration of these elements throughout the region. The calculation of the unity factor was performed with only the Am-241 and Pu values.

To address the possibility of potential U-233 contamination in the excavated soil samples, a series of Bateman decay chain calculations were performed to identify a nuclide that would provide a sensitive indication of U-233 concentration in soil. This nuclide is Pb-212 that is a daughter of the U-232 that is present in the U-233 as a contaminant. A review of the data from the excavation samples showed that none had Pb-212 activity above that expected from the naturally occurring Th-232 parent. (Th-232 also produces Pb-212 as well as U-232.) These results indicate no contamination from U-233.

A sample of sludge was taken from the storm sewer that lay under Lab 43. This sample contained 125 pCi Co-60/g and 9 pCi Cs-137/g that originated from material that had leaked into the storm sewer from the Hot Cells. (10) The excavation soil samples data were reviewed and found to indicate that Co-60 and Cs-137 concentrations were all below 1 pCi/g. Radiation levels were measured with the RS-111 in the excavations under Lab 43 and under the Fan Room. No readings above background were found. These results indicate no contamination from Co-60 or Cs-137.

The continued ingrowth of Am-241 was recognized and evaluated for its effect upon activity levels in the future. The Am-241 concentration will reach a maximum in about another 65 years. The maximum Unity Factor for excavation samples would be about 0.25 at that time.

5.2.3 Excavated Soil Drums Survey

The data are summarized in Table 5-10 for the excavated soil release survey. There are 989 drums of soil that meet release limits. The results for Am-241 and plutonium represent 311 samples in which Am-241 was detected and 673 samples where Am-241 was reported at the lower limit of detection. The analyses for thorium and uranium indicate primarily background concentrations for these two elements are contained in the releasable drums. The background concentrations for thorium and uranium have been deducted for the calculation of the unity factor for the releasable drums.

The data from analyses of the samples of excavated soil drums was reviewed for Pb-212 content to address the possibility of potential U-233 contamination. These data showed that 18 drums had Pb-212 activity above that expected from the naturally occurring Th-

232 parent. A statistical evaluation of both the Pb-212 and Ac-228 activities indicated these 18 samples had equal concentrations of these isotopes. (Th-232 produces Ac-228 and Pb-212 daughters. These two daughters will be in secular equilibrium in geologic soil. Thus, if their concentrations are found to be equal, a conclusion may be drawn that the Pb-212 originated from Th-232 rather than from U-232 which can also be a parent.) These results indicate no contamination from U-233.

The excavation soil drum samples data were reviewed and found to indicate that Co-60 and Cs-137 concentrations were all below 1 pCi/g. These results indicate no contamination from Co-60 or Cs-137.

The continued ingrowth of Am-241 was recognized and evaluated for its effect upon activity levels in the future. The Am-241 concentration will reach a maximum in about another 65 years. The maximum Unity Factor for excavated soil samples would be about 0.40 at that time.

There were 709 drums of soil that did not meet release limits. The results for Am-241 and plutonium represented 694 samples in which Am-241 was detected and 15 samples where Am-241 was reported at the lower limit of detection. The analyses for thorium and uranium indicated some contamination from these two elements was present in the soil in these drums. The background concentrations for thorium and uranium have not been deducted for the calculation of the unity factor for these drums. All 709 drums have been shipped to a commercial radwaste burial site for disposal.

5.2.4 Soil Survey Data Analysis

The data used to prepare Tables 5-8, 5-9, and 5-10 have been summarized statistically and are presented in Table 5-11. Examination of Table 5-11 shows that the mean of the excavation samples is less than the 99.7% upper confidence level of the background soil samples for Am-241, plutonium, Th-232, and uranium. Therefore, we have 99.7% confidence that the concentations of any of these substances in the excavation samples do not statistically exceed their concentrations in the background soil samples. The same statement is made for the excavated soil samples.

5.3 Decontamination Waste Survey

The data are summarized in Table 5-12 for the decontamination waste release survey. There were a total of 55 drums of paint chips, concrete chips, floor tile, and sand removed from Phase I during the decontamination of the rooms. The decontamination waste was sampled and analyzed in the same manner as the excavated soil. The analyses showed that 35 of these drums meet the release limits for unrestricted disposal. These drums are being retained at the LRC until approved for release. The other 20 drums have been shipped to a commercial radwaste burial site for disposal.

TABLE 5-1

SUMMARY OF AVERAGE ORIGINAL DIRECT ALPHA SURVEY RESULTS

Location	Direct Alpha Survey Results Number of Grids			Total Number of Grids
	30	30-100	>100	
	(average dpm/100 sq. cm.)			
Front Offices	550	2		552
Front Hall	312	3		315
Hall 23	173	1		174
Lab 25	147	1		148
Lab 26*	412			412
Lab 27	553	11		564
Lab 43	366	32	2	400
Lab 44	209	60	11	280
Lab 50	232	36		268
Labs 51 & 52	241	31		272
Lab 53	104	26	12	142
Lab 54	105	37		142
Pit	17	41	46	104
Old Central Stores	566			566
Total	3,987	281	71	4,339

* Data for Lab 26 also includes the Janitor's Closet and Filter Room.

TABLE 5-2

SUMMARY OF MAXIMUM ORIGINAL DIRECT ALPHA SURVEY RESULTS

Location	Direct Alpha Survey Results Number of Readings (maximum dpm/100 sq. cm.)			Total Number of Readings
	30	30-300	>300	
Front Offices	7,055	4		7,059
Front Hall	4,196	5		4,201
Hall 23	2,428	2		2,430
Lab 25	1,943	1		1,944
Lab 26*	5,810			5,810
Lab 27	8,186	29		8,215
Lab 43	5,579	393	7	5,979
Lab 44	3,645	549	20	4,214
Lab 50	4,022	162		4,184
Labs 51 & 52	3,380	265		3,645
Lab 53	1,605	304	19	1,928
Lab 54	1,571	448		2,019
Pit	539	724	105	1,368
Old Central Stores	8,462			8,462
Total	58,421	2,887	150	61,458

* Data for Lab 26 also includes the Janitor's Closet and Filter Room.

TABLE 5-3

SUMMARY OF ORIGINAL ALPHA SMEAR SURVEY RESULTS

Location	Alpha Smear Survey Results Number of Grids (dpm/100 sq. cm.)			Total Number of Grids
	0.1	0.1-5	5-10	
Front Offices	439	92	21	552
Front Hall	234	73	8	315
Hall 23	161	13		174
Lab 25	130	17	1	148
Lab 26*	367	40	5	412
Lab 27	491	66	7	564
Lab 43	280	78	42	400
Lab 44	232	45	3	280
Lab 50	211	46	11	268
Labs 51 & 52	233	36	4	272
Lab 53	127	14	1	142
Lab 54	111	24	7	142
Pit	81	19	4	104
Old Central Stores	462	91	13	566
Total	3,561	651	127	4,339

* Data for Lab 26 also includes the Janitor's Closet and Filter Room.

TABLE 5-4

SUMMARY OF AVERAGE RELEASE DIRECT ALPHA SURVEY RESULTS

Location	Direct Alpha Survey Results Number of Grids			Total Number of Grids
	30	30-100	>100	
	(average dpm/100 sq. cm.)			
Front Offices	552			552
Front Hall	313	2		315
Hall 23	174			174
Lab 25	148			148
Lab 26*	412			412
Lab 27	554	10		564
Lab 43	394	6		400
Lab 44	259	21		280
Lab 50	267	1		268
Labs 51 & 52	260	12		272
Lab 53	113	29		142
Lab 54	123	19		142
Pit	104			104
Old Central Stores	566			566
Total	4,239	100		4,339

* Data for Lab 26 also includes the Janitor's Closet and Filter Room.

TABLE 5-5

SUMMARY OF MAXIMUM RELEASE DIRECT ALPHA SURVEY RESULTS

Location	Direct Alpha Survey Results Number of Readings 30 (maximum dpm/100 sq. cm.)	30-300	>300	Total Number of Readings
Front Offices	7,059			7,059
Front Hall	4,197	4		4,201
Hall 23	2,430			2,430
Lab 25	1,944			1,944
Lab 26*	5,810			5,810
Lab 27	8,187	28		8,215
Lab 43	5,955	24		5,979
Lab 44	4,129	85		4,214
Lab 50	4,181	3		4,184
Labs 51 & 52	3,495	150		3,645
Lab 53	1,770	158		1,928
Lab 54	1,907	112		2,019
Pit	1,368			1,368
Old Central Stores	8,462			8,462
Total	60,894	564		61,458

* Data for Lab 26 also includes the Janitor's Closet and Filter Room.

TABLE 5-6

ALPHA SURVEY RESULTS
dpm/100 sq. cm.

	Direct Alpha Surveys By Grid	Direct Alpha Surveys By Reading	Alpha Smear Surveys By Grid
Sample Size	4339	61,458	4,339
Mean	30.22	30.19	0.73
Standard Deviation	3.5	3.6	1.47
Error on Mean	0.053	0.015	0.02
99.7% UCL	30.38	30.24	0.80
99.7% LCL	30.06	30.14	0.66

TABLE 5-7

SUMMARY OF RELEASE DIRECT BETA AND GAMMA AND SMEARABLE BETA SURVEY RESULTS FOR 242 FLOOR GRID BLOCKS IN PHASE I

Direct Gamma Survey Results dpm/100 sq. cm. Average Value	Direct Beta Survey Results dpm/100 sq. cm. Average Value	Smearable Beta Survey Results dpm/100 sq. cm. Average Value	Decision
300	300	300	Accept

Direct Gamma Survey Results dpm/100 sq. cm. Maximum Value	Direct Beta Survey Results dpm/100 sq. cm. Maximum Value	Smearable Beta Survey Results dpm/100 sq. cm. Maximum Value	Decision
300	300	360	Accept

TABLE 5-8

ANALYSES OF BACKGROUND SOIL SAMPLES

Number of Samples	Activity, pCi/gram							
	Am-241*		Plutonium*		Th-232		Uranium	
	Avg	Max	Avg	Max	Avg	Max	Avg	Max
107	0.33	0.54	1.43	2.33	1.28	2.12	1.40	2.51

* The values shown for Am-241 and plutonium represent minimum detectable levels; i. e., they do not actually indicate the presence of americium or plutonium, but indicate an upper limit for the values if they were present.

TABLE 5-9

ANALYSES OF EXCAVATION RELEASE SOIL SAMPLES

Number of Samples	Activity, pCi/gram								Unity Factor	
	Am-241*		Plutonium*		Th-232		Uranium			
	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
279	0.36	1.46	1.56	6.31	1.04	1.75	1.26	2.87	0.06	0.23

* Of the 279 values represented for Am-241 and plutonium in this table, 203 are minimum detectable concentrations; i. e., they do not actually indicate the presence of americium or plutonium, but indicate an upper limit for the values if they were present.

TABLE 5-10

ANALYSES OF EXCAVATED SOIL SAMPLES

Number of Samples	Activity, pCi/gram								Unity Factor	
	Am-241		Plutonium		Th-232		Uranium			
	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
989*	0.37	1.71	1.60	7.39	1.13	1.20	1.31	3.78	0.06	0.39
709	98	5,910	423	25,500	4.70	25.2	22.3	1,670	17.1	1,687

* Of the 989 values represented for Am-241 and plutonium in this category, 673 are minimum detectable concentrations; i. e., they do not actually indicate the presence of americium or plutonium, but indicate an upper limit for the values if they were present.

TABLE 5-11
SOIL SAMPLES ANALYSIS RESULTS

	Am-241 Activity, pCi/g		
	Background	Excavation	Excavated Soil
Sample Size	107	279	989
Mean	0.33	0.36	0.37
Standard Deviation	0.14	0.16	0.33
Error of Mean	0.01	0.01	0.01
99.7% UCL	0.37	0.39	0.40
99.7% LCL	0.30	0.33	0.34

	Plutonium Activity, pCi/g		
	Background	Excavation	Excavated Soil
Sample Size	107	279	989
Mean	1.43	1.56	1.60
Standard Deviation	0.69	0.69	1.43
Error of Mean	0.06	0.04	0.05
99.7% UCL	1.60	1.68	1.73
99.7% LCL	1.26	1.44	1.46

	Th-232 Activity, pCi/g		
	Background	Excavation	Excavated Soil
Sample Size	107	279	989
Mean	1.28	1.04	1.13
Standard Deviation	0.27	0.18	0.24
Error of Mean	0.03	0.01	0.01
99.7% UCL	1.35	1.07	1.16
99.7% LCL	1.21	1.01	1.11

	Uranium Activity, pCi/g		
	Background	Excavation	Excavated Soil
Sample Size	107	279	989
Mean	1.40	1.26	1.31
Standard Deviation	0.33	0.33	0.40
Error of Mean	0.03	0.02	0.01
99.7% UCL	1.47	1.32	1.35
99.7% LCL	1.32	1.20	1.27

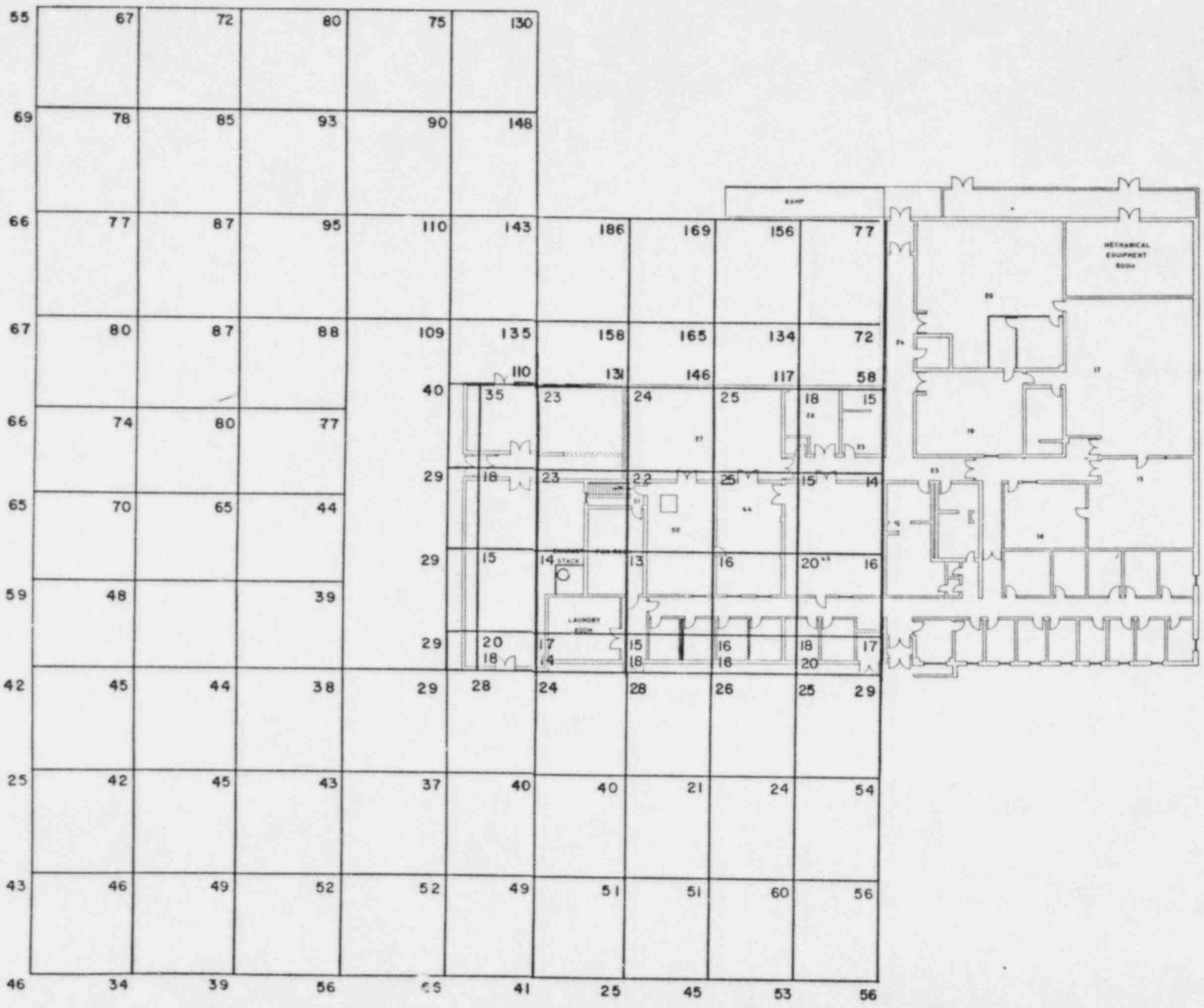
TABLE 5-12

ANALYSES OF DECONTAMINATED WASTE SAMPLES

Number of Samples	Activity, pCi/gram								Unity Factor	
	Am-241		Plutonium		Th-232		Uranium			
	Avg	Max	Avg	Max	Avg	Max	Avg	Max	Avg	Max
35	0.28	1.00	1.21	4.32	0.31	1.54	1.97	7.56	0.17	0.55
20	21	235	91	1,015	1.66	9.29	24	118	4.50	37

FIGURE 5-1. EXTERNAL GAMMA SURVEY, μR/HOUR

(Survey Conducted With RS-111 Environmental Monitor)



6.0 SURVEY INTERPRETATION

An extensive decontamination program was conducted throughout Phase I of Building C. Based on the survey results shown in Section 5.0, Phase I meets or surpassess all applicable release limits and can be released for unrestricted use pending approval by the NRC.

Comprehensive surveys were performed on the room's surfaces to measure direct and smearable alpha radioactivity. A statistical survey was performed for beta-gamma radioactivity. Fixed alpha contamination was the primary surface contamination found in Phase I with most of the readings (71%) being at the lower limit of detection. Americium, plutonium, thorium, and uranium from nuclear fuels R&D were the only contaminants found in the soil under Phase I of Building C. Excavation of soil under the drains continued until samples from the surfaces of the excavation demonstrated release limits had been met with most of the samples (72%) being at background concentrations. A total of 1,688 55-gallon drums of soil were excavated. The 702 drums of contaminated soil were shipped to a licensed commercial radwaste burial site for disposal. The remaining 982 drums of soil are being retained at the LRC until approved for release.

The scope of the decontamination project and the procedures, equipment, and analyses applied give strong assurance that the measured values of residual radioactivity are representative of Phase I and all release limits have been met. Thus, the decontamination and decommissioning project for Phase I has been successfully completed. Therefore, upon the concurrence of the NRC, Phase I will be released for unrestricted use.

7.0 REFERENCES

1. Docket No. 070-00824, NRC Materials License SNM-778, as renewed, Expires July 31, 1985.

2. Memo, A.F. Olsen, B&W, to W.T. Crow, NRC, "Decommissioning Plan for the Lynchburg Research Center's Building C", March 28, 1983.

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