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Decommissioning Plan for the Ward Center for Nuclear Studies at Cornell University

Facilities Inventory Bldg. No. 2061

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Prepared for:
Cornell University
Ithaca, New York

Prepared by:
Duratek, Inc
Commercial Operations
1009 Commerce Park Drive,
Suite 100
Oak Ridge, TN 37830

DECOMMISSIONING PLAN
for the
WARD CENTER for NUCLEAR STUDIES
at
CORNELL UNIVERSITY

Facilities Inventory Bldg. No. 2061

Prepared By: Paul C Ely — Paul Ely — 7/28/03 — Date

Reviewed By: Doug Schult — 7/28/03 — Date

Approved By: Robin Shult, General Manager — 7/28/03 — Date

Prepared By
Duratek, Inc.
Commercial Services
1009 Commerce Park Drive, Suite 100
Oak Ridge, TN 37830

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ACRONYMS and ABBREVIATIONS

ALARA	As Low As Is Reasonably Achievable
ANSI	American National Standards Institute
ARA	Airborne Radioactivity Area (see 10 CFR 20)
ASME	American Society of Mechanical Engineers
CDE	Committed Dose Equivalent
CFR	Code of Federal Regulations
cm	centimeter
COMPASS	COMPASS Computer Code Version 1.0.0 development sponsored by the NRC
Cornell	Cornell University
cpm	counts per minute
D&D	Decontamination and Decommissioning
DAC	Derived Air Concentration (see 10 CFR 20)
$DCGL_W$	Derived Concentration Guideline Levels
$DCGL_{EMC}$	Elevated Measurement Comparison DCGL
DECON	Decontamination Decommissioning Option
Director Ward Center	Ward Center Director for Nuclear Studies
DOC	Decommissioning Operations Contractor
dpm	disintegrations per minute
DQO	Data Quality Objective
EDE	Eye Dose Equivalent (see 10 CFR 20)
ENTOMB	Entombment Decommissioning Option
FSS	Final Status Survey
g	gram, a unit of mass
GET	General Employee Training
GM	Geiger-Mueller
GST	General Site Training
HEPA	High Efficiency Particulate Air (Filter)
HP	Health Physics
HPGe	High Purity Germanium Detector
HSA	Historical site Assessment
HWP	Hazardous Work Permit
IH	Industrial Hygiene
LLD	Lower Limit of Detection
LLRW	Low-Level Radioactive Waste
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*, NUREG-1575
MDA	Minimum Detectible Activity
mR	milli-Roentgen, 10^{-3} Roentgen
mrem	millirem, 10^{-3} rem
MSHA	U.S. Mine Safety and Health Administration
mSv	milli-Sievert (unit of dose equivalence, see 10 CFR 20), 10^{-3} Sievert
MW	Megawatt

NIOSH	National Institute for Occupational Safety and Health
NQA	Nuclear Quality Assurance
NRC	U. S. Nuclear Regulatory Commission
NYS	New York State
OSHA	Federal Occupational Safety and Health Acts
pCi	pico-curie, a unit of radioactivity (2.22 disintegrations per minute) 10^{-12} curie
PCM	Personnel Contamination Monitor
POA	Possession Only Amendment
POL	Possession Only License
QA	Cornell Quality Assurance
QAPP	Quality Assurance Project Plan
QC	Quality Control
RSO	Radiation Safety Officer
RWP	Radiation Work Permit
SDE	Shallow Dose Equivalent (see 10 CFR 20)
SNM	Special Nuclear Material
SP	Safety Program
SS	Stainless Steel
Sv	Sievert (unit of dose equivalence, see 10 CFR 20)
TEDE	Total Effective Dose Equivalent (see 10 CFR 20)
TLD	Thermoluminescent dosimeter
TRIGA	Teaching Research Isotope General Atomic reactor
TS	Technical Specification
USNRC	U.S. Nuclear Regulatory Commission
Ward Center	Ward Center for Nuclear Studies
WBS	Work Breakdown Structure
ZPR	Zero Power Reactor

1.0 SUMMARY OF PLAN

1.1 Introduction

1.1.1 Overview

The Cornell Ward Center for Nuclear Studies TRIGA Reactor and Zero Power Reactor (ZPR) provided training for Nuclear Engineering students and various services for researchers in all departments of the College of Engineering, the College of Arts and Sciences (departments of Physics, Chemistry, Biology) and the College of Veterinary Medicine. Cornell University stopped routine operation of the Ward Center TRIGA Reactor on June 30, 2002 and plans to submit a request for a possession only license in 2003. The TRIGA is currently operated for short periods of time at low power levels in order to maintain operator qualifications. The University permanently ceased operation of the ZPR reactor on September 6, 1996. There are no plans to resume reactor operations. Temporarily mothballing the reactor TRIGA is not a reasonable option. Hence, the University wishes to proceed with its decommissioning and the termination of the associated reactor licenses. Cornell therefore has filed the appropriate decommissioning amendment requests together with this decommissioning plan with the NRC. As with other facilities of this nature, the Ward Center is contaminated with varying amounts of radioactive material and small amounts of hazardous material, though the characterization study indicates that practices employed by Cornell to minimize the spread of contamination were effective and contamination is relatively modest. Decontamination and Decommissioning (D&D) of the Ward Center will eliminate the potential for future inadvertent environmental releases. The goal of the proposed D&D activities is termination of the Ward Center TRIGA Reactor Nuclear Regulatory Commission (NRC) License R-80, Doc. No.50-157 and Zero Power Reactor Facility License R-89, Doc. No.50-97 and release of the reactor portions of the Ward Center for "unrestricted use." A New York State (NYS) licensed gamma irradiation facility located in Ward Center will be decommissioned and the NYS license amended accordingly. The term "unrestricted use" means that there will be no future restrictions on the use of the site other than those imposed by the City of Ithaca zoning ordinances.

The regional location of Cornell University is shown in; Figure 1-2 depicts the Ward Center site and adjacent Cornell structures; the Ward Center site is depicted on

Figure 1-3. Figure 1-4, Figure 1-5 and Figure 1-6 presents plan views of the three floors of the Ward Center. This Decommissioning Plan has been prepared using the guidance and format of NUREG-1537 Rev. 0, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors* (Ref. 1.1) and includes additional guidance from NUREG–1727, *NMSS Decommissioning Standard Review Plan* (Ref. 1.2). A summary profile for the Ward Center TRIGA and ZPR reactors is provided in Table 1-1 and Table 1-2.

Figure 1-1 Map of the Area Surrounding Cornell University

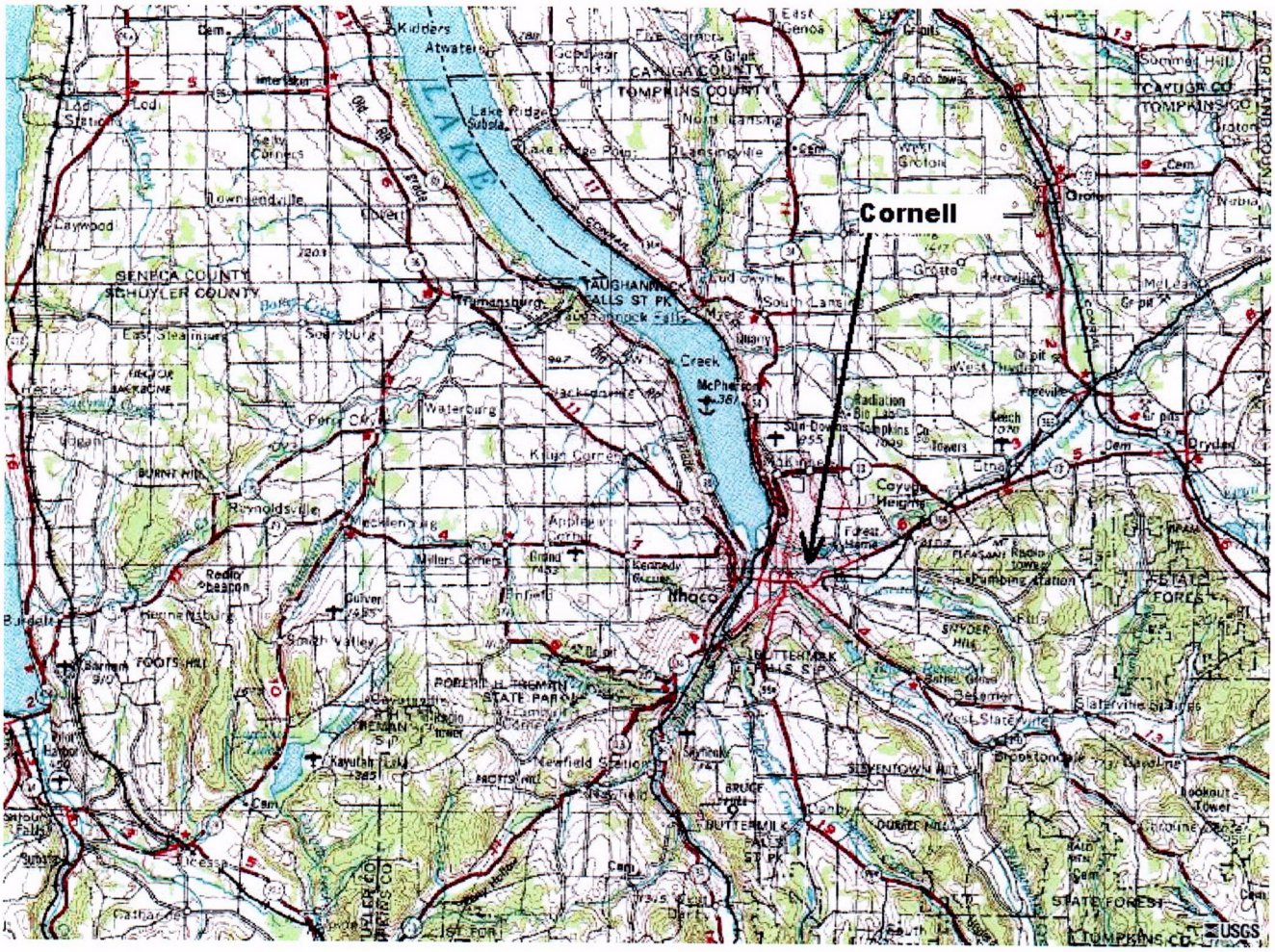


Figure 1-2 Cornell University Campus

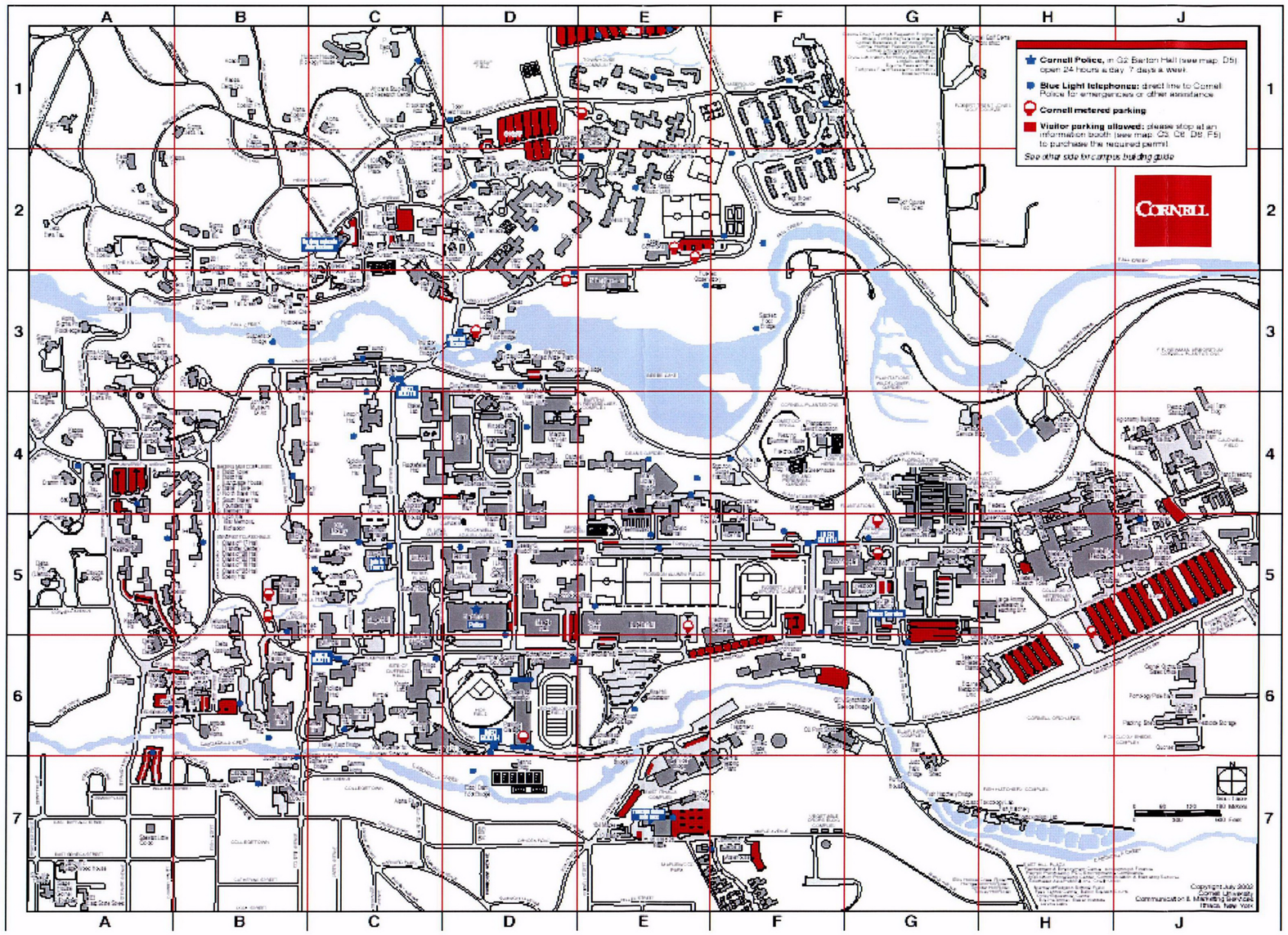


Figure 1-3 Cornell University Ward Center Site

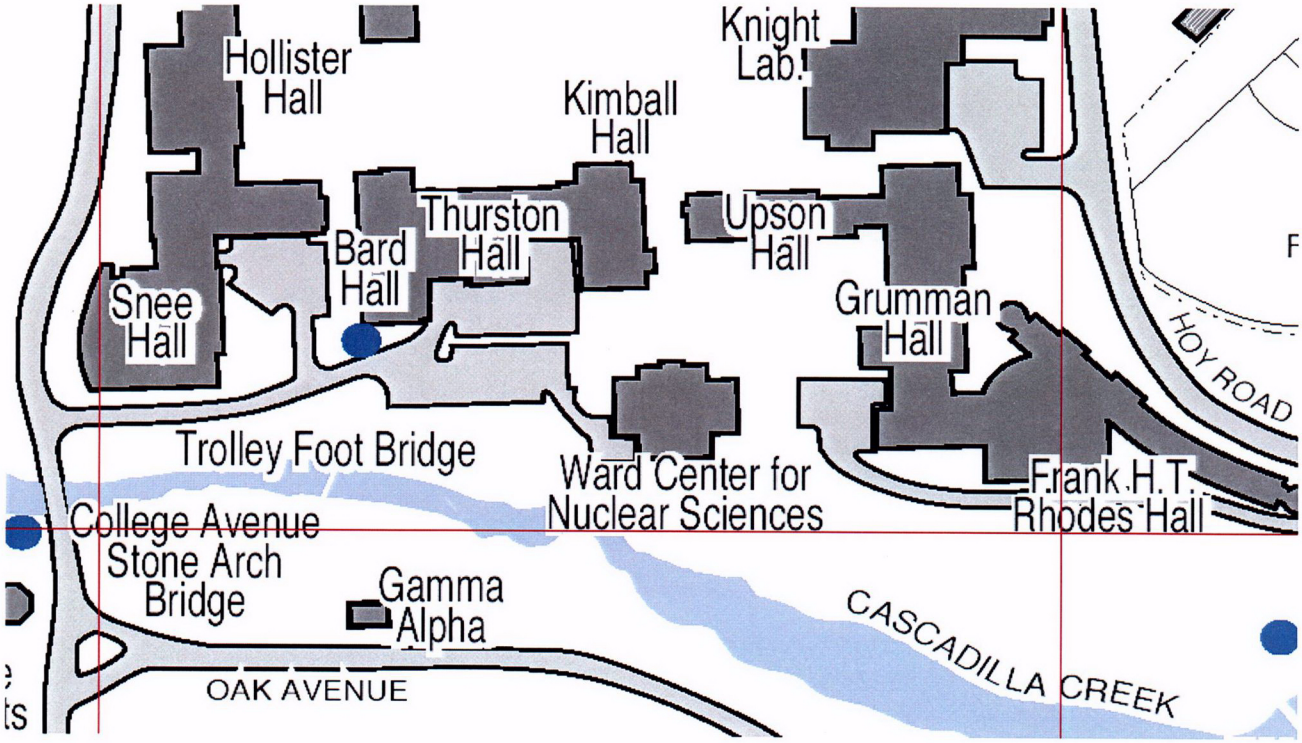


Figure 1-4 Ward Center Basement Plan View

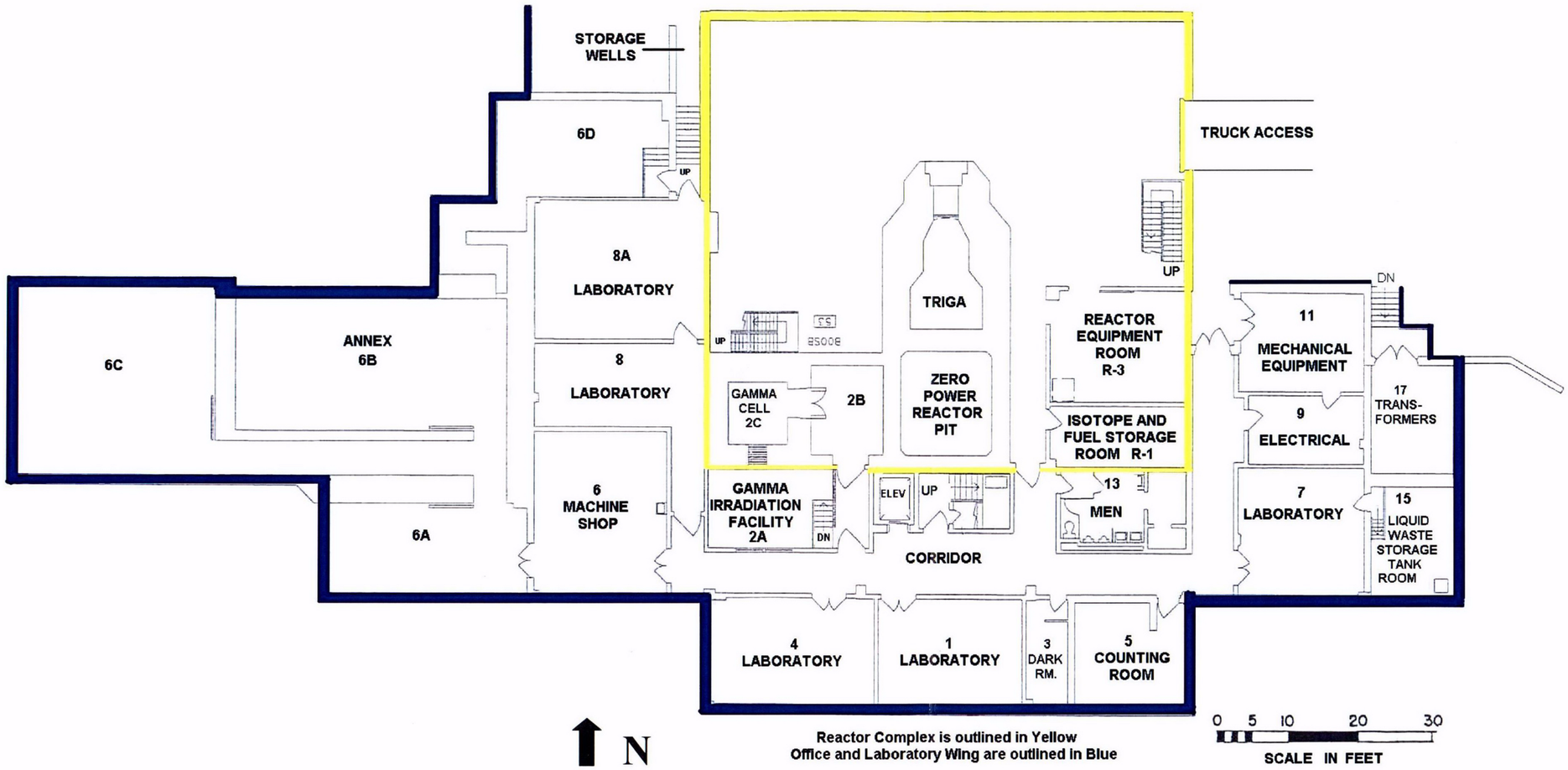


Figure 1-5 Ward Center 1st Floor Plan View

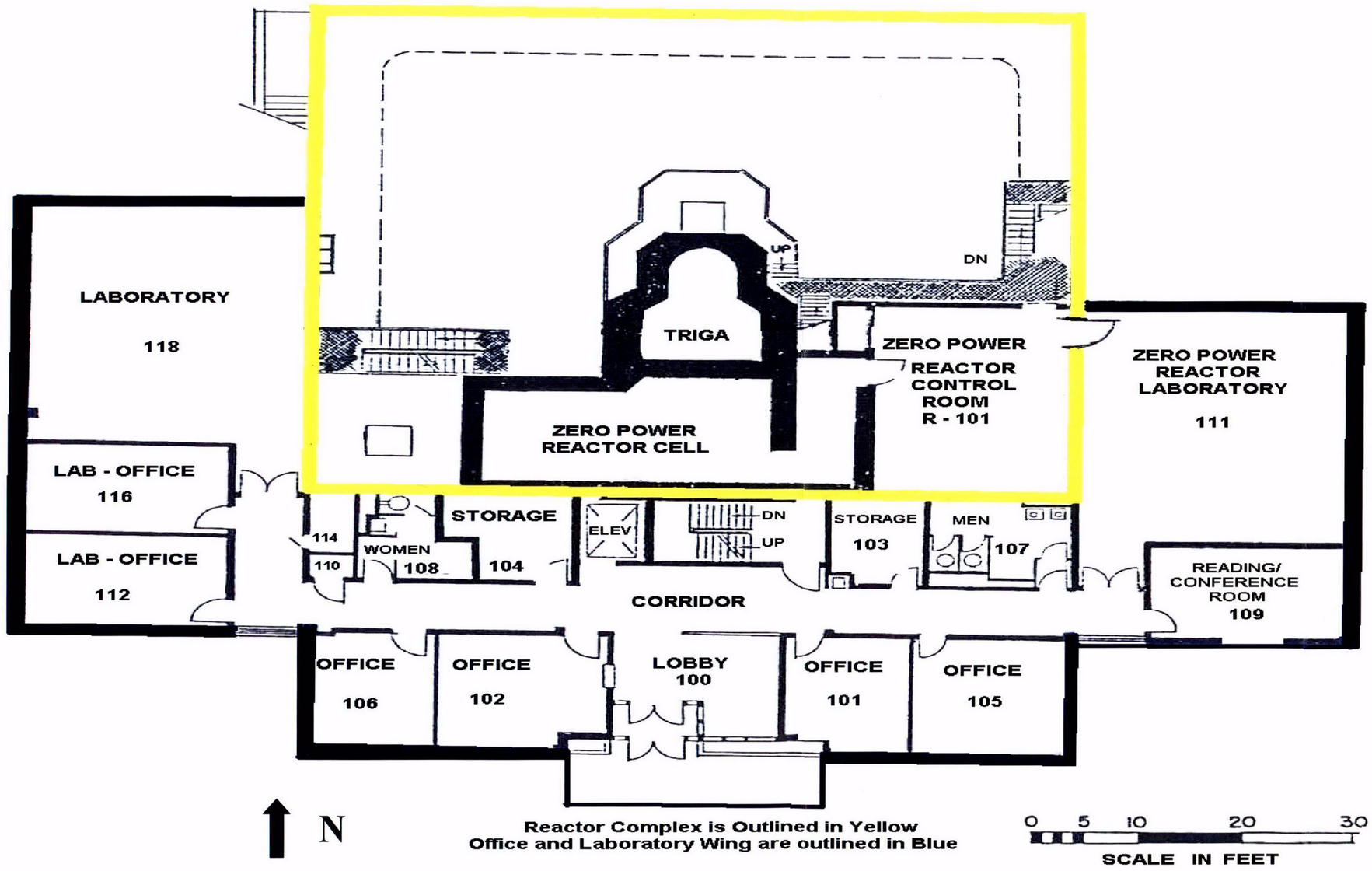


Figure 1-6 Ward Center 2nd Floor Plan View

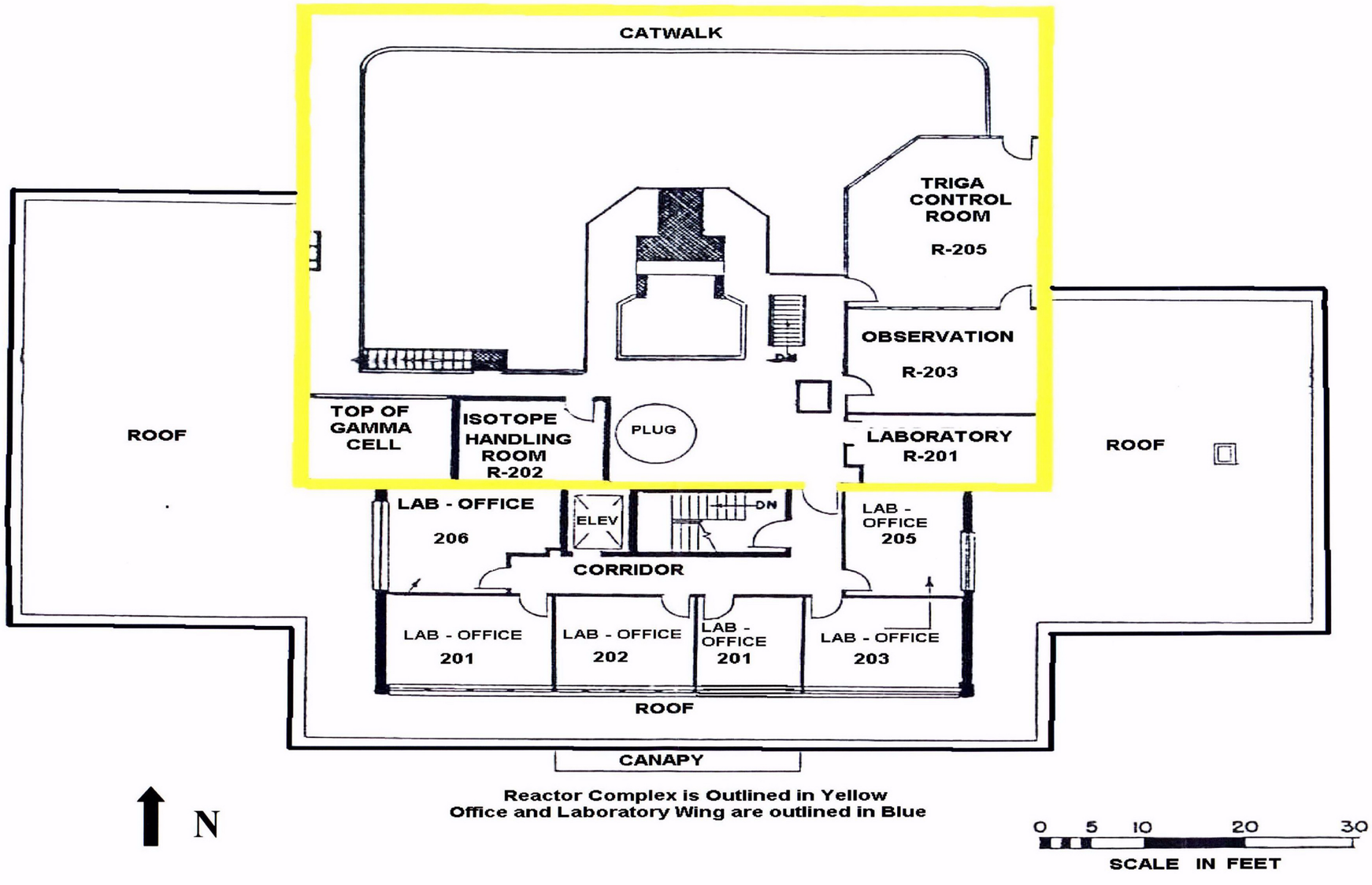


Table 1-1 Profile of the Ward Center TRIGA Reactor

Item Description	
General Reactor information:	
Type:	TRIGA Mark II
Owner/Operator:	Cornell University
Licensee:	Cornell University
Architect/Engineer	Vitro Engineering Company
Nuclear Design:	General Atomic Division of General Dynamics
Principal Uses:	Training and Research
Reactor Operation and Authorization:	
Initial Criticality:	January 12, 1962
USNRC Utilization Facility License #:	R-80
USNRC Facility Docket #:	50-157
Reactor Specifications:	
Thermal Power, Steady (kW):	500 as of 1983
Thermal Power, Pulsed, (MW):	1,000
Maximum Flux SS, Thermal (n/cm^2-s):	3.0×10^{12}
Equilibrium Core Size (Fuel Elements)	85
Rods per Element	1
Dimension of Rods, mm	37.3x720
Element Cladding Material:	Aluminum and Stainless Steel
Coolant:	Light Water
Moderator:	Light Water
Reflector:	Graphite
Reflector Number of Sides	4
Control Rod Material	B4C
Control Rods Number	4

Table 1-2 Profile of the Zero Power Reactor

Item Description	
General Reactor information:	
Category	Critical Assembly
Type	Tank
Owner:	Cornell University
Operator:	Cornell University
Licensee:	Cornell University
Principal Uses:	Training and Research
Reactor Operation and Authorization:	
Initial Criticality:	January 1, 1962
Date Secured:	May 1, 1997
USNRC Utilization Facility License #:	R-89
USNRC Facility Docket #:	50-97
Reactor Specifications:	
Thermal Power, Steady State	0.1 kW
Maximum Flux SS, Thermal (n/cm^2-s):	1.0×10^9
Maximum Flux SS, Fast (n/cm^2-s):	5.0×10^8
Moderator:	Light Water
Coolant:	Light Water
Reflector:	H2O
Reflector Number of Sides	4
Control Rod Material	B4C
Control Rods Number	
Equilibrium Core Size	228
Rods per Element	1
Dimension of Rods, mm	15x1219
Cladding Material	AL ALLOY
Uranium Density, g/cm3	10.2
Fuel Fabricator	GE

1.1.2 Decommissioning Plan Provisions

This Decommissioning Plan provides the following:

- A description of the present radiological condition of the Ward Center and site environs.
- A description of the planned approach to be employed to decommission the Ward Center.
- Descriptions of the methods that will be utilized to ensure protection of the health and safety of the workers and to protect the environment and the public from radiological hazards associated with Ward Center Decommissioning Project activities.
- A description of Ward Center physical security and material accountability controls that will be in place during the various phases of Decommissioning Project activities.
- A description of radioactive waste management and disposal.
- A cost estimate for decommissioning the Ward Center and the source of funding for these activities.
- A schedule for the Ward Center Decommissioning Project.
- A description of the quality assurance program applicable to the Ward Center Decommissioning Project.
- A description of the training program to be established for personnel performing work in support of the Ward Center Decommissioning Project.
- An Environmental Report concerning the expected impact of performing the activities involved in the Ward Center Decommissioning Project.

1.2 Background

Site and Facility History

Cornell University

The property, on which is situated the Cornell University Ward Center, was designated for construction in 1959. The Ward Center was constructed between 1959 and 1962. The Ward

Center configuration is shown in Figure 1-4, Figure 1-5 and Figure 1-6. The land area is not well defined, as there are no boundaries between the Ward Center and the nearby engineering buildings. The Reactor Facility footprint is 10,000 square feet. The total building area is 20,000 square feet on three floor levels.

The areas listed in this section of the Ward Center decommissioning plan included only those rooms in the building where remediation could be required based upon the characterization study survey performed in February 2003. The rooms excluded include classrooms and faculty/student offices in which radioactive materials had never been used.

Table 1-3 summarizes the results of the characterization survey and identifies areas containing residual activity. The characterization survey report should be reviewed in detail to determine the scope of remediation in each area.

Table 1-3 Characterization Survey Summary

Survey Package Number	Location Description	Survey Results
A0001	Zero Power Reactor Control Room, Rm 101	Residual Activity Not Detected
A0002	**Zero Power Reactor Cell**	**Residual Activity Detected**
A0003	Liquid Waste Storage Tank Room1	Residual Activity Not Detected
A0004	**Reactor BioShield Exterior Wall**	**Residual Activity Detected**
A0005	**East Side of Reactor Complex**	**Residual Activity Detected**
A0006	West Side of Reactor Complex	Residual Activity Not Detected
A0007	First Floor of Reactor Complex	Residual Activity Not Detected
A0008	**Second Floor of Reactor Complex**	**Residual Activity Detected**
A0009	**Zero Power Reactor Laboratory, Rm 111**	**Residual Activity Detected**
A0010	Reactor Equipment Room, Rm R-3	**Residual Activity Detected**
A0011	**Isotope and Fuel Storage Room, Rm R-1**	**Residual Activity Detected**
A0012	TRIGA Control Room, RM R-205	Residual Activity Not Detected
A0013	**Observation Room, Rm R-203**	**Residual Activity Detected**
A0014	Laboratory, Rm R-201	Residual Activity Not Detected
A0015	**Isotope Handling Room, Rm-202**	**Residual Activity Detected**
B0001	Laboratory Wing; Hallways, Stairwells, and Elevator	Residual Activity Not Detected
B0002	Mechanical, Electrical and Laboratory, Rms 7, 9, and 11	Residual Activity Not Detected
C0001	Reactor Complex Ceilings	Residual Activity Not Detected
D0001	**Reactor Complex Drains, Ventilation, and Pneumatic Transfer System**	**Residual Activity Detected**
E0001	Building Exterior	Residual Activity Not Detected

TRIGA and ZPR Reactors

In 1959 Cornell began construction of a facility to house the TRIGA Reactor, the ZPR Reactor, the Gamma Cell and supporting systems (e.g., Instrumentation and Control Systems, Forced Cooling System, Water Demineralization System, Ventilation/Exhaust System, Radiation Monitoring Systems, etc.). Following construction and reactor hardware installation, the TRIGA Reactor was brought to initial criticality in January of 1962. The TRIGA was routinely operational from that date until June 30, 2002. The TRIGA is currently operated for short periods of time at low power levels in order to maintain operator qualifications. Cornell plans to request that the USNRC issue an amendment to the TRIGA facility license to place the reactor in Possession-Only-Amendment (POA) status. The ZPR ceased operations in 1996, but parts of the system are still in place.

Current Facility Status

It is anticipated that the TRIGA Reactor, situated in the Reactor Complex, will be placed in "Possession-Only-Amendment" (POA) status, through an amendment to the USNRC License No. R-80, in 2003. The TRIGA is currently operated for short periods of time at low power levels in order to maintain operator qualifications.

The ZPR ceased operations in 1996. The ZPR fuel was returned to the DOE in April 2000.

Ward Center utility services required for facility operation and maintenance under POA status conditions are active.

Manually actuated and automated fire alarm systems in the Ward Center are operational.

Ward Center security and radiological alarm systems will remain active.

1.2.2 Reactor Decommissioning Overview

Prior to implementing the decommissioning actions described herein, the Ward Center will have been cleared of all extraneous fixtures, equipment and materials. The majority of the remediation will focus on components with the TRIGA reactor's pool, the bioshield surrounding the TRIGA reactor, and possibly portions of the floor drains within the reactor complex. In other areas of the facility only minor remediation requirements are anticipated. The general activities to complete the Plan objectives are:

- Remove the components within the TRIGA reactor's pool.
- Remove the activated/contaminated portion of the bioshield.
- Remediate the floor drains if required.
- Perform additional decontamination and dismantlement of the structure and equipment in accordance with this plan.

- Prepare the decommissioning generated material for release or disposal (as appropriate). Either decontaminate and release the material as non-radioactive waste, or package for transport as radioactive waste.
- Ship all radioactive waste off-site to a licensed waste processor or disposal facility.
- Perform and document the final status survey(s) and submit a request to the USNRC for termination of the reactor licenses.

1.2.3 Estimated Cost

The cost estimate is consistent with the scope of work covering D&D of the Ward Center. D&D of the Ward Center will be accomplished without dismantlement of the building. The detailed estimated cost to decommission the Ward Center licensed areas is presented in the Decommissioning Cost Estimate for the Ward Center, Ithaca, NY (Ref. 1-3). This project is estimated to cost **$3,603,086**. A cost breakdown is given in Table 1-4 Decommissioning Cost Summary - Ward Center.

Table 1-4 Decommissioning Cost Summary - Ward Center

Operation	Man-hours	Labor Plus Trav. & Liv.	Equipment, Contracts & Supplies	Radwaste Shipping & Disposal*	Total Cost
TRIGA Reactor	746	$54,191	$27,775	$212,973	$294,939
TRIGA Bioshield & Beam Ports	5338	$424,827	$273,787	$741,581	$1,440,196
Reactor Bay	2374	$189,406	$52,730	$244,492	$486,628
Office & Laboratory Wing	926	$74,416	$16,941	$11,028	$102,384
Zero Power Reactor	128	$10,272	$2,338	$1,518	$14,128
Characterization Surveys	1040	$90,220	$4,274	$0	$94,494
Final Surveys	4160	$360,880	$17,097	$0	$377,977
Planning, Training, & Mobilization	272	$21,370	$0	$0	$21,370
Owner Oversight & Licensing	693	$50,353	$0	$0	$50,353
Totals	**15676**	**$1,275,934**	**$394,943**	**$1,211,592**	**$2,882,469**
			25% CONTINGENCY		**$720,617**
				GRAND TOTAL	**$3,603,086**

* The estimate for LLW disposal is based upon the assumption that the activated waste in the TRIGA reactor's poolwaste will be buried at the Barnwell, South Carolina site and all other radioactive waste will be buried at the Envirocare of Utah site.

1.2.4 Availability of Funds

Estimates of the costs of decommissioning of Ward Center USNRC licensed facility are provided in this plan. Cornell University is committed to providing the funding for decommissioning of the Ward Center.

1.2.5 Program Quality Assurance

A Quality Assurance Project Plan (QAPP) will be developed to incorporate the applicable portions of 10 CFR 50, Appendix B and 10 CFR 71, Subpart H. In addition, the QAPP will utilize a graded approach that bases the level of controls on the intended use of the results and the degree of confidence needed in their quality. ANSI/ASQC E4-1994 (ASQC 1995) and Appendix K of MARSSIM will be used to provide guidance in quality systems, the collection and evaluation of environmental data, and for developing a QAPP.

An extensive quality assurance program will be implemented throughout the Ward Center decommissioning effort to assure that work does not endanger public safety and to assure the safety of the decommissioning staff.

Quality assurance efforts during the Ward Center decommissioning period will include the following:

- Performing QA functions for procurement
- Qualifying suppliers
- Auditing project activities
- Monitoring worker performance for compliance with work procedures
- Verifying compliance of radioactive shipments with appropriate procedures and regulations
- Performing dimensional, visual, nondestructive examinations or other required inspection services to assure compliance with work plans
- Maintaining auditable files

The QAPP will be issued and approved by Cornell University and it will be documented by written procedures and implemented throughout the decommissioning project in accordance with those procedures. The management of those organizations participating in the QAPP shall regularly review the status and adequacy of that part of the plan that they are implementing. All changes to the Plan shall be governed by measures commensurate with those applied to the original issue.

The Quality Assurance Project Plan will incorporate the items discussed in the following subsections.

1.2.5.1 Quality Assurance Responsibilities

The Quality Assurance organizations of Cornell University and the decommissioning contractor have the responsibility, authority and organizational freedom to:

- Identify quality problems
- Take action to stop unsatisfactory or unsafe work and control further processing, delivery, installation or use of nonconforming items
- Initiate, recommend or provide solutions
- Verify implementation of solutions.

Cornell University, as the reactor license holder, has the ultimate responsibility for the implementation of the QA Plan for the Ward Center, both by Cornell and its decommissioning subcontractor(s). Cornell University shall verify compliance through periodic audits.

1.2.5.2 Quality Requirements for Instrumentation

Calibration

Field instruments and associated detectors shall be calibrated on a semi-annual basis using National Institute of Standards and Technology (NIST) traceable sources and appropriate calibration equipment and laboratory instruments shall be calibrated on an annual basis.

Calibration labels showing instrument identification number, calibration date and calibration due date shall be attached to all field and laboratory instrumentation.

Response Testing

All instrumentation will be inspected and source checked daily prior to use to verify calibration status and proper operation. Control checks and/or source check criteria will be established prior to the initial use of the instruments

Maintenance

Limited maintenance, such as changing Mylar windows, high voltage cables, etc., may be performed on-site by qualified personnel. Following the change of essential components for maintenance, limited calibration may be performed on site by qualified personnel.

Record Keeping

Calibration and maintenance records, or copies of these records, shall be maintained on site where they will be available for review. The results of the daily instrument functional checks will be recorded on separate log sheets for each instrument and maintained on-site.

1.2.5.3 Sampling and Analysis Quality Control

Sample Collection

Direct surface beta measurements, removable contamination measurements, gamma exposure rates, soil sampling and any specialized measurements will be performed to provide data required to meet the guidance provided in 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use* (Ref. 1-4), NUREG-1575, Multi-*Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 1-5), and NUREG-1727, *NMSS Decommissioning Standard Review Plan* (Ref. 1-2).

Sample QC

Quality Control (QC) samples will be obtained for minimum of 10% of all samples collected for radionuclide specific analysis. QC samples for direct measurements and smears are not required. The QC samples will be a combination of split, duplicate, blank, and/or spiked samples.

Sample Identification

Direct surface beta measurements, removable contamination samples, exposure rates, and any specialized measurements will be identified as to location, type of measurement, specific instrument and probe used, sample time and date (as appropriate) and name of the person collecting the data.

Soil samples will be identified with a unique sample number, sample location, depth of sample, sample time and date as appropriate, and the name of the person collecting the sample.

Sample Chain-of-Custody

Sample chain-of-custody shall be initiated for those samples being sent off site for analysis or transferred to another organization for analysis. A sample Chain-of-Custody Record will be generated which will document the sample identification and sample transfer and will accompany the sample during shipping to the new custodian of the sample.

Sample Analysis

Vendor laboratories shall be on a QA Approved Suppliers List for the decommissioning contractor or Cornell University for the type of analytical services being provided. Cornell has the ultimate responsibility for ensuring that decommissioning sample analysis specifications and laboratory capabilities meet data quality requirements.

Sample Documentation

Sample identification information, sample Chain-of-Custody Records, sample analysis results, vendor laboratory qualification records, or copies of these records, shall be maintained on site where they will be available for review.

1.2.5.4 Record Keeping

Measures shall be established to control the issuance of documents and changes to documents that prescribe activities affecting quality, such as procedures, drawings and specifications. These measures shall ensure that documents and changes to documents are reviewed for adequacy, approved for release by authorized personnel and distributed to and implemented at the location where the prescribed activity is performed.

Procedure Control

Procedures shall be controlled to ensure that current copies are provided to personnel performing the prescribed activities. Procedures shall be independently reviewed by a qualified person and shall be approved by a management member of the organization responsible for the prescribed activity. Significant changes to procedures shall be reviewed and approved in the same manner as the original.

Radioactive Shipment Package Documents

All documents related to a specific shipping package for radioactive material shall be controlled by appropriate procedures. All significant changes to such documents shall be similarly controlled.

Final Survey Documents

All documents related to the final status survey shall be controlled by appropriate procedures. All significant changes to such documents shall be similarly controlled. This documentation would normally include a Survey Plan, Survey Packages, Survey Results and Survey Report.

1.2.5.5 Handling, Storage and Shipping

Approved procedures shall be utilized to control the handling, storage and shipping of radioactive materials.

Radioactive Material Storage

Areas shall be provided in the Reactor Complex for storage of radioactive material to ensure physical protection and control of the stored material. The handling, storage and shipment of radioactive material shall be controlled through the following requirements:

- Procedures shall be provided for handling, storage and shipping operations.
- Established safety requirements concerning the handling, storage and shipping of packages for radioactive material shall be followed.
- Shipments shall not be made unless all tests, certifications, acceptances and final inspections have been completed.

Shipping and Packaging

Shipping and packaging documents for radioactive material shall be consistent with pertinent regulatory requirements.

1.2.5.6 Quality Assurance Records

Sufficient records shall be maintained to furnish evidence of activities important to safe decommissioning as required by code, standard, and specification or project procedures. Records shall be identifiable, available and retrievable. The records shall be reviewed to ensure their completeness and ability to serve their intended function. Requirements shall be established concerning record collection, safekeeping, retention, maintenance, updating, location, storage, preservation, administration and assigned responsibility. Requirements shall be consistent with applicable regulations and the potential for impact on quality and radiation exposure to the workers and the public.

Typical records would include:

- Proposed Decommissioning Plan
- Procedures
- Reports
- Personnel qualification records
- Radiological and environmental site characterization records, including final site release records
- Dismantlement records
- Inspection, surveillance, audit and assessment records

Health and Safety Related Activities

Records that have a potential for impact on quality and radiation exposure to the workers and the public include the following:

- Work Permits
- Work Procedures
- Contamination Survey Reports
- Radiation Survey Reports
- Airborne Survey Reports
- Counting data or air samples and gamma spectrum analysis
- Instrument calibrations
- Source inventory and storage
- Radioactive material inventory and storage
- Shipment records
- Incidents and accidents
- Confined space entry permits
- Monitoring records for oxygen deficient and explosive atmospheres

Personal Records

Typical records containing personal information that may impact quality and radiation exposure to the workers and the public are as follows:

- Dosimetry Records
- Bioassay analysis
- Respiratory protection qualifications (medical/clearance and fit test)
- Training records
- Visitor logs and exposure information

1.2.5.7 Audits

Audits shall be implemented to verify compliance with appropriate requirements of the Quality Assurance Project Plan and to determine the effectiveness of the plan. The audits shall be performed in accordance with written procedures or checklists by trained and qualified personnel not having direct responsibility in the areas being audited.

Audit Reports

Reports of the results of each audit shall be prepared. These reports shall include a description of the area audited, identification of the individual responsible for implementation of the audited provisions and for performance of the audit, and identification of discrepant areas. The audit report shall be distributed to the appropriate level of management and to those individuals responsible for implementation of audited provisions.

Audit Corrective Action

Measures shall be established to ensure that discrepancies identified by audits are resolved. These measures shall include notification of the manager responsible for the discrepancy and verification of satisfactory resolution. Discrepancies shall be resolved by the manager

responsible for the discrepancy. Higher levels of management shall resolve disputed discrepancies.

Follow-up action, including re-audit of deficient areas, shall be taken as indicated.

REFERENCES FOR SECTION 1

1-1 NUREG- 1537 Rev. 0, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors".

1-2 NUREG–1727, "NMSS Decommissioning Standard Review Plan".

1-3 Cornell University, *Decommissioning Cost Estimate Ward Center, Ithaca, New York*, Revision 0, March 2002, prepared by Duratek, Inc.

1-4 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use.*

1-5 NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM).*

1-6 Characterization Survey Report for the Ward Center for Nuclear Studies at Cornell University, Facilities Inventory Bldg. No. 2061, May 2003.

2.0 DECOMMISSIONING ACTIVITIES

The decommissioning alternative selected for the Ward Center is the removal of the facility from service and reduction of the residual radioactivity to a level that will permit termination of the reactor licenses and beneficial reuse of the property. The facility will be surveyed and left in place.

2.1 Decommissioning Activities

The objective of Ward Center Decommissioning is the regulatory release of the TRIGA and ZPR reactors and the gamma irradiation facility located within the Ward Center to unrestricted use. On this basis the safe storage (SAFSTOR) or entombment (ENTOMB) decommissioning options were considered inappropriate to Cornell University's future plans.

SAFSTOR poses essentially the same potential risks and environmental impacts as the proposed project, but for a much greater period of time. This alternative would necessitate continued surveillance and maintenance of the Ward Center over a substantial time period during which the risk of environmental contamination would continue to exist.

ENTOMB would necessitate continued surveillance and maintenance of the Ward Center over a substantial time period. During this period, the risk of environmental contamination would continue to exist.

DECON is the decommissioning option chosen by Cornell University. To the extent possible, decontamination of facility equipment and structural components will be conducted so as to minimize radioactive waste. Structural portions of the building and surrounding soils and materials found to be radiologically contaminated and/or activated shall be remediated, decontaminated, sectioned and removed or processed, as necessary. This would be followed by an extensive and comprehensive final radiation and contamination survey demonstrating that the Ward Center meets the NRC criteria for release to unrestricted use. The results of this final survey will be documented in a report to be submitted to the USNRC in support of a request that the site be released to unrestricted use and the reactor licenses terminated.

2.2 Facility Radiological Status

2.2.1 Facility Operating History

TRIGA Startup:	January 1962
TRIGA Limited Use:	June 30, 2002. Limited operation to be followed by an application for a Possession-Only-Amendment (POA) status in 2003, USNRC Utilization Facility License. #R-80.
ZPR Startup:	January 1962
ZPR Shutdown:	September 6, 1996, USNRC Utilization Facility License #R-89, changed by a Possession-Only-Amendment (POA) status in 1997.

The TRIGA and ZPR reactors were constructed at Cornell to provide for the training of Nuclear Engineering students and for research by all Departments of Engineering and the departments in the College of Arts and Sciences (Physics, Chemistry, Biology) and the College of Veterinary Medicine. The integrated power generated during operation of the TRIGA Reactor is estimated at 2,901 MW-hours.

The memoranda sent to the Ward Laboratory Safety Committee were reviewed, to identify events that have, or could have, resulted in contamination of areas within the Ward Center. Table 2-1 identifies these events.

Table 2-1 Ward Center Radiological Incident History

Report Date	Event Date	Event Location and Description
Jun. 16, 1965	June 1962	Radioactive resins were found in routine samples taken from the liquid waste hold-up tank. The samples had an effective half-life of 20 days and there was no indication of fission product material. Since resins were found only on one occasion and that was immediately after regeneration it is highly probable that the resins were washed out of the bed during the backwash cycle due to an excessive flow rate.
May 25, 1966	May 20, 1966	Chemical reaction with radioactive solution in the Chemistry Lab of the Nuclear Reactor Lab. A two-liter waste storage bottle containing perchloric acid had a large amount of ethyl alcohol added to it. An oxidation reaction occurred generating enough heat to cause local boiling and spattering of the solution. A plastic bag contained most of the material, the rest was wiped up form the bench top. The radioactive material involved was 27.6 μCi of Co-60 and 35.5 μCi of Fe-59.
May 25, 1966	May 18, 1966	On May 18, 1966, after removing a sample from the Lazy Susan following a 4-hour run at 100 kW, the air particulate monitor alarm sounded. The strip chart recorder showed a sustained abnormally high count rate. The fixed filter paper was removed and analyzed with a gamma spectrometer. The results together with the measured half-life gave a positive indication of Cl-38. The presence of chlorine in the Lazy Susan was decided to have come from the use of Trichloroethylene during a cleaning operation about 6 weeks previously. Cl-38 is only detected after TRIGA operation and when the specimen container is rapidly removed from the Lazy Susan. After discussing the problem the Safety Committee recommended that the remaining chlorine bearing material be removed by using dry clean swabs.
Oct. 24, 1968	Oct. 24, 1968	A terrestrial rock sample was removed from the Central Thimble after irradiation. The sample was put in a plastic bag and had a monitored activity of approximately 70 mR/hr. The sample then exploded due to internal pressure. Several pieces of the plastic sample bottle flew across the room. There was contamination on the clothing of the personnel in the area and the air particulate monitor in the area had elevated readings as did the stack monitor. The personnel were decontaminated by showering. The contaminant was Na-24. The contamination was over the second floor of the reactor complex.

Report Date	Event Date	Event Location and Description
Aug. 13, 1976	Aug. 11, 1976	A small leak of several ml/min was detected in the east wall of the biological shield on 8/12/76 and was observed to be diminishing. A smaller leak on the west wall of the biological shield was detected on 8/11/76 and by 8/13/76 had completely stopped. This leak had been active on various occasions in the past. The leak on the east wall is connected with recent low pool water temperature and stops when the pool water temperature increases.

2.2.2 Current Radiological Status of the Facility

2.2.2.1 General

Routine radiological surveys show that the radiation levels and contamination levels measured at the Ward Center have consistently been low. A characterization survey completed in February 2003, and summarized in Appendix A, confirmed that only minor quantities of residual radioactivity or radioactive contamination are present. The information indicates that the radioactive portions of the facility are primarily confined to the reactor internals and reactor pool.

Estimates of the radioactivity inventory can be determined by considering the constituent elements of the material in question and calculating the duration of exposure to the neutron flux and the energies of the incident neutrons. Direct measurements, however, are generally more reliable and will be used during actual removal and/or dismantlement of components. This information will further define the basis for specifying the necessary safety measures and procedures for the various dismantling, removal, decontamination, waste packaging and storage operations so that exposure to personnel is maintained ALARA.

2.2.2.2 Principal Radioactive Components

This section is based upon process knowledge and direct measurements. The most highly radioactive components to be handled and processed during Ward Center Decommissioning that may range over ≈ 5 R/hr at the surface are:

- Control Rods estimated at about 400 mR/hr at six inches.
- Hot Thimbles estimated at about 20 R/hr.
- Hydraulic Rabbit (Al) about 25' long estimated at about 6 R/hr.

2.2.2.3 Radionuclides

The radionuclides known to be present, or possibly present in detectable levels within the Ward Center, are listed in Table 2-2.

2.3 DECOMMISSIONING TASKS

2.3.1 Activities and Tasks

2.3.1.1 Preparation of the Ward Center for Decommissioning

2.3.1.1.1 Characterization Surveys

As part of Decommissioning Project planning actions, studies have been conducted to determine the type, quantity, condition and location of radioactive materials, which are, or may be, present in the Ward Center and surrounding areas. A contractor, Duratek, Inc., completed a comprehensive characterization survey of the Ward Center in February 2003. A summary of these surveys are provided in this document as Appendix A: *Summary of Characterization Results*. Detailed survey results are presented in the Characterization Survey Report, reference 2-2.

2.3.1.1.2 General Cleanup of Ward Center

In preparation for decommissioning activities, non-reactor related equipment and materials situated throughout the Reactor Complex have been collected, surveyed, packaged and appropriately dispositioned in accordance with established procedures.

2.3.1.1.3 Decontamination of the Facility

This Decommissioning Plan pertains to the dismantling of the reactors and associated systems in a safe manner and in accordance with ALARA principles, and the decontamination and survey of the entire Ward Center. Views of the Ward Center are shown in Figure 2-1 and Figure 2-2.

Table 2-2 List of Expected Radionuclides

Nuclide	Half-Life (yr)	Decay Mode
^{3}H	12.28	β^-
^{14}C	5730	β^-
^{54}Mn	0.86	ε
^{55}Fe	2.73	ε
^{57}Co	0.74	ε
^{58}Co	0.19	ε
^{60}Co	5.27	β^-
^{59}Ni	76000	ε
^{63}Ni	100	β^-
^{65}Zn	0.67	ε
^{90}Sr	29.1	β^-
^{94}Nb	20000	β^-
^{99}Tc	213000	β^-
^{124}Sb	0.16	β^-
^{125}Sb	2.76	β^-
^{129}I	15,700,000	β^-
^{134}Cs	2.07	β^-
^{137}Cs	30.17	β^-
^{144}Ce	0.78	β^-
^{152}Eu	13.48	β^-, β^+, ε
^{154}Eu	8.8	β^-
^{155}Eu	4.96	β^-
^{210}Pb	22.26	β^-
^{230}Th	77,000	α

Symbols/Abbreviations:

α = Alpha
β^- = Beta
β^+ = Positron
ε = Electron Capture

Radionuclide Half-Life values and Decay Mode information used above are taken from Ref. 2-1.

The list of expected radionuclides provided above is based on the assumption that reactor operation resulted in neutron activation of reactor core components and other integral hardware or structural members situated adjacent to, or in close proximity to, the reactor core. Specific items to be considered exposed to neutron activation include materials composed of aluminum, steel, stainless steel, graphite, cadmium, lead, concrete and possibly others. The determination of residual activity in structures surrounding the reactor will be based upon direct measurements and sampling.

2.3.1.1.3.1 Disposition of Decommissioning Equipment and Materials

The equipment, materials, instrumentation, and tools that are used or encountered during the decommissioning will be handled as described below:

- The above items may be surveyed and released on site as clean waste if the residual radioactivity is less than the values specified in Table 1 of NRC Regulatory Guide 1.86, "Termination of Operating Licenses for Nuclear Reactors," June 1974,
- The above items may be shipped directly for disposal as radioactive waste.
- The above items may be shipped to a licensed radioactive material processing facility for survey and release, decontamination followed by survey and release, or shipment for disposal as radioactive waste.
- The above items may be shipped to a licensed facility for holding until they are utilized on another project involving radioactive materials.
- No contaminated items as listed above will be left on site.

2.3.1.1.3.2 Reactor Containment Structure

- The equipment, materials, instrumentation, and tools that are used during the decommissioning will be handled as described above in Section 2.3.1.1.3.1.
- All contaminated equipment will be removed and all other equipment will be surveyed and left in place.
- Reactor complex ventilation system filters will be removed and the remaining system will be surveyed and left in place.
- Concrete floors will be decontaminated by removing a portion of the upper concrete surface, as necessary. Tubes and drains will be surveyed and decontaminated as required.
- Building roof exhaust pipe will be surveyed and left in place.
- The Ward Center Crane will be utilized during the decommissioning activities. It will be surveyed, decontaminated in place as required and left intact and in operating condition.

2.3.1.1.3.3 Reactor and Pool

- Reactor components and activated pool hardware will be removed in hardware liners for disposal as LLRW. A cask will be brought in and loaded with the hardware liners and shipped to the Barnwell, South Carolina LLW facility for disposal. The removal of these items can take place with the pool either filled or drained.
- When no longer useful as a radiological shield, the reactor pool water will be surveyed and discharged.
- The dismantling of the reactor support structure and pool will proceed with an initial cleaning of the pool floor and walls. If appropriate a coating may be applied to "fix" the contamination.
- The Thermal Column will be removed.
- The beam port extension tubes will be removed.
- All other hardware and debris present in the pool will be removed and similarly processed.
- Potentially activated pool concrete will be removed down to floor level. Portions of the concrete may be released as uncontaminated. The remainder will be handled as potentially radioactive material or as radioactive material.
- Surface and coring samples of the pool concrete floor in the vicinity of the reactor core will be performed to determine the extent of the activated concrete.
- Activated concrete with activity concentrations in excess of release criteria will be disposed of as radioactive waste.
- The remaining tasks are removal of residual surface contamination in the rooms, and performance of the final status survey. The packaged waste is to be shipped to a licensed processing or disposal facility.

Figure 2-1 Ward Center Elevation View

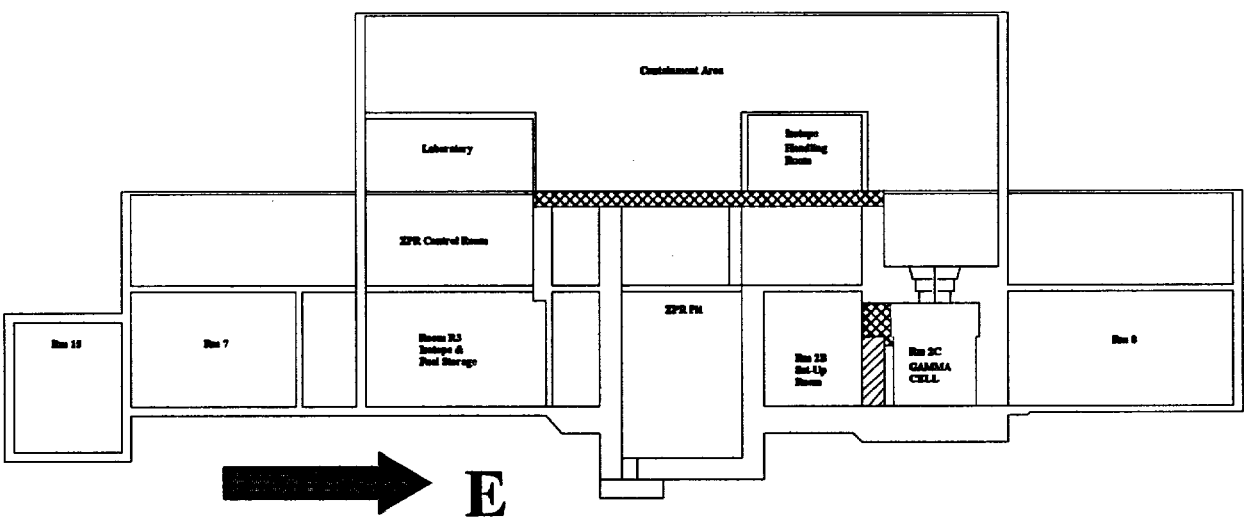
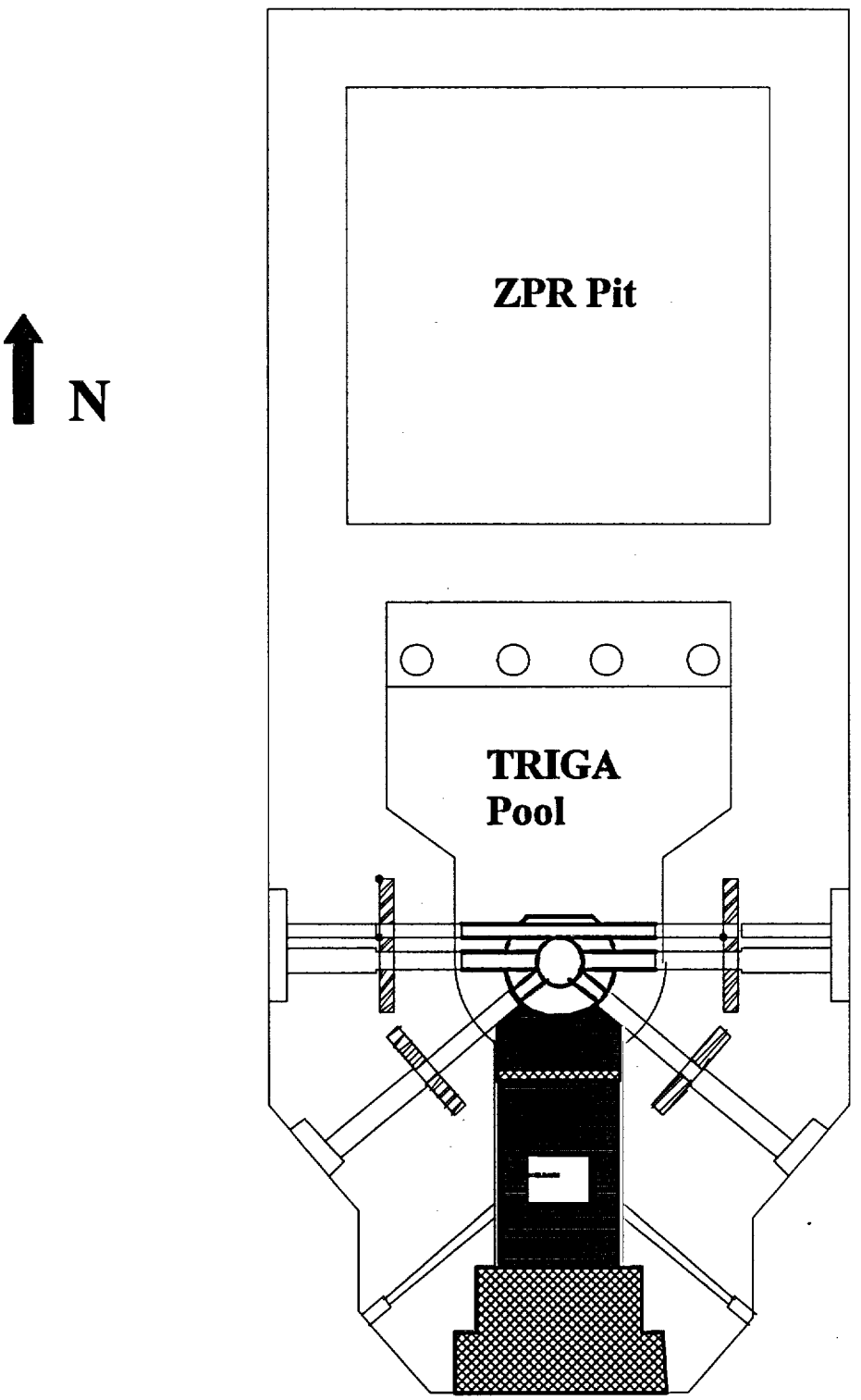


Figure 2-2 TRIGA Pool and ZPR Pit



2.3.1.1.3.4 Remaining Rooms and Structure

- The reactor associated equipment, materials, instrumentation, and tools will be handled as described above in Section 2.3.1.1.3.1. This includes demineralizer process equipment, heat exchanger equipment, contaminated hoods, and process equipment associated with the beam ports and equipment in the gamma cell.
- Contaminated room surfaces will be decontaminated.

2.3.1.2 Dismantling Sequence

Dismantling will occur sequentially by the schedule shown in Section 2.3.2. Items removed will be grouped as follows:

Group 1 Equipment that does not have induced radioactivity but which may have surface contamination.

Group 2 Core components and other components that have induced radioactivity, including pool concrete that has been activated.

Group 3 Reactor support systems.

Group 4 Equipment, tools and systems that become contaminated during decommissioning operations.

Components and equipment in the four groups are identified in Table 2-3, Table 2-4, Table 2-5 Table 2-6 Equipment Used In Decommissioning Operations - Group 45 and Table 2-8.

The control rods in the TRIGA pool are expected to have the highest dose rates from induced radioactivity. The control rods and other Group 2 items will be hoisted from the pool within shielded containers that will have been prepared to accept the items. Additional shielding will be provided for worker protection if necessary.

After pool components, equipment and parts listed in Table 2-3 and Table 2-4 have been removed; plastic contamination control barriers may be utilized to contain materials generated during bioshield removal. Depending on the demolition methods utilized there will be concrete dust or concrete mud generated during the demolition. During the demolition the airborne and surface activity levels will be monitored to determine if contamination control barriers are needed.

Table 2-3 Components with Potential Surface Contamination –Group 1

TRIGA Reactor Systems	Demineralizer resin, tanks, pipe loop and floor drains
	Heat exchanger, heat exchanger piping loop
	Pneumatic systems
Laboratory Areas	Fume hoods, sink drains, drains and HVAC
Beam Port and Thermal Column	
ZPR Systems	Miscellaneous cleanup systems, filters and resins
Beam Plug Storage Wells	
Contaminated pool concrete	

Table 2-4 Components with Induced Radioactivity - Group 2

Reflector Platform
Reflector
Grid plates
Graphite Dummy Elements
Control Rod Guide Tubes
Control rods
Source Holder
Ion Chambers and Mounting Assembly
Beam Tube nose pieces and targets
Fasteners and connectors
Pneumatic transfer rabbits and system tips
Graphite Thermal Column
Activated concrete

Table 2-5 Reactor Support Systems – Group 3

Collant System
Clean Up System
Purge System
Floor Drains

Table 2-6 Equipment Used In Decommissioning Operations - Group 4

General ventilation system
Temporary localized ventilation system
Confinement barrier
Contaminated tools and equipment
Contaminated clothing

The TRIGA bioshield structure will be removed. This may involve an initial surface decontamination prior to removal of the structure depending on the surface activity levels found after the pool is drained. To minimize dust dispersal, a localized HEPA vacuum system may be used in the area where concrete is being demolished. The embedded piping that passes from the pool to the heat exchanger and the demineralizer system will be removed during the pool structure demolition.

Post-remediation surveys of the remaining building floor concrete may include concrete and soil/rock/shale coring sampling and analysis. As the removal of activated material proceeds, the radioactive material will be packaged for shipment and disposal.

There are two potential radiological safety concerns during performance of this task: 1) external exposure from the activated components in the pool, and 2) inhalation of airborne material. To minimize the risk, during occupancy, the work areas will be monitored frequently and radiation levels will be monitored continuously, to determine sudden changes in the radiological conditions.

The water treatment system will be removed which includes the L-1 Mixed Bed Deionizer, and the L-2 Carbon filter along with associated pipe, valves and instrumentation. The pool water cooling system will also be removed which includes a heat exchanger that utilizes campus-supplied chilled water, two pumps and associated piping valves and controls. The water treatment system is housed in the Reactor Equipment Room. The cooling system is mounted in the Reactor Bay on the exterior wall of the Reactor Equipment Room.

The hoods in the Isotope Handling Room and the ZPR laboratories will be removed. All parts of the Pneumatic Transfer System will be removed with exception of supplied air and electrical controls.

The ZPR is no longer operational and significant progress has been made in preparing the facility for release for unrestricted use. The two cleanup filters and the demineralizer associated with the ZPR will be removed. It is anticipated that the remaining equipment can be surveyed and left in place.

The HVAC System will be left in place except that all filters will be removed.

2.3.1.3 Surveys

Following decontamination and remediation activities of the reactor, a final status survey (FSS) of each of the reactor rooms and other applicable locations covering the Ward Center will be performed and documented.

2.3.2 Schedule

The project schedule is presented as Figure 2-3. This schedule was developed using Microsoft Project. Based on project schedule information documented here in Figure 2-3, Cornell estimates that a formal request for termination of Facility Licenses No. R-80 and R-89 will be submitted to the USNRC approximately eighteen months after the approval of the decommissioning plan is received from the USNRC. The Ward Center Decommissioning Project is currently scheduled to run from January 2004 to May 2005. Changes to the schedule may be made at Cornell's discretion as a result of resource allocation, availability of a radioactive waste burial site, interference with ongoing Cornell activities, ALARA considerations, further characterization measurements and/or temporary on site radioactive waste storage operations.

2.4 Decommissioning Organization and Responsibilities

Cornell is committed to, and retains ultimate responsibility for, full compliance with the existing USNRC reactor licenses and the applicable regulatory requirements during decommissioning. University policies and goals will be followed to ensure high standards of performance in accomplishing the decommissioning tasks.

The Office of the Vice Provost for Research, with support from the TRIGA Reactor D&D Oversight Committee and the Cornell Project Manager, will monitor decommissioning operations to ensure they are being performed safely and according to federal, state, and local regulatory requirements (NRC, EPA, DOT, etc.) and will approve of DOC procedures used during the decommissioning as described in this plan. Consistent with Cornell University policy, the Radiation Safety Committee (RSC) has certain responsibilities to review and approve policies, procedures, programs and facilities pursuant to the safe use of radiological materials and radiation producing equipment. The RSC's jurisdiction will extend to all decommissioning activities dealing with radioactive material and radiological controls.

The planned organization for the Ward Center Decommissioning as shown in will be maintained, however individuals performing the functions may vary over the project duration. Specialized contractors may be utilized under the direction of the Office of the Vice Provost for Research when necessary and appropriate.

2.4.1 Contractor Assistance

Cornell University management will select a qualified contractor to perform the Ward Center Decommissioning Project. The team will consist of Cornell personnel and the selected contractor. Cornell will be in charge of overall project management; a Decommissioning Operations Contractor (DOC) will manage the physical decommissioning work, provide health physics support, radiation surveys, and waste packaging, processing, and shipping.

The DOC has not been selected yet. Cornell will select a contractor through university established procurement procedures and standards requiring a rigorous source evaluation and review process. The review and evaluation specifications define scope and method of selection and criteria for contractor qualifications, experience, and reputation. The contractor qualifications and experience required include the following:

a. Demonstration of experience in the performance of the following tasks:

- Integration of decommissioning, dismantlement and demolition plans.
- Waste management and other methods used to minimize final waste disposal costs.
- Decontamination and remediation of facilities and equipment.
- Use of survey equipment and techniques suitable for compliance with current NRC or MARSSIM survey criteria.
- Use of inventory and tracking mechanisms to assure accurate waste tracking.
- Development and execution of radiological and industrial safety programs that will be used during the D & D.
- Selection, design and/or procurement of appropriate containers and packaging for radioactive and hazardous waste, and transportation to approved treatment and disposal facilities.
- Performing license termination surveys on a project of similar size and scope.
- Package, manifest, transport, process and dispose of radioactive waste.

b. The decommissioning contractor selected must have a QA program that meets the requirements under 10 CFR 71 "Packaging and Transportation of Radioactive Material", Subpart H "Quality Assurance". In addition, the contractor's QA program must meet the applicable criteria from 10 CFR 50, Appendix B and the American Society of Mechanical Engineers (ASME) NQA-1. One of the applicable criteria that must be included is a QA Approved Suppliers List.

c. The decommissioning contractor must have an NRC or agreement state license authorizing decommissioning activities at remote sites. The contractor must also have the programs and procedures necessary to perform such activities.

d. The contractor should be prepared to provide qualified personnel, including but not limited to the following:

- Project Manager
- Certified Health Physicist with MARSSIM survey experience
- Waste management
- Industrial hygienist
- Civil and mechanical engineer
- Quality assurance engineer
- Construction supervisor
- Planning and scheduling specialist
- Decontamination and waste technicians
- Radiological safety engineer, foreman and technicians

Official decommissioning project records will be hardcopy documents maintained in secure cabinets. The contractor will maintain working documents, and Cornell will maintain completed or final project records and documents. These decommissioning files will be available at the Reactor Facility for inspection by the NRC.

Contractors and subcontractors performing work under this Decommissioning Plan will be required to comply with applicable Cornell policies and procedures.

Figure 2-3 Ward Center Decommissioning Schedule

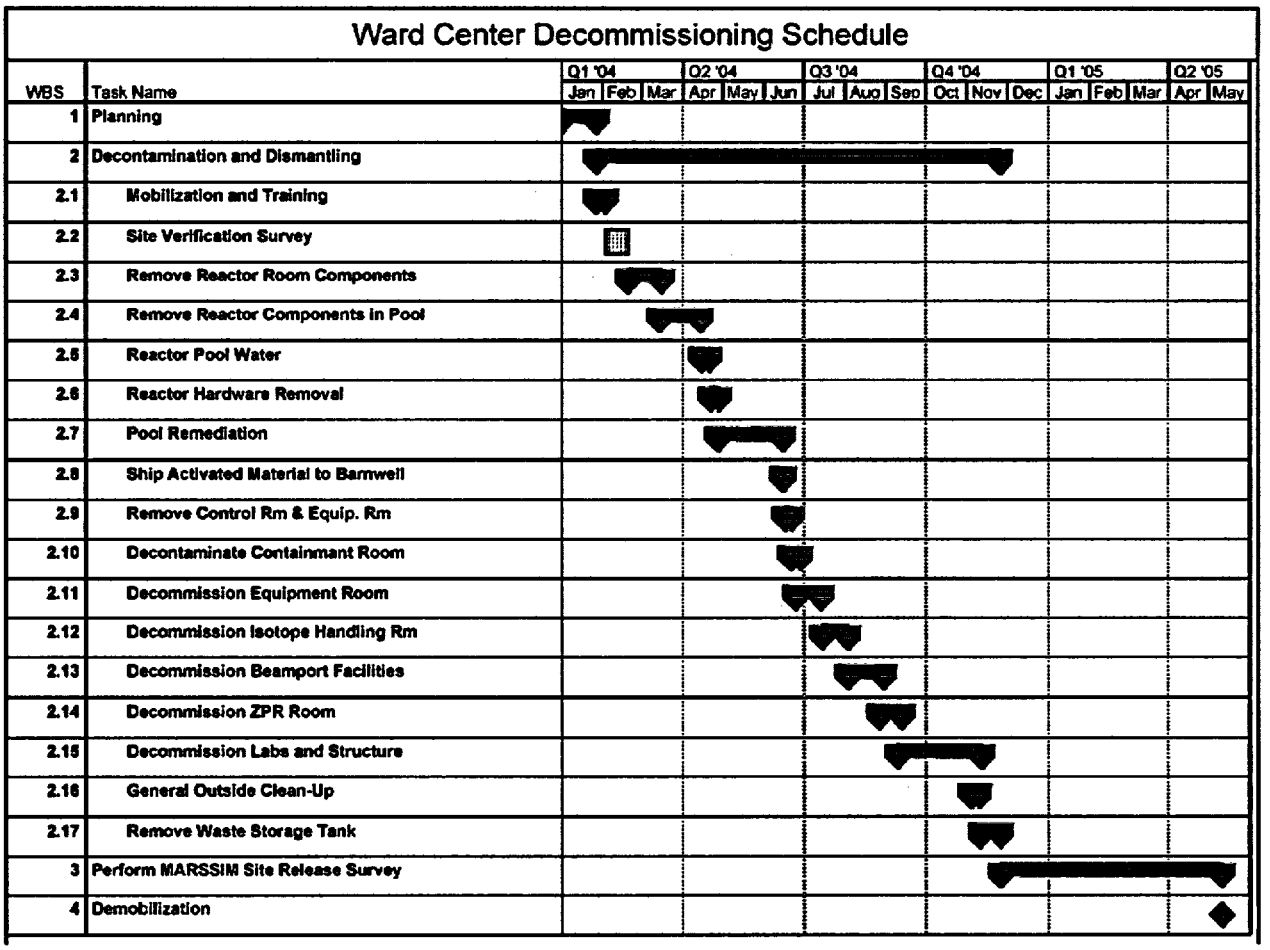
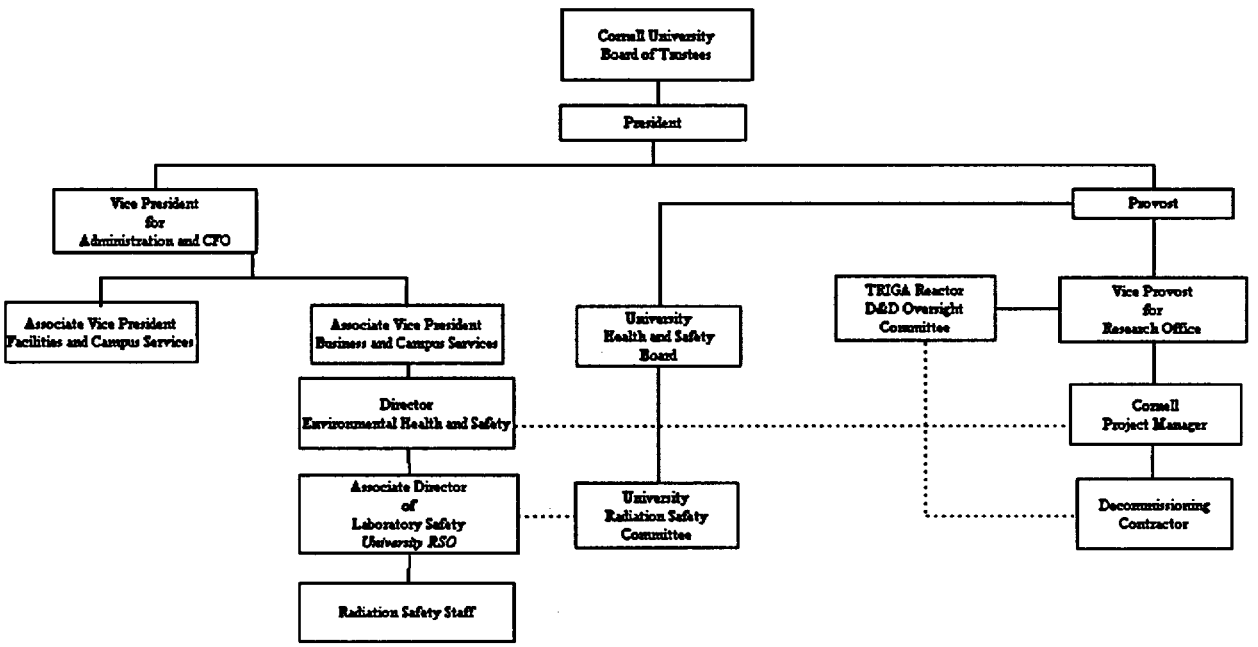


Figure 2-4 Ward Center Decommissioning Organization



2.4.2 Ward Center Director for Nuclear Studies

The Ward Center Director functions include:

- Controlling and maintaining safety during decommissioning activities and protecting of the environment
- Reporting of performance
- Approving minor changes to the decommissioning plan and procedures (which do not change the original intent and do not involve an unreviewed safety question)
- Oversight and coordination of Cornell functional groups and decommissioning contractors
- Ensuring that the conduct of decommissioning activities complies with applicable regulations and is in accordance with Cornell licenses.

The minimum qualifications for the Ward Center Director are:

- Current or previously certified reactor operator
- Ten years of management experience in the nuclear industry
- Familiarity with the Ward Center Facility
- Appropriate training in radiation protection, nuclear safety, hazard communication and industrial safety.

2.4.3 Reactor Supervisor

The functions of the Ward Center Reactor Supervisor include:

- Maintaining the TRIGA Reactor in a safe and proper condition during the evolution of Decommissioning Project activities, in accordance with the requirements set forth in the applicable USNRC facility licenses
- Review of plans and procedures
- Providing engineering support for the decommissioning activities

The minimum qualifications for this position are:

- Current or previously certified reactor operator
- At least 2 years of experience in Reactor Operation at the TRIGA Facility, or at least 6 years of experience in Reactor Operations.

2.4.4 Radiation Safety Officer

The Radiation Safety Officer shall be responsible for providing radiological support in the decommissioning of the Ward Center. This function ensures that the activities involving potential radiological exposure are conducted in compliance with the applicable licenses, Federal and State regulations, and Ward Center standard operating procedures. The position includes responsibility for maintaining the TRIGA surveillance and monitoring program and for HP radiological protection procedures.

The Radiation Safety Officer for Cornell University will have oversight of all D&D operations. The scope of his oversight will include all D&D operations that involve work with systems or materials that have a radiological component.

The minimum qualifications for this position are:

- An advanced degree in health physics or a related field
- Ten years supervisory experience in health physics
- Ten years operational experience related to radiation safety

The RSO is responsible for ensuring that:

a. Radiological controls are in place prior to and during any work involving radiation
b. Applicable license conditions are satisfied
c. Applicable state and federal regulations are met.

The Radiation Safety Officer has the authority to:

a. Implement any actions necessary to ensure that radiological controls are implemented and followed
b. Stop or modify radiological work immediately and then make changes to RWPs within 24 hours.

2.5 Training Program

Individuals (employees, contractors and visitors) who require access to the work areas or a radiologically restricted area will receive training commensurate with the potential hazards to which they may be exposed.

Radiation protection training will be provided to personnel who will be performing remediation work in radiological areas or handling radioactive materials. The training will ensure that decommissioning project personnel have sufficient knowledge to perform work activities in accordance with the requirements of the radiation protection program and accomplish ALARA goals and objectives. The principle objective of the training program is to ensure personnel understand the responsibilities and the required techniques for safe handling of radioactive materials and for minimizing exposure to radiation.

Records of training will be maintained which will include trainees names, dates of training, type of training, test results, authorization for protective equipment use, and instructor's name. Radiation protection training provides the necessary information for workers to implement sound radiation protection practices. The following are examples of the training programs applicable to remediation activities.

2.5.1 General Site Training

A general training program designed to provide orientation to project personnel and meet the requirements of 10 CFR Part 19 will be implemented. General Site Training (GST) will be required for all personnel assigned on a regular basis to the remediation project. This training will include:

- Project orientation/access control
- Introduction to radiation protection
- Quality assurance
- Industrial safety
- Emergency procedures

2.5.2 Radiation Worker Training

Radiation Worker Training (RWT) will be required for all individuals directly associated with the Ward Center Decommissioning, and the training will include the following topics:

- Fundamentals of Radiation

- Biological Effects of Radiation
- External Radiation Exposure Limits and Controls
- Internal Radiation Limits and Controls
- ALARA Program (Program, Objectives, Investigational Limits, Keeping Doses ALARA)
- Contamination Limits and Controls
- Management and Control of Radioactive Waste.

Personnel who have documented equivalent RWT from another site may be waived from taking training except for training on Cornell administrative limits and emergency response, and will be required to pass the written examination and demonstration exercises.

2.5.3 Respiratory Protection Training

Personnel whose work assignments require the use of respiratory protection devices will receive respiratory protection training in the devices and techniques that they will be required to use. The training program will follow the requirements of 10 CFR 20 Subpart H (Ref. 2-2), Regulatory Guide 8.15 (Ref. 2-3), NUREG 0041 (Ref. 2-4) and 29 CFR 1910.134 (Ref. 2-5). Training will consist of a lecture session and a simulated work session. Personnel who have documented equivalent respiratory protection training may be waived from this training.

2.6 Decontamination and Decommissioning Documents and Guides

Health physics, industrial health criteria and other standards that guide the activities described in this Decommissioning Plan are discussed in 3.1, RADIATION PROTECTION, 3.2, RADIOACTIVE WASTE MANAGEMENT, 3.3, GENERAL INDUSTRIAL SAFETY PROGRAM, and 3.4, RADIOLOGICAL ACCIDENT ANALYSES. Relevant documents and guides used are noted therein.

2.7 Facility Release Criteria

The proposed decommissioning alternative that has been presented in this Decommissioning Plan does not necessitate the major dismantlement of the Ward Center building. The results of the site and facility radiological characterization have indicated that the building structures may be directly releasable without need for extensive decontamination.

This section provides the specific criteria for release of the Ward Center. The Final Release survey will use the Derived Concentration Guideline Levels (DCGL's) developed from the characterization survey data (Ref. 2-6) and the current NRC guidance for license termination in Subpart E, *Radiological Criteria for License Termination*, of 10 CFR Part 20, *Standards of Protection Against Radiation* (Ref. 2-7). Subpart E, 10 CFR 20.1402, *Radiological Criteria for Unrestricted Use* (Ref. 2-8), allows termination of a license and release of a site for unrestricted use if the residual radioactivity that is distinguishable from background radiation results in a total effective dose equivalent to an average member of a critical group that does not exceed 25

millirem (0.25 millisevert) per year and the residual radioactivity has been reduced to levels that are as low as is reasonably achievable (ALARA). The current NRC guidance for acceptable license termination screening values (meeting the 10 CFR 20.1402 criteria) of common radionuclides for building surface contamination and surface soil contamination are presented in NUREG-1757, Volume 1 *Consolidated NMSS Decommissioning Guidance, Decommissioning Process for Materials Licenses, Appendix B*, (Ref. 2-9). An ALARA analysis is not needed. As stated in NUREG-1727, Volume 1, Appendix D, "in light of the conservatism in the building surface and surface soil generic screening levels developed by the NRC staff, the staff presumes, absent information to the contrary, that licensees or responsible parties that remediate building surfaces or soil to the generic screening levels do not need to demonstrate that these levels are ALARA."

Upon completion of the decontamination and remediation activities (e.g. see Section 2.3 Decommissioning Tasks), a final status survey of the Ward Center will be performed using the method described in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 2-11). The results of the survey(s) will be summarized in a report which will be submitted to NRC, as required by the U.S. Nuclear Regulatory Commission NUREG 1537 (Ref. 2-12), in support of a license termination request.

If it is impractical or not possible to satisfy release criteria (or conclusively demonstrate that they have been met), the location/item will be treated as radioactively contaminated and dispositioned as low-level waste.

The characterization did not indicate that there was any surface soil contamination. The release criteria for surface soil will be based upon the relative concentrations of isotopes on the material and their respective release criteria if more than one category of nuclide for beta-gamma emitters applies from Table 2-8. In addition small amounts of concrete from the radiologically controlled area may be released using the volumetric soil release criteria.

If additional screening values are required for nuclides not included in Table 2-7 or Table 2-8, they will be calculated using the NRC's D and D Code with default values.

Table 2-7 License Termination Screening Values for Building Surface Contamination

Radionuclide	Symbol	Acceptable screening levels[1] for unrestricted release (dpm/100 cm^2)[2]
Hydrogen-3 (Tritium)	^{3}H	1.2E+08
Carbon-14	^{14}C	3.7E+6
Sodium-22	^{22}Na	9.5E+03
Sulfur –35	^{35}S	1.3E+07
Chlorine-36	^{36}Cl	5.0E+05
Manganese-54	^{54}Mn	3.2E+04
Iron-55	^{55}Fe	4.5E+06
Cobalt-60	^{60}Co	7.1E+03
Nickel-63	^{63}Ni	1.8E+06
Strontium-90	^{90}Sr	8.7E+03
Technetium-99	^{99}Tc	1.3E+06
Iodine-129	^{129}I	3.5E+04
Cesium-137	^{137}Cs	2.8E+04
Iridium-192	^{192}Ir	7.4E+04

[1]Screening levels are based on the assumption that the fraction of removable surface contamination is equal to 0.1. For cases when the fraction of removable contamination is undetermined or higher than 0.1, users may assume, for screening purposes, that 100 percent of surface contamination is removable, and therefore the screening levels should be decreased by a factor of 10. Alternatively, users having site-specific data on the fraction of removable contamination, based on site-specific resuspension factors, (e.g., within 10 percent to 100 percent range) may calculate site-specific screening levels using D and D Version 2.

[2]Units are disintegrations per minute (dpm) per 100 square centimeters (dpm/100 cm2). One dpm is equivalent to 0.0167 becquerel (Bq). Therefore, to convert to units of Bq/m2 multiply each value by 1.67. The screening values represent surface concentrations of individual radionuclides that would be deemed in compliance with the 0.25 mSv/yr (25 mrem/yr) unrestricted release dose limit in 10 CFR 20.1402. For radionuclides in a mixture, the "sum of fractions" rule applies; see Part 20, Appendix B, Note 4.

Table 2-8 License Termination Screening Values for Surface Soil

Radionuclide	Symbol	Surface Soil Screening Values for unrestricted release (pCi/g)[2]
Hydrogen-3 (Tritium)	^{3}H	1.1E+02
Carbon-14	^{14}C	1.2E+1
Sodium-22	^{22}Na	4.3E+00
Sulfur –35	^{35}S	2.7 E+02
Chlorine-36	^{36}Cl	3.6 E-01
Calcium-45	^{45}Ca	5.7 E+01
Scandium-46	^{46}Sc	1.5E+01
Manganese-54	^{54}Mn	1.5E+01
Iron-55	^{55}Fe	1.0E+04
Cobalt-57	^{57}Co	1.5E+02
Cobalt-60	^{60}Co	3.8E+00
Nickel-59	^{59}Ni	5.5E+03
Nickel-63	^{63}Ni	2.1E+03
Strontium-90	^{90}Sr	1.7E+00
Niobium-94	^{94}Nb	5.8E00
Technetium-99	^{99}Tc	1.9E+01
Iodine-129	^{129}I	5.0E-01
Cesium-134	^{134}Cs	5.7E+00
Cesium-137	^{137}Cs	2.8E+04
Europium-152	^{152}Eu	8.7E+00
Europium-154	^{154}Eu	8.0E+00
Iridium-192	^{192}Ir	4.1E+01
Lead-210	^{210}Pb	9.0E-01
Radium-226	^{226}Ra	7.0E-01
Radium-226+C	^{226}Ra+C	6.0E-01
Actinium-227	^{227}Ac	5.0E-01
Actinium-227+C	^{227}Ac+C	5.0E-01
Thorium-228	^{228}Th	4.7 E+00

Radionuclide	Symbol	Surface Soil Screening Values for unrestricted release (pCi/g)[2]
Thorium-228+C	^{228}Th+C	4.7 E+00
Thorium-230	^{230}Th	1.8 E+00
Thorium-230+C	^{230}Th+C	6.0 E-01
Thorium-232	^{232}Th	1.1 E+00
Thorium-232+C	^{232}Th+C	1.1 E+00
Protactinium-231	^{231}Pa	3.0 E-01
Protactinium-231+C	^{231}Pa+C	3.0 E-01
Uranium-234	^{234}U	1.3 E+01
Uranium-235	^{235}U	8.0 E+00
Uranium-235+C	^{235}U+C	2.9 E-01
Uranium-238	^{238}U	1.4 E+01
Uranium-238+C	^{238}U+C	5.0 E-01
Plutonium-238	^{238}Pu	2.5 E+00
Plutonium-239	^{239}Pu	2.3 E+00
Plutonium-241	^{241}Pu	7.2 E+01
Americium-241	^{241}Am	2.1 E+00
Curium-242	^{242}Cm	1.6 E+02
Curium-243	^{243}Cm	3.2 E+00

[1]These values represent surficial surface soil concentrations of individual radionuclides that would be deemed in compliance with the 25 mrem/y (0.25 mSv/y) unrestricted release dose limit in 10 CFR 20.1402. For radionuclides in a mixture, the "sum of fractions" rule applies; see Part 20, Appendix B, Note 4.

[2]Screening values are in units of (pCi/g) equivalent to 25 mrem/y (0.25 mSv/y). To convert from pCi/g to units of becquerel per kilogram (Bq/kg) divide each value by 0.027. These values were derived using D and D screening methodology (NUREG/CR-5512, Volume 3). They were derived based on selection of the 90th percentile of the output dose distribution for each specific radionuclide (or radionuclide with the specific decay chain). Behavioral parameters were set at the mean of the distribution of the assumed critical group. The metabolic parameters were set at "Standard Man" or at the mean of the distribution for an average man.

[3]"Plus Chain (+C) " indicates a value for a radionuclide with its decay progeny present in equilibrium. The values are concentrations of the parent radionuclide, but account for contributions from the complete chain of progeny in equilibrium with the parent radionuclide (NUREG/CR-5512 Volumes 1, 2, and 3).

REFERENCES FOR SECTION 2

2-1 *The Health Physics and Radiological Health Handbook*, Revised Edition 1992, Editor by B. Shleien.

2-2 10 CFR 20 Subpart H, *Respiratory Protection and Controls to Restrict Internal Exposure in Restricted Areas.*

2-3 Regulatory Guide 8.15, *Acceptable Programs for Respiratory Protection*; Revision 1, October, 1999

2-4 NUREG 0041, *Manual of Respiratory Protection Against Airborne Radioactive Materials*

2-5 29 CFR 1910.134, *Respiratory Protection*

2-6 Characterization Survey Report for the Ward Center for Nuclear Studies at Cornell University, Facilities Inventory Bldg. No. 2061, May 2003

2-7 10 CFR 20 Subpart E, *Radiological Criteria for License Termination*

2-8 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use*

2-9 NUREG-1757, *Consolidated MSS Decommissioning Guidance, Decommissioning Process for Materials Licenses*, September 2002

2-10 NUREG-1727, *NMSS Decommissioning Standard Review Plan*, September 2000

2-11 NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*

2-12 NUREG 1537, *Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors*, February 1996

3.0 OCCUPATIONAL AND PUBLIC HEALTH AND SAFETY

3.1 Radiation Protection

3.1.1 Ensuring As Low As Reasonably Achievable (ALARA) Radiation Exposures

Decommissioning activities at the Ward Center involving the use and handling of radioactive materials will be conducted in a manner such that radiation exposure will be maintained As Low As Reasonably Achievable (ALARA), taking into account the current state of technology and economics of improvements in relation to the benefits.

ALARA Program

The Cornell practice during this project will be as follows:

- A documented ALARA evaluation will be required for specific tasks if a Project HP determines that 5% of the applicable dose limits (collective dose) for the following may be exceeded:
  - Total Effective Dose Equivalent (TEDE) (5 rem)
  - The sum of the Deep-Dose Equivalent (DDE) and the Committed Dose Equivalent (CDE) to any individual organ or tissue other than the lens of the eye (50 rem)
  - Eye Dose Equivalent (EDE) (15 rem)
  - Shallow-Dose Equivalent to the skin or any extremity (SDE) (50 rem)

Decommissioning Project management positions responsible for radiation protection and maintaining exposures ALARA during decommissioning include the Ward Center Director and Radiation Safety Officer.

Methods for Occupational Exposure Reduction

Various methods will be utilized during the Decommissioning Project work to ensure that occupational exposure to radioactive materials is kept ALARA. The methods include the Radiological Work Permit (RWP), special equipment, technique, and practices as described in the following subsections. Work will be performed in accordance with reactor licenses and/or this Decommissioning Plan.

Radiological Work Permits (RWPs)

A Radiation Work Permit (RWP) will be used for the administrative control of personnel entering or working in areas that have radiological hazards present. Work techniques will be specified in such a manner that the exposure for all personnel, individually and collectively, are maintained ALARA. RWPs will not replace work procedures, but will act as a supplement to procedures. Radiation work practices will be considered when procedures are developed for work that will take place in a radiologically controlled area.

Project RWPs will describe the job to be performed, define protective clothing and equipment to be used, and personnel monitoring requirements. RWPs will also specify any special instructions or precautions pertinent to radiation hazards in the area including listing the radiological hazards present, area dose rates and the presence and intensity of hot spots, loose surface radioactivity, and other hazards as appropriate. The HP organization will ensure that radiation, surface radioactivity and airborne surveys are performed as required to define and document the radiological conditions for each job.

RWPs for jobs with low dose commitments will be approved at the HP technician or HP supervisory level while RWPs for jobs with potentially high dose commitment or significant radiological hazards will be approved by the RSO. Examples of topics covered by implementing procedures for the Radiation Work Permits are:

- Requirements, classifications and scope for RWPs;
- Initiating, preparing and using RWPs;
- Extending expiration dates of an RWP; and
- Terminating RWPs

Respiratory Protection and TEDE ALARA Evaluations

The use of engineering controls to mitigate the airborne radiological hazard at the source will be the first choice with respect to controlling the concentrations of airborne radioactive material. There may be, however, circumstances where engineering controls are not practical or may not be sufficient to prevent airborne concentrations in excess of those that constitute an airborne radioactivity area. In such circumstances where worker access is required, respiratory protective equipment will be utilized to limit internal exposures. Any situation wherein workers are allowed access to an airborne radioactivity area, or allowed to perform work that has a high degree of likelihood to generate airborne radioactivity in excess of 0.1 DAC, the decision to allow access will be accompanied by the performance of representative measurements of airborne radioactivity to assess worker intake. The results of DAC-hour tracking and air sample results for intake will be documented in accordance with appropriate regulations. Workers will provide nasal smears for HP evaluation following the use of respiratory protective equipment for radiological purposes, as necessary.

Control and Storage of Radioactive Materials

The Cornell HP Program establishes radioactive material controls that ensure:

- Deterrence of inadvertent release of licensed radioactive materials to unrestricted areas.
- Confidence that personnel are not inadvertently exposed to licensed radioactive materials.
- Minimization of the volume of radioactive wastes generated during the decommissioning.

All material leaving the Restricted Area will be surveyed to ensure that radioactive material is not inadvertently released from the Ward Center. See Section 3.1.3 "Radioactive Materials Controls" for a description of the specific survey methods that will be used.

3.1.2 Health Physics Program

Project Health Physics Program - General

Cornell has procedures in place that will be implemented during the Ward Center Decommissioning Project. If additional Health Physics procedures are required at some point in the work to support the decommissioning, they will be developed and approved in accordance with Cornell Health Physics policy and procedure.

Cornell senior management is readily accessible to ensure timely resolution of difficulties that may be encountered. The RSO, while organizationally independent of the Project staff, have direct access to the Ward Center Director on a daily basis, and have full authority to act in all aspects of protection of workers and the public from the effects of radiation. Conduct of the Ward Center Decommissioning Project HP program will be evaluated according to Cornell policy.

Audits, Inspections, and Management Review

During Decommissioning Project work, aspects of the Project may be assessed and reported by the Contractor's Quality Assurance Department, through audits, assessments and inspections of various aspects of decommissioning performance, including HP, as described in Section 1.2.5 Program Quality Assurance.

Audits of the Cornell Health Physics program are conducted in accordance with the requirements of 10 CFR 20. These audits will include aspects of the Ward Center Decommissioning Project.

Additional assessments or management reviews may be performed when deemed appropriate by the Office of the Vice Provost for Research.

Health Physics Equipment and Instrumentation

HP equipment and instrumentation suitable to permit ready detection and quantification of radiological hazards to workers and the public will be chosen to ensure the validity of measurements taken during remediation and final release surveys. The selection of equipment and instrumentation to be utilized will be based upon detailed knowledge of the radiological contaminants, concentrations, chemical forms and chemical behaviors that are expected to exist as demonstrated during radiological characterization, and as known from process knowledge of the working history of the Ward Center. Equipment and instrumentation selection also takes into account the working conditions, contamination levels and source terms that are reasonably expected to be encountered during the performance of decommissioning work, as presented in this Plan.

The following sections present details of the equipment and instrumentation planned for use during the decommissioning. It is anticipated that through retirement of worn or damaged equipment/instrumentation or increase in quantities of available components or instruments, that new technology will permit upgrades or, at a minimum, like-for-like replacements. Cornell is committed to maintaining conformance to minimum performance capabilities stated in this Plan whenever new components or instruments are selected.

Criteria for Selecting Equipment and Instrumentation for Conduct of Radiation and Contamination Surveys and Personnel Monitoring

A sufficient inventory and variety of instrumentation will be maintained on site to facilitate effective measurement of radiological conditions and control of worker exposure consistent with ALARA, and to evaluate the suitability of materials for release to unrestricted use. Instrumentation and equipment will be capable of measuring the range of dose rates and radioactivity concentrations expected to be encountered during the decontamination and decommissioning activities associated with the Ward Center, including implementation of a final status survey.

Project HP staff will select instrumentation that is sensitive to the minimum detection limits for the particular task being performed, but also with sufficient range to ensure that the full spectrum of anticipated conditions for a task or survey can be met by the instrumentation in use. Consumable supplies will conform to manufacturer and/or regulatory recommendation to ensure that measurements meet desired sensitivity and are valid for the intended purpose.

Storage, Calibration, Testing and Maintenance of Health Physics Equipment and Instrumentation

Survey instruments will be stored in a common location under the control of Ward Center Decommissioning Project HP personnel. A program to identify and remove from service inoperable or out-of-calibration instruments or equipment as described in HP procedures will be adhered to throughout the Ward Center Decommissioning Project. Survey instruments, counting equipment, air samplers, air monitors and personnel contamination monitors will be

calibrated at license-required intervals, manufacturer-prescribed intervals (if shorter frequency) or prior to use against standards that are NIST traceable in accordance with approved calibration laboratory procedures, HP procedures, or vendor technical manuals. Survey instruments will be operationally checked daily when in use. Counting equipment operability will be verified daily when in use. The personnel contamination monitors are operationally tested on a daily basis when work is being performed.

Specific Health Physics Equipment and Instrumentation Use and Capabilities

Table 3-1 provides details of typical HP equipment and instrumentation that is planned for use in the Ward Center Decommissioning Project. This list is neither inclusive nor exclusive.

Table 3-1 Health Physics Equipment and Instrumentation

Instrument Model	Detector Type	Instrument Range	Application
Eberline-RO-2 and 2A	Ionization chamber	RO-2 0-5,000 mR/hr RO-2A 0-50 R/hr RO-20 0-60 R/hr	Beta/gamma exposure rate measurements
Eberline Teletector-6112/B	GM tube	0-1,000 R/hr	Telescoping detector for high range
Ludlum Model 2350/2350-1 Data Logger with 43-37 probe	Gas Flow Proportional	0-500,000 cpm	Alpha and beta/gamma floor monitor 550 cm^2 ^{137}Cs efficiency approximately 30% 4π ^{239}Pu efficiency appropriately 17% 4π
Ludlum Model 44-2 probe for use with 2350	1" x 1" NaI Scintillator	0-2,860 µR/hr (i.e., 0-2.8 mR/hr)	Gamma exposure rates
Ludlum Model 44-40 probe for use with 2350	GM tube	0-500,000 cpm	Shielded pancake detector ^{137}Cs efficiency approximately 19% 4π ^{239}Pu efficiency appropriately 15% 4π
Ludlum Model 43-68 probe for use with 2350	Gas Flow Proportional	0-500,000 cpm	Alpha and beta/gamma monitor 125 cm^2 ^{137}Cs efficiency approximately 30% 4π ^{239}Pu efficiency appropriately 20% 4π
Ludlum Model 43-94 pipe probe for use with 2350	Gas Flow Proportional	0-500,000 cpm	0.5 inch probe for 0.75 to 1 inch pipe diameters
Ludlum Model 43-98 pipe probe for use with 2350	Gas Flow Proportional	0-500,000 cpm	1.5 inch probe for 2 to 3 inch pipe diameters
Ludlum Model SP-113-3M pipe probe for use with 2350	3 GM tubes	0-500,000 cpm	Motorized spider probe with three 1.13" OD probes total area 19.4 cm^2 for 3 to 6 inch straight pipe
Ludlum Model SP-113-3T pipe probe for use with 2350	3 GM tubes	0-500,000 cpm	Motorized spider probe with three 1.13" OD probes total area 19.4 cm^2 for 3 to 6 inch pipe with bends
Ludlum Model SP-175-3 M pipe probe for use with 2350	3 GM tubes	0-500,000 cpm	Motorized spider probe with three 1.75" OD probes total area 46.5 cm^2 for 4 to 12 inch straight pipe
Tennelec Model LB 5100 W	Gas Flow Proportional	CPU operated	Low-Level α/β smear samples
Ludlum-177	ZnS(Ag) scintillation	0-500,000 cpm	Hand-held alpha frisker (50 cm^2 area) ^{239}Pu efficiency 15% 4π ^{230}Th efficiency 23% 4π
Ludlum Model 19 µR	NaI (Tl) Scintillator	0-5,000 µR/hr (i.e., 0mR/hr)	Low gamma exposure rates
Eberline Model RO-7	Ionization chamber	0-20,000 R/hr	Low to high gamma exposure rate measurements
EG&G NOMAD or equivalent Gamma Spectroscopy System	HPGe	N/A	Gamma spectrometry measurement of water, air, smear/media samples (e.g., soil, asphalt, concrete, tar, vegetation)
Eberline Personnel Contamination Monitor PCM-1B	Gas Flow Proportional	N/A	Personnel contamination monitor/walk-in monitor with microprocessor control
F&J Model HV-1 "Hi-Vol"	N/A	5-30 cfm	High volume air sampling for minimum detection capability
F&J Model LV-14M Gooseneck "Lo-Vol"	N/A	0.35-3.5 cfm	Low volume air sampling for long term air sampling
Ludlum Model 333-2 air monitor	GM	$10\text{-}10^5$ cpm	Local airborne monitor with alarm capability

Policy, Method, Frequency and Procedures

The Ward Center Decommissioning Project will utilize the existing Cornell HP Program for the Project. Cornell's existing program will be augmented as necessary using plans and procedures provided by the decommissioning contractor.

Airborne Effluent Monitoring — During the decommissioning effort where a temporary barrier with an exhaust system is in use, the ventilation system exhaust points from the temporary barrier will be sampled continuously downstream of the HEPA filtration system.

Radiation Surveys — Radiation, airborne radioactivity and contamination surveys during decommissioning will be conducted in accordance with approved HP procedure(s). The purposes of these surveys will be to (1) protect the health and safety of workers, (2) protect the health and safety of the general public, and (3) demonstrate compliance with applicable license, federal and state requirements, as well as Decommissioning Plan commitments. HP personnel will verify the validity of posted radiological warning signs during the conduct of these surveys. Surveys will be conducted in accordance with procedures utilizing survey instrumentation and equipment suitable for the nature and range of hazards anticipated. Equipment and instrumentation will be calibrated and, where applicable, operationally tested prior to use in accordance with procedural requirements. Routine surveys are conducted at a specified frequency to ensure that contamination and radiation levels in unrestricted areas do not exceed license, federal, state or site limits. HP staff will also perform surveys during decommissioning whenever work activities create a potential to impact radiological conditions.

Personnel Monitoring - Internal and External — External monitoring will be conducted in accordance with approved procedures. Prospective external exposure evaluations will be performed prior to initiating decommissioning activities and whenever changes in conditions warrant. Visitors to the Ward Center will be monitored in accordance with requirements specified in Cornell HP procedures and according to the radiological hazards of areas to be entered.

Internal monitoring will be conducted in accordance with approved procedures. This prospective internal exposure evaluation will be evaluated on an annual basis, at a minimum, or whenever significant changes in planned work evolutions warrant it. A comprehensive air-sampling program will be conducted at the Ward Center to evaluate worker exposures regardless of whether internal monitoring is specified. The results of this air-sampling program will be utilized to ensure validity of specified internal monitoring requirements for decommissioning personnel. If, at any time during the decommissioning, hazards that may not be readily detected by the preceding measures are encountered, special measures or bioassay, as appropriate, will be instituted to ensure the adequate surveillance of worker internal exposure.

Monitoring will be required if the prospective dose evaluation shows that an individual(s) dose is likely to exceed 10% of the applicable limits, and for individuals entering a high or very high radiation area.

Respiratory Protection - The Decommissioning Project respiratory protection program will include direction for use of National Institute for Occupational Safety and Health/Mine Safety and Health Administration (NIOSH/MSHA) certified equipment. This program will be reviewed and approved by Cornell HP to ensure adherence to the requirements of 10CFR20. The Cornell industrial hygienist may be consulted to advise the decommissioning contractor on issues about air quality and the use of respiratory protection. The Director of Environmental Health and Safety has supervisory control over the IH position.

NIOSH/MSHA approved air purifying respirators include full face piece assemblies with air purifying elements to provide respiratory protection against hazardous vapors, gases, and/or particulate matter to individuals in airborne radioactive materials areas. Individuals may be required to use continuous or constant flow full-face airline respirators for work in areas with actual or potential airborne radioactivity. The RSO will also ensure that the respiratory protection program meets the requirements of 10 CFR Part 20, subpart H.

Maintenance — When respiratory protection equipment requires cleaning, the filter cartridges will be removed. The respirator will be cleaned and sanitized after every use with a cleaner/sanitizer and then rinsed thoroughly in plain warm water in accordance with HP procedures.

Storage — Respiratory protective equipment will be kept in proper working order. When any respirator shows evidence of excessive wear or has failed inspection, it will be repaired or replaced. Respiratory protective equipment that is not in use will be stored in a clean dry location.

Contamination Control - Contamination control measures that will be employed include, as appropriate, the following:

- Worker training will incorporate methods and techniques for the control of radioactive materials, and proper use and donning/doffing of protective clothing
- Procedures will incorporate HP controls to minimize spread of contamination during work
- Radiological surveys will be scheduled and conducted by HP
- Containment devices such as designed barriers, containers and plastic bags will be used to prevent the spread of radioactive material
- Physical decontamination of Ward Center areas or items
- Physical barriers such as Herculite sheeting, strippable paint, and tacky mat step-off pads to limit contamination spread
- Posting, physical area boundaries and barricades
- Clean step-off pads at the entrance point to contaminated areas

Personnel entries into radiological contaminated areas will require the use of protective clothing. This clothing will consist of a suitable combination of items such as the following, dependent upon the conditions outlined in the RWP:

- Heavyweight lab coat
- Heavyweight canvas, cotton, or cotton/polyester coveralls
- Heavyweight hoods
- Plastic calf-high booties
- Rubber, plastic or cloth shoe covers
- Plastic or rubber gloves which may require cloth liners.
- Tyvek paper coveralls or plastic rain suit disposable outer clothing
- Face shield or other protective device

Access Control - A Restricted Area (RA) will be established and properly posted and monitored to prevent unauthorized access.

Engineered Controls - Personnel exposure to airborne radioactive materials will be minimized by utilizing engineering controls such as the following:

- Ventilation devices — in-place or portable HEPA filters or Ward Center ventilation systems, local exhaust by use of vacuums
- Containment devices — designed containment barriers, containers, plastic bags, tents, and glove-bags
- Source term reduction — application of fixatives prior to handling, misting of surfaces to minimize dust and resuspension

Airborne Radioactivity Monitoring - Monitoring for the intake of radioactive material is required by 10 CFR 20.1502(b) if the intake is likely to exceed 0.1 ALI (annual limit on intake) during the year for an adult worker, or if the committed effective dose equivalent is likely to exceed 0.10 rem (1.0 mSv) for the occupationally exposed minor or declared pregnant woman. Air sampling will be performed in areas where airborne radioactivity is present or likely.

Prospective estimates of worker intakes and air concentrations used to establish monitoring requirements will be based on consideration of the following:

- The quantity of material(s) handled
- The ALI for the nuclides of interest
- The release fraction for the radioactive material(s) based upon its physical form and use
- The type of confinement being used for the material(s) being handled
- Other factors that may be applicable

HP personnel will use technical judgment in determining the situations that necessitate air sampling regardless of generalized, prospective evaluations done for the Ward Center.

Prior to identifying the location for an air sampler, the purpose of the radiological air sample will be identified. Various reasons exist for collecting air samples. The following are a few examples:

- Estimation of worker intakes
- Verification of confinement of radioactive materials
- Early warning of abnormal airborne concentrations of radioactive materials
- Determining the existence of criteria for posting an Airborne Radioactivity Area (ARA).

Smoke tubes and buoyant markers may then be used to determine airflow patterns in the area. Airflow patterns may be reevaluated if there are changes at the Ward Center that may impact the validity of the sampling locations. Such factors might include the following:

- Changes in the work process
- Changes in the ventilation system
- Use of portable ventilation that might alter earlier assessments

After identifying the purpose for the air sample and establishing flow patterns, air sample locations are chosen as follows:

- For verification of confinement of radioactive materials:
  - Locate samplers in the airflow near the potential or actual release point.
  - More than one sampling point may be appropriate when there are more than one potential or actual release points.
- For estimation of a worker intake:
  - Sampler intakes will be located as close to the worker's breathing zone as practical without interfering with the work or worker

General workplace air sampler intakes will not be placed in or near ventilation exhaust ducts unless their purpose is to detect system leakage during normal operation, and if quantitative measurements of workplace concentrations are not required. Locations or number of air samplers will be changed when dictated by modifications to facility structure, changes in work processes, or elimination of potential sources.

A sufficient inventory and variety of operable and calibrated portable and semi-portable air sampling equipment will be maintained to allow for effective collection, evaluation, and control of airborne radioactive material and to provide backup capability for inoperable equipment. Air sampling equipment will be calibrated at prescribed intervals or prior to use against certified equipment having known valid relationships to nationally recognized standards. Table 3-1 lists anticipated air-sampling equipment.

When the work being performed is a continuous process, a continuous sample with a weekly exchange frequency is appropriate. For situations where short-lived radionuclides are important considerations, the exchange frequency will be adjusted accordingly. Longer sample exchange frequencies may be approved by HP management for situations where airborne radioactive material and nuisance dust are expected to be relatively low. Grab sampling for continuous processes may also be approved by HP management based upon consideration of variability of the expected source term for the facility and process. Grab sampling is the appropriate means of airborne sampling for processes conducted intermittently, and for short duration radiological work that involves a potential for airborne release.

Potential Sources of Radiation or Contamination Exposure to Workers and Public as a Result of Decommissioning Activities

Sources of radiation or contamination exposure may be assessed by process knowledge, radiological survey data, surveys performed during characterization, previous and current job coverage surveys, or daily, weekly and monthly routine surveys.

Classification of potential sources may also be identified by radionuclide, physical properties, volatility and radioactivity.

Worker exposure to significant external deep-dose radiation fields is considered unlikely during this project due to the nature of the contaminants and/or the work precautions and techniques employed. Worker exposure to airborne radioactivity may occur during decontamination operations/work evolutions that may involve abrasives or methods that volatilize loose and/or fixed contamination.

Exposure of the public to external or internal radiation from this Decommissioning Project is not considered credible because of the confinement provided by the facility and the access control provided for the facility and the area surrounding it.

The types of exposure controls used take into account the current state of technology and the economics of improvements in relation to the benefits. Control of potential sources of radiation exposure to workers and public as a result of decommissioning activities will be achieved through, but not limited to, the use of administrative, engineering and physical controls.

Administrative controls consist of, but are not limited to:

- Administrative dose limits that are lower than regulatory limits
- Training
- Radiological surveys.

Physical barriers such as radiological warning rope/ribbon, in combination with radiological warning tape, lockable doors/gates as well as information signs and flashing lights or other applicable barriers may also be used.

Engineering controls may consist of but are not limited to:

- HEPA ventilation/enclosures
- Protective clothing/equipment
- Access restrictions/barriers
- Confinement.

Health Physics Policies for Contractor Personnel

Contractor personnel will be used during the Ward Center Decommissioning Project. Contractors who will work with licensed radioactive materials will be required to:

- Attend and complete appropriate radiation safety course
- Provide required exposure history information
- Read and sign an applicable RWP and comply with instructions
- Follow all special instructions given by HP.

3.1.3 Radioactive Materials Controls

Cornell's radiation protection program establishes radioactive material controls that ensure the following:

- Prevention of inadvertent decommissioning radioactive waste (licensed) material release to uncontrolled areas.
- Assurance that personnel are not inadvertently exposed to radiation from licensed radioactive decommissioning waste materials.
- Minimization of the amount of radioactive waste material generated during decommissioning.

Decommissioning waste materials will not be released as clean waste. Such waste materials to be removed from the reactor facility will be shipped to an off-site licensed radioactive waste processing facility for survey, processing and disposal.

Pool water releases will be analyzed and filtered to ensure that discharges to sanitary sewerage will meet the requirements of 10 CFR 20.2003 disposal by release into sanitary sewerage and Cornell liquid discharge procedures.

3.1.4 Dose Estimates

The total projected occupational exposure to complete the decommissioning of the Ward Center is estimated to be 18.34 person-rem. This estimated was taken from NUREG/CR-1756 (Ref. 3-4). The estimate in this document was developed for a reference research reactor, a 1,000 kW TRIGA reactor.

This estimate is provided for planning purposes only. Detailed exposure estimates and exposure controls shall be developed during detailed planning of the decommissioning activities. Area dose rates used for this estimate are based on process knowledge and current survey maps (where available).

The dose estimate to members of the public as a result of decommissioning activities is estimated to be negligible. This is because site perimeter controls will restrict members of the public from the area where decommissioning activities are taking place. This is consistent with the estimate given for the "reference research reactor" in the *"Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities"* (NUREG-0586) (Ref. 3-5). The dose to the public during decommissioning (DECON) and truck transport transportation of radioactive waste from the reference research reactor referred to in the Final Generic Impact Statement is estimated to be "negligible (less than 0.1 man-rem)."

Activated pieces and any contaminated debris will be removed and shielded if required to meet U.S. DOT shipping requirements and disposal site Waste Acceptance Criteria.

3.2 Radioactive Waste Management

3.2.1 Radioactive Waste Processing

The processes of decontamination, remediation and dismantlement of the Ward Center will result in solid and liquid low-level radioactive waste, mixed waste and hazardous waste. Limited soil remediation is anticipated which will result in solid radioactive waste. This waste will be handled (processed and packaged), stored and disposed of in accordance with applicable sections of the Code of Federal Regulations (CFR), disposal site Waste Acceptance Criteria, New York State Department of Environmental Conservation Requirements, Ward Center Licenses and Permits, and the applicable implementing plans and procedures. Radioactive waste processing includes waste minimization or volume reduction, radioactive and hazardous waste segregation, waste characterization, neutralization, stabilization, solidification and packaging.

3.2.2 Radioactive Waste Disposal

Low-level radioactive waste will be processed and packaged for disposal at a licensed low-level waste site such as the Envirocare of Utah site or the Barnwell, South Carolina site. The volume of low-level radioactive waste is estimated at 4,700 cu. ft. Mixed low-level waste will be prepared for shipment to off-site commercial processing and disposal facilities such as Envirocare of Utah.

10 CFR 61, *Licensing Requirements for Land Disposal of Radioactive Waste, Subpart D — Technical Requirements for Land Disposal Facilities*, establishes minimum radioactive waste classification, characterization and labeling requirements. These requirements will be ensured through the implementation of project packaging and characterization procedures, Disposal Site

Waste Acceptance Criteria for the contractor selected disposal site(s) and the Project-Specific Quality Assurance Plan. Training/ Qualifications will be provided for project waste management personnel to assure conformance to applicable 10 CFR 61 requirements as stated in the specific implementing procedures and plans. Audits and surveillances will be conducted per the Project-Specific Quality Assurance Plan based on ASME-NQA-1 and the requirements of 10 CFR 71.

10 CFR 71, Packaging and Transportation of Radioactive Material, establishes requirements for packaging, shipment preparation and transportation of licensed material. Cornell University is licensed by the USNRC to receive, possess, use and transfer licensed byproduct and source materials. 10 CFR 71 requirements will be met through the implementation of Cornell approved packaging and shipping procedures. Training will be provided for waste management personnel to assure conformance to applicable 10 CFR 71 requirements. Quality Assurance will confirm conformance to 10 CFR 71 Subpart H (Quality Assurance) requirements through the implementation of a Cornell approved Project-Specific Quality Assurance Plan. The Cornell Quality Assurance Program for Radioactive Materials Packages will ensure compliance with 10 CFR Part 71, Subpart H.

10 CFR 20.2006, *Transfer for Disposal and Manifests*, establishes requirements for controlling transfers of low-level radioactive waste intended for disposal at a land disposal facility; establishes a manifest tracking system; supplements requirements concerning transfers and record keeping; and requires generator certification that transported materials are properly classified, described, packaged, marked and labeled, and are in proper condition for transport. These requirements will be met through the implementation of project and Cornell packaging and shipping procedures with the oversight of DOC and Cornell Quality Assurance.

Radiological and mixed wastes will be disposed of at disposal sites per the applicable Disposal Site's Acceptance Criteria. Associated implementing plans and procedures will reflect the characterization, processing, removal of prohibited items, packaging and transportation requirements. Appropriate documentation will be submitted to designated disposal sites including, as required, certification plans, qualification statements, assessments, waste stream analysis, evaluations and profiles, transportation plans, and waste stream volume forecasts. Waste characterization, waste designation, waste traceability, waste segregation, waste packaging, waste minimization, and quality assurance and training requirements of the designated disposal sites will be incorporated in implementing procedures to assure conformance to disposal site requirements.

Generator State (New York) and Treatment/Storage/Disposal Facility States (Utah, South Carolina, etc.) requirements for radioactive and mixed waste management will be incorporated into plans and procedures to assure conformance with applicable state regulations, licenses and permits. Applicable state regulations include New York State Department of Environmental Conservation Requirements and Utah Department of Environmental Quality Rules (R313) for the control of ionizing radiation reflected in Envirocare's Utah Radioactive Material License, UT 2300249.

Radioactive waste will be staged in designated controlled areas in accordance with USNRC 10 CFR 19 and 20 requirements. Mixed wastes will be staged in designated controlled areas per EPA 40 CFR requirements, 10 CFR 19 and 20, and per local and state permits. Measures will be implemented through plans and procedures to control the spread of contamination, limit radiation levels, prevent unauthorized access, prevent unauthorized material removal, prevent tampering, and prevent weather damage. The designated controlled areas will be approved by Radiological Work Permits (RWP) and/or Hazardous Work Permits (HWP). An HWP will be used when controls are imposed to protect against non-radiological hazards. The Cornell Associate Director of Laboratory and Radiation Safety is responsible for HRWP approval. The Director of Environmental Health and Safety has supervisory control over the Cornell Associate Director of Laboratory and Radiation Safety.

Radioactive and mixed waste material will be packaged for shipment per 10 CFR, 40 CFR, 49 CFR, and the designated Disposal Site Criteria and placed in permitted interim storage (staged) until shipped. The quantity of waste packages staged for shipment will be a function of waste generation and packaging rate, shipment preparation rate, shipment rate, and disposal site acceptance rate. To meet this objective, shipments will be scheduled throughout the life of the Project to designated treatment, storage, and disposal facilities.

Radioactive material storage areas will be contained inside posted restricted areas according to existing Cornell procedures and consistent with 10 CFR 20.

3.3 General Industrial Safety Program

Industrial safety and industrial hygiene personnel, along with project management, shall be responsible to ensure that the project meets all occupational health and safety requirements. The primary functional responsibility is to ensure compliance with the OSHA of 1973. Specific responsibilities include conducting an industrial training program to instruct employees in general safe work practices; reviewing Decommissioning Project procedures to verify adequate coverage of industrial safety and industrial hygiene concerns and requirements; performing periodic inspections of work areas and activities to identify and correct any unsafe conditions and work practices; providing industrial hygiene services as required; and advising Project management on industrial safety matters and on the results of periodic safety inspections.

All personnel working on the Ward Center Decommissioning Project will receive Health and Safety training in order to recognize and understand the potential risks involving personnel health and safety associated with the work at the Ward Center. The Health and Safety training implemented at the Ward Center is to ensure compliance with the requirements of the USNRC (10 CFR), the EPA (40 CFR), and OSHA (29 CFR). Workers and regular visitors will be familiarized with plans, procedures and operation of equipment to conduct themselves safely. In addition, each worker must be familiar with procedures that provide for good quality control. Section 2.5, TRAINING PROGRAM, provides additional information.

3.4 Radiological Accident Analyses

Potential radiological accidents during the decommissioning of the Ward Center will be mainly associated with the reactor pool. These accidents were analyzed and are reported in DRTK-CALC-WARD-001, Rev. 0, *Radiological Accident Analysis for Ward Center Decommissioning Plan*, Appendix B.

REFERENCES FOR SECTION 3

3-1 *Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination,* the Federal Register (63 FR 64132, 11/18/98)

3-2 Table 1 - Acceptable License Termination Screening Values of Common Radionuclides for Building Surface Contamination

3-3 NUREG-1727, *NMSS Decommissioning Standard Review Plan*, September 2000

3-4 NUREG/CR-1756, *Technology, Safety and Costs of Decommissioning Reference Nuclear Research and Test Reactors*, March 1982

3-5 NUREG-0586, *Final Generic Environmental Impact Statement on Decommissioning of Nuclear Facilities*

4.0 PROPOSED FINAL RADIATION SURVEY PLAN

The intended course of action for Ward Center decommissioning, based upon consideration of site and facility radiological characterization results, is to decontaminate structural materials to the extent practicable in balance with radioactive waste minimization considerations, and dismantle Ward Center systems to the extent necessary for remediation, and packaging for burial those materials that cannot reasonably be decontaminated. As such, the Final Status Survey Plan (and subsequent Final Status Survey Report) discussed in this section deals with release of the Ward Center building structure and grounds to unrestricted use. This section will also discuss the survey methods that will be utilized.

4.1 Description of Final Status Survey Plan

The purpose of the Final Status Survey is to demonstrate that the radiological condition of the Ward Center structures are at or below established release criteria (see Section 2.7). It is anticipated that the U.S. NRC will then terminate the Ward Center reactor licenses and release all areas of the Ward Center, except for the State licensed gamma irradiation facility, for unrestricted use.

Cornell will develop its Final Status Survey Plan using the guidance provided in NUREG-1727, *NMSS Decommissioning Standard Review Plan* (Ref. 4-1) and NUREG-1575, Multi-*Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 4-2).

A final status survey plan will be developed after the decommissioning contract is awarded. The basis for the design of the final status survey is the MARSSIM. The overall goal of the FSS design is to ensure surveys are planned and conducted in such a manner that ensure the proper decision is made as to whether or not to accept or reject the null hypothesis (Null hypothesis, H0: residual radioactivity in the survey unit exceeds the release criterion). The COMPASS computer code (Ref. 4-3) will also be used as part of the survey planning and survey assessment process.

The major inputs into the FSS planning process are the development of Data Quality Objectives (DQOs) (see section 4.1), review and modification as necessary of the designation of class 1, 2, and 3 areas (see section 4.4), the designation of survey units within each area classification (see section 4.4), the review of contaminants and establishment of Derived Concentration Guideline Levels (DCGL) (see sections 2.7 and 4.3), and the selection of appropriate survey instrumentation (see section 3.1).

The survey plan will serve as the guidance document for development of the survey package instructions used during implementation of the final status survey. The facility will be sectioned into survey units according to guidance provided in MARSSIM. Plots, diagrams, and facility layout drawings will be developed to illustrate the classification of the survey units. In addition to a final status survey plan, a survey package portfolio will be developed for each survey unit. Each survey package will include survey unit specific instructions, describe the survey unit size, grid spacing, scan area prescribed and prescribed number of static measurements including the location and spacing.

As the survey progresses, reevaluation of the survey plan may be necessary based on newly acquired survey data. If a condition not encompassed by the survey plan is discovered, the survey plan may undergo revision to address the condition. The condition with the revised survey plan will be fully disclosed and provided to the Cornell University Radiation Safety Committee for review and concurrence prior to further performance of the final status survey as it applies to the revised information.

To prevent recontamination of the clean areas, administrative and physical access controls of surveyed radiologically clean areas will be instituted. Control of surveyed areas will be accomplished administratively by written instruction contained in the final survey plan and by training of project personnel. Control of surveyed areas may be accomplished physically by placing rope barriers, locking doors where able, etc. and placing signs to notify personnel regarding the condition of an area.

The Final Status Survey Plan will contain the criteria used to assess all final survey data including the statistical tests performed and state the conclusion based upon statistical test results.

The Final Status Survey Plan will be developed according to the guidance provided in MARSSIM and based upon the following assumptions:

- The results of the characterization were reviewed and the Ward Center was determined to be impacted based on the operational history, characterization data and professional judgment.
- The screening activity levels for building surfaces are based on the assumption that the fraction of removable surface contamination is equal to 0.1. The fraction of activity that is removable will be verified. If the removable fraction exceeds 0.1 then more decontamination will be performed or site specific DCGL values will need to be applied.
- Decision Errors -there are two types of decision errors applied to analytical results: Type I (α) and Type II (β) errors. A Type I error, or false positive, is the probability that null hypothesis is rejected when it should be accepted. A Type II error, or false negative, is the probability of determining that null hypothesis is accepted when it should be rejected. The probability of making decision errors can be controlled by adopting an approach called hypothesis testing. The null hypothesis (H0) is treated like a baseline condition and is defined by MARSSIM as:

  H0 = residual radioactivity in the survey unit exceeds the release criterion.

  This means that the site or survey area is assumed contaminated until proven otherwise. For the purpose of this final survey, Type I or α error will be set at 0.05 or 5 percent and Type II or β error will be set at 0.05 or 5 percent.

- For the Ward Center the decision has not been made whether or not survey data will be evaluated relative to a reference background area. As such the survey planning process and survey data assessment process may utilize either the Sign test or the Wilcoxon Rank Sum (WRS) test to determine if any residual contamination in a survey unit exceeds the DCGL. The selection process for determining which test method to use will be documented.

- Any background count rate information required for input into the survey planning process will be obtained prior to performing the final status survey. The standard deviation in the background count rate will be calculated based on the data obtained. The background information will be input into COMPASS where it is stored. COMPASS automatically calculates the standard deviation. The background information is stored as part of the general site information and not on a survey unit specific basis.

- Once the final survey has been performed, survey data will be converted to DCGL units and compared to the DCGLs. Individual measurements and sample concentrations will be compared to DCGL levels for evidence of small areas of elevated activity. Data will then be evaluated using the appropriate statistical test method (Sign test or WRS test) to determine if they exceed the release criterion. If the release criterion has been exceeded (null hypothesis proven true) the TRIGA Reactor D&D Oversight Committee will determine appropriate further actions. If all data points are less than the DCGL levels, no statistical test need be performed.

- If the release criterion has not been exceeded (null hypothesis proven false), the results of the survey will be compared with the data quality objectives established during the planning phase of the project. If the data quality objectives have been satisfied, the survey unit will be suitable to release for unrestricted use.

4.1.1 Review and Approval of Final Status Survey Plan

Cornell is utilizing Method 1 from section 14 of NUREG-1727, *NMSS Decommissioning Standard Review Plan (SRP)* (Ref. 4-1), to submit information to the NRC on facility radiation surveys. Cornell has submitted information to the NRC on release criteria, characterization surveys, and operational surveys as part of the decommissioning plan. In addition Cornell has committed to using the MARSSIM approach in developing the final radiological survey. Cornell will then submit information to the NRC on Final Status Survey Design, when the design of the final radiological survey for the site has been completed. The Final Status Survey Report will be submitted after the final radiological survey has been performed.

The Final Status Survey Plan will be prepared by the decommissioning contractor who will review and approve the plan utilizing their internal review and approval process. Then, the plan will be presented for approval to the Office of the Vice Provost for Research, in consultation with the TRIGA Reactor D&D Oversight Committee and the Cornell Project manager, together with a technical review, to ensure that the Final Status Survey Plan utilizes the guidance provided in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM). Following the approval of this document by Cornell, it will be submitted to the NRC for review and acceptance as being adequate to demonstrate compliance with radiological criteria for license termination.

The Final Status Survey Plan will include sufficient information to allow the NRC to determine that the final status survey design is adequate to demonstrate compliance with the radiological criteria for license termination. The information will include:

- A brief overview describing the final status survey design;
- A description and map or drawing of impacted areas of the site, area, or building classified by residual radioactivity levels (Class 1, Class 2, or Class 3) and divided into survey units, with an explanation of the basis for division into survey units. Maps will have compass headings indicated;

- A description of the background reference areas and materials, if they will be used, and a justification for their selection;
- A summary of the statistical tests that will be used to evaluate the survey results, including the elevated measurement comparison, if Class 1 survey units are present, a justification for any test methods not included in MARSSIM, and the values for the decision errors (and) with a justification for values greater than 0.05;
- A description of scanning instruments, methods, calibration, operational checks, coverage, and sensitivity for each media and radionuclide;
- For in-situ sample measurements made by field instruments, a description of the instruments, calibration, operational checks, sensitivity, and sampling methods, with a demonstration that the instruments, and methods, have adequate sensitivity;
- A description of the analytical instruments for measuring samples in the laboratory, including the calibration, sensitivity, and methodology for evaluation, with a demonstration that the instruments and methods have adequate sensitivity;
- A description of how the samples to be analyzed in the laboratory will be collected, controlled, and handled;
- A description of the final status survey investigation levels and how they were determined;
- A summary of any significant additional residual radioactivity that was not accounted for during site characterization;
- A summary of direct measurement results and/or soil concentration levels in units that are comparable to the DCGL and, if data is used to estimate or update the survey unit;
- A summary of the direct measurements or sample data used to both evaluate the success of remediation and to estimate the survey unit variance.

4.1.2 Means for Ensuring that all Equipment, Systems, Structures and Site are Included in the Survey Plan

Every item that is to be removed from the Ward Center will be evaluated for its ability to be decontaminated. Further, items will be radiologically surveyed to ensure that radioactive (i.e., licensed) materials are not inadvertently removed from the facility (see Section 2.3.1.1.3.1). When it is impractical or not possible to decontaminate an item such that it exhibits no discernable facility-related activity when surveyed following methods presented in Section 2.3.1.1.3.1, the item will be treated as radioactive waste. Items that exhibit no discernible facility-related activity will be disposed of as uncontaminated waste. The systematic approach to Ward Center decommissioning will ensure that every item or structural component in the Ward Center is specifically evaluated for release before beginning the Final Status Survey. The Final Status Survey will break the Ward Center into three classes (as suggested in MARSSIM) to ensure adequate survey coverage in support of a license termination request and subsequent release of the property for unrestricted use.

4.1.3 Means for Ensuring that Sufficient Data is Included to Achieve Statistical Goals

Cornell will develop the Ward Center Final Status Survey Plan using the guidance presented in NUREG- 1727, *NMSS Decommissioning Standard Review Plan* (Ref. 4-1) and NUREG-1575, Multi-*Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Ref. 4-2). By using this guidance, the Project will satisfy the U.S. NRC recommended statistical goals.

4.2 Background Survey Results

The Final Status Survey Guideline values for residual activity are taken to be levels above the naturally occurring background radiation. However, if the final status survey results are significantly below the release guideline levels, the licensee may opt not to use background subtraction. The number of samples collected in each survey unit and in background reference areas will be sufficient to satisfy the statistical goals. The final status survey will consist of a combination of direct beta measurements and samples for radionuclide specific analysis.

Background radiation as encountered at any location includes contributions due to natural radiation sources and man-made sources. Natural radiation sources include terrestrial radioactivity due to naturally occurring radioisotopes in soils and construction media, airborne radioactivity (principally radon and radon progeny) from the radioactive decay of certain of these naturally occurring radioisotopes, and cosmic radiation from high-speed particle interactions in the earth's atmosphere. Man-made background radiation, as it would impact the Final Status Survey, would consist primarily of atmospheric fission product fall-out due to weapons testing and reactor accidents and any contribution that might exist as a result of activities of other licensees.

4.3 Final Release Criteria - Residual Radiation and Contamination Levels

The criteria for release of the Ward Center to unrestricted use, after completion of the decommissioning activities described in this plan, are presented in Section 2.7. In summary, they are:

1. The generic screening values provided in Tables B.1 and B.2 of Appendix B in NUREG 1757 (Ref. 4-4), and
2. A limit specified in 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use* (Ref. 4-5).

4.4 Measurements for Demonstrating Compliance with Release Criteria

4.4.1 Instrumentation - Type, Specifications and Operating Conditions

Instrumentation utilized during the Final Release Survey (and equipment and materials survey) will be selected based upon the need to ensure that site residual radiation will not exceed the release criteria. In order to achieve this goal, instrumentation sensitive to the isotopes of concern and capable of measuring levels below the guideline values for those isotopes will be selected. Instrumentation available for the Final Status Survey, and their respective detection range capability is presented in Table 3-1 of this plan. Instrumentation sensitivities were determined following the guidance of NUREG-1507 (Ref. 4-6) using nominal literature values for background, response and site conditions. Refinements to these detection sensitivity estimates will be made, as necessary, on the basis of actual instrument response and background data gathered during site survey activities. Instrumentation used in the surveys will be calibrated against sources and standards that are NIST-traceable and representative of the isotopes encountered at the Ward Center. When used, instruments will be operationally tested daily, or prior to each use, whichever is less frequent. Instruments will not be used in conditions that are not in conformance with manufacturer recommendations.

4.4.2 Measurement Methodology for Conduct of Surveys

This Decommissioning Plan presumes that the Ward Center will have been decontaminated to the extent practicable prior to the Final Status Survey. The Ward Center structure and site will be methodically remediated, as necessary, prior to conduct of the Final Status Survey. The characterization results and the continuous feedback from remediation surveys will be the basis for remediation efforts. The Ward Center Final Status Survey Plan will include several steps to calculate the number of measurements and samples required, according to MARSSIM guidance, to release the site without restrictions. These steps include:

- Classify survey units
- Specify the decision error
- Determine the DCGL
- Calculate the relative shift (COMPASS, Ref. 4-3 may be utilized)
- Obtain the number of samples per survey unit (COMPASS, Ref. 4-3 may be utilized)
- Estimate the sample grid spacing
- Perform evaluation for small areas with elevated radioactivity
- Determine if the number of samples is reasonable.

Classify Survey Units

The Ward Center will be broken into four classes of survey areas. Class 1 is an area with the highest potential for contamination. Class 2 is an area that was impacted or has a low potential for delivering a dose above the release criteria and has little or no potential for containing small areas of elevated activity. Class 3 is an area with the lowest potential for contamination.

The final status survey plan and survey package portfolios for each survey unit will include a discussion regarding the facility history, characterization survey results, and evaluations used to support survey unit classification.

Specify the Decision Error

There are two types of decision error (applied here to analytical results), Type I (alpha) and Type II (beta). A Type I error is described as the probability of determining that a result is above a criterion when it actually is not (false positive). A Type II error is described as the probability of determining that a result is below a criterion when it actually is above it (false negative). Both types of error will be set at 0.05 (5%).

Determine the DCGL

The derived concentration guideline level (DCGL) is defined in MARSSIM as the radionuclide-specific concentration within a survey unit corresponding to the release criterion. The radionuclides identified at the Ward Center during radiological characterization efforts were ^{137}Cs (predominant nuclide), ^{3}H, ^{14}C, ^{54}Mn, ^{57}Co, ^{58}Co, ^{60}Co, ^{63}Ni, ^{65}Zn, ^{124}Sb, ^{129}I, ^{134}Cs, ^{152}Eu, ^{154}Eu, ^{155}Eu, ^{210}Pb, ^{227}Th, ^{228}Th, ^{230}Th, ^{232}Th, $^{233/234}U$, ^{235}U and ^{238}U. The DCGL values were discussed in Section 2.7. Some of the identified radionuclides are naturally accurring or known to be present in background.

As stated in NUREG-1727 Appendix D, in light of the conservatism in the building surface and surface soil generic screening levels developed by the NRC staff, the staff presumes, absent information to the contrary, that licensees or responsible parties that remediate building surfaces or soil to the generic screening levels do not need to demonstrate that these levels are ALARA.

Gross activity DCGLs and $DCGL_{EMC}$ (elevated measurement comparison DCGLs) will be developed during the planning stage for the final status survey that will consider "hard-to-detect" radionuclides for surfaces. The site specific DCGLs will be calculated based on the relative fraction of each radionuclide in the expected radionuclide mix. Once developed, the values will be submitted for review and concurrence.

Calculate the Relative Shift

The relative shift is defined as Δ/σ where Δ is the DCGL - LBGR (Lower Bound of the Gray Region) and σ is the standard deviation of the contaminant distribution. In order to calculate the relative shift, the DCGL must be determined and two assumptions must be made to estimate the LBGR and the standard deviation of the measurement distribution. MARSSIM suggests that the LBGR be set at 50%, of the DCGL but can be adjusted later to provide a value for the relative shift between the range of 1 to 3. The standard deviation may be calculated from preliminary survey data, prior surveys of similar areas and materials or the standard deviation of a reference background area.

It should be noted that σ represents the standard deviation prior to release after all area decontamination is thought to be complete. If no reference data is available to make a reasonable estimate of the background standard deviation, MARSSIM suggests using 30% of the mean survey unit background. For the Ward Center, data from the facility characterization or from post-remediation surveys will be used to calculate the standard deviation value for each survey unit. The value for LBGR is input into COMPASS. The relative shift is automatically calculated and reported by COMPASS.

Obtain the Number of Samples per Survey Unit

Once the relative shift is determined the calculated value, Δ/σ, can be used to obtain the minimum number of measurements or samples necessary to reject the null hypothesis based upon the initial assumptions and justify that the survey unit meets the requirements for release for unrestricted use. MARSSIM Table 5-3 contains the number of samples or measurements necessary for the given decision errors, α and β, and the calculated relative shift, Δ/σ, when dealing with non-radionuclide specific measurements or when the radionuclide is present in the background. The value N/2 from Table 5-3 represents the number of samples or measurements to be collected in each survey unit and the reference background area. MARSSIM Table 5-5 provides the number of measurements of samples for the case in which the radionuclide is not in the background.

Estimate the Sample Grid Spacing

The grid spacing for the measurement and samples is estimated in two ways depending upon the shape of the grid (either triangular or rectangular grid). If a triangular grid is used, the grid spacing is estimated as follows:

$$L = \sqrt{\frac{A}{0.866N}}$$

Where:

L = Distance between measurement locations
A = Survey unit Area
N = Number of measurements

If a square grid is used, the spacing is estimated as follows:

$$L = \sqrt{\frac{A}{N}}$$

Perform Evaluation for Small Areas with Elevated Radioactivity

After the grid spacing has been calculated, the area between samples can also be calculated. For example, if the grid spacing is 10 m for a square grid, then there can be an undetected pocket of elevated radionuclide concentrations 100 m^2 in area. Adjustments to the grid spacing (i.e., additional sampling) may be necessary depending on the following three factors:

- The class of the survey unit;
- The ability to scan for the radionuclide; and
- The minimum potential size of the elevated activity that could produce an exposure above the dose or risk criterion.

Determine if the Number of Samples is Reasonable

Assuming that the number of samples per unit has been calculated, it should then be determined if that number is reasonable. It is possible, even if MARSSIM guidance was strictly followed, that there are too few samples to produce the desired level of comfort. It is the responsibility of the site managers and health physicists to evaluate whether the number of samples is reasonable. If it is determined that the number of samples is inadequate or excessive, the data quality objectives should be reevaluated.

4.4.3 Scan Surveys

Following remediation and prior to conducting sampling, beta scans for surfaces and structures and gamma scans for environs will be performed over 100% of the Class I surfaces, 50% of the Class II surfaces and 25% of the Class III surfaces. A scanning response exceeding an action level set based on Section 6.8.2 of NUREG-1507 will be investigated/sampled/re-surveyed and, if necessary, remediated. If remediation is performed, scanning shall be repeated to demonstrate effectiveness of the remediation.

4.4.4 Soil Sampling

Soil samples will be obtained to a depth of 15 cm; samples will be packaged and uniquely identified in accordance with chain-of-custody and site-specific procedures.

4.4.5 Sample Analysis

Samples will be transferred to a radio-analytical laboratory for analyses in accordance with documented laboratory-specific standard methods. In accordance with MARSSIM, analytical

techniques will provide a minimum detection level of 50% of the individual radionuclide $DCGL_W$ (or $DCGL_{EMC}$) values for all primary contaminants. If these analyses indicate residual activity exceeding guideline levels, further remediation will be performed, as required, and scans and sampling of the remediated area will be repeated.

4.4.6 Investigation Levels

Radiation levels identified by scans that indicate potential residual radioactive contamination above background will be investigated to identify the source, level and extent of such residual activity. Areas that contain residual radioactivity concentrations of individual radionuclides, or sum-of-ratio concentrations above respective guideline values, will be remediated, reclassified (as necessary) and re-surveyed.

4.5 Methods to be Employed for Reviewing, Analyzing, and Auditing Data

4.5.1 Laboratory/Radiological Measurements Quality Assurance

During decommissioning survey activities, many direct and indirect measurements and sample media samples will be collected, measured and analyzed for radiological contaminants. The results of these surveys will be utilized to evaluate the suitability of the material or item for release to unrestricted use, or whether decontamination of structures, components, and the surrounding site have achieved the desired result. Sample collection, analysis, and the associated documentation will adhere to written procedures and meet the guidance of the U.S. NRC, as well as comply with recognized industry recommendations and good practices. Outside (i.e., non-Cornell) laboratories selected to analyze Ward Center decommissioning samples shall be approved by Cornell and listed on the QA Approved Suppliers List.

The decommissioning contractor selected must have a QA program that meets the requirements under 10 CFR 71 "Packaging and Transportation of Radioactive Material", Subpart H "Quality Assurance". In addition the contractor's QA program must meet the applicable criteria from 10 CFR 50, Appendix B; the American Society of Mechanical Engineers (ASME) NQA-1. One of the applicable criteria that must be included is a QA Approved Suppliers List. The contractor will maintain the QA Approved Suppliers List. The University will assess the effectiveness of the contractors QA program either through direct audits performed by either the Cornell Project Manager, or by audits performed by contracted audit personnel, or by the acceptance of audits performed by other organizations.

Organizations that perform radiological monitoring measurements recognize the need to establish quality assurance programs to assure that radiological monitoring measurements are valid. These programs are established for the following reasons: (1) to readily identify deficiencies in the sampling and measurement processes to those individuals responsible for these activities so that prompt corrective action can be taken, and (2) to routinely monitor the survey and laboratory measurement results in order to assure that results and conclusions are valid.

4.5.2 Supervisory and Management Review of Results

Health Physics technicians who are trained and qualified will conduct radiological surveys. In addition, a senior level member of the Health Physics staff other than the individual that performed the survey will review radiological surveys and sample results. Final Status Survey data will also be reviewed by the RSO.

REFERENCES FOR SECTION 4

4-1 NUREG-1727, *NMSS Decommissioning Standard Review Plan*, September 2000

4-2 NUREG-1575, Multi-*Agency Radiation Survey and Site Investigation Manual (MARSSIM)*

4-3 *COMPASS Code* Version 1.0.0 was developed under the sponsorship of the U.S. Nuclear Regulatory Commission for implementation of MARSSIM in support of the decommissioning license termination rule (10 CFR Part 20, Subpart E)

4-4 NUREG-1757, Volume 1, *Consolidated MSS Decommissioning Guidance, Decommissioning Process for Materials Licenses*, September 2002

4-5 10 CFR 20.1402 *Radiological Criteria for Unrestricted Use*

4-6 NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*

5.0 TECHNICAL SPECIFICATIONS

After the nuclear fuel is removed from the reactor and shipped off site, most of the technical specifications for the operating license will not apply after the license is amended to possession –only or modified by an order to decommission as discussed in NUREG-1737 (Ref. 5-1). The applicable Technical Specifications for the Ward Center TRIGA Reactor decommissioning will be set forth in an amendment request to Facility License No. R-80, Docket No. 50-157.

As decommissioning progresses, further requests for changes to the Technical Specifications may be submitted in an application for amendment to the license pursuant to 10 CFR 50.59.

REFERENCES FOR SECTION 5

5-1 NUREG- 1537 Rev. 0, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors"

6.0 PHYSICAL SECURITY PLAN

All radiation restricted areas are secured from unauthorized entry. During non-working hours, all nuclear facility sensitive areas are locked. Cornell maintains routine, periodic police surveillance of the reactor site.

Existing physical security and material control and accounting plans approved by the Nuclear Regulatory Commission as may be amended will continue to be implemented.

These existing plans meet the requirements in NUREG-1537, Chapter 17 (Ref. 6-1)

REFERENCES FOR SECTION 6

6-1 NUREG- 1537 Rev. 0, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors".

7.0 EMERGENCY PLAN

As required by the USNRC, Cornell University has a Reactor Facility Emergency Plan for responding to emergencies at the Reactor Facility. The purpose of this plan is to minimize any emergency's effect on the public, personnel, reactor facility and the environment surrounding the facility. Removal of spent fuel from the site will significantly reduce the potential for significant release of radioactive material off site. Any airborne or liquid releases due to decommissioning activities would have negligible impact off site. The most likely accident scenario is a contaminated and/or injured individual. This scenario is adequately addressed by the existing emergency plan. Training will be provided to key personnel to ensure their familiarity with the emergency plan and their expected responses.

8.0 ENVIRONMENTAL REPORT

The Environmental Report (Ref. 8-1) is provided as Appendix C.

REFERENCES FOR SECTION 8

8-1 *Environmental Report for the Ward Center for Nuclear Studies at Cornell University Facilities Inventory Bldg. No. 2061*, March 2003.

9.0 CHANGES TO THE DECOMMISSIONING PLAN

As the decommissioning progresses, and up until the termination of the license, changes to the Technical Specifications will be via a Request for License Amendment pursuant to 10 CFR 50.90 (Ref. 9-1).

Cornell requests that changes to the Decommissioning Plan be allowed with local approval by the Office of the Vice Provost for Research, in consultation with the TRIGA Reactor D&D Oversight Committee and the Cornell Project Manager, and without prior USNRC approval, unless an unreviewed safety question is involved. An unreviewed safety question involves:

1. The increase of probability of occurrence or the increase of consequences of an accident or malfunction of equipment important to safety compared to that situation previously evaluated in the SAR, or

2. The possibility for an accident or malfunction of a different type than previously analyzed in the SAR, or

3. The reduction in margin of safety as defined in the SAR.

Reports and records of changes to the Decommissioning Plan, and retention of documents, will be in accordance with the applicable portions of 10 CFR 50.59 (Ref. 9-2).

REFERENCES FOR SECTION 9

9-1 10 CFR 50.90, *Application for amendment of license or construction permit.*

9-2 10 CFR 50.59, *Changes, tests and experiments.*

APPENDIX A
SUMMARY OF CHARACTERIZATION RESULTS

SUMMARY OF CHARACTERIZATION RESULTS

In December of 2002, Duratek, Inc. was awarded a contract by Cornell University to assist them with the Phase I activities associated with the decommissioning and decontamination, D&D, of the Ward Center for Nuclear Studies. The Ward Center for Nuclear Studies housed two reactors. A Zero Power Reactor that has essentially been decommissioned, although its possession only license has not been terminated and a TRIGA Reactor that was still operational during the Phase I activities.

The Phase I activities include the performance of a characterization survey and the preparation of a decommissioning plan. Phase II will involve the implementation of the decommissioning plan. This characterization survey report presents the results of the characterization survey. The decommissioning plan will be based in part on the results of the characterization survey and it is expected that the characterization survey report will be included as an appendix to the decommissioning plan. The intent of the decommissioning plan is to summarize the actions necessary to terminate the licenses for both the Zero Power Reactor and the TRIGA Reactor.

The scope of the characterization survey included the reactor complex, with the exception of the gamma irradiation facility, and several rooms/laboratories located in the office and laboratory wing used to support reactor operations. The areas within the office and laboratory wing included in the characterization survey were those areas having the greatest potential for residual contamination due to the operations of the Zero Power Reactor and TRIGA Reactor. The gamma irradiation facility was not included in the characterization survey since it is licensed separately by the State of New York and no plans to terminate its license were finalized prior to the completion of the Phase I activities. It is expected that all areas within the Ward Center for Nuclear Studies, with the possible exception of the gamma irradiation facility, will be included in the Final Status Survey performed at the end of Phase II to demonstrate that the criteria for release for unrestricted use have been met and justifying termination of the licenses for both the Zero Power Reactor and the TRIGA Reactor.

A historical site assessment (HSA) was performed prior to the start of the characterization survey. The HSA involved a site walk-down, discussions with current employees, and a review of facility records. Information obtained during the HSA was included in the characterization survey plan and in the survey packages.

The characterization survey of the Ward Center for Nuclear Studies included measurements for total alpha activity, total beta activity, removable beta activity, removable alpha activity, and exposure rates. Representative samples were also collected for off site analyses. Typically, characterization surveys of TRIGA reactors include coring the bioshield to assess neutron activation within the shield. Since the TRIGA reactor within the Ward Center for Nuclear Studies was still operational during characterization, coring the bioshield was not feasible. Therefore theoretical neutron activation analyses were performed to estimate the extent of the neutron activation in the bioshield.

The areas included in the characterization survey were divided into 20 survey packages. Each survey package contained detailed instructions, drawings, and location codes to facilitate the collection of approximately 10,000 measurements and/or samples. Table 1.1 provides a brief overview of the results of the characterization surveys.

Table 1.1

Overview of Characterization Survey

Survey Package Number	Location Description	Survey Results
A0001	Zero Power Reactor Control Room, Rm 101	Residual Activity Not Detected
A0002	**Zero Power Reactor Cell**	**Residual Activity Detected**
A0003	Liquid Waste Storage Tank Room1	Residual Activity Not Detected
A0004	**Reactor BioShield Exterior Wall**	**Residual Activity Detected**
A0005	**East Side of Reactor Complex**	**Residual Activity Detected**
A0006	West Side of Reactor Complex	Residual Activity Not Detected
A0007	First Floor of Reactor Complex	Residual Activity Not Detected
A0008	**Second Floor of Reactor Complex**	**Residual Activity Detected**
A0009	**Zero Power Reactor Laboratory, Rm 111**	**Residual Activity Detected**
A0010	Reactor Equipment Room, Rm R-3	**Residual Activity Detected**
A0011	**Isotope and Fuel Storage Room, Rm R-1**	**Residual Activity Detected**
A0012	TRIGA Control Room, RM R-205	Residual Activity Not Detected
A0013	**Observation Room, Rm R-203**	**Residual Activity Detected**
A0014	Laboratory, Rm R-201	Residual Activity Not Detected
A0015	**Isotope Handling Room, Rm-202**	**Residual Activity Detected**
B0001	Laboratory Wing; Hallways, Stairwells, and Elevator	Residual Activity Not Detected
B0002	Mechanical, Electrical and Laboratory, Rms 7, 9, and 11	Residual Activity Not Detected
C0001	Reactor Complex Ceilings	Residual Activity Not Detected
D0001	**Reactor Complex Drains, Ventilation, and Pneumatic Transfer System**	**Residual Activity Detected**
E0001	Building Exterior	Residual Activity Not Detected

Table 1.2 provides the bases used for identifying a survey unit in Table 1.1 as having residual activity.

Table 1.2
Basis for Identifying Residual Activity

Survey Package Number	Location Description	Basis
A0002	Zero Power Reactor Cell	Elevated activity concentrations identified in filter and resin media (Tables 10.17, 10.18 and 10.19).
A0004	Reactor BioShield Exterior Wall	Elevated total beta activity measurement(s) on the east wall, and elevated exposure rate measurements and removable beta activity measurements within beam ports (Table 9.5 and Survey Package A0004).
A0005	East Side of Reactor Complex	Elevated total beta activity measurements in trench adjacent to vertical thermal column and elevated total beta activity measurements and removable beta activity measurements within storage wells (Table 9.6).
A0008	Second Floor of Reactor Complex	Elevated total beta activity measurement on catwalk and below reactor covers (Table 9.9). The elevated measurement result on the catwalk was due to a hot particle, which was removed and analyzed (Table 10.4).
A0009	Zero Power Reactor Laboratory, Rm 111	Elevated total beta and total alpha activity measurements within the hood in the vicinity of the filter housing (Table 9.10).
A0010	Reactor Equipment Room, Rm R-3	Elevated total beta activity measurements on the outside of the mixed bed deionizer and elevated exposure rate readings above the floor in the vicinity of the mixed bed deionizer (Table 9.11). Elevated activity concentrations identified in resin samples and a sample from the sump (Tables 10.5, 10.6 and 10.7).
A0011	Isotope and Fuel Storage Room, Rm R-1	Elevated total beta activity measurements on the floor (Table 9.12). Elevated tritium smears (Table 10.1).
A0013	Observation Room, Rm R-203	Elevated exposure rate measurement above the floor (Table 9.14).
A0015	Isotope Handling Room, Rm-202	Elevated total beta activity measurements on the hood, sink, and HVAC exhaust, and an elevated total alpha activity measurement on the hood (Table 9.16). Elevated activity concentration identified in sample from drain (Table 10.2).
D0001	Reactor Complex Drains, Ventilation, and Pneumatic Transfer System	Elevated total beta activity measurements in drain 2 and drain 6 (Table 9.20).

While Tables 1.1 and 1.2 can be used to identify areas with residual activity, more detailed information is required to determine the magnitude and extent of the residual activity.

This detailed information is provided in subsequent sections of the report and in the attachments and appendices. The results of measurements made during the characterization survey are presented in three different ways, each with an increased level of detail:

- Summary Statistics, Tables 9.2 through 9.21
- Data Summaries, Attachment 1 through 4
- Survey Packages, Appendix A

Sample analysis results of samples collected for off site analysis are summarized in Tables 10.1 through 10.19. Attachment 5 contains a summary of the analysis results and case narratives. Appendix D contains the level 4 reports of analyses.

The areas identified as containing residual activity may not require remediation. Remediation requirements will be dependent on the criteria for release for unrestricted use, the magnitude of contamination, the extent of the contamination, the radionuclides present and their relative fractions. This characterization survey report should be reviewed in detail prior to determining if remediation may be required.

The results of the characterization survey can be used to support numerous activities associated with the preparation of the decommissioning plan. The results:

- Identify areas containing, or likely to contain, residual contamination.
- Identify the radionuclides of interest and their relative fractions.
- Provide information necessary to justify proposing the screening values in Tables B.1 and B.2 of Appendix B in NUREG 1757 as the criteria for release for unrestricted use.
- Provide information necessary to ensure the proper interpretation of survey results during remedial action and final status surveys.
- Provide information necessary to estimate the scope of the decommissioning.
- Provide information necessary to estimate waste volumes and allowable disposal options.
- Provide information necessary to assist in the classification of survey units in support of the final status survey.

The results of the characterization survey demonstrated that practices employed by Cornell to minimize the spread of contamination were effective. In general contamination was confined to those areas and systems expected to be contaminated. Although the Nuclear Regulatory Commission has not yet approved the proposed criteria for release for unrestricted use, several of the areas surveyed appear to meet the proposed criteria for release for unrestricted use in their current state. Care should be taken to minimize the potential spread of contamination to these areas during future decommissioning activities.

REFERENCES FOR APPENDIX A

A-1 *Characterization Survey Report for the Ward Center for Nuclear Studies at Cornell University, Facilities Inventory Bldg. No. 2061*, Rev. 0, May 2003, Duratek, Inc.

APPENDIX B
ENVIRONMENTAL REPORT for DECOMMISSIONING the WARD CENTER for NUCLEAR STUDIES at CORNELL UNIVERSITY