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April 8, 2011

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 2055-0001

RE: **Ford Nuclear Reactor - Technical Specification Amendment Request**
Decommissioning Plan – Revised Section 4.0 (Final Status Survey Plan)
Docket 50-2 / License R-28

Licensing Branch:

The University of Michigan (U-M) is requesting an amendment to the Ford Nuclear Reactor (FNR) Decommissioning Plan that was submitted to the Commission in a correspondence dated January 10, 2006. As a result of the removal of the FNR pool and extensive remediation effort within the FNR facility since December 2007, the U-M requests Section 4.0 ('Final Status Survey') of the Decommissioning Plan be revised in its entirety to more accurately reflect the present condition of the facility. A copy of the revised Final Status Survey Plan is enclosed with this correspondence.

The enclosed Final Status Survey (FSS) Plan replaces the 'Proposed Final Survey Plan' (Chapter 4.0) of the January 2006 Decommissioning Plan. It was prepared in accordance with the guidelines and recommendations presented in NUREG-1757 ('Consolidated NMSS Decommissioning Guidance') and NUREG-1575 ('Multi-Agency Radiation Survey and Site Investigation Manual'). The process emphasizes the use of Data Quality Objectives and Data Quality Assessment, along with a quality assurance / quality control program.

This FSS Plan incorporates project-specific information relative to post-remediation facility conditions and potential radiological contaminants, guidelines for residual building surface and soil contamination levels, sampling and measurement methods, survey unit identification and classification, and data evaluation techniques. A Quality Assurance Project Plan (QAPP), applicable to FSS activities, has also been prepared.

The U-M is requesting that three units associated with the FNR decommissioning project be incorporated by license amendment into the FSS Plan at a later date. These three units include: (1) the below-grade foundation drain tile system located outside the FNR on the east side of the building, (2) the FNR foundation cavity located beneath the FNR southwest freight door, and (3) the short FNR floor crack located just north of the FNR southwest freight door and next to a shallow trench from a removed radioactive waste line. These three units will be surveyed and evaluated outside the bounds of the enclosed FSS Plan.

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Refer to the two sketches enclosed with this correspondence depicting the foundation drain tile system adjacent to the FNR basement, FNR foundation cavity located on the first floor, and the FNR floor crack located near the foundation cavity. In addition, please note that the RESRAD computer model code will be used to develop DCGLs for the small volume of sub-surface soil in the vicinity of the foundation drain. These DCGL values will be submitted under separate cover for NRC review and concurrence.

While the remediation effort and radiological assessment of these three isolated locations continue, the U-M would like to proceed with the Final Status Survey within the general FNR facility.

Thank you for your time, effort, and consideration with respect to this FNR license (R-28) amendment. Please do not hesitate to contact me at OSEH / Radiation Safety Service [(734) 647-2251] should you have any questions or comments regarding the revised Final Status Survey Plan. We look forward to your approval so we can initiate the final status survey of the FNR facility.

Sincerely,

Mark L. Driscoll

Mark L. Driscoll
Director / Radiation Safety Officer
Radiation Safety Service / OSEH

MLD/mld
NRCFNRR-28AmendmentD&DFSSPlanSec4040611

cc: Terry Alexander, Executive Director, OCS
Robert Blackburn, Manager, Laboratory Operations, MMPP
Theodore Smith, FNR Project Manager, NRC Headquarters (Mailstop T-8F5)
William Snell, Senior Health Physicist, NRC Region III
FNR Decommissioning File

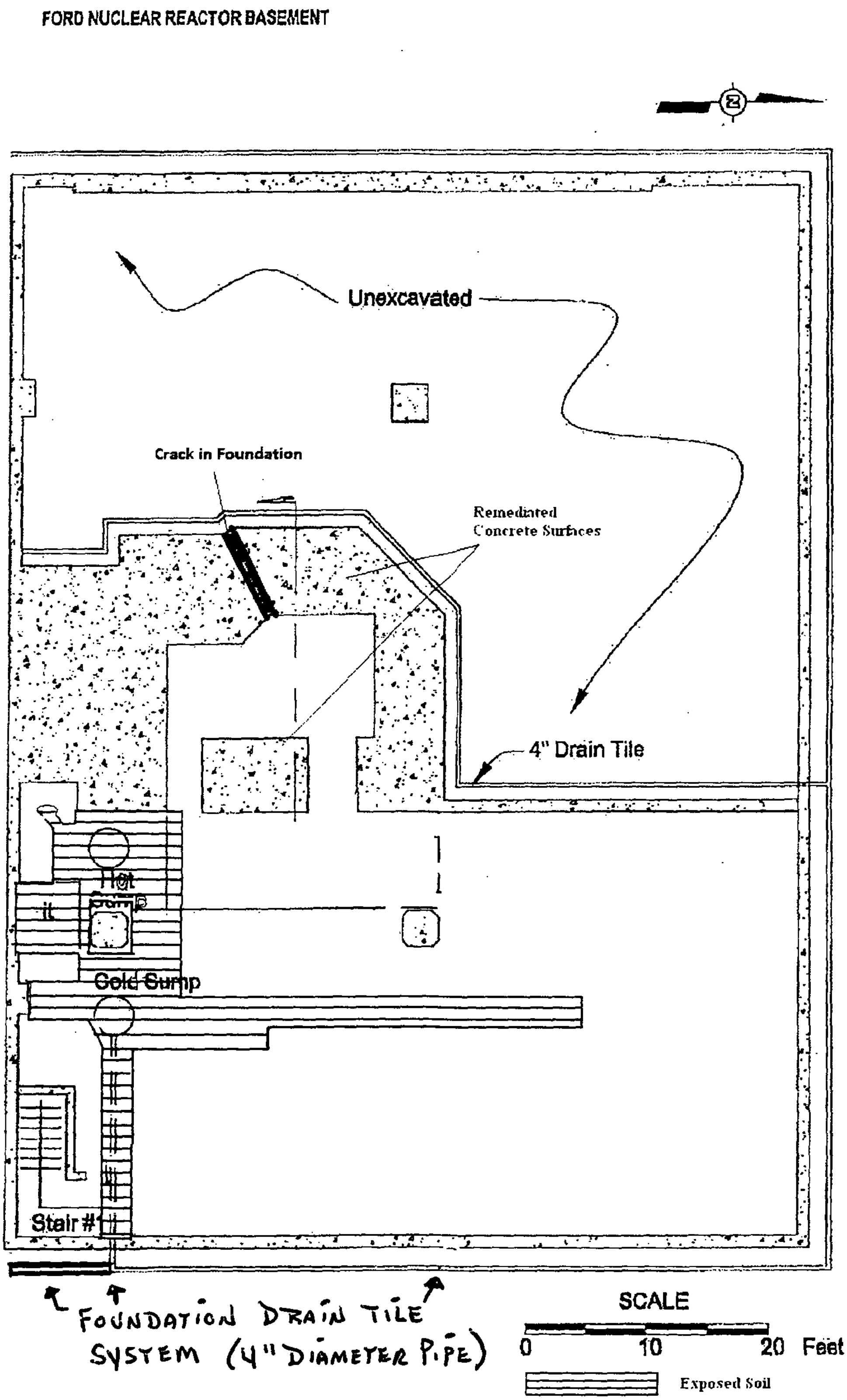

Figure 4.1 Floor Plan of the Ford Nuclear Reactor Building Basement

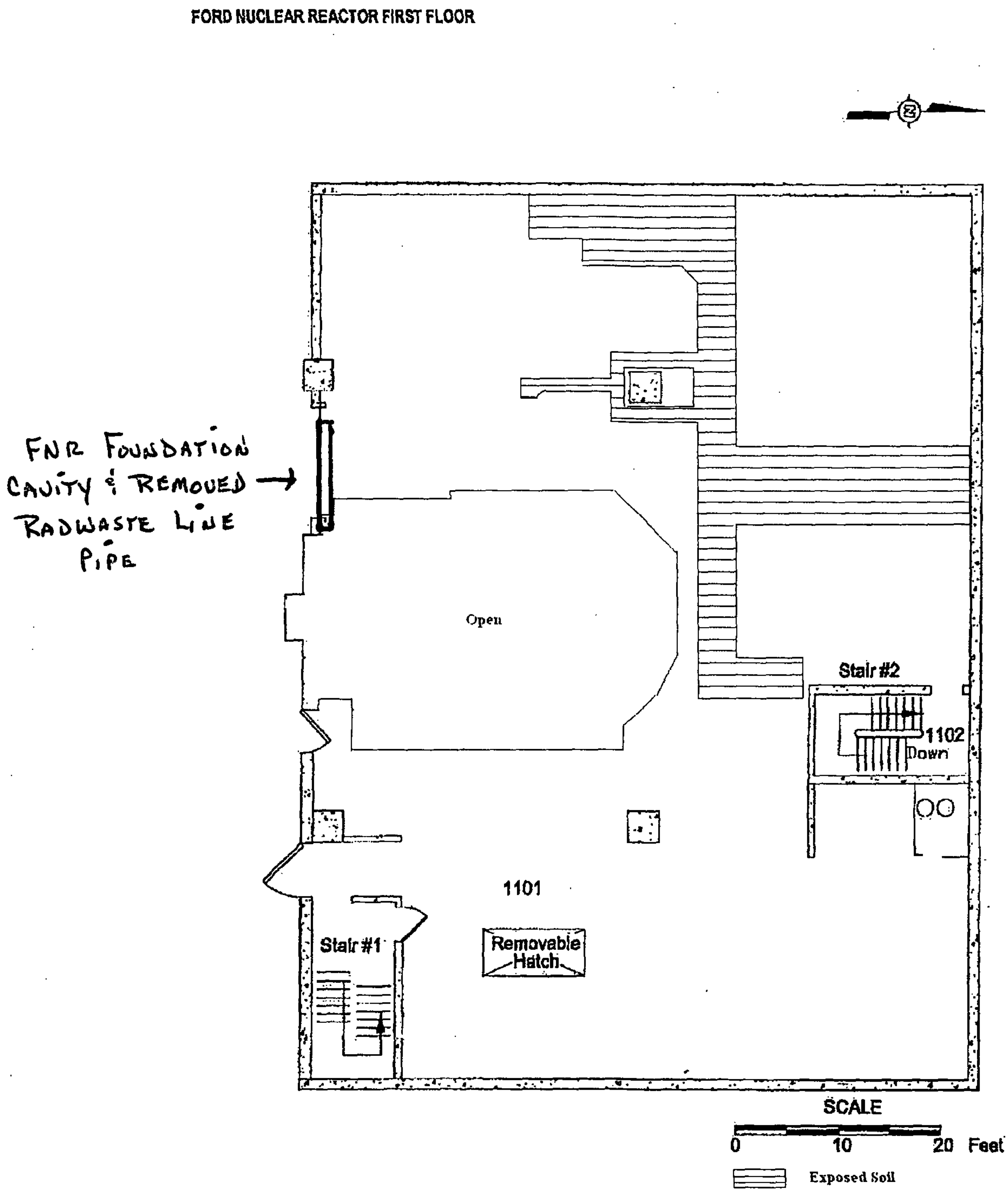

Figure 4-2 Floor Plan of the Ford Nuclear Reactor First Floor

4.0 Final Status Survey Plan

4.1 Introduction

The Ford Nuclear Reactor (FNR) at the University of Michigan (UM) was a light-water cooled and moderated open-pool design reactor. The reactor was licensed (License R-28, Docket 50-2) by the US Nuclear Regulatory Commission (NRC to operate at a power level of 2 Megawatt (MW) thermal. The reactor began operation in 1957 and provided neutron and gamma irradiation services, neutron beam port experimental facilities, and training facilities for use by faculty, students, and researchers from the UM, other universities, and industrial organizations. In July 2003, the reactor was shut down. Fuel was removed from the facility in December 2003, followed closely by initiation of decommissioning activities. These decommissioning activities are described in *University of Michigan Decommissioning Plan for the Ford Nuclear Reactor*, Revision 1, January 5, 2006 (Decommissioning Plan). The objective of the decommissioning is to remove radiological materials and equipment associated with the FNR-licensed operations, such that radiological conditions satisfy NRC criteria for future unrestricted use of the facility and thus permit termination of the NRC license. A Final Status Survey (FSS) will be performed to demonstrate that these NRC criteria have been satisfied. This document describes the FSS Plan.

This Plan replaces the "Proposed Final Status Survey Plan" (Chapter 4.0) of the January 2006 Decommissioning Plan. It was prepared in accordance with the guidelines and recommendations presented in NUREG-1757, *Consolidated NMSS Decommissioning Guidance,* and NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM). The process emphasizes the use of Data Quality Objectives (DQOs) and Data Quality Assessment (DQA), along with a quality assurance/quality control program. The graded approach concept will be followed to assure that survey efforts are maximized in those areas having the greatest potential for residual contamination or the highest potential for adverse impacts of residual contamination.

This Plan incorporates project-specific information, relative to post-remediation facility conditions and potential radiological contaminants, guidelines for residual building surface and soil contamination levels, sampling and measurement methods, survey unit identification and classification, and data evaluation techniques. A Quality Assurance Project Plan, (QAPjP), applicable to the FSS activities, has also been prepared.

4.2 Facility Description

The Ford Nuclear Reactor is located at 2301 Bonisteel Boulevard on the North Campus of the University of Michigan, approximately 1.3 miles northeast of the central business district of Ann Arbor, Michigan. The FNR building is a windowless, reinforced concrete structure with brick veneer. Internal walls are of concrete block. The footprint of the building is approximately 70 feet (21.3 m) long and 68 feet (20.7 m) wide; the building height is approximately 69 feet (21.0 m) of which about 14 feet (4.3 m) and 23 feet (7.0 m) are below grade on the east and west sides, respectively. During operation, the facility consisted of four levels - reactor access and control (3rd floor), maintenance and other support facilities and systems (2nd floor), beamport experimental area (1st floor), and liquid cooling and waste systems (basement). There was a cooling tower above the reactor pool level. FNR is contiguous with the Michigan Memorial Phoenix Project (MMPP). Some systems, including exhaust ventilation ducts from the beamport floor and neutron activation laboratory, piping to liquid waste retention tanks, access ports to the MMPP hot cells, and neutron activation pneumatic transfer systems were shared by the two buildings. The portions of piping, leading to liquid waste retention tanks in MMPP will be retained and used under the UM broad scope NRC license.

The FNR utilized low-enriched uranium Material Test Reactor heterogeneous plate-type fuel. The reactor core was suspended about 20 feet below the surface of the 10 feet x 20 feet x 27 feet deep pool, containing approximately 5.0×10^4 gallons of deionized water. The pool was lined with ceramic tile and surrounded by a biological shield of barytes concrete. Spent fuel, reactor handling tools, and miscellaneous experimental equipment were stored in the pool. Pool water was purified by a deionizer system. The primary cooling system was a closed loop and included a heat exchanger and associated piping. The secondary cooling system was a counter-flow heat exchanger, and heat was dissipated to the atmosphere through an evaporative cooling tower on the building roof. The deionizer and heat exchanger systems were located on the basement level. Treated water and water from seepage and leaks was collected and pumped to retention tanks in the adjacent Michigan Memorial Phoenix Project.

General reactor building exhaust was through the FNR facility stack. Localized exhausts for the experimental areas, source storage ports, and laboratory hoods were filtered through HEPA units and discharged through the MMPP ventilation systems. The FNR was serviced by sanitary and storm liquid waste systems, but potentially contaminated liquids were not discharged through these systems. There is a French drain system external to the foundation of the FNR building.

Fifty storage ports extended through the west wall of the first floor of the facility, into the soil external to the building. These ports were used to store irradiated components and one of the ports housed two PuBe neutron sources.

Chapter 2 of the Decommissioning Plan describes the Ford Nuclear Reactor (FNR) facility, its operational history, and the radiological status, prior to remediation and decontamination actions. In addition to the removal and disposition of reactor core assembly and miscellaneous reactor operating materials and tools, remedial actions included extensive removal, disposition and/or decontamination of the following potentially contaminated equipment, components, building areas, and materials:

- Biosafety shield,
- Hold-up tank & pipes,
- Primary pumps & pipes,
- Secondary heat exchanger & pumps,
- Hot & cold DI system,
- Floor drains and drain piping,
- Hot & cold sumps (including overflow pit),
- Transfer chute,
- Thermal column door and trench,
- Underground storage ports (west side of building) and surrounding soil,
- Beam port floor janitor closet tub / drain & water lines,
- Supply & exhaust ventilation system,
- Heating system,
- Electrical (including exposed conduit and most wire),
- Men's & women's rest room (toilets / sinks / water),
- 1st and 2nd floor janitor's closet (water & drains),
- Primary water treatment room,
- Reactor bridge (removed, but saved for historical purposes),
- Control room (saved control console),
- Counting room,
- Pneumatic transfer system and tube room / lab, and
- Fuel vault.

Large sections of the concrete structure with a potential for containing volumetric contamination, due to its location relative to the reactor core, were removed and sampling was performed to demonstrate that volumetric contamination is not present in the remaining concrete. Also, sections of cracked concrete foundation and slab were removed to assure that leakage did not result in contamination of sub-floor soil. Paint and floor/wall coverings have been removed from building surfaces, considered to be potentially contaminated, and the surfaces smoothed to facilitate surveys. Surfaces have been vacuumed and wiped down to remove loose contamination; routine radiological control surveys have demonstrated the absence of removable activity.

Municipal water supply and sanitary, and storm drain systems remain.

Figures 4-1 through 4-5 are floor plans of the FNR facility, illustrating the as-left conditions.

4.3 Radiological Contaminants and Criteria

Samples of construction materials and soil were obtained and analyzed during the remediation process and after remediation was completed to identify radiological contaminants that might remain at the time of the final status survey. The process, whereby the residual potential contaminants was determined, is described in Appendices A and D. Potential contaminants in both soil and structural surfaces are:

- Co-60
- Ag-108m
- Ag-110m
- Cs-137

Future uses of the former FNR facility have not yet been completely defined; however, it is likely that the facility will continue being used in some capacity for University of Michigan academic programs. For these reasons the most restrictive exposure scenarios, i.e., building occupancy and residential farmer are

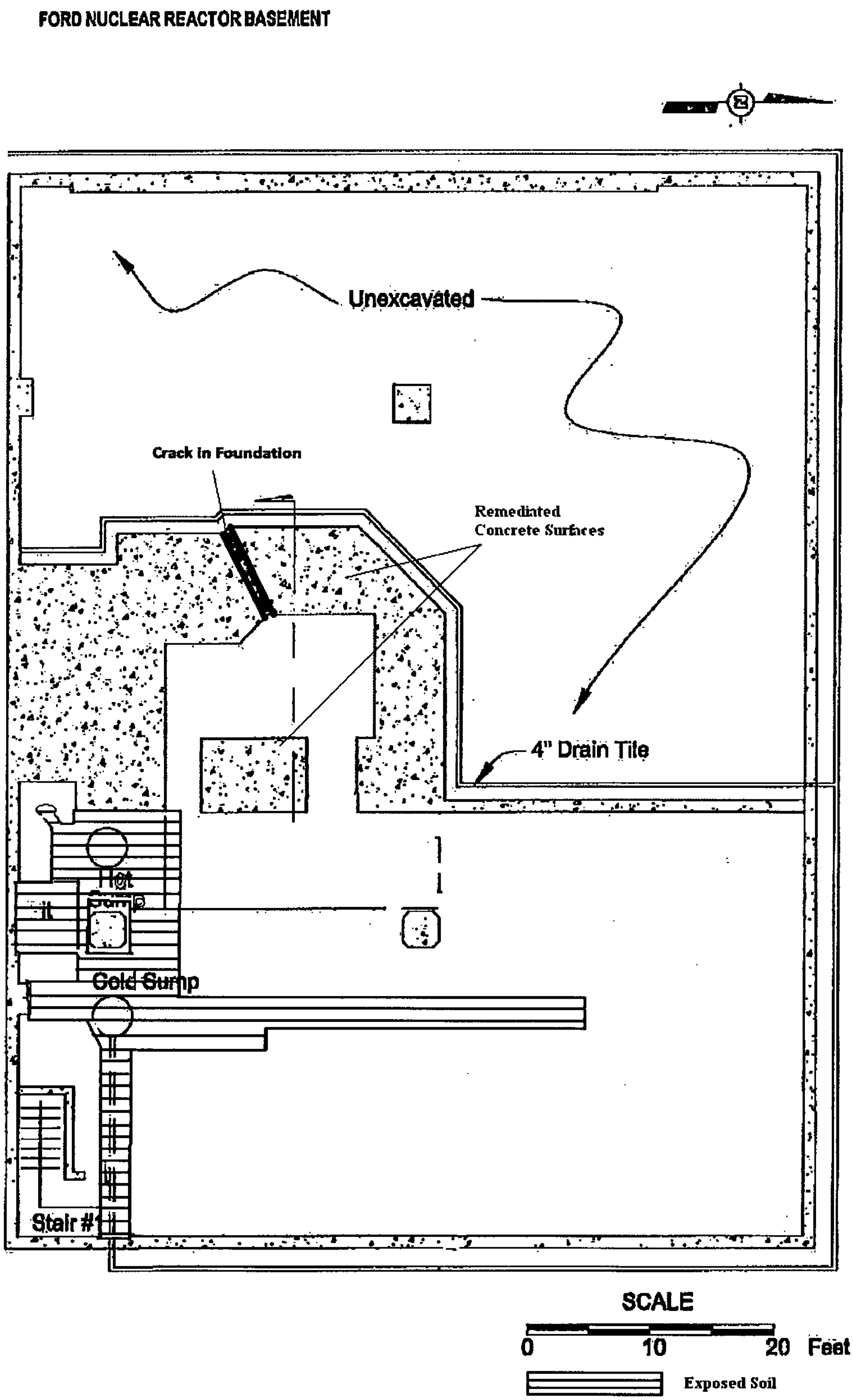

Figure 4.1 Floor Plan of the Ford Nuclear Reactor Building Basement

FORD NUCLEAR REACTOR FIRST FLOOR

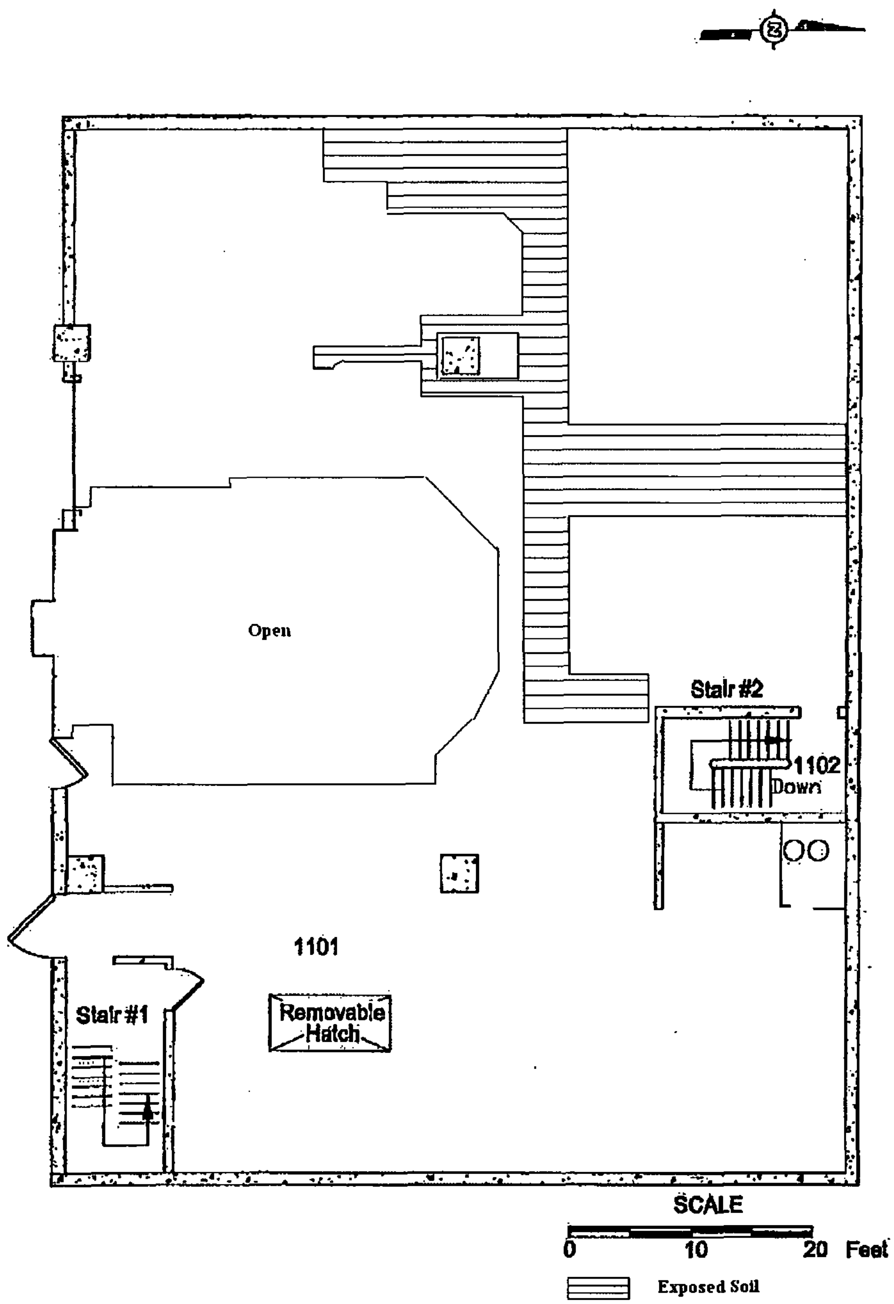

Figure 4-2 Floor Plan of the Ford Nuclear Reactor First Floor

FORD NUCLEAR REACTOR 2ND FLOOR

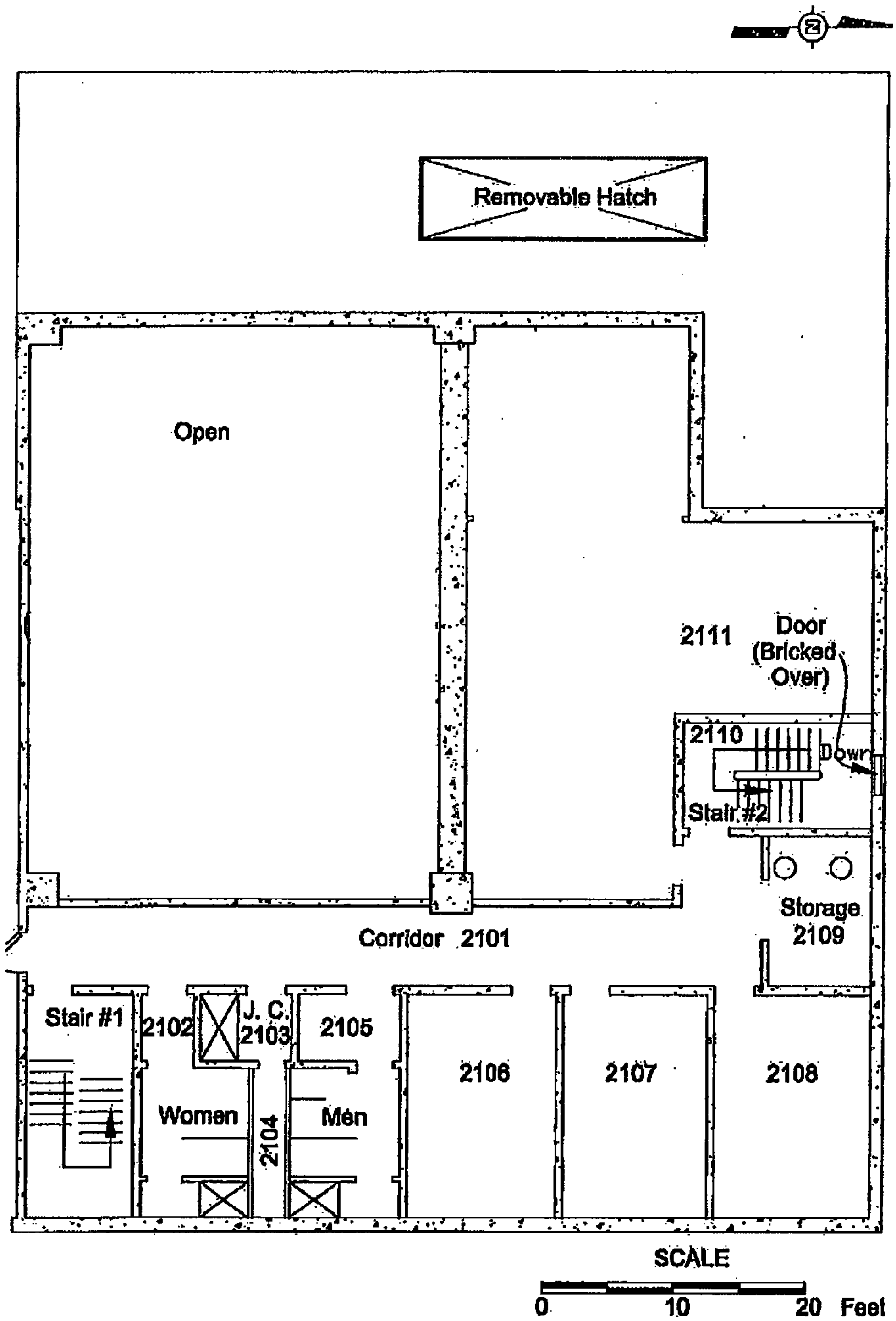

Figure 4-3 Floor Plan of the Ford Nuclear Reactor Second Floor

FORD NUCLEAR REACTOR THIRD FLOOR

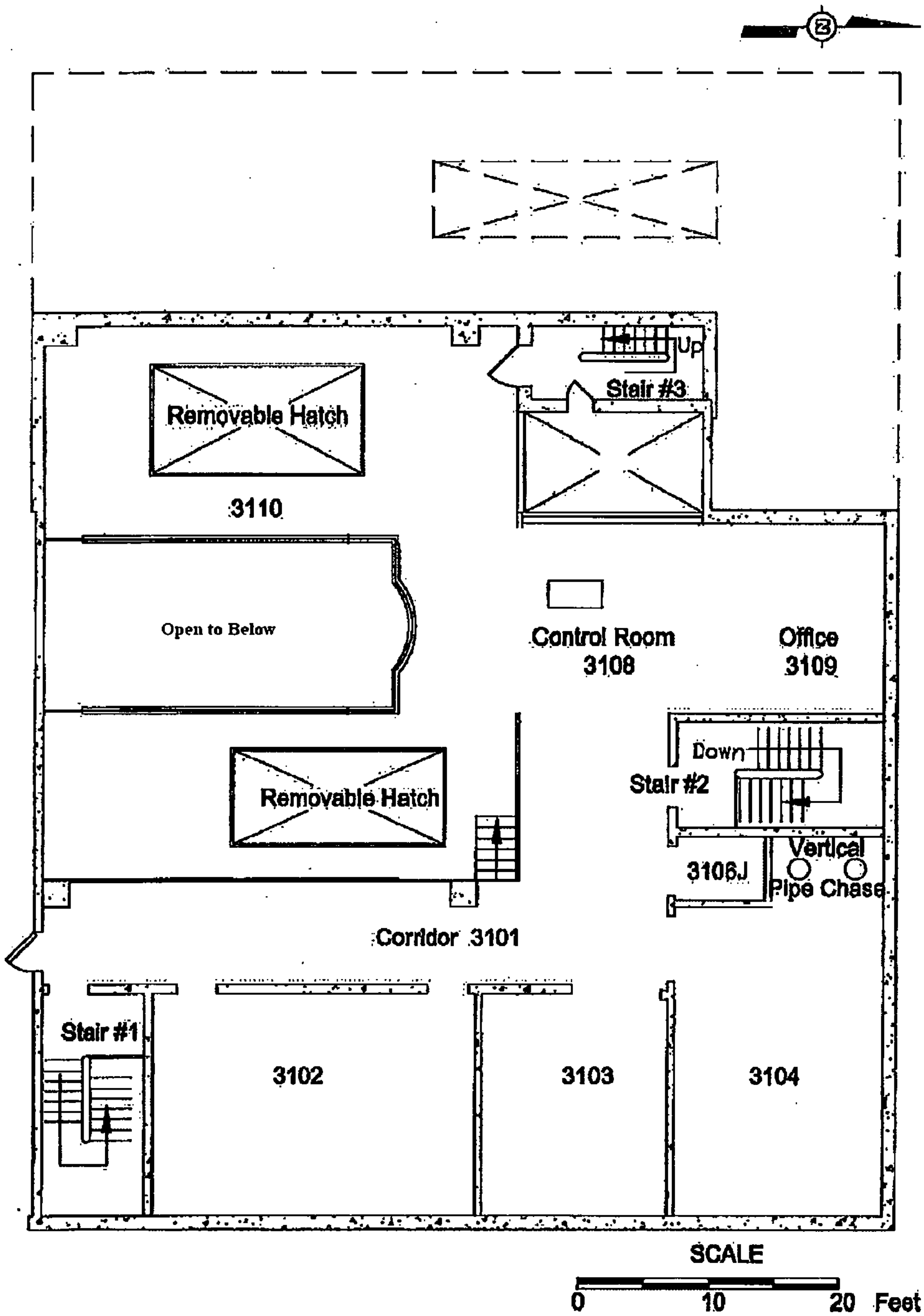

Figure 4-4 Floor Plan of the ford Nuclear Reactor Third Floor

FORD NUCLEAR REACTOR 4TH FLOOR

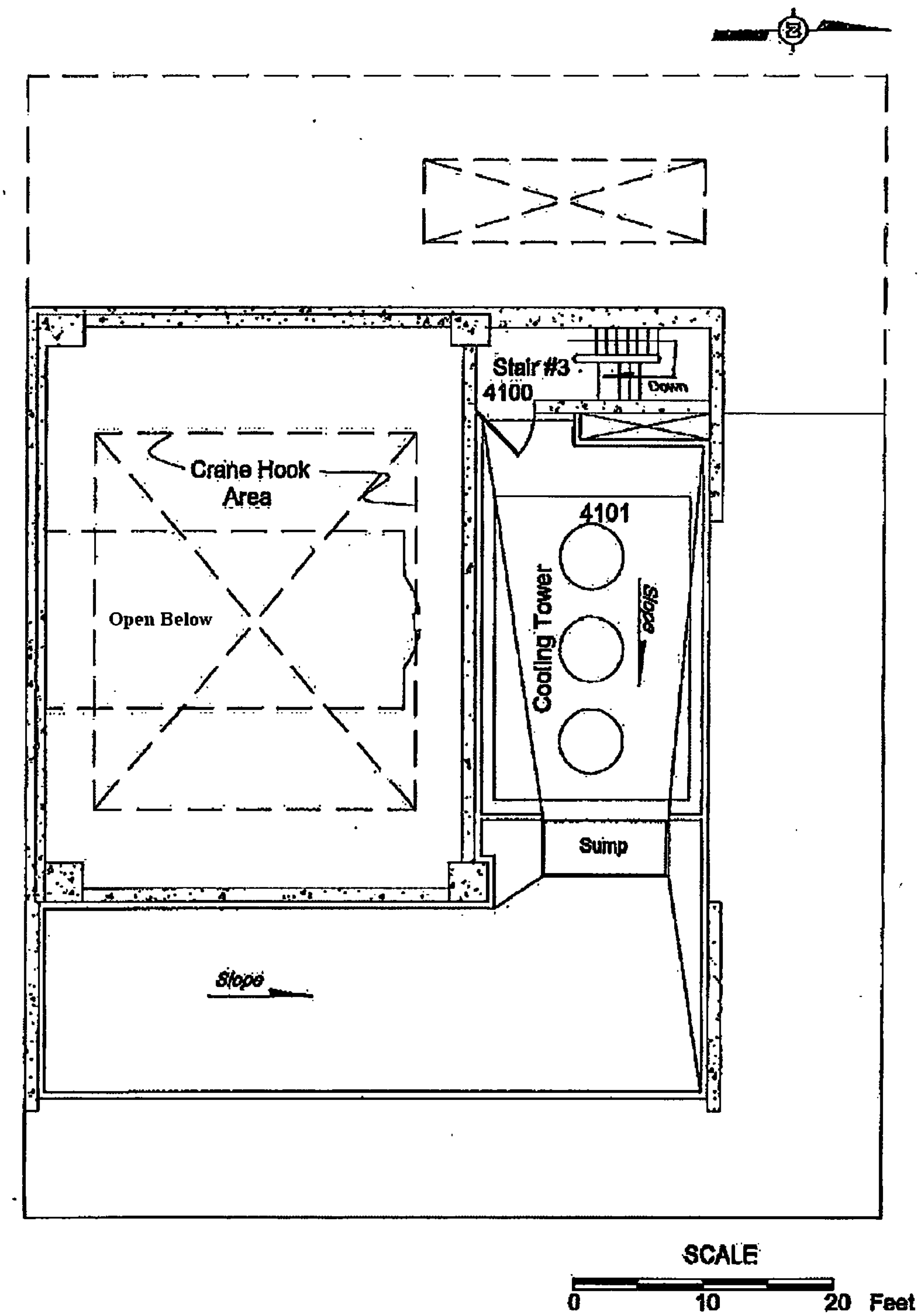

Figure 4-5 Floor Plan of the Ford Nuclear Reactor Fourth Floor

assumed for potential future exposure to residual surface contamination and soil contamination, respectively. It has been decided that use of Default Screening Values for residual levels of radiological contamination on structure surfaces and in soil will provide a conservative approach to assuring that the annual NRC dose criteria of 25 mrem from residual contamination in this facility is not exceeded. Appendix B presents the justification for use of Default Screening Values. Based on this justification, the conservative Default Screening Values (NUREG/CR-5512, Vol 3) for the potential radionuclide contaminants have been selected as acceptable final status criteria (i.e., DCGLs). An exception is Ag-108m, for which Default Screening Values are not provided. The DandD software was therefore used to develop Default Screening Values for Ag-108m, based on the relative dose factors of Ag-110m and Ag-108m, as presented in Federal Radiation Guides #11 and #12. The DCGL development process for Ag-108m is described in further detail in Appendix C.

Satisfying surface contamination criteria will be demonstrated by measurement of gross beta activity. Appendix D describes development of a gross beta criterion for the FNR. The resulting gross-beta DCGL is 5130 dpm/100 cm^2.

Satisfying soil contamination criteria will be demonstrated by the sum-of-ratios approach. The sum of ratios (SOR) of gamma contaminant concentrations to their respective Default Screening Values, indicated below, must therefore be $\leq$ Unity (i.e., $\leq$1.0).

Radionuclide	**Default Screening Value for Soil (pCi/g)**
Co-60	3.8
Ag-108m	8.2
Ag-110m	4.92
Cs-137	11.0

Section 4.6.4 provides details on the approaches to demonstrate that criteria have been met.

4.4 Quality Assurance Program

A Final Status Survey Quality Assurance Project Plan (QAPjP), appropriate for implementing the final status survey and developing associated documentation, has been developed. That QAPjP incorporates the appropriate regulatory requirements applicable to the planning and conduct of radiological surveys necessary for the termination of the FNR license and the release of the site for unrestricted use.

4.5 Final Status Survey Approach

The objective of the FSS is to demonstrate that remedial actions have been effective in removal/reduction of radiological materials and contamination, and that as-left radiological conditions satisfy the NRC-approved criteria for termination of the FNR License and for future use of the FNR facility without radiological restrictions. The FSS will be performed in accordance with guidelines and recommendations presented in NUREG-1757 and MARSSIM. FSS activities will be performed by trained and qualified personnel, using properly calibrated equipment, sensitive to the potential contaminants, and following documented operating procedures. Appendix A of the QAPjP contains a list of the procedures, applicable to this FSS.

4.5.1 Classification by Contamination Potential

For the purposes of guiding the degree and nature of final status survey coverage, areas are first classified as *impacted*, i.e., areas that may have residual radioactivity from licensed activities, or *non-impacted*, i.e., areas that are considered unlikely to have residual radioactivity from licensed activities. Non-impacted areas do not require further evaluation. For impacted areas MARSSIM identifies three classifications of areas, according to contamination potential.

- Class 1 – Areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiation surveys) above the DCGL. Examples include: site areas previously subjected to remedial actions; locations where leaks or spills are known to have occurred; and former waste storage areas.

- Class 2 – Areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination, but are not expected to exceed the DCGL. Examples include: locations where radioactive materials were present in unsealed form; potentially contaminated transport routes; areas handling low concentrations of radioactive materials; and areas on the perimeter of former contamination control areas.

- Class 3 – Any impacted areas that are not expected to contain any residual radioactivity, or are expected to contain levels of residual radioactivity at a small fraction of the DCGL, based on site operating history and previous radiation surveys. Examples include: buffer zones around Class 1 and Class 2 areas, and areas with a very low potential for residual contamination, but having insufficient information to justify a non-impacted classification.

Facility history (including the Historical Site Assessment and radiological monitoring conducted during characterization) and remedial activities are the bases for classification.

Once approval of the Final Status Survey Plan is obtained through a subsequent license amendment request to the NRC, the UM may make changes to the classification of an area as long as the classification is changed to one of higher contamination potential. A license amendment pursuant to 10 CFR 50.90 shall be obtained if the change would decrease an area classification (i.e., impacted to non-impacted, Class 1 to Class 2, Class 2 to Class 3, or Class 1 to Class 3).

4.5.2 Identification of Survey Units

Impacted areas are divided into survey units for implementing the FSS. A survey unit is a portion of a facility with common contaminants and contamination potential and contiguous surfaces or areas. Table 4-1 lists the survey unit areas suggested by MARSSIM for application at the FNR facility. The area of individual survey unit will follow these suggested maximum sizes. Impacted structure surfaces of $\leq 10\ m^2$ and impacted land surfaces of $\leq 100\ m^2$ will not be designated as survey units. Instead, a minimum of 4 measurements (or samples) will be obtained from such areas, based on judgment, and compared individually with the DCGL.

TABLE 4-1. MARSSIM – RECOMMENDED SURVEY UNIT AREAS

Class	Recommended Survey Unit Area	
	Structures	Land
1	up to 100 m^2	up to 2000 m^2
2	100 to 1000 m^2	2000 to 10,000 m^2
3	no limit	no limit

m^2 – square meter

Based on a historical assessment, preliminary survey data obtained in November 2002, the characterization survey in April 2003, and radiological monitoring conducted during remedial activities, a listing of facility areas that are currently expected to be included in the final status survey, is presented in Table 4-2, along with the estimated areas, anticipated contamination potential classifications, and the projected number of survey units within each area. This list of survey units differs slightly from the initial list, provided in the Decommissioning Plan; differences are primarily due to deletion of some survey units (e.g., pool walls, pits and sumps, and ventilation equipment) which were removed during remediation. Actual survey unit boundaries and classifications will be determined at the time of final status survey design, and survey unit classifications and surface areas may change as final remedial activities are completed. If classifications and boundaries change, surveys will be redesigned and the survey and data evaluation will be repeated, as necessary. Classifications and survey unit boundaries may change, based on results as the final status survey progresses. If classifications or boundaries change, the survey of the survey unit will be redesigned and the survey and data evaluation repeated.

TABLE 4-2. FNR SURVEY AREAS AND FINAL STATUS SURVEY CLASSIFICATIONS

Room or Area	Surface	Class	Approx. Surface Area (m^2)	No. of Survey Units	Remarks
Basement	Floor and walls	1	290	3	
Basement	Ceiling	2	190	1	
Basement	Pits and sumps	1	20	1	Small area – sumps and pits between sumps removed
1st Floor (includes JC 1103)	Floor and lower walls	1	650	7	
1st Floor	Upper walls and ceiling	2	700	1	
1st Floor	Source storage ports	1	<10	1	Small soil area- storage ports removed and soil adjacent to ports 1 and 2 excavated
2nd Floor Rm 2111	All	2	250	1	
2nd Floor Rm 2109	All	2	70	1	
2nd Floor Rms 2106/2107/2108	All	2	260	1	
2nd Floor Rms 2105/2102	All	2	140	1	
2nd Floor Rms 2103/2104	All	2	55	1	
2nd Floor Corridor 2101	All	2	175	1	
3rd Floor Rm 3102	All	2	145	1	

Room or Area	Surface	Class	Approx. Surface Area (m^2)	No. of Survey Units	Remarks
3rd Floor Rm 3103	Floor and lower walls	1	60	1	
3rd Floor Rm 3103	Upper walls and ceiling	2	40	1	
3rd Floor Rm 3104	Floor and lower walls	1	75	1	
3rd Floor Rm 3104	Upper walls and ceiling	2	50	1	
3rd Floor Rm 3106J	All	1	25	1	
3rd Floor Corridor 3101	All	2	160	1	
3rd Floor Rms 3108/3109	All	2	150	1	
3rd Floor Rm 3010A	Floor	1	90	1	
3rd Floor Rm 3010A	South wall (lower)	1	40	1	
3rd Floor Rm 3010A	West wall (lower)	1	30	1	
3rd Floor Rm 3010A	All other wall sections and ceiling	2	210	1	
4th floor cooling tower	All	3	350	1	
Stair No. 2	All	3	180	1	
Stair No. 1	All	3	230	1	
Reactor stack Plenum	All	1	100	1	
Inside drains and piping	Interior surfaces	1	5	1	Small area

Room or Area	Surface	Class	Approx. Surface Area (m^2)	No. of Survey Units	Remarks
Outside drains and piping	Interior surfaces	1	1	10	Foundation drain area
Building exterior	Walls and Roof	3	340	1	Doors, vents, stacks
Soil beneath reactor basement	Exposed soil surface	1	100	1	About 120 m^3 soil volume
Outside areas	Soil and concrete	1	150	2	Storage pad areas (west side- temporarily fenced-off D&D shipment staging area)

4.5.3 Testing to Demonstrate Compliance

The Null Hypothesis for the statistical test to demonstrate compliance with project criteria is "Residual FNR radiological contamination levels exceed project criteria". The objective of the FSS is to reject this Null Hypotheses, by demonstrating at a Type I (α) decision error level of 0.05 (i.e., 95% confidence level) that the contamination does not exceed criteria. The Type II (β) decision error level is also 0.05. Because there are multiple potential contaminants in soil, compliance with soil criteria will be evaluated using the sum-of-ratios (SOR) approach. There are multiple building surface types (concrete, metal, wood, glass, etc.) in most survey units and individual survey unit measurements will be adjusted for appropriate material background contributions, using the paired-data approach. For both the soil and building surface surveys, the sign test is the appropriate statistical test of compliance.

4.5.4 Survey Data Requirements

To establish the number of data points needed to demonstrate that residual contamination criteria have been satisfied, a parameter known as the "relative shift", which effectively describes the distribution of final sample data, is calculated, as follows:

(1) Δ/σ = (DCGL-LBGR)/ σ

where:

Δ/σ	=	relative shift
DCGL	=	cleanup level (Section 4.3).
LBGR	=	lower bound of the gray region and is defined in the DQOs as 50 percent of the DCGL. Where final sample data are not yet available, MARSSIM guidance (Section 5.5.2.2) assigns a value of one-half of the DCGL for the LBGR.
σ	=	standard deviation of the sample concentrations in the survey unit. Where final sample data are not yet available, MARSSIM guidance (Section 5.5.2.2) is to use a value of 30 percent of the DCGL.

Using the equation for relative shift and MARSSIM guidance for situations where final sample data are not yet available, the relative shift for design purposes is (1 - 0.5)/0.3 for a value of 1.67. Based on the relative shift of 1.67 and Type I and Type II decision errors of 0.05, the number of required data points from each survey unit to perform the sign test, as obtained from MARSSIM guidance (Table 5.5) is 17.

Once actual sample data are collected, the MARSSIM DQO process requires a retrospective assessment of the selected LBGR and σ values, to confirm that an adequate number of data points was obtained for final evaluation.

4.5.5 Survey Locations

MARSSIM recommends a random-start systematic triangular measurement or sampling pattern for FSS of Class 1 and Class 2 survey units. This type of triangular pattern will be used for this final status survey, except where dimensions and/or other factors related to a specific survey unit require use of an alternate pattern. The spacing (L) between data points on a triangular pattern is determined by:

$$L = [(\text{Survey Unit Area})/(0.866 \times \text{number of data points})]^{1/2}$$

To simplify the designation of data points while assuring a sufficient number of data points are obtained for statistical purposes, the value of L is rounded to the nearest whole meter. If the systematic pattern does not provide sufficient data points to satisfy the number determined in Section 4.5.4, additional data points will be identified, using a random-number technique.

For FSS of Class 3 survey units, measurement or sampling data points will be judgmental, based on professional opinion. These data points will be biased to locations considered to have the highest probability of residual contamination, with additional locations chosen to provide distributed survey unit coverage.

4.5.6 Survey Design Packages

FSS designs will be prepared and documented in a survey design package. Multiple survey units, having similar history, classification, and conditions, may be covered by one design package. These design packages will include survey unit maps and drawings, classification, scan frequency, data point locations, a description of unusual/unique conditions that may require deviation from standard survey techniques, and alternative techniques to be used in such cases.

4.5.7 Survey Instrumentation

Table 4-3 is a list of radiological survey instrumentation that will be used to implement the FNR FSS.

TABLE 4-3. INSTRUMENTATION FOR FNR FINAL STATUS SURVEY

Detector	Type	Make	Meter	Application	Sensitivity (dpm/100 cm^2, except as noted)	
					Scanning	Static Count (1 minute)
44-142	Beta Scintillation	Ludlum	2221	Beta scan and measurement	2000	500
43-37	Gas Proportional Floor/Wall Monitor	Ludlum	2221	Beta scan	1200	N/A
44-10	NaI	Ludlum	2221	Gamma scan	1.7 pCi/g Co-60 3.0 pCi/g Ag-108m (surface soil)	N/A
Tennelec LB5100	Gas proportional	Tennelec	N/A	Alpha smear measurement	N/A	5
Tennelec LB5100	Gas proportional	Tennelec	N/A	Beta smear measurement	N/A	10

cm^2 – square centimeter, dpm – disintegrations per minute, g – gram., pCi – picocuries.

These instruments are maintained and calibrated in accordance with UM procedures HP-211 and HP-402. For simplicity in application to FSS, instrument response (efficiency) is based on NIST-traceable sources of Tc-99 (beta E_{MAX} = 292 keV) and Th-230 (alpha E = 4.68 MeV). The energies of these radionuclides are representative of the dominant potential contaminants and thus will provide conservative overestimates of the contaminant mixture. For field measurement applications, calibration represents 2π response. Effects of surface conditions on measurements are integrated into the overall instrument response through use of a "source efficiency" factor, in accordance with the guidance in ISO-7503-1, *Evaluation of Surface Contamination – Part 1: Beta Emitters and Alpha Emitters* (First Edition) and NUREG/CR-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Fields Conditions.* Default source efficiency factors, of 0.5 for beta-emitters > 0.4 MeV E_{max} and 0.25 for beta-emitters between 0.150 MeV and 0.400 MeV E_{max} (per ISO-7503-1) are generally applicable to anticipated FNR contaminants and surface conditions. For the predominant maximum beta energy of approximately 0.300 MeV from Co-60, a source efficiency value of 0.37 will be used. If contaminants or conditions in specific survey units are not consistent with use of these default values, specific instrument response and source efficiency factors will be determined and documented in the final status survey packages for those survey units.

Detection sensitivities are estimated using the guidance in MARSSIM and NUREG-1507, *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Fields Conditions* (NRC, 1997b). Instrumentation and survey techniques are chosen with the objective of achieving detection sensitivities of ≤ 50% of the criteria for structure surfaces, for both scanning and direct measurement. This assures identification of areas potentially exceeding the established project criteria.

Measuring instruments are calibrated at prescribed time periods or usage and whenever the accuracy of the equipment is suspect. Calibration is performed using standards traceable to NIST or an equivalent standard organization. Instruments are suitably marked or otherwise identified to indicate calibration status. Instruments found to be out of calibration, require a documented evaluation, commensurate with the significance of the condition, of the validity of data obtained with that instrument since its previous acceptable performance.

Instruments are properly handled and stored to maintain accuracy and shall follow ANSI N323B-2003.

Operational and background checks will be performed at the beginning and end of each day of final status survey activity and whenever there is reason to question instrument performance. These checks should follow procedure HP-401.

4.5.8 Background and Reference Area Measurements

In addition to the instrumentation background response, many construction materials and environmental media (e.g., soil, sediment) contain naturally occurring levels of radioactive materials, which contribute to a survey measurement. Background contributions must therefore be determined, if 1) the residual contamination includes a radionuclide that occurs in background, or 2) measurements are not radionuclide-specific. Multiple background determinations will be required for the final status survey. A set of reference measurements must be obtained for each instrument being used for survey unit evaluation. For applications involving the Sign test, sufficient background determinations will be made for each media or surface material and with each instrument to provide an average background level that is accurate to within +/- 20 percent; this usually requires 8 to 10 measurements, which are then evaluated using the procedure described in draft NUREG/CR-5849, *Manual for Conducting Radiological Surveys in Support of License Termination* (NRC, 1992a), and additional data points obtained, as necessary. Reference area and background requirements will be identified at the time of individual survey unit final status survey design. With several exceptions, structural material backgrounds will be obtained from surfaces in the Cooley Building Tunnel, which is of similar construction and age as the FNR Building, but without a history of radioactive materials use. Because there are no other known sources of high-density concrete in University facilities, background measurements for this material will be obtained at ceiling and upper wall locations in areas of the FNR, where use history indicates a negligible potential for impact by facility operations. Another structural material for which a source outside the FNR has not been identified is the glazed tile in janitor closets, restrooms, and change rooms. It is proposed to obtain background measurements for this material at ceiling and upper wall locations in the 2nd floor women's restroom, where the potential for impact by facility operations is considered negligible. Bulk samples of high-density and glazed tile material from these locations will be analyzed to confirm the absence of other than naturally occurring radioactive material.

4.5.9 Survey Reference Systems

A grid system will be established on surfaces to provide a means for referencing measurement and sampling locations. On Class 1 and 2 structure surfaces, a 1-m interval grid will be established; a 5-m interval grid will be established on Class 3 structure surfaces; and a 10-m interval grid will be established for land area surfaces. Grid systems typically originate at the southwest corner of the survey unit, but specific survey unit characteristics may necessitate alternate grid origins. Grids are assigned alphanumeric indicators to enable survey location identification. Structure grids are referenced to building features; open land grids are referenced to the state or federal planar grid system. Maps and plot plans of survey areas will include the grid system identifications. Systems and surfaces of less than 20 m^2 will not be gridded, but survey locations will be referenced to prominent facility features. Procedure FSS-02 describes mapping and gridding for FSS purposes.

4.5.10 Survey Techniques

Data collected for final status survey of structure surfaces will consist of scans to identify locations of residual contamination, direct measurements of beta surface activity, and measurements of removable beta surface activity. Final status survey of open land (soil) areas will consist of scans to identify locations of residual contamination and samples of soil, analyzed for potential contaminants. Additional measurements and samples will be obtained, as necessary, to supplement the information from these typical survey activities. Survey techniques are described in more detail in this section.

4.5.10.1 Beta Surface Scans

Beta scanning of structure surfaces will be performed to identify locations of residual surface activity. Gas-flow proportional detectors and scintillation detectors will be used for beta scans. Floor monitors with 580 cm^2 gas proportional detectors will be used for floor and other larger accessible horizontal surfaces; hand-held 100 cm^2 scintillation detectors will be used for surfaces not accessible by the floor monitor. Scanning will be performed with the detector within 0.5 cm of the surface (if surface conditions prevent this distance, the detection sensitivity for an alternate distance will be determined and the scanning technique adjusted accordingly). Scanning speed will be no greater than 1 detector width per second. Audible signals will be monitored and locations of elevated direct levels identified for further investigation.

Minimum scan coverage will be 100 percent for Class 1 surfaces, 25 percent for Class 2 surfaces, and 10 percent for Class 3 surfaces. Coverage for Class 2 and Class 3 surfaces will be biased towards areas considered by professional judgment to have highest potential for contamination.

4.5.10.2 Gamma Surface Scans

Gamma scanning surfaces will be performed on structure and soil surfaces to identify locations of residual surface activity. NaI gamma scintillation detectors (2 inch x 2 inch) will be used for these scans. Scanning will be performed by moving the detector in a serpentine pattern, while advancing at a rate of approximately 0.5 m per second. The distance between the detector and the surface will be maintained within 5 cm of the surface. Audible signals will be monitored and locations of elevated direct levels identified for further investigation.

Minimum scan coverage will be 100 percent for Class 1 surfaces, 25 percent for Class 2 surfaces, and 10 percent for Class 3 surfaces. Coverage for Class 2 and Class 3 surfaces will be biased towards areas considered by professional judgment to have highest potential for contamination.

4.5.10.3 Surface Activity Measurements

Direct measurement of beta surface activity will be performed at designated locations using a 100-cm^2 plastic scintillation detector. Measurements will be conducted by integrating the count over a 1-minute period. Where adverse surface conditions may result in underestimating activity by direct measurements, surface samples will be obtained for laboratory analyses. Need for such sampling will be identified in final status survey design for specific survey units.

4.5.10.4 Removable Activity Measurements

A smear for removable activity will be performed at each direct surface activity measurement location. A 100 cm^2 surface area will be wiped with a 2 inch diameter paper filter or cloth, using moderate pressure. Smears will be analyzed onsite for gross alpha and gross beta activity using a Tennelec gas proportional automatic sample counter.

4.5.10.5 Soil Sampling

Samples of surface (upper 15 cm) soil will be obtained from selected locations using a hand trowel or bucket auger. Approximately 500 to 1000 g of soil will be collected at each sampling location.

4.5.10.6 Special Situations

There will likely be several areas that do not meet the definition of exposed soil or structure surfaces. Examples include the foundation drain around the exterior foundation and the soils in the immediate vicinity of the removed source storage tubes. Where such special situations are encountered, survey approaches and evaluation methods will be developed on a case by case basis and described in the survey design package.

4.6 Data Evaluation and Interpretation

4.6.1 Sample Analysis

Smears for removable activity will be analyzed by the onsite laboratory for gross alpha and gross beta activity. Soil will be screened onsite for gamma emitters and, if screening indicates the sum-of-ratios for the four contaminants of concern (see Section 4.3) is less than unity, samples will be analyzed at the commercial offsite laboratory by gamma spectrometry for final evaluation that decommissioning criteria have been satisfied.

4.6.2 Data Conversion

Measurement data will be converted to units of dpm/100 cm^2 or pCi/g for comparison with guidelines and/or for statistical testing. Where appropriate for

Sign tests, data will be adjusted for material and instrument background contributions.

4.6.3 Data Assessment

Data will be reviewed to assure that the type, quantity, and quality are consistent with the survey plan and design assumptions. Data standard deviations will be compared with the assumptions made in establishing the number of data points. Individual and average data values will be compared with guideline values and proper survey area classifications will be confirmed. Individual measurement data in excess of the guideline level for Class 2 areas and in excess of 25 percent of the guideline for Class 3 areas will prompt investigation. Patterns, anomalies, and deviations from design assumption and plan requirements will be identified. Need for investigation, reclassification, remediation, and/or resurvey will be determined; a resolution will be initiated and the data conversion and assessment process repeated for new data sets.

4.6.4 Determining Compliance with Guidelines

4.6.4.1 Sign Test

For a structure surface survey unit to be evaluated using the Sign test, individual activity values and the average and standard deviation activity values will be calculated.

If all individual values for a survey unit are less than the guideline level, that survey unit satisfies the criterion and no further evaluation is necessary; the null hypothesis is rejected, and the survey unit meets the established criteria.

If any individual value is greater than the guideline value, the null hypothesis is accepted, and the survey unit does not meet the established criteria; investigation, remediation, reclassification, and/or resurvey will be performed, as appropriate.

4.6.4.2 Unity Rule Sign Test

For an open land or structure surface survey unit to be evaluated using the Unity Rule Sign test, individual activity values and the ratios of the activity values to their respective guideline values will be calculated. For each data location add the ratios together to determine the Sum of Ratios.

If all Sum of Ratios values for the survey unit are less than 1, that survey unit satisfies the criterion and no further evaluation is necessary; the null hypothesis is rejected, and the survey unit meets the established criteria.

If the Sum of Ratios value for any sample is greater than 1, the survey unit does not satisfy the criterion. The null hypothesis is accepted, and investigation, remediation, reclassification, and/or resurvey will be performed, as appropriate.

4.7 Isolation and Control Measures

Following completion of FSS, the survey unit will be isolated and access controlled. Routine access, equipment removal, material storage, and worker and material transit through the area without proper controls are no longer allowed. One or more of the following administrative and physical controls will be established to minimize the possibility of introducing radioactive material from ongoing decommissioning activities in adjacent or nearby areas:

- Personnel training,
- Installation of barriers to control access to the area(s),
- Installation of postings with access and egress requirements, and/or
- Locking or otherwise securing.

Isolation and control will be discontinued following NRC acceptance that the project decommissioning criteria have been satisfied.

4.8 Final Status Survey Report

A report describing the survey procedures and findings will be prepared for submission to the NRC in support of license termination. The survey report will provide a complete record of the facility's radiological status and a comparison to the site release criteria. The survey report will include survey data and overall conclusions, which demonstrate that the FNR Facility meets the radiological criteria for unrestricted use. Information such as the number and type of measurements, basic statistical quantities, and statistical test results will be included in the report. The survey report will contain additional detail to enable an independent or third party re-creation and evaluation of the survey results and a determination as to whether the site release criteria have been met.

The following outline illustrates a general format that may be used for the final status survey report and may be adjusted to provide a clearer presentation of the information. The level of detail will be sufficient to clearly describe the final status survey program and certify the results.

Information to be submitted:

- A summary of the results of the final status survey,
- A discussion of any changes that were made in the final status survey from what was proposed in the LTP or other prior submittals,
- A description of the method by which the number of samples were determined for each survey unit,

- A summary of the values used to determine the numbers of samples and a justification for these values (refer to Section 4.5.4),
- The results for each survey unit including:
    1. Number of samples taken for the survey unit.
    2. A map or drawing of the survey unit showing the reference system and random start systematic sample locations for Class 1 and 2 survey units, and random locations shown for Class 3 survey units and reference areas.
    3. Measured sample concentrations.
    4. Statistical evaluation of the measured concentrations.
    5. Judgmental and miscellaneous sample data sets reported separately from those samples collected for performing the statistical evaluation.
    6. Discussion of anomalous data including any areas of elevated direct radiation detected during scanning that exceeded the investigation level or measurement locations in excess of the DCGLw.
    7. A description of follow-up actions and results.
    8. A statement that a given survey unit satisfied the DCGLw.
- A description of any deviations from initial survey design and survey techniques, and
- A description of the investigation and follow-up actions when the FSS fails to demonstrate that the criteria have been satisfied.

4.9 References

Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM), NUREG-1575 (Rev. 1), US Nuclear Regulatory Commission, 2000.

University of Michigan Decommissioning Plan for the Ford Nuclear Reactor (Rev 1.), University of Michigan, January 2006.

Consolidated NMSS Decommissioning Guidance. NUREG-1757, US Nuclear Regulatory Commission, 2000.

Residual Radioactive Contamination from Decommissioning, NUREG/CR-5512 Vol. 3, US Nuclear Regulatory Commission, 2000.

Manual for Conducting Radiological Surveys in Support of License Termination, NUREG/CR-5849 (draft), US Nuclear Regulatory Commission, 1992.

Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions, NUREG/CR-1507, US Nuclear Regulatory Commission, 1997.

Evaluation of Surface Contamination - Part 1: Beta Emitters and Alpha Emitters, ISO-7503-1, International Organization for Standardization, 1988.

Installed Radiation Protection Instrumentation Test and Calibration - Portable survey Instruments for Near Background Operation, ANSI-N323B-2003, American national Standards Institute, 2003.

Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Federal Guidance Report No. 11, EPA-520/1-88-1988, Environmental Protection Agency, 1988.

External Exposure to Radionuclides in Air, Water, and Soil, Federal Guidance Report No. 12, EPA-402-R-93-081, Environmental Protection Agency, 1993.

Appendix A

Identification of Residual Radiological Contaminants at the Remediated Ford Nuclear Reactor Facility

Numerous radionuclides were potential contaminants at the FNR as a direct result of reactor operations (i.e., fission and activation products) as well as experiments performed in the facility. Research of historical documents, interviews, and preliminary characterization of the facility identified the radionuclides potentially present at the time decommissioning was initiated as Sb-125, C-14, Cs-137, Co-60, Eu-152, Eu-154, Fe-55, H-3, Mn-54, Ni-63, Ag-108m, Ag-110m, and Zn-65. Monitoring of waste and the remaining structure during the remedial activities identified Ba-133 (from activation of high-density barytes concrete) as an additional potential contaminant.

As part of the decontamination and dismantlement efforts, items and structural components in close proximity to the reactor core, including most of the high-density barytes concrete bioshield, were removed. Direct monitoring and sampling of surfaces after remediation was complete, indicated little, if any, residual surface contamination. Table A-1 presents a summary of analyses of samples, representative of as-left surface conditions.

Table A-1 Analyses of Post-Remediation Samples

Radionuclide	Samp 1 (pCi/g)	Samp 2 (pCi/g)	Samp 3 (pCi/g)	Samp 4 (pCi/g)	Samp 5 (pCi/g)	Samp 6 (pCi/g)	Samp 7 (pCi/g)
H-3	<2.04	<2.17	<2.17	<2.21	<2.11	0.62	1.49
C-14	<1.09	<1.14	<1.08	<1.12	<1.07	<0.47	1.26
Fe-55	<7.72	<8.17	<11.7	<10.4	<9.03	<20.1	<17.4
Co-60	<0.05	0.55	0.43	4.21	<0.08	<0.03	<0.03
Ag-108m	<0.05	0.30	0.14	0.36	<0.08	<0.03	<0.03
Ag-110m	<0.07	<0.12	<0.19	<0.27	<0.06	<0.07	<0.05
Cs-137	<0.04	<0.07	0.24	1.77	<0.07	0.02	<0.03
Ba-133	<0.06	0.11	<0.13	<0.14	<0.09	<0.10	<0.24
Mn-54	<0.07	<0.12	<0.19	<0.24	<0.08	<0.07	<0.16
Eu-152	<0.32	<0.55	<0.91	<0.72	<0.54	<0.59	<1.03

Sample 1: UM-2009-06-08-01; Concrete grindings from foundation under North side of former reactor pool
Sample 2: UM-2009-06-10-01; Concrete grindings from foundation under West side of former reactor pool
Sample 3: UM-2009-06-12-01; Concrete grindings from foundation under former reactor thermal column
Sample 4 UM-2009-06-19-01; Concrete grindings from foundation directly beneath former reactor core

Sample 5: UM-2010-01-29-01; Concrete grindings from foundation under West side of former reactor pool
Sample 6: UM-2010-05-18-01; Concrete grindings from foundation under West side of former reactor pool; after additional remediation of area identified by gamma scan
Sample 7: UM-2010-05-27-01; Concrete grindings from foundation under West side of former reactor pool; after additional remediation of area identified by gamma scan

It is evident from these analyses of post-remediation samples that only a few samples contained positive concentrations of radionuclides, attributable to FNR operations. Most concentrations were either less than laboratory detection limits or very low, relative to typical DCGL levels. Co-60, Ag-108m, and Cs-137 are the only radionuclides identified in more than 2 of the 7 samples and/or at concentrations that could be considered positive indication of their presence. Because of the high fraction of non-detectable levels, these data cannot be used to develop meaningful radionuclide ratios for the remediated facility.

Several samples were obtained during remediation from locations contaminated by leakage of reactor pool water and thus believed representative of potential surface contamination throughout the FNR facility. Table A-2 presents a summary of analytical results for these samples. It should be noted that, based on the absence of non-gamma-emitting radionuclides in the post-remediation samples, these analyses included only gamma spectrometry.

Table A-2 Analyses of Residue Samples

Radionuclide*	Sample 8 (pCi/g)	Sample 9 (pCi/g)	Sample 10 (pCi/g)	Sample 11 (pCi/g)	Average Fraction
Co-60	37.7	12.1	0.35	4.6	0.312
Ag-108m	71.5	29.3	2.3	<0.03	0.588
Ag-110m	5.87	2.09	<0.06	<0.46	0.048
Cs-137	1.89	1.50	0.20	<0.03	0.021
Mn-54	0.28	<0.14	<0.02	<0.02	0.003
Zn-65	1.56	0.48	0.05	<0.05	0.012
Ba-133	1.07	0.92	<0.04	<0.04	0.012
Eu-152	<0.29	<0.30	<0.06	<0.06	0.004

* Analyses were by gamma spectrometry and did not include hard-to-detect radionuclides. No other gamma-emitting contaminants were detected.

Sample 8: UM-2009-08-10-01; Concrete grindings from core A in floor slab crack.
Sample 9: UM-2009-10-01-01; Concrete grindings from core L in floor slab crack.
Sample 10: UM-2010-09-16-D823-821; Material from Drain Tile.
Sample 11: UM-2010-08-27-02; Soil beneath MMPP/FNR freight door.

The fractional contributions of the radionuclides in samples 8-11 were calculated and the average contribution for these four samples were determined. Results are presented in Table A-2. To maximize potential contributions to future occupant dose for surrogate

determination, where the activity was reported as less than the minimum detectable activity (MDA), the MDA value was used in calculating the activity ratios. Appendix D describes application of these ratios in establishing a gross beta DCGL for surface contamination at FNR.

Appendix B

Justification for Use of Default Screening Values for FNR Soils and Surfaces

In accordance with Section 6.6.6 of NUREG-1757, the following conditions must be satisfied to justify use of the Default Screening Values:

- Building Surface Contamination

  1. The contamination on building surfaces should be surficial and non-volumetric (e.g., <10 mm (0.4 in).

     Justification: Paint and tile have been removed to expose potentially contaminated structure surfaces. Fixtures and portions of the structural concrete in proximity to the reactor core, where activation may have resulted in volumetric contamination, have been removed. Samples of remaining concrete, representing material at 0.5 to 2.0 and 2.0 to 4.0 inches below the surface, were obtained at two locations, which are closest to the former position of the reactor core. Analyses of these samples did not identify any detectable radionuclides of reactor origin (see Table B-1), indicating absence of volumetric contamination.

  2. Contamination on surfaces is mostly fixed (not loose), with the fraction of loose contamination not to exceed 10 percent of the total surface activity.

     Justification: Routine surveys, during and following remediation, did not identify the presence of removable contamination. Smears for removable contamination will be obtained at direct measurement locations during the FSS. Removable contamination must be less than 10% of the gross beta DCGL.

  3. The screening criteria may not be applied to surfaces as buried structures (e.g., drainage or sewer pipes) or mobile equipment within the building; such surfaces and buried surfaces will be treated on a case-by-case basis.

     Justification: Potentially impacted piping, including imbedded piping and adjacent concrete, has been removed, with exception of the short section of piping to the foundation drain on the Basement level. Survey and evaluation of the drain system will be performed separately.

- Surface Soil Contamination

  1. The initial residual radioactivity (after decommissioning) is contained in the top layer of the surface soil (e.g., approximately 15 cm (6 in)).

     Justification: A small volume of soil around a storage tube in the west wall of the first floor level, used to store several PuBe neutron sources, was removed and scans and sampling of the remaining soil surfaces was performed. That evaluation has been completed and results will be provided separate from the remaining facility FSS. The foundation drain, around the foundation of the FNR received a short-term release of low-level contaminated water. Sampling of soil from that system has been performed and results will be provided separate from the remaining facility FSS. Otherwise, potential contamination of soil is limited to soil surfaces on the basement level, exposed during removal of impacted imbedded piping, and soil beneath the first floor at the doorway (South West Freight) between the FNR and MMPP Buildings, resulting from seepage of pool water through a small crack in the bioshield and a possible liquid spill on the floor above the gap between the FNR/MMPP buildings. Consequently, the source of any contamination of soil, other than that in the vicinity of the storage tubes, foundation drain system, and gap between the FNR and MMPP will be due to dispersal of contamination from structure surfaces and will be limited to the exposed soil surfaces.

2. The unsaturated zone and the ground water are initially free of contamination.

   Justification: As part of the initial facility characterization in 2007, a ground water monitoring well, installed near the entrance to the MMPP, which is downstream from the FNR facility, was sampled. Sampling of that well (Table B-2) did not identify evidence that the ground water has been impacted as a result of FNR operations.

3. The vertical saturated hydraulic conductivity at the specific site is greater than the infiltration rate.

   Justification: No residual radiological contamination of subsurface soil, due to past FNR operations, has been identified. The elevations of the soil in the vicinity of the source storage tubes, cavity beneath the MMPP/FNR SW freight door, and French drain are approximately 839, 829, and 823 ft., respectively. Elevation of the upper bound of the saturated zone is 809 ft. The vertical distance from contaminated soil to the water table is therefore at least 14 ft. There are currently no liquid discharges from the FNR to the ground water in the vicinity of this facility.

Based on results of monitoring in support of remedial actions and ongoing radiological surveys during and following remediation, the above criteria are satisfied. Therefore, the conservative Default Screening Values (NUREG/CR-5512, Vol 3) for the potential radionuclide contaminants have been selected as acceptable final status criteria (i.e., DCGLs).

Table B-1 Analyses of Concrete Cores

Radionuclide	Concentration (pCi/g)		
	2010-06-17-02	2010-06-17-03	2010-06-17-04
	0.5 – 2.0 inches	0.5 – 2.0 inches	0.5– 2.0 inches
Co-60	<0.01	<0.03	<0.03
Ag-108m	<0.01	<0.03	<0.03
Ag-110m	<0.01	<0.03	<0.03
Cs-137	<0.01	<0.04	<0.03
Mn-54	<0.08	<0.04	<0.03
Zn-65	<0.04	<0.11	<0.10
Ba-133	<0.03	<0.07	<0.07
Eu-152	0.03	<0.08	0.11

Table B-2 Analyses of Ground Water Samples from Well Near PML Entrance

Radionuclide	Concentration (pCi/l)	
	7/2/2007	8/8/2007
Gross alpha	58.2 ± 9.7	20.1 ± 6.5
Gross beta	67.2 ± 8.4	31.3 ± 7.1
H-3	<706	<648
Co-60	<6.68	<9.88
Cs-137	<5.69	<8.07
Ag-108m	<6.03	<7.31
Ag-110m	<5.28	<8.53
Mn-54	<7.03	<8.85
Zn-65	<14.1	<20.6
Eu-152	<42.0	<53.4

Appendix C

Development of Default Screening Values for Ag-108m

Default Screening Values, listed in NUREG/CR-5512, Volume 3, do not include the radionuclide Ag-108m. Also, the DandD code, used to develop those Default Screening Values, does not include the dose values for that radionuclide. Therefore the following approach was used to develop Default Screening Values for Ag-108m:

1. DandD Version 2.2.0 was used to calculate contributions of individual pathways (i.e., by excluding all other pathways) to the dose (mrem/y) from 1000 dpm/100 cm^2 Ag-110m for the Building Occupancy scenario and from 1.0 pCi/g for the Residential scenario. The surface activity and soil concentrations of Ag-110m, consistent with a 25 mrem/y dose, were then calculated to confirm that the calculation was performed correctly. The resulting calculations yielded 10205 dpm/100 cm^2 and 4.87 pCi/g, as compared with the values of 1.02E+4 dpm/100 cm^2 and 4.92 pCi/g, respectively, in NUREG/CR-5512, Volume 3. (Refer to attached table)

2. These individual pathway doses for Ag-110m were adjusted by multiplying the Ag-110m contributions by the Ag-108m to Ag-110m ratios of the following dose values for external and internal exposure, as presented in FRG #12 and FRG #11, respectively.

Pathway	Ag-110m Dose	Ag-108m Dose
External - surface	2.65E-15 Sv/Bq s m^{-2}	1.60E-15 Sv/Bq s m^{-2}
External - 15 cm thick	7.93E-17 Sv/Bq s m^{-3}	4.61E-17 Sv/Bq s m^{-3}
Inhalation	2.17E-08 Sv/Bq	1.07E-08 Sv/Bq
Ingestion	2.92E-09 Sv/Bq	2.06E-09 Sv/Bq

3. The resulting individual Ag-108m doses for all pathways were then calculated and the surface activity and soil concentration values consistent with a 25 mrem/y dose were calculated, yielding Default Screening Values of 1.70E+04 dpm/100 cm^2 and 8.20 pCi/g for building surface and surface soil contamination, respectively.

Scenario	Pathway	Ag-110m Dose (mrem/1000 dpm/100 cm²)	Dose factors (Ag-108m/Ag-110m)	Ag-108m Dose (mrem/1000 dpm/100 cm²)
Building Occupancy				
	External Exposure	2.34E+00	0.604	1.41E+00
	Inhalation	1.05E-01	0.493	5.18E-02
	Ingestion	7.88E-03	0.705	5.56E-03
	total	2.45E+00		1.47E+00
	Default Screening Value for 25mrem/y	1.02E+04 (dpm/100 cm²)		1.70E+04 (dpm/100 cm²)
		Ag-110m Dose (mrem/1.0 pCi/g)	Dose factors (Ag-108m/Ag-110m)	Ag-108m Dose (mrem/1.0 pCi/g)
Residential				
	External Exposure	4.58E+00	0.581	2.66E+00
	Inhalation	1.22E-05	0.493	6.01E-06
	Sec. Ingestion	9.62E-05	0.705	6.78E-05
	Agricultural	5.59E-01	0.705	3.94E-01
	Drinking Water	1.36E-20	0.705	9.59E-21
	Irrigation	1.34E-19	0.705	9.45E-20
	Surface Water	7.26E-22	0.705	5.08E-22
	total	5.14E+00		3.05E+00
	Default Screening Value for 25mrem/y	4.87 pCi/g		8.20 pCi/g

Appendix D

Gross Beta DCGL for Radionuclide Mixture at FNR

Appendix A described the mixture of radionuclides, determined for samples from the FNR, during and following completion of remediation. Because of the general absence of contamination in the post-remediation samples, it was decided that the samples, obtained before remediation was completed, would be used to develop a radionuclide mixture for purposes of demonstrating final radiological conditions satisfy the NRC requirements for decommissioning. Table A-2 from Appendix A lists the following contributors to the radionuclide mix:

Concentrations of Mn-54, Zn-65, Ba-133, and Eu-152 were very low in the samples during remediation and were not present in post remediation samples; these radionuclides were therefore deleted from the list of residual radionuclides, leaving only Co-60, Ag-108m, Ag-110m., and Cs-137 as potential contaminants in the remediated facility. The fractional contributions of radionuclides to the pre-remediation and post-remediation mixture, are presented in the following table.

Radionuclide	Average Fraction	
	Pre Remediation	Post Remediation
Co-60	0.312	0.322
Ag-108m	0.588	0.607
Ag-110m	0.048	0.050
Cs-137	0.021	0.021
Mn-54	0.003	Negligible .
Zn-65	0.012	Negligible .
Ba-133	0.012	Negligible .
Eu-152	0.004	Negligible .

Each of the radionuclides in the post-remediation mixture decays to some extent by emitting beta particles. The abundance (A) of beta emissions per decay is 1.0 for Co-60 and Ag-110m, 0.85 for Cs-137 and 0.087 for Ag-108m.

To develop a gross-beta DCGL for the structural surfaces, the fractional contribution (f) of each of the radionuclide contaminants to the total mix was divided by the Default Screening DCGL for that radionuclide. The gross DCGL was then calculated by:

$$\text{Gross Beta DCGL} = \frac{\text{fraction of beta emitters (i.e., f x A)}}{\Sigma\,(\text{f/DCGL})}$$

$$\text{Gross Beta DCGL} = \frac{0.443}{(0.322/7050) + (0.607/17000) + (0.050/10200) + (0.021/28000)}$$

The resulting gross beta DCGL value is 5130 dpm/100 cm^2.