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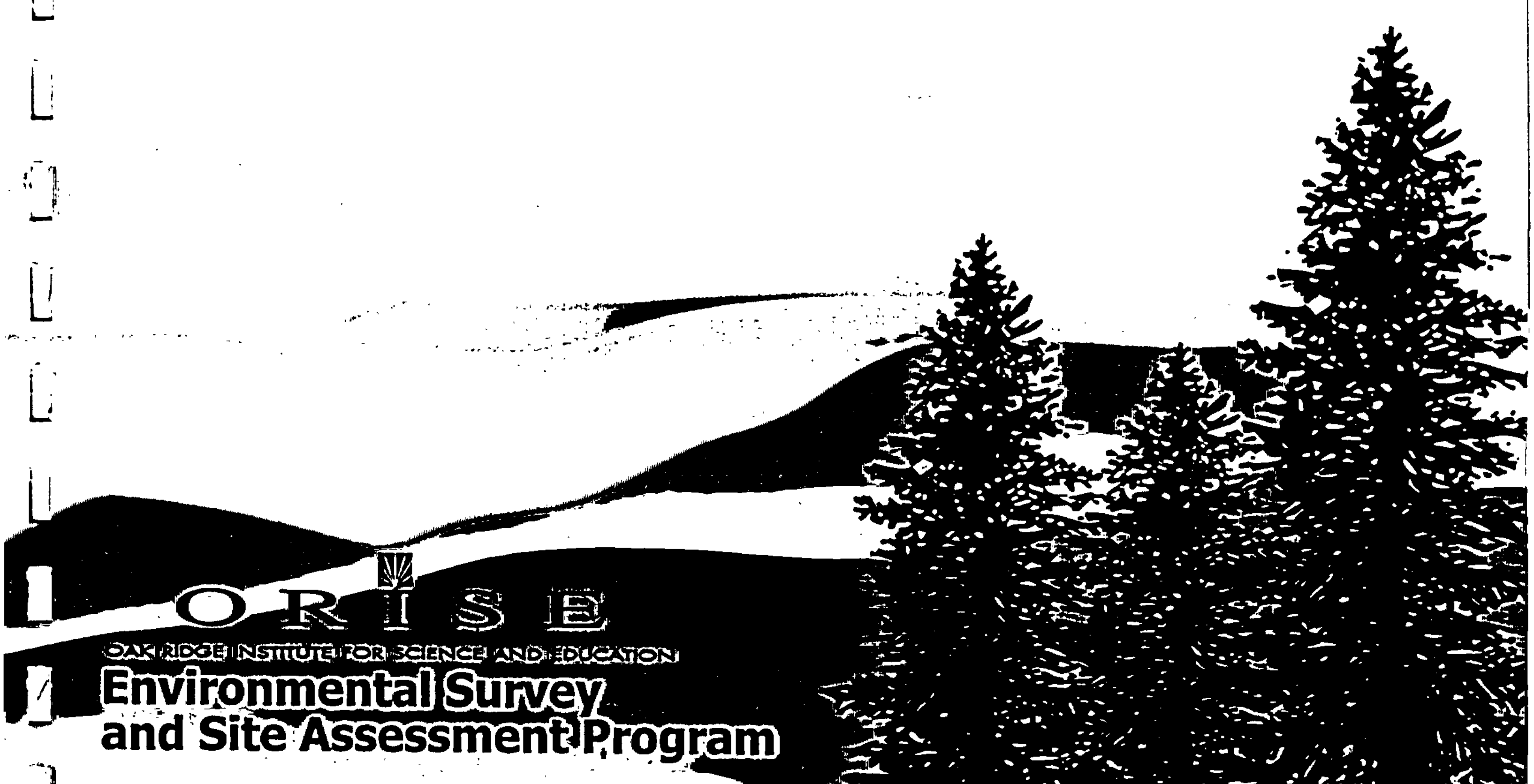
CONFIRMATORY SURVEY OF THE MANHATTAN COLLEGE ZERO POWER REACTOR MANHATTAN COLLEGE RIVERDALE, NEW YORK

T. J. VITKUS

Prepared for the
U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation



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NOTICES

ORISE 05-0917

CONFIRMATORY SURVEY
OF THE
MANHATTAN COLLEGE ZERO POWER REACTOR
MANHATTAN COLLEGE
RIVERDALE, NEW YORK

Prepared by

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Prepared for the

U.S. Nuclear Regulatory Commission
Office of Nuclear Reactor Regulation

FINAL REPORT

JUNE 2005

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CONFIRMATORY SURVEY
OF THE
MANHATTAN COLLEGE ZERO POWER REACTOR
MANHATTAN COLLEGE
RIVERDALE, NEW YORK

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ABBREVIATIONS AND ACRONYMS

ε_i	instrument efficiency
ε_s	surface efficiency
ε_{total}	total efficiency
b_i	number of background counts in the interval
BKG	background
cm	centimeter
cpm	counts per minute
d′	index of sensitivity
DOE	U.S. Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
ESSAP	Environmental Survey and Site Assessment Program
FSS	final status survey
ISO	International Standards Organization
ITP	Intercomparison Testing Program
keV	kiloelectron volt
m^2	square meter
MAPEP	Mixed Analyte Performance Evaluation Program
MCZPR	Manhattan College Zero Power Reactor
MDC	minimum detectable concentration
MDCR	minimum detectable count rate
MeV	million electronvolts
mm	millimeter
NaI	sodium iodide
NIST	National Institute of Standards and Technology
NRC	Nuclear Regulatory Commission
NRIP	NIST Radiochemistry Intercomparison Program
NRR	Office of Nuclear Reactor Regulation
ORISE	Oak Ridge Institute for Science and Education
μrem/h	microrem per hour
μR/h	microroentgens per hour

CONFIRMATORY SURVEY
OF THE
MANHATTAN COLLEGE ZERO POWER REACTOR
MANHATTAN COLLEGE
RIVERDALE, NEW YORK

INTRODUCTION AND SITE HISTORY

Manhattan College operated the Manhattan College Zero Power Reactor (MCZPR), following its construction and achievement of criticality in 1964, under U.S. Nuclear Regulatory Commission (NRC) License No. R-94. The MCZPR was a light water moderated, 0.1 watt, pool type reactor initially fueled with 92% enriched uranium and refueled in 1992 with 19% enriched uranium. The reactor was associated with the Manhattan College Nuclear Engineering Facility. In addition to the MCZPR, the facility also included a graphite moderated sub-critical reactor and a light water-moderated sub-critical reactor.

The MCZPR ceased operation in 1996 at which time the plutonium-beryllium neutron source and fuel were removed, placed in storage, and then shipped to Los Alamos National Laboratory and the University of Texas, respectively in 2003 and 2004. Decommissioning of the MCZPR was performed in accordance with the facility's NRC-approved decommissioning plan and included the removal of the reactor components, fuel assemblies, source storage containers, and other empty containers and non-radioactive components (MC 1998 and 2004). There was no history of any contamination instances over the operating lifetime of the reactor. The two sub-critical reactors had been removed from the facility in 1992.

A final status survey (FSS) of the facility was performed based on the guidance provided in draft NUREG/CR-5849 (NRC 1992). The FSS did not identify any residual contamination, with enriched uranium as the primary contaminant of concern. Source leak test records eliminated other radionuclides as potential contaminants of concern. The survey results were provided in an FSS report and Manhattan College has requested release of the facility for unrestricted use (MC 2004). In conjunction with this request, the NRC's Headquarters Office of Nuclear Reactor Regulation (NRR) requested that the Oak Ridge Institute for Science and Education's (ORISE)

Environmental Survey and Site Assessment Program (ESSAP) perform a confirmatory survey of the MCZPR facility.

SITE DESCRIPTION

The MCZPR is located on the first floor of the Leo Engineering Building on Corlear Avenue, two blocks from the Manhattan College main campus, in the Riverdale section of the Bronx in New York City, New York. The survey areas consisted of Room 221 where the MCZPR and two sub-critical reactors were located and Room 109, which is directly beneath Room 221 and was used for storage of the fuel and sources. Figures 1 and 2 show the first and second floor plot plans.

OBJECTIVES

The objectives of the confirmatory survey were to provide independent contractor FSS data reviews and to generate independent radiological data for use by the NRC in evaluating the adequacy and accuracy of the licensee's procedures and FSS results.

DOCUMENT REVIEW

ESSAP reviewed the licensee's FSS report for adequacy and appropriateness taking into account the decommissioning plan and draft NUREG/CR-5849 considerations (MC 1998 and 2004 and NRC 1992).

PROCEDURES

Survey activities were conducted in accordance with a site-specific confirmatory survey plan and the ORISE/ESSAP Survey Procedures and Quality Assurance Manuals (ORISE 2005a, 2004a and b). ESSAP's confirmatory surveys included investigations of the ZPR room (Room 221) and the adjacent sub-critical reactor laboratory, and Room 109 (fuel and source storage room).

Reference System

Measurements and sampling locations were referenced to the existing grid system.

Surface Scans

Surface scans for gamma radiation were conducted over 100 percent of the accessible surfaces in each room. Alpha and alpha plus beta scans were conducted on up to 75% of the floor and lower walls in each area. Scans were performed using NaI scintillation and gas proportional detectors coupled to ratemeters or ratemeter-scalers with audible indicators. Any locations of elevated direct radiation identified were investigated further.

Surface Activity Measurements

Construction material-specific background measurements were collected from a non-impacted background reference area for correcting gross activity measurements performed on structural surfaces. Direct measurements for total alpha and beta activity were performed on floors, lower walls and equipment at 30 judgmental locations. Figures 3 through 5 show the measurement locations within each room. Measurements were made using gas proportional detectors coupled to portable ratemeter-scalers. Smear samples, for determining removable activity levels, were collected from each direct measurement location.

Exposure Rate Measurements

Exposure rate measurements were made within each of the three rooms at one meter above the floor using a microrem meter (Figures 3 through 5). The background exposure rate was measured in the building main corridor.

SAMPLE ANALYSIS AND DATA INTERPRETATION

Samples and data were returned to ORISE's ESSAP Oak Ridge, Tennessee facility for analysis and interpretation. Sample analyses were performed in accordance with the ORISE/ESSAP Laboratory Procedures Manual (ORISE 2004c). Smear samples were analyzed for gross alpha and gross beta activity using a low-background gas proportional counter. Smear results and direct measurements for total surface activity were converted to units of disintegrations per minute per 100 square centimeters (dpm/100 cm^2).

Confirmatory survey data were then compared with the applicable NRC guidelines for release without radiological restrictions (NRC 1974 and 1996).

FINDINGS AND RESULTS

DOCUMENT REVIEW

ESSAP's review of the licensee's FSS report determined that the FSS generally followed the guidance provided in draft NUREG/CR-5849 and demonstrated compliance with the guidelines for release without radiological restrictions. Comments ESSAP identified in the project documentation were provided to NRC/NRR (ORISE 2005b).

SURFACE SCANS

Surface scans did not identify any residual alpha, beta, or gamma radiation on structural or equipment surfaces investigated. However during these investigations, two potentially radioactive items were identified and turned over to the licensee for disposition. These items included a rod marked as contaminated with uranium-235 and a broken radiation monitor that exhibited elevated alpha plus beta radiation levels.

SURFACE ACTIVITY LEVELS

Confirmatory survey surface activity levels are provided in Table 1. Total alpha activity measurements ranged from -16 to 32 dpm/100 cm^2 and total beta activity ranged from -910 to 620 dpm/100 cm^2. Removable activity levels ranged from 0 to 7 dpm/100 cm^2 for gross alpha and from -4 to 10 dpm/100 cm^2 for gross beta.

EXPOSURE RATES

The background exposure rate was 6 μR/h. Exposure rates in the surveyed areas ranged from 4 to 8 μR/h.

COMPARISON OF RESULTS WITH GUIDELINES

The licensee reported that the primary radionuclides of concern would be uranium isotopes from the reactor fuel. Because uranium emits both alpha and beta radiation at varying ratios dependent upon the percent enrichment, both alpha and beta measurements were made and compared with the NRC's Regulatory Guide 1.86 uranium guidelines (NRC 1974). Additionally, beta measurements were also compared with the guidelines for mixed activation and fission products (NRC 1974). These guidelines are as follows:

Total Activity

5000 α/β-γ dpm/100 cm^2, averaged over a 1 m^2 area
15,000 α/β-γ dpm/100 cm^2, maximum in a 100 cm^2 area

Removable Activity

1000 α/β-γ dpm/100 cm^2

The exposure rate guideline is 5 μR/h above background (NRC 1996).

All total and removable activity levels and exposure rates were less than the guidelines.

SUMMARY

At the request of the U.S. Nuclear Regulatory Commission Headquarter's Office of Nuclear Reactor Regulation, the Environmental Survey and Site Assessment Program of the Oak Ridge Institute for Science and Education conducted a confirmatory survey of the former Manhattan College School of Engineering Zero Power Reactor facility on April 7, 2005. The results of the survey did not identify any residual surface contamination and determined that surface activity levels and exposure rates were less than the applicable NRC guidelines for release of the facility for unrestricted use, thereby confirming the licensee's final status survey results.

FIGURES

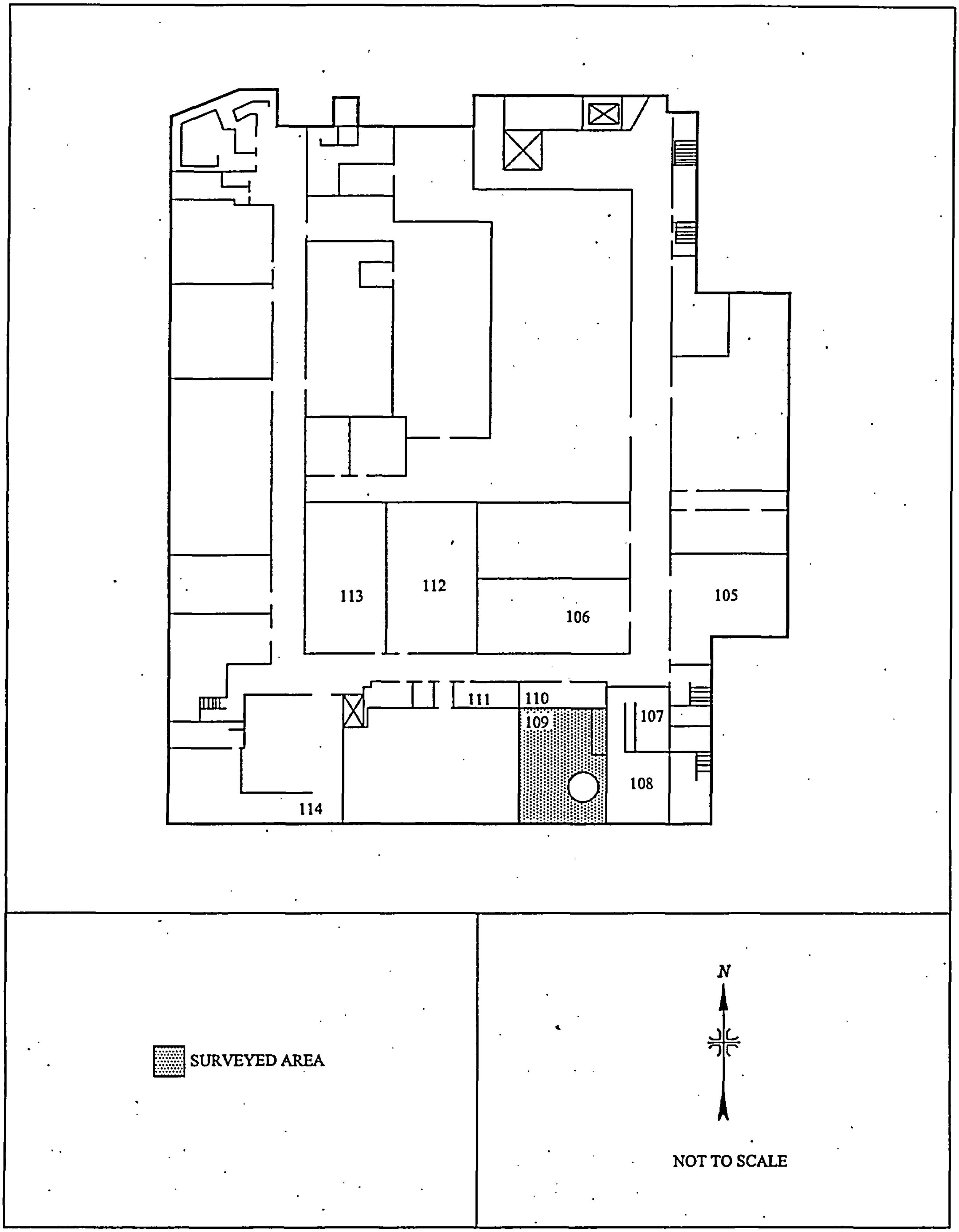

FIGURE 1: Leo Engineering Building, First Floor - Floor Plan

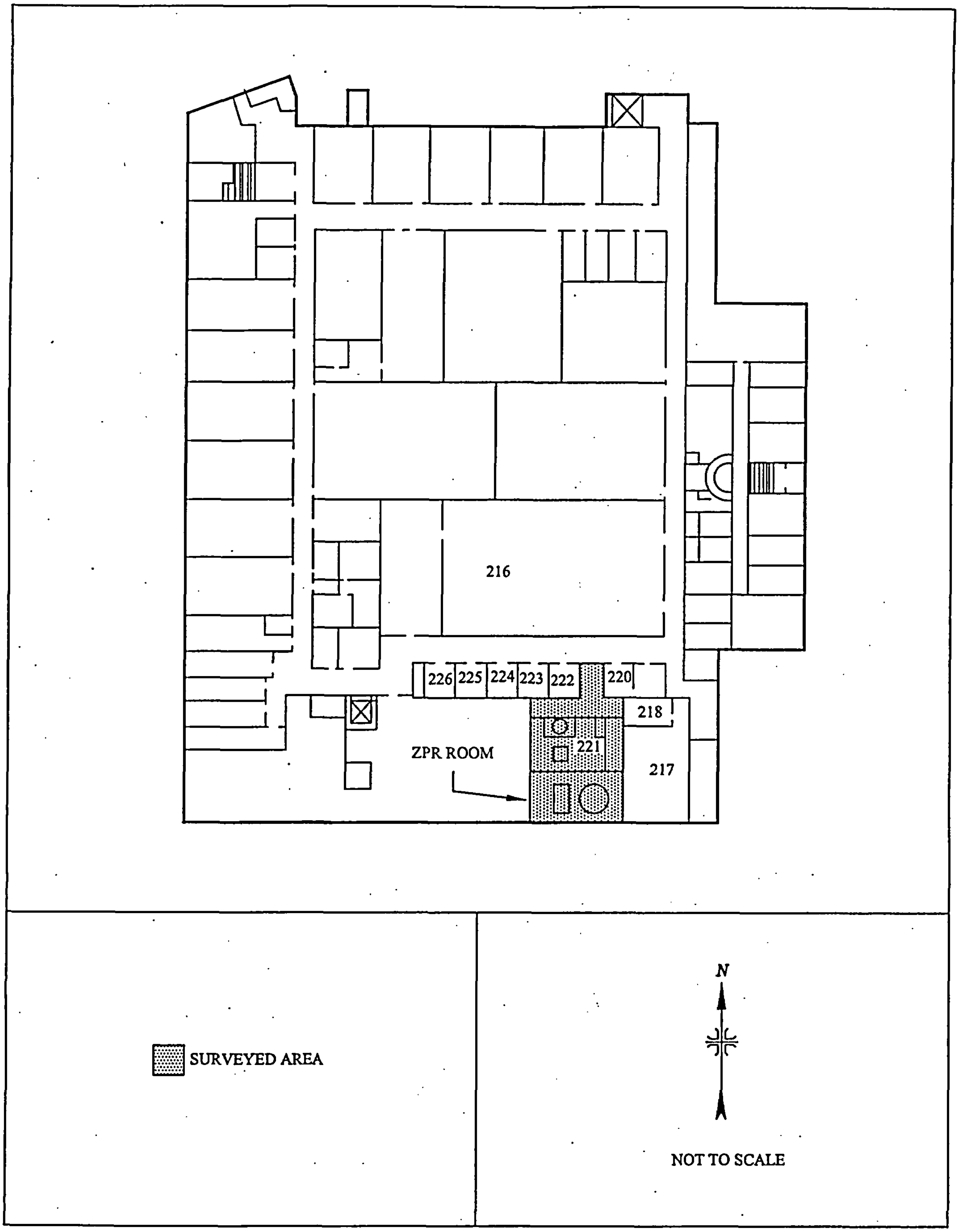

FIGURE 2: Leo Engineering Building, Second Floor - Floor Plan

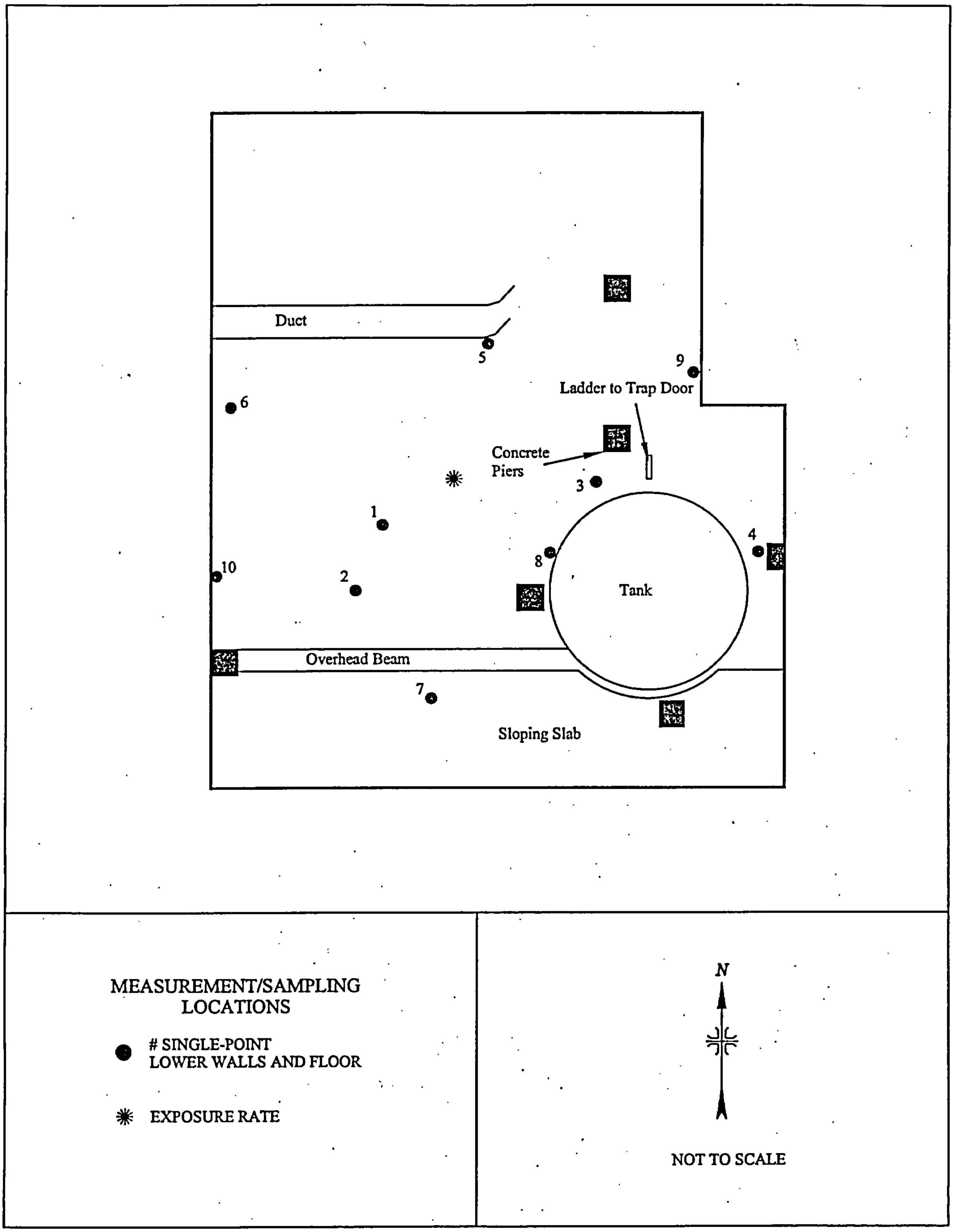

FIGURE 3: Fuel and Source Storage Room, Room 109 - Measurement and Sampling Locations

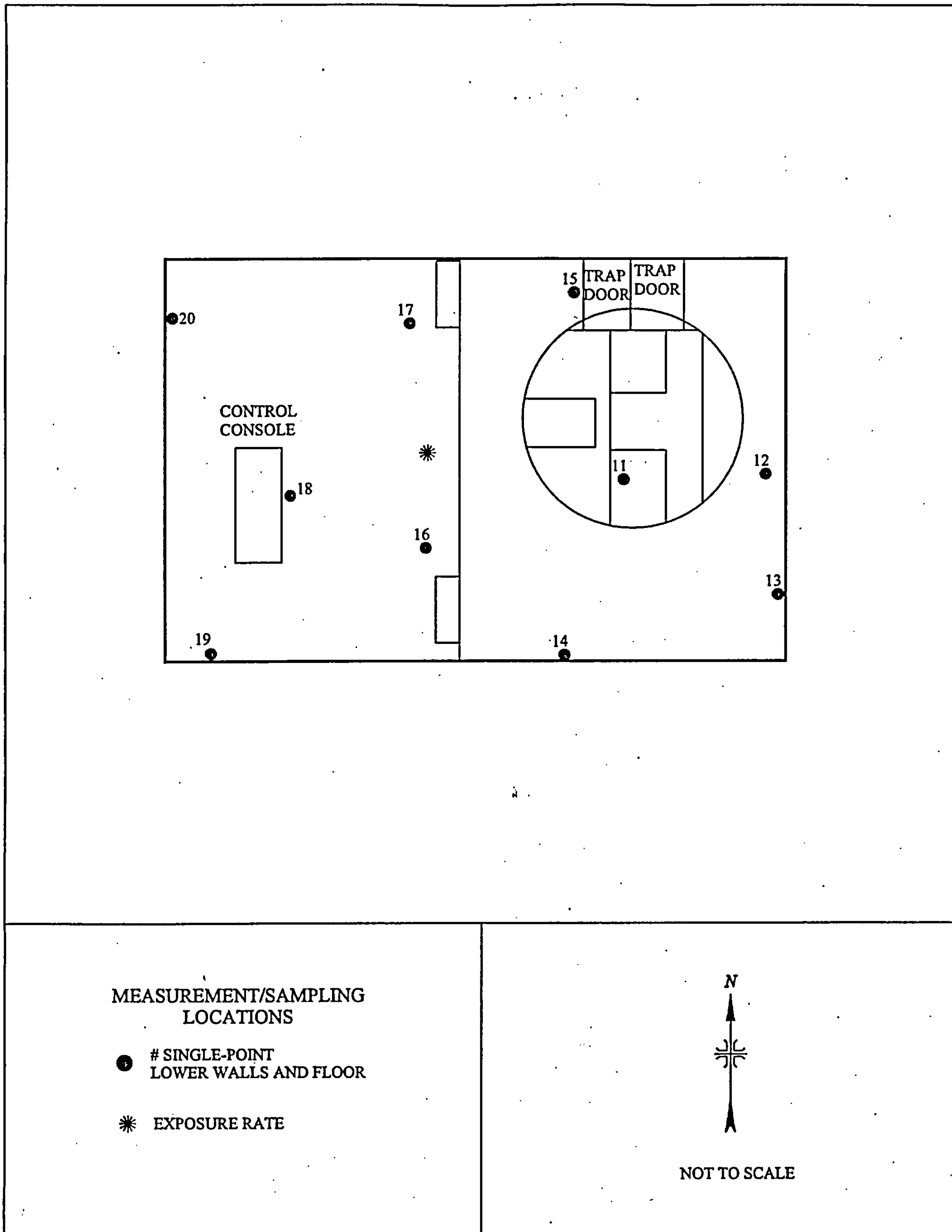

FIGURE 4: MCZPR Laboratory - Measurement and Sampling Locations

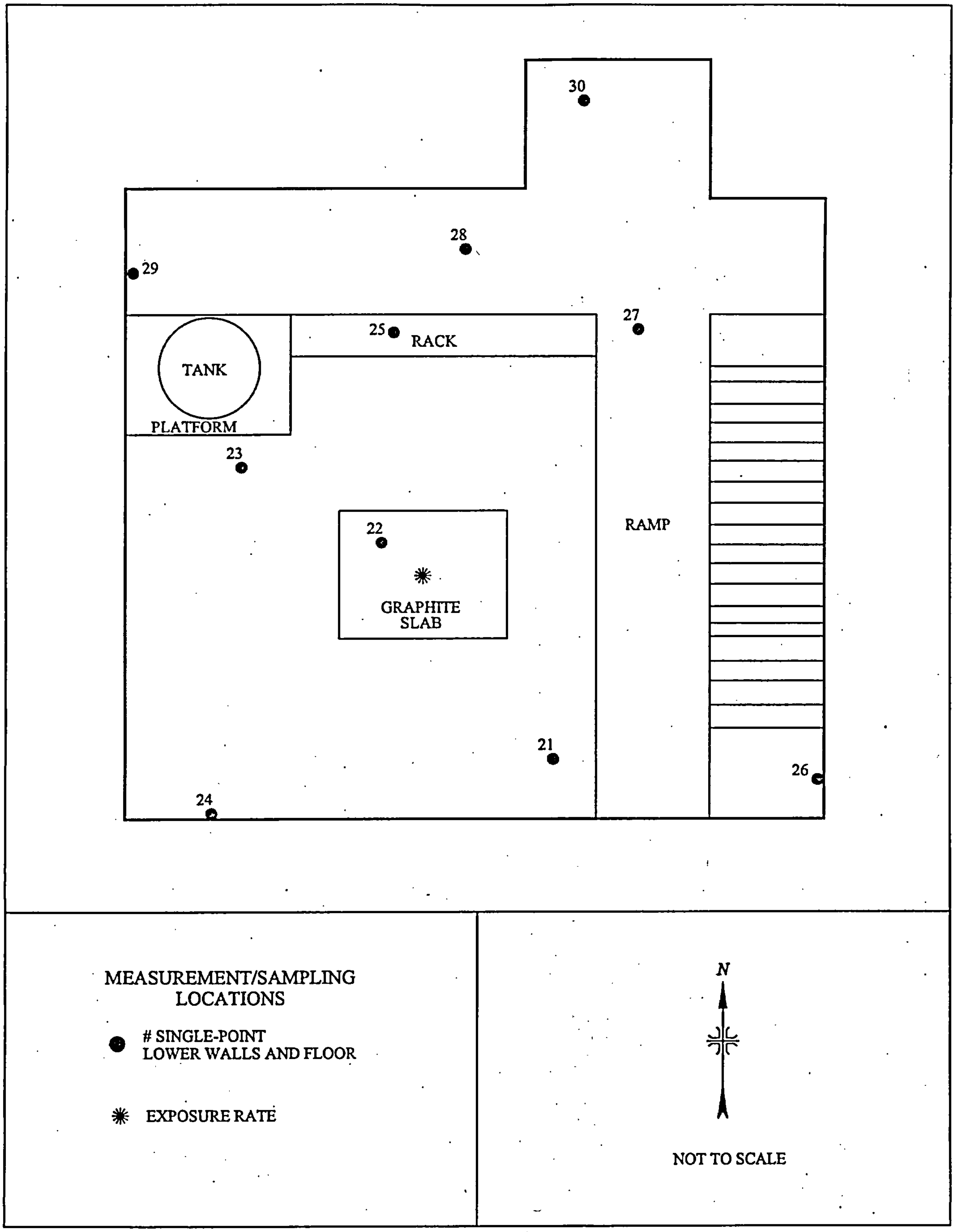

FIGURE 5: Sub-Critical Reactor Laboratory - Measurement and Sampling Locations

TABLE

TABLE 1

SURFACE ACTIVITY LEVELS
MANHATTAN COLLEGE ZERO POWER REACTOR
MANHATTAN COLLEGE
RIVERDALE, NEW YORK

Room/Location[a]	Surface[b]	Total Activity (dpm/100 cm^2)		Removable Activity (dpm/100 cm^2)	
		Alpha	Beta	Alpha	Beta
Fuel and Source Storage Room					
1	F	-16	360	1	6
2	F	-16	410	1	-2
3	F	-8	340	1	-1
4	F	32	380	0	3
5	F	-16	280	0	-2
6	F	-8	270	0	4
7	LW	8	620	0	-1
8	E	-8	-210	1	6
9	LW	24	180	7	-2
10	LW	0	-87	0	2
MCZPR Laboratory					
11	F	24	-320	0	-3
12	F	32	-580	0	2
13	LW	24	-370	1	1
14	LW	16	-390	5	4
15	F	8	-530	0	5
16	F	0	-210	1	2
17	F	-16	-630	0	-1
18	F	-8	-910	0	-1
19	LW	0	40	0	4
20	LW	8	56	0	2
Sub-critical Reactor Laboratory					
21	F	-8	-700	0	5
22	F	0	100	1	9
23	F	0	-910	0	3
24	LW	0	180	0	10
25	E	0	79	1	-1
26	LW	8	-670	0	2
27	F	16	-250	1	-1
28	F	0	-420	0	-4
29	LW	-8	400	3	2
30	F	8	-590	0	-2

[a]Refer to Figures 3 through 5.
[b]F=floor, LW=lower wall, E=equipment

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Manhattan College (MC). Decommissioning Plan, Manhattan College Zero Power Reactor, License No. R-94, Docket No. 50-199, Revision 1. Riverdale, NY; July 1998.

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U.S. Nuclear Regulatory Commission (NRC). Termination of Operating Licenses for Nuclear Reactors. Washington, DC: U.S. Government Printing Office; Regulatory Guide 1.86; June 1974.

U.S. Nuclear Regulatory Commission. Manual for Conducting Radiological Surveys in Support of License Termination. Washington, DC; Draft NUREG/CR-5849; June 1992.

U.S. Nuclear Regulatory Commission. Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors. Washington, DC; NUREG-1537; February 1996.

APPENDIX A

MAJOR INSTRUMENTATION

APPENDIX A
MAJOR INSTRUMENTATION

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

SCANNING INSTRUMENT/DETECTOR COMBINATIONS

Alpha-Beta

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

Gamma

Ludlum Model 12
(Ludlum Measurements, Inc., Sweetwater, TX)
coupled to
Victoreen NaI Scintillation Detector Model 489-55, Crystal: 3.2 cm x 3.8 cm
(Victoreen, Cleveland, OH)

DIRECT MEASUREMENT INSTRUMENT/DETECTOR COMBINATIONS

Alpha and Beta

Ludlum Ratemeter-Scaler Model 2221
coupled to
Ludlum Gas Proportional Detector Model 43-68, Physical Area: 126 cm^2
(Ludlum Measurements, Inc., Sweetwater, TX)

Gamma

Bicron Micro-rem Meter
(Bicron Corporation, Newbury, OH)

LABORATORY ANALYTICAL INSTRUMENTATION

Low Background Gas Proportional Counter
Model LB-5100-W
(Canberra/Tennelec, Meriden, CT)

APPENDIX B

SURVEY AND ANALYTICAL PROCEDURES

APPENDIX B
SURVEY AND ANALYTICAL PROCEDURES

PROJECT HEALTH AND SAFETY

The proposed survey and sampling procedures were evaluated to ensure that any hazards inherent to the procedures themselves were addressed in current job hazard analyses. All survey and laboratory activities were conducted in accordance with ORISE health and safety and radiation protection procedures.

A walkdown of the survey areas was performed in order to evaluate and identify potential health and safety issues. Survey work was performed per the ORISE generic health and safety plans, and a site-specific integrated safety management pre-job hazard checklist.

QUALITY ASSURANCE

Analytical and field survey activities were conducted in accordance with procedures from the following documents of the Environmental Survey and Site Assessment Program:

- Survey Procedures Manual, (September 2004)
- Laboratory Procedures Manual, (August 2004)
- Quality Assurance Manual, (August 2004)

The procedures contained in these manuals were developed to meet the requirements of Department of Energy (DOE) Order 414.1B and the U.S. Nuclear Regulatory Commission *Quality Assurance Manual for the Office of Nuclear Material Safety and Safeguards* and contain measures to assess processes during their performance.

Quality control procedures include:

- Daily instrument background and check-source measurements to confirm that equipment operation is within acceptable statistical fluctuations.

- Participation in MAPEP, NRIP, and ITP Laboratory Quality Assurance Programs.

- Training and certification of all individuals performing procedures.

- Periodic internal and external audits.

CALIBRATION

Calibration of all field and laboratory instrumentation was based on standards/sources, traceable to NIST, when such standards/sources were available. In cases where they were not available, standards of an industry-recognized organization were used.

Detectors used for assessing surface activity were calibrated in accordance with ISO-7503[1] recommendations. The total efficiency (ε_{total}) was determined for each instrument/detector combination and consisted of the product of the 2π instrument efficiency (ε_i) and surface efficiency (ε_s): $\varepsilon_{total} = \varepsilon_i \times \varepsilon_s$. The static alpha ε_i was 0.40 calibrated to Th-230 and the beta static ε_i was determined to be 0.40 calibrated to Tc-99. The scanning ε_i was approximately 0.38 for Tc-99 based on ESSAP experience.

Tc-99 was selected as the calibration source (maximum beta energy of 292 keV) as it provides a conservative representation of the beta emissions from enriched uranium. ISO-7503 recommends an ε_s of 0.25 for beta emitters with a maximum energy of less than 0.4 MeV (400 keV) and an ε_s of 0.5 for maximum beta energies greater than 0.4 MeV. Since the maximum beta energy for the enriched uranium series is primarily less than 0.4 MeV, an ε_s of 0.25 was used to calculate the beta ε_{total} of 0.10. ISO-7503 also recommends an ε_s of 0.25 for alpha emitters. The resultant alpha ε_{total} was 0.10.

SURVEY PROCEDURES

Surface Scans

Surface scans were performed by passing the detectors slowly over the surface; the distance between the detector and the surface was maintained at a minimum—nominally about 1 cm. A NaI scintillation detector was used to scan for elevated gamma radiation. Floor and wall surfaces

[1]International Standard. ISO 7503-1, Evaluation of Surface Contamination - Part 1: Beta-emitters (maximum beta energy greater than 0.15 MeV) and alpha-emitters. August 1, 1988.

were scanned using small area (126 cm^2) hand-held detectors. Identification of elevated levels was based on increases in the audible signal from the recording and/or indicating instrument.

Scan minimum detectable concentrations (MDCs) were estimated using the calculational approach described in NUREG-1507[2]. The scan MDC is a function of many variables, including the background level. The construction material beta background count rates that included painted brick, painted concrete block, painted concrete, and wood, metal, and graphite for the gas proportional detectors ranged from 183 to 519 cpm and was 380 cpm for ambient air measurements. Alpha backgrounds ranged from 1 to 2 cpm. Additional parameters selected for the calculation of scan MDCs included a two-second observation interval, a specified level of performance at the first scanning stage of 95% true positive rate and 25% false positive rate, which yields a *d'* value of 2.32 (NUREG-1507, Table 6.1), and a surveyor efficiency of 0.5. To illustrate an example for the hand-held gas proportional detectors, the minimum detectable count rate (MDCR) and scan MDC can be calculated as follows for painted concrete surfaces:

b_i = (337 cpm) (2 sec) (1 min/60 sec) = 11.2 counts
MDCR = (2.32) (11.2 counts)$^{1/2}$ [(60 sec/min) / (2 sec)] = 233 counts per minute (cpm)
$MDCR_{surveyor}$ = 233 / (0.5)$^{1/2}$ = 330 cpm

The scan MDC is calculated using the scanning ε_{total} of 0.10:

$$Scan\,MDC = \frac{MDCR_{surveyor}}{\varepsilon_{total}}\ \mathrm{dpm/100\,cm^2}$$

The beta scan MDC for the gas proportional detectors used was approximately 3,300 dpm/100 cm^2 for concrete surfaces and the alpha scan MDC was approximately 200 dpm/100 cm^2.

Surface Activity Measurements

Measurements of total alpha and beta surface activity levels were performed using gas proportional detectors with portable ratemeter-scalers. Count rates (cpm), which were integrated

[2]NUREG-1507. Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions. US Nuclear Regulatory Commission. Washington, DC; June 1998.

over one minute with the detector held in a static position, were converted to activity levels (dpm/100 cm^2) by dividing the net count rate by ε_{total} and correcting for the physical area of the detector.

Because different building materials (concrete, brick, wood, steel, etc.) may have different background levels, average background count rates were determined for representative construction materials encountered in the surveyed areas at a location of similar construction and having no known radiological history.

The static beta MDCs—calculated using the average construction material background count rates within the building—for the single gas proportional detector (calibrated to Tc-99) used for surface activity measurements ranged from 520 to 870 dpm/100 cm^2. The alpha static MDC ranged from 60 to 80 dpm/100 cm^2 calibrated to Th-230. The physical surface area assessed by the gas proportional detector used was 126 cm^2.

Removable Activity Measurements

Removable gross alpha and gross beta activity levels were determined using numbered filter paper disks, 47 mm in diameter. Moderate pressure was applied to the smear and approximately 100 cm^2 of the surface was wiped. Smears were placed in labeled envelopes with the location and other pertinent information recorded.

Exposure Rate Measurements

Measurements of dose equivalent rates (µrem/h) were performed at 1 meter above the surface using a Bicron microrem meter. Although the instrument displays data in µrem/h, the µrem/h to µR/h conversion is essentially unity.

Radiological Analysis

Gross Alpha/Beta

Smears were counted for two minutes on a low-background gas proportional system for gross alpha and beta activity. The MDCs of the procedure were 9 dpm/100 cm^2 and 15 dpm/100 cm^2 for gross alpha and gross beta, respectively.

Detection Limits

Detection limits, referred to as minimum detectable concentration (MDC), were based on 3 plus 4.65 times the standard deviation of the background count $[3 + (4.65\sqrt{BKG})]$. Because of variations in background levels, measurement efficiencies, and contributions from other radionuclides in samples, the detection limits differ from sample to sample and instrument to instrument.

APPENDIX C

REGULATORY GUIDE 1.86

June 1974

U.S. ATOMIC ENERGY COMMISSION

REGULATORY GUIDE

DIRECTORATE OF REGULATORY STANDARDS

REGULATORY GUIDE 1.86

TERMINATION OF OPERATING LICENSES FOR NUCLEAR REACTORS

A. INTRODUCTION

Section 50.51, "Duration of license, renewal," of 10 CFR Part 50, "Licensing of Production and Utilization Facilities," requires that each license to operate a production and utilization facility be issued for a specified duration. Upon expiration of the specified period, the license may be either renewed or terminated by the Commission. Section 50.82, "Applications for termination of licenses," specifies the requirements that must be satisfied to terminate an operating license, including the requirement that the dismantlement of the facility and disposal of the component parts not be inimical to the common defense and security or to the health and safety of the public. This guide describes methods and procedures considered acceptable by the Regulatory staff for the termination of operating licenses for nuclear reactors. The Advisory Committee on Reactor Safeguards has been consulted concerning this guide and has concurred in the regulatory position.

B. DISCUSSION

When a licensee decides to terminate his nuclear reactor operating license, he may, as a first step in the process, request that his operating license be amended to restrict him to possess but not operate the facility. The advantage to the licensee of converting to such a possession-only license is reduced surveillance requirements in that periodic surveillance of equipment important to the safety of reactor operation is no longer required. Once this possession-only license is issued, reactor operation is not permitted. Other activities related to cessation of operations such as unloading fuel from the reactor and placing it in storage (either onsite of offsite) may be continued.

A licensee having a possession-only license must retain, with the Part 50 license, authorization for special nuclear material (10 CFR Part 70, "Special Nuclear Material"), byproduct material (10 CFR Part 30, "Rules of General Applicability to Licensing of Byproduct Material"), and source material (10 CFR Part 40, "Licensing of Source Material"), until the fuel, radioactive components, and sources are removed from the facility. Appropriate administrative controls and facility requirements are imposed by the Part 50 license and the technical specifications to assure that proper surveillance is performed and that the reactor facility is maintained in a safe condition and not operated.

A possession-only license permits various options and procedures for decommissioning, such as mothballing, entombment, or dismantling. The requirements imposed depend on the option selected.

Section 50.82 provides that the licensee may dismantle and dispose of the component parts of a nuclear reactor in accordance with existing regulations. For research reactors and critical facilities, this has usually meant the disassembly of a reactor and its shipment offsite, sometimes to another appropriately licensed organization for further use. The site from which a reactor has been removed must be decontaminated, as necessary, and inspected by the Commission to determine whether unrestricted access can be approved. In the case of nuclear power reactors, dismantling has usually been accomplished by shipping fuel offsite, making the reactor inoperable, and disposing of some of the radioactive components.

Radioactive components may be either shipped offsite for burial at an authorized burial ground or secured on the site. Those radioactive materials remaining on the site must be isolated from the public by physical barriers or other means to prevent public access to hazardous levels of radiation. Surveillance is necessary to assure the long term integrity of the barriers. The amount of surveillance required depends upon (1) the potential hazard to the health and safety of the public from radioactive material remaining on the site and (2) the integrity of the physical barriers. Before areas may be released for unrestricted use, they must have been decontaminated or the radioactivity must have decayed to less than prescribed limits (Table I).

The hazard associated with the retired facility is evaluated by considering the amount and type of remaining contamination, the degree of confinement of the remaining radioactive materials, the physical security provided by the confinement, the susceptibility to release of radiation as a result of natural phenomena, and the duration of required surveillance.

C. REGULATORY POSITION

1. APPLICATION FOR A LICENSE TO POSSESS BUT NOT OPERATE (POSSESSION-ONLY LICENSE)

A request to amend an operating license to a possession-only license should be made to the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545. The request should include the following information:

a. A description of the current status of the facility.

b. A description of measures that will be taken to prevent criticality or reactivity changes and to minimize releases of radioactivity from the facility.

c. Any proposed changes to the technical specifications that reflect the possession-only facility status and the necessary disassembly/retirement activities to be performed.

d. A safety analysis of both the activities to be accomplished and the proposed changes to the technical specifications.

e. An inventory of activated materials and their location in the facility.

2. ALTERNATIVES FOR REACTOR RETIREMENT

Four alternatives for retirement of nuclear reactor facilities are considered acceptable by the Regulatory staff. These are:

a. **Mothballing.** Mothballing of a nuclear reactor facility consists of putting the facility in a state of protective storage. In general, the facility may be left intact except that all fuel assemblies and the radioactive fluids and waste should be removed from the site. Adequate radiation monitoring, environmental surveillance, and appropriate security procedures should be established under a possession-only license to ensure that the health and safety of the public is not endangered.

b. **In-Place Entombment.** In-place entombment consists of sealing all the remaining highly radioactive or contaminated components (e.g., the pressure vessel and reactor internals) within a structure integral with the biological shield after having all fuel assemblies, radioactive fluids and wastes, and certain selected components shipped offsite. The structure should provide integrity over the period of time in which significant quantities (greater than Table I levels) of radioactivity remain with the material in the entombment. An appropriate and continuing surveillance program should be established under a possession-only license.

c. **Removal of Radioactive Components and Dismantling.** All fuel assemblies, radioactive fluids and waste, and other materials having activities above accepted unrestricted activity levels (Table I) should be removed from the site. The facility owner may then have unrestricted use of the site with no requirement for a license. If the facility owner so desires, the remainder of the reactor facility may be dismantled and all vestiges removed and disposed of.

d. **Conversion to a New Nuclear System or a Fossil Fuel System.** This alternative, which applies only to nuclear power plants, utilizes the existing turbine system with a new steam supply system. The original nuclear steam supply system should be separated from the electric generating system and disposed of in accordance with one of the previous three retirement alternatives.

3. SURVEILLANCE AND SECURITY FOR THE RETIREMENT ALTERNATIVES WHOSE FINAL STATUS REQUIRES A POSSESSION-ONLY LICENSE

A facility which has been licensed under a possession-only license may contain a significant amount of radioactivity in the form of activated and contaminated hardware and structural materials. Surveillance and commensurate security should be provided to assure that the public health and safety are not endangered.

a. Physical security to prevent inadvertent exposure of personnel should be provided by multiple locked barriers. The presence of these barriers should make it extremely difficult for an unauthorized person to gain access to areas where radiation or contamination levels exceed those specified in Regulatory Position C.4. To prevent inadvertent exposure, radiation areas above 5 mR/hr, such as near the activated primary system of a power plant, should be appropriately marked and should not be accessible except by cutting of welded closures or the disassembly and removal of substantial structures and/or shielding material. Means such as a remote-readout intrusion alarm system should be provided to indicate to designated personnel when a physical barrier is penetrated. Security personnel that provide access control to the facility may be used instead of the physical barriers and the intrusion alarm systems.

b. The physical barriers to unauthorized entrance into the facility, e.g., fences, buildings, welded doors, and access openings, should be inspected at least quarterly to assure that these barriers have not deteriorated and that locks and locking apparatus are intact.

c. A facility radiation survey should be performed at least quarterly to verify that no radioactive material is escaping or being transported through the containment barriers in the facility. Sampling should be done along the most probable path by which radioactive material such as that stored in the inner containment regions could be transported to the outer regions of the facility and ultimately to the environs.

d. An environmental radiation survey should be performed at least semiannually to verify that no signficant amounts of radiation have been released to the environment from the facility. Samples such as soil, vegetation, and water should be taken at locations for which statistical data has been established during reactor operations.

e. A site representative should be designated to be responsible for controlling authorized access into and movement within the facility.

f. Administrative procedures should be established for the notification and reporting of abnormal occurrences such as (1) the entrance of an unauthorized person or persons into the facility and (2) a significant change in the radiation or contamination levels in the facility or the offsite environment.

g. The following reports should be made:

(1) An annual report to the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545, describing the results of the environmental and facility radiation surveys, the status of the facility, and an evaluation of the performance of security and surveillance measures.

(2) An abnormal occurrence report to the Regulatory Operations Regional Office by telephone within 24 hours of discovery of an abnormal occurrence. The abnormal occurrence will also be reported in the annual report described in the preceding item.

h. Records or logs relative to the following items should be kept and retained until the license is terminated, after which they may be stored with other plant records:

(1) Environmental surveys;

(2) Facility radiation surveys,

(3) Inspections of the physical barriers, and

(4) Abnormal occurrences.

4. DECONTAMINATION FOR RELEASE FOR UNRESTRICTED USE

If it is desired to terminate a license and to eliminate any further surveillance requirements, the facility should be sufficiently decontaminated to prevent risk to the public health and safety. After the decontamination is satisfactorily accomplished and the site inspected by the Commission, the Commission may authorize the license to be terminated and the facility abandoned or released for unrestricted use. The licensee should perform the decontamination using the following guidelines:

a. The licensee should make a reasonable effort to eliminate residual contamination.

b. No covering should be applied to radioactive surfaces of equipment or structures by paint, plating, or other covering material until it is known that contamination levels (determined by a survey and documented) are below the limits specified in Table I. In addition, a reasonable effort should be made (and documented) to further minimize contamination prior to any such covering.

c. The radioactivity of the interior surfaces of pipes, drain lines, or ductwork should be determined by making measurements at all traps and other appropriate access points, provided contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. 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 should be assumed to be contaminated in excess of the permissable radiation limits.

d. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated in excess of the limits specified. This may include, but is not limited to, special circumstances such as the transfer of premises to another licensed organization that will continue to work with radioactive materials. Requests for such authorization should provide:

(1) Detailed, specific information describing the premises, equipment, scrap, and radioactive contaminants and the nature, extent, and degree of residual surface contamination.

(2) A detailed health and safety analysis indicating that the residual amounts of materials on surface areas, together with other considerations such as the prospective use of the premises, equipment, or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

e. Prior to release of the premises for unrestricted use, the licensee should make a comprehensive radiation survey establishing that contamination is within the limits specified in Table I. A survey report should be filed with the Director of Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545, with a copy to the Director of the Regulatory Operations Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report should:

(1) Identify the premises;

(2) Show that reasonable effort has been made to reduce residual contamination to as low as practicable levels;

(3) Describe the scope of the survey and the general procedures followed; and

(4) State the finding of the survey in units specified in Table I.

After review of the report, the Commission may inspect the facilities to confirm the survey prior to granting approval for abandonment.

5. REACTOR RETIREMENT PROCEDURES

As indicated in Regulatory Position C.2, several alternatives are acceptable for reactor facility retirement. If minor disassembly or "mothballing" is planned, this could be done by the existing operating and maintenance procedures under the license in effect. Any planned actions involving an unreviewed safety question or a change in the technical specifications should be reviewed and approved in accordance with the requirements of 10 CFR §50.59.

If major structural changes to radioactive components of the facility are planned, such as removal of the pressure vessel or major components of the primary system, a dismantlement plan including the information required by §50.82 should be submitted to the Commission. A dismantlement plan should be submitted for all the alternatives of Regulatory Position C.2 except mothballing. However, minor disassembly activities may still be performed in the absence of such a plan, provided they are permitted by existing operating and maintenance procedures. A dismantlement plan should include the following:

a. A description of the ultimate status of the facility

b. A description of the dismantling activities and the precautions to be taken.

c. A safety analysis of the dismantling activities including any effluents which may be released.

d. A safety analysis of the facility in its ultimate status.

Upon satisfactory review and approval of the dismantling plan, a dismantling order is issued by the Commission in accordance with §50.82. When dismantling is completed and the Commission has been notified by letter, the appropriate Regulatory Operations Regional Office inspects the facility and verifies completion in accordance with the dismantlement plan. If residual radiation levels do not exceed the values in Table I, the Commission may terminate the license. If these levels are exceeded, the licensee retains the possession-only license under which the dismantling activities have been conducted or, as an alternative, may make application to the State (if an Agreement State) for a byproduct materials license.

TABLE I

ACCEPTABLE SURFACE CONTAMINATION LEVELS

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

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

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

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

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

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