Final Status Survey Plan

Buffalo Materials Research Center

Prepared for:

University at Buffalo
The State University of New York

Buffalo Material Research Center
Office of Environment, Health, and Safety Services

Completed by:

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Revision 0
June 20, 2012

SUMMARY OF CHANGES

Revisions to the Final Status Survey Plan will be tracked when revisions are issued. Changed sections will be identified by special demarcation in the margin. A summary description of each revision will be noted in the following table.

Revision Number	Date	Description of Change
0	June 20, 2012	Initial Issue

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ABBREVIATIONS/ACRONYMS

μR/hr	microRoentgen per hour
2x2 NaI	2-inch by 2-inch sodium iodide detector
AEC	Atomic Energy Commission
BMRC	Buffalo Materials Research Center
Bq	Bequerels
cm^2	Centimeter Squared
cpm	counts per minute
CFR	Code of Federal Regulations
D&D	Decontamination and Decommissionoing
DCGL	Derived Concentration Guideline Level
$DCGL_{emc}$	Derived Concentration Guideline Level Elevated Measurement Comparison
DOC	Design and Oversight Contractor
DP	Decommissioning Plan
DQO	Data Quality Objective
DPM or dpm	disintegrations per minute
FSS	Final Status Survey
FSSP	Final Status Survey Plan
kw	kilowatt
LBGR	Lower Bound of the Gray Region
m	meter
m^2	Meters square
MARSSIM	Multi-Agency Radiation Site Survey and Investigation Manual, NUREG-1575
MDA	Minimum Detectable Activity
MDC	Minimum Detectable Concentration
MDCR	Minimum Detectable Count Rate
MDC_{scan}	Minimum Detectable Concentration for scans
mrem	Millirem
NaI	Sodium Iodide
NELAP	National Environmental Laboratory Accreditation Program
NVLAP	National Voluntary Laboratory Accreditation Program
MWt	Megawatt thermal
NIST	National Institute of Standards and Technology
NRC	U.S. Nuclear Regulatory Commission
ORISE	Oak Ridge Institute for Science and Education

pCi/g	Picocuries per gram
PULSTAR	Pulse Training Assembled Reactor
QA/QC	Quality Assurance/Quality Control
SSC	Systems/Structures/Components
University	State University of New York at Buffalo
VSP	Visual Sample Plan ©
WRS	Wilcoxon Rank Sum

Radionuclide Abbreviations

Ag	Silver
C	Carbon
Cs	Cesium
H	Hydrogen
Pu	Plutonium
Sr	Strontium
Th	Thorium
ZnS	Zinc Sulfide

Ag	Silver
C	Carbon
Cs	Cesium
H	Hydrogen
Pu	Plutonium
Sr	Strontium
Th	Thorium

1.0 INTRODUCTION

1.1 Purpose

This Final Status Survey Plan (FSSP) was prepared to support the termination of U.S. Nuclear Regulatory Commission (NRC) Reactor License number 77 (R-77) which covered the operation of the nuclear research reactor at the Buffalo Materials Research Center (BMRC) on the South Campus of the State University of New York at Buffalo (University). This FSSP describes the activities that the University's Design and Oversight Contractor (DOC) will perform to demonstrate that residual radioactivity in the footprint of the BMRC following demolition meets the derived concentration guideline levels (DCGLs). The DCGLs will be approved by the NRC through their acceptance and approval of the facility Decommissioning Plan (DP) (Reference 7.1) which describes the overall decommissioning approach.

1.2 Scope

This plan describes the purpose, scope and technical approach used during the final status survey (FSS) of the BMRC. The guidance provided in NUREG-1575, *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (Reference 7.2) was used in designing survey and sampling efforts described in this FSSP to demonstrate compliance with the DCGLs.

At the time of the FSS, the BMRC and all of its structures, systems and components will have been completely dismantled or demolished and completely dispositioned per the BMRC DP. The condition of the area to be surveyed will be a 15-20 foot excavation with a bedrock floor and soil sidewalls. The BMRC FSS will incorporate on-site radiological survey techniques as well as off-site laboratory analysis of soil samples. On-site techniques will include walk-over gamma radiation surveys and other direct radiation measurements with portable radiation detection equipment.

Decommissioning operations may require modifications to this FSSP which may include, but are not limited to: adjustments of the boundaries of a survey unit, the addition of survey units, or substitution of survey instruments. Modifications to this plan altering the intent or purpose of the FSS or affecting the overall quality of survey data shall be approved by the University. A license amendment is not required for issuing a revision to this FSSP except as noted in Section 9.0 of the DP.

2.0 SITE DESCRIPTION

2.1 Facility and Reactor Description

The University is licensed by the NRC to possess radioactive materials within the BMRC. The BMRC reactor is located on the South Campus of the University at Buffalo in the city of Buffalo, New York, as shown in Figure 1.

Figure 2-1: University of Buffalo South Campus

The reactor was defueled in 2005 and has entered the Decontamination and Decommissioning (D&D) with the goal of removing the facility in its entirety and subsequent termination of the NRC license. This FSS Plan is in support of a DP developed in accordance with Chapter 17 of NUREG -1537 Part 1, *Guidance for Preparing and Reviewing Applications for Licensing of Non-Power Reactors*.

The BMRC building is comprised of an administrative/laboratory wing (administrative wing) and a vapor containment building (containment building) with three levels in each. See Figures 2, 3, and 4 at the end of this section for the control, gamma, and neutron deck layouts respectively. The three levels are: neutron deck (lowest level, i.e. sub-grade), gamma deck (2nd level, i.e. middle level), and control deck (top floor). The neutron deck of the administrative wing (known as the Subbasement) houses numerous systems/structures/components (SSCs) that support operation of the reactor. The remainder of the administrative wing contains 20 rooms which are a mixture of offices, laboratories, utility rooms, and classrooms.

The facility was constructed in 1959, went into operation on March 24, 1960, and was operated by The Western New York Nuclear Research Center, Inc, a subsidiary of the State University of New York, under Atomic Energy Commission (AEC) license number R-77. The facility licensee was changed to the Nuclear Science and Technology Center followed by a change to the Buffalo Materials Research Center in 1973 and 1985, respectively. The licensed power was 250 kw thermal with operations of 2 MWt possible for short times. In 1991, the reactor was retrofitted with a 0.75 inch thick aluminum liner. This new liner supplements the original 0.25 inch thick aluminum liner and has a 0.75 inch air gap between the two.

The reactor core had been located in a pool-type tank that is 29 feet deep with horizontal dimensions of 13 feet by 7 feet, located in the containment building of the BMRC. The tank contains approximately 13,700 gallons of demineralized water. The reactor fuel consisted of zircalloy clad PULSTAR fuel elements.

Several events have occurred at the BMRC during its operational history that have led to the determination that the buildings, structures, and immediate surrounding soils are impacted from historical operations at BMRC. Additional details of the reactor, the site, licensing history, and operational history are documented in the BMRC Historical Site Assessment and the DP.

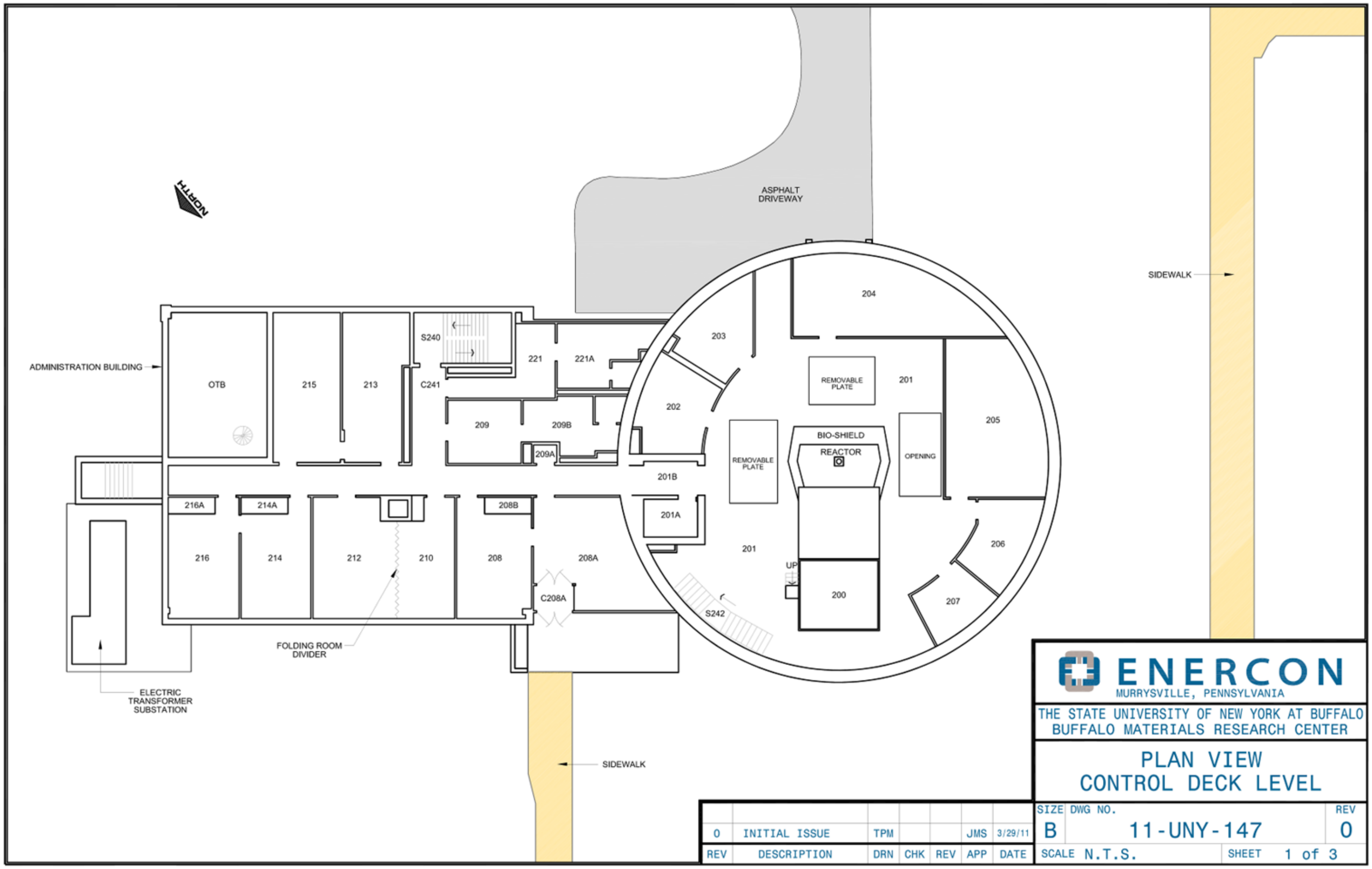


Figure 2-2: Control Deck Layout

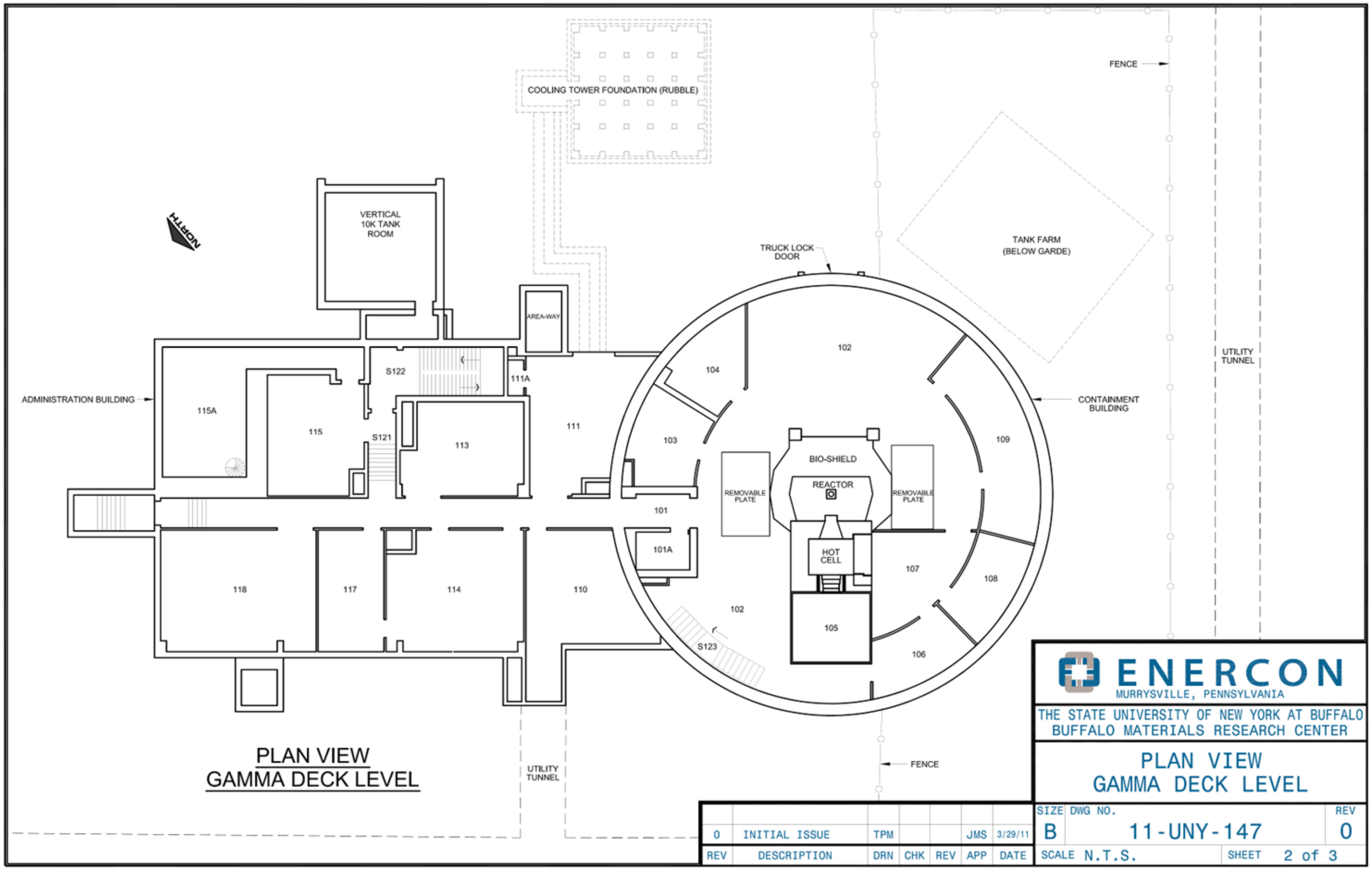


Figure 2-3: Gamma Deck Layout

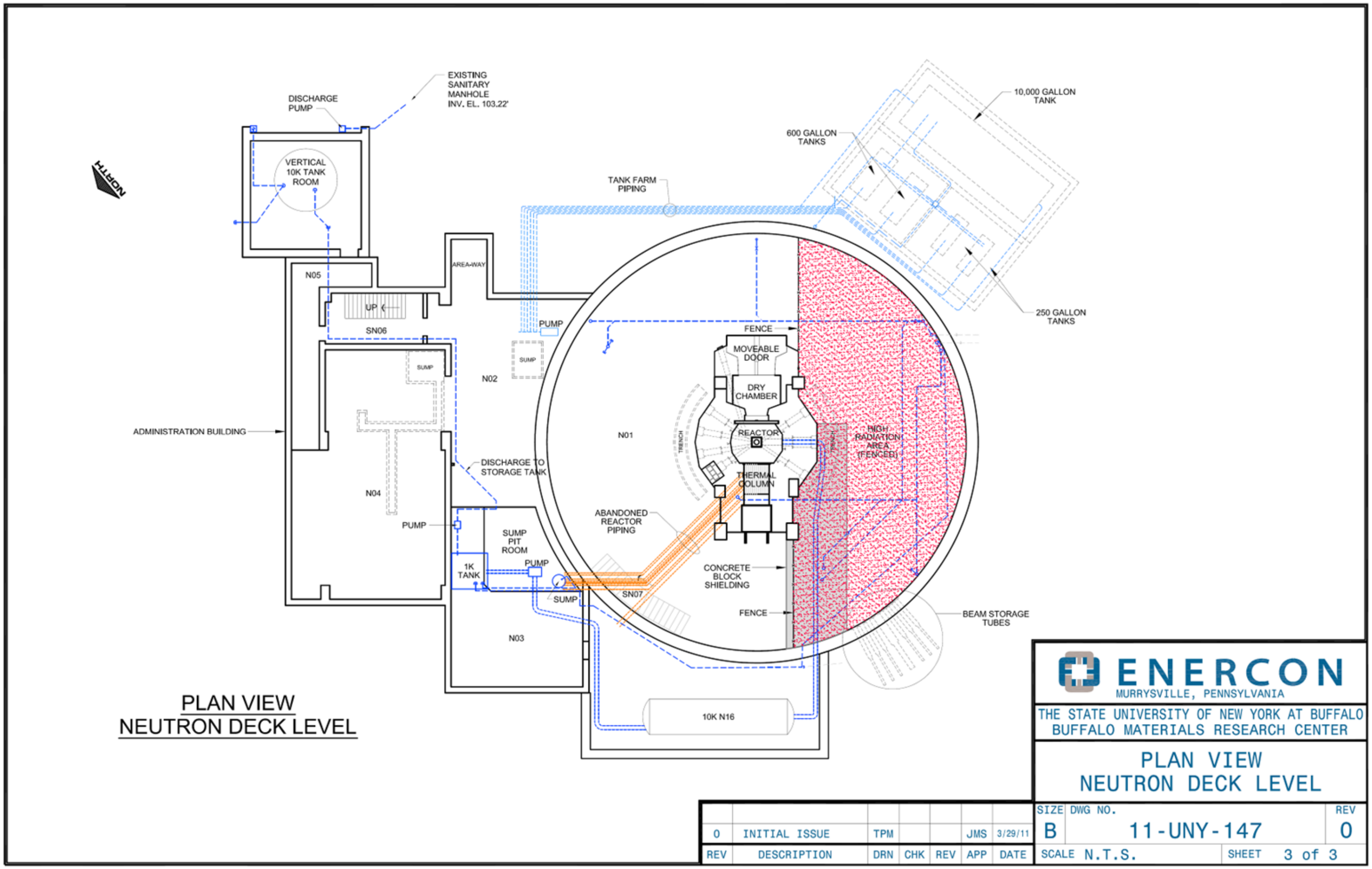


Figure 2-4: Neutron Deck Layout

2.2 Radionuclides of Concern

During characterization of the site, a list of radionuclides of concern (ROCs) was developed based on analysis results of soils samples, waste tank liquid samples, and smears collected for 10CFR Part 61 waste characterization data. The analysis results did not provide indications of BMRC derived ROCs; therefore, the selected ROCs for soils were based the results from the waste tanks and the Part 61 data.

The following table provides the comprehensive list of the radionuclides of concern for the BMRC and an updated matrix of the applicable area/media of where the radionuclide is of concern.

Table 2-1 BMRC Radionuclides of Concern

Radionuclide	Half Life (yr)	Emission	Area(s) of Concern
Ag-108m	4.38E+02	β, γ	Soil; Tank Water; SSCs
Am-241	4.32E+02	α, γ	Tank sediment
C-14	5.73E+03	β	Laboratory areas
Co-60	5.27E+00	β, γ	Soil; SSCs; Bioshield
Cs-137	3.01E+01	β, γ*	Soil; SSCs; Bioshield
Eu-152	1.36E+01	β, γ	Soil; SSCs; Bioshield
Eu-154	8.59E+00	β, γ	Soil; SSCs; Bioshield
H-3	1.23E+01	β	Soil; Bioshield and Tank Water
Ni-63	1.00E+02	β	Soil; SSCs; Bioshield
Pu-238	8.78E+01	α, γ	Tank sediment
Pu-239	2.41E+04	α, γ	Tank sediment
Pu-240	6.60E+03	α, γ	Tank sediment
Sr-90	2.88E+01	β	SSCs; Ventilation systems; Soil

* γ emission from Ba-137m progeny.

3.0 FINAL STATUS SURVEY PROCESS

3.1 Overview

The FSS will include the entire construction are of the BMRC decommissioning. All BMRC specific systems and structures will have been removed along with the BMRC itself. The FSS will encompass the entire area contained within the project construction fence; primarily the 15-20 foot excavation required for removal of the building structures, systems, and components. The surface under the Containment Building, the Tank Farm, and the subbasement is bedrock and will be surveyed in a fashion similar to concrete. Remaining areas will be surveyed as surface soils with samples collected for volumetric analyses.

Following all reactor dismantlement, building demolition, and remediation activities, FSS packages will be prepared per the process described in this plan which includes the following five (5) major steps in the FSS process:

1. Survey preparation
2. Survey design
3. Data collection
4. Data validation, assessment and evaluation
5. Documentation of survey results

3.1.1 Survey Preparation

Survey preparation is the first step in the FSS process and occurs after remediation is completed. Where remediation was required, a post-remediation survey is performed to confirm that remediation was successful prior to initiating final survey activities. Following the post-remediation survey, the FSS is performed.

The area to be surveyed is isolated and/or controlled to ensure that radioactive material is not reintroduced into the area from ongoing demolition or remediation activities nearby, and to maintain the final configuration of the area. Tools, equipment, and materials not needed to support survey activities are to be removed from the survey area. Routine access, material storage, and worker transit through the area are not allowed.

3.1.2 Survey Design

The survey design process establishes the methods and performance criteria used to conduct the survey. Survey design assumptions are documented in a survey package for each survey unit and also documented in the FSS Report as described in this plan. Bedrock surfaces and soil areas are organized

into survey areas and classified by contamination potential of the area. Survey unit size is based on the assumptions in the dose assessment models in accordance with the guidance provided in the MARSSIM.

3.1.3 Data Collection

After preparation of the FSS design, the FSS data is collected. Trained and qualified personnel perform the necessary measurements using calibrated instruments in accordance with approved procedures and instructions contained in the survey package.

3.1.4 Data Assessment and Evaluation

Survey data assessment is performed to verify that the data are sufficient to demonstrate that the survey unit meets the unrestricted use criterion (i.e., the Null Hypothesis may be rejected). Statistical analyses are performed on the data and the data are compared to investigation levels. Depending on the results of an investigation, the survey unit may require further remediation, reclassification, and/or resurvey. Graphical representations of the data, such as posting plots or histograms, may be generated to provide qualitative information from the survey and to verify the assumptions in the statistical tests, such as spatial independence, symmetry, data variance and statistical power. Additional data needs, if required, are identified during this review.

3.1.5 Documentation of Survey Results

Survey results are documented by Survey Area in the FSS report. The FSS data is reviewed, analyzed, and processed, and the results documented in the FSS Report. The FSS Report documents the necessary data and analyses from the FSS and is submitted by the licensee to the USNRC along with a request for license termination.

3.2 Release Criteria

3.2.1 Volumetric DCGL

Upon approval of the DP, the NRC will approve the site DCGLs for soil as provided in Table 3-1. The DCGLs are the screening levels for radionuclide concentrations in soils in picocuries per gram (pCi/g) as provided in the NRC's supplemental guidance (Reference 7.3) to the License Termination Rule (Reference 7.4). When applying the DCGLs in Table 3-1, the sum-of-the-fractions rule applies. That is, the sum of the ratios of the radionuclide concentrations to the DCGLs must be less than 1.0.

Table 3-1: DCGLs for Primary Radionuclides of Concern in Soil

Radionuclide	NRC Screening Value for Surface Soils (pCi/g)	Selected DCGL Value (pCi/g)*
Ag-108m	None	8.2
Am-241	None	2.1
C-14	12	12
Co-60	3.8	3.8
Cs-137	11	11
Eu-152	8.7	6.9
Eu-154	8	8
H-3	110	110
Ni-63	2,100	2,100
Pu-238	2.5	2.5
Pu-239/240	2.3	2.3
Sr-90	1.7	1.7

*Source: *Decommissioning Plan, Buffalo Materials Research Center*, February 2012

Release criteria for the bedrock materials uses the NRC screening values for building surfaces as found in Appendix B of NUREG-1757, *Consolidated Decommissioning Guidance* and presented in Table 3-2. Release criteria for radionuclides not in Table 3-2 will be consistent with the Reg Guide 1.86 values stated in Section 2.2.3.1 of the DP. The bedrock will be prepped prior to the FSS by removing loose materials, i.e. concrete dust, pieces, and dirt. The stated DCGLs assume that at least 90% of the measured radioactive material is fixed radioactive material. Loose contamination smears will be collected in conjunction with static measurement to ensure that the amount of loose radioactive materials does not exceed 10% of the release criteria.

Table 3-2: NRC License Termination Screening Levels for Building (Bedrock) Surfaces

Radionuclide	NRC Screening Value (dpm/100cm^2)*
Ag-108m	17,000
C-14	3,700,000
Co-60	7,100
Cs-137	28,000
H-3	120,000,000
Ni-63	1,800,000
Sr-90	8,700

*Source: *Decommissioning Plan, Buffalo Materials Research Center*, February 2012

3.2.2 Gross Beta DCGL

The bedrock beneath the BMRC structures is considered non-pourous; therefore, any contamination present would only be on the surface. Collecting volumetric samples on a surface contaminated material such as the bedrock, is not considered appropriate as the results would not be representative of the actual concentration. Additionally, there is no exposure route for any radioactive material that may reside on the bedrock due to no groundwater, the 15-20 feet of soil cover, and no vegetation, fishing, or grazing of animals present in the area after license termination. A potential exposure scenario for the bedrock, however, could be an exposed crawl space or subbasement of a building constructed in the area where the BMRC once stood. The bedrock would be similar to a surface contaminated concrete floor for exposure pathways. For building surfaces such as concrete, gross beta measurements are typically performed. Since the bedrock is similar to concrete gross beta measurements will be performed on the bedrock surfaces and will be evaluated as if they are building surfaces.

Generally, to perform surveys that address multiple radionuclides, the expected distribution of the radionuclides must be known. However, it is not anticipated that the bedrock will exhibit residual radioactive materials at or above the release criteria. Characterization data collected beneath the floor of the neutron deck supports this assumption, consequently a radionuclide distribution was not calculated and, as a conservative assumption, all detectable beta/gamma surface activity will be assumed to be Co-60 since it has the most conservative screening level of 7,100 dpm/100cm^2.

Investigation of an area will be performed when a measurement exceeds the gross beta DCGL, i.e. 7,100 dpm/100cm^2. The investigation will consist of a detailed scan of the area immediately surrounding the elevated measurement to determine the extent of the elevated area. Static measurements may be performed if additional elevated areas are detected. Volumetric sampling may be performed to determine the specific isotopic content. Determination of elevated measurement comparison values will be performed, if necessary, and documented in detail in the FSS report.

3.3 Surveys and Sampling

The BMRC footprint will be comprised of four Class 1 survey units; the N16 vault, containment, sub-basement, and tank farm areas. The side slope areas surrounding the excavation will be a single Class 2 survey unit. The remainder of the project area will be classified as a single Class 3 survey unit. The classifications are based on the potential for radioactive materials or contamination to be present in the survey unit following remediation according to MARSSIM protocols (Reference 7.2). Anticipated survey units are shown by classification in Figure 3-1.

3.3.1 Class 1 Excavation Area

The bottom of the excavated area will consist of four Class 1 survey units based on MARSSIM recommendations. MARSSIM recommends that exterior Class 1 survey units be limited to 2,000 m^2. The DOC will perform a 100% walk-over survey using a gas proportional floor monitor (or equivalent instrumentation) and collect fixed point measurements at predetermined locations using a random start grid pattern. Area exposure rates will be taken at one meter above ground surfaces at the location of each sample point using an exposure rate meter measuring in units of microRoentgen per hour (µR/hr).

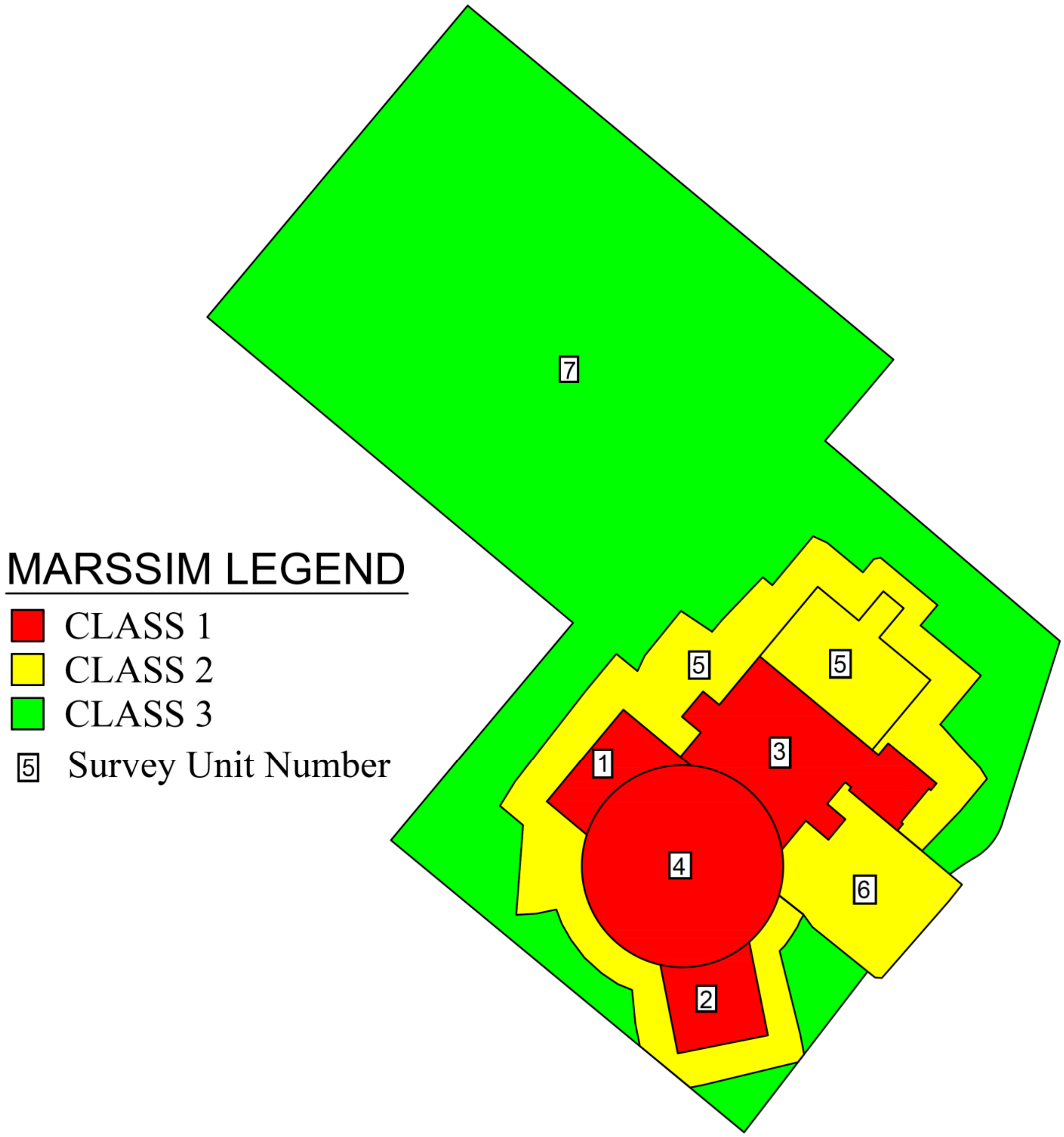
3.3.2 Class 2 Area

The sideslopes of the excavation area will be a single Class 2 survey unit and will receive a minimum 25% walkover scan using 2x2 NaI detectors, direct measurements will be made, and soil samples will be collected at predetermined locations using a random start grid pattern. Radiation measurements and sample collection, preparation, and analysis will be prescribed in specific survey packages or FSS procedures. Area exposure rates will be taken at one meter above ground surfaces at the location of each sample point using an exposure rate meter measuring in units of µR/hr.

3.3.3 Class 3 Area

The remaining property of the BMRC project area will be a single Class 3 survey unit and will receive scans using the NaI detectors in the one meter area surrounding the selected sample locations, direct measurements will be made, and soil samples will be collected at predetermined locations using randomly selected sample locations. Radiation measurements and sample collection, preparation, and analysis will be prescribed in specific survey packages. Area exposure rates will be taken at one meter above ground surfaces at the location of each sample point using an exposure rate meter measuring in units of µR/hr.

Figure 3-1: Anticipated Survey Units



3.4 Measurement and Sample Locations

Visual Sample Plan© (VSP) or other such software is used to plot the actual survey locations to the nearest 0.1 m. The development of measurement locations within a survey unit will be accomplished using the assistance of the most recent version of the VSP software, or another similar software package. VSP has been developed by Pacific Northwest National Laboratory to aid in the development,

generation, and evaluation of sampling locations to meet various regulatory guidance documents and is regularly used by the NRC's Independent Verification Contractor ORISE. One key aspect of VSP is the ability to import standard AutoCAD© drawings (DXF file extensions) or ESRI ArcView ShapeFiles (SHP file extensions) and output sample locations using the units within the drawing. The preferred format for this project will be AutoCAD© DXF files.

Measurement locations within the survey unit will be clearly identified and documented for purposes of reproducibility. Actual measurement locations will be identified by tags, labels, paint marks, or photographic record. An identification code and will match a survey location to a particular survey unit.

Sample points for Class 1 and Class 2 survey units will be based on a systematic pattern or grid throughout the survey unit by randomly selecting a start point coordinate. VSP uses a random number generator to determine the start point of the square grid pattern. Random measurement locations are used for Class 3 survey units. These sample location coordinates will be determined using VSP.

Measurement locations selected using either a random selection process or a random-start systematic pattern that do not fall within the survey unit or that cannot be surveyed due to site conditions will be relocated to the nearest location that can be surveyed within the survey unit. The justification for the movement of a measurement location shall be described in the FSS Report.

3.5 MARSSIM Statistical Parameters

The MARSSIM describes the process for determining the number of survey measurements necessary to ensure a data set sufficient for statistical analysis. Sample size is based on the relative shift, the Type I and II errors, sigma, and the specific statistical test used to evaluate the data.

Alternate processes may be used if they gain NRC and industry acceptance between the time this plan is adopted and the commencement of FSS activities. However, new technologies must still meet the applicable requirements of this plan, i.e., calibration, detection limit, areal coverage, and operator qualification.

3.5.1 Statistical Test Determination

Appropriate tests will be used for the statistical evaluation of survey data. Tests such as the Sign Test and Wilcoxon Rank Sum (WRS) Test will be implemented using unity rules, surrogate methodologies, or combinations of unity rules and surrogate methodologies, as described in the MARSSIM and NUREG-1505 chapters 11 and 12.

If the contaminant is not in the background or constitutes a small fraction of the DCGL, the Sign Test will be used. If background is a significant fraction of the DCGL, the WRS Test will be used. It is anticipated that the Sign Test will be the only statistical test applied to the collected data because of the small fraction of the DCGL that background radionuclides will contribute.

3.5.2 Establish Decision Errors

The probability of making decision errors is controlled by hypothesis testing. The survey results will be used to select between one condition of the environment (the null hypothesis) and an alternate condition (the alternative hypothesis). These hypotheses, chosen from MARSSIM Scenario A, are defined as follows:

- Null Hypothesis (H_0): The survey unit does not meet the release criteria.
- Alternate Hypothesis (H_a): The survey unit does meet the release criteria.

A Type I decision error would result in the release of a survey unit containing residual radioactivity above the release criteria. It occurs when the Null Hypothesis is rejected, but in reality is true. The probability of making this error is designated as "α."

A Type II decision error would result in the failure to release a survey unit when the residual radioactivity is below the release criteria. This occurs when the Null Hypothesis is accepted when it is not true. The probability of making this error is designated as "β."

Appendix E of NUREG-1727 recommends using a Type I error probability (α) of 0.05 and states that any value for the Type II error probability (β) is acceptable. Following the guidance, α will be set at 0.05. A β of 0.05 will initially be selected based on site-specific considerations. The β may be modified, as necessary, after weighing the resulting change in the number of required survey measurements against the risk of unnecessarily investigating and/or remediating survey units that are truly below the release criteria.

3.5.3 Relative Shift

The relative shift (Δ/σ) is a calculated value. Delta (Δ) is equal to the DCGL minus the lower boundary of the gray region (LBGR). The standard deviation (σ) used for the relative shift calculation may be recalculated based on the most current data obtained from post-remediation or post-demolition surveys; or from background reference areas, as appropriate. The LBGR may be adjusted to obtain an optimal

value for the relative shift, normally between 1.0 and 3.0. Administratively, the relative shift will have a maximum value of 3.0.

3.5.4 Lower Boundary of the Gray Region

The LBGR is the point at which the Type II (β) error applies. The default value of the LBGR is initially set at the mean of the post-remediation survey results, if available, or at 0.5 times the DCGL, whichever is higher. If the relative shift is greater than 3.0, then the number of data points, N, listed for the relative shift values of 3.0 from Table 5.5 or Table 5.3 in the MARSSIM, will normally be used as the minimum sample size.

3.5.5 Standard Deviation

The standard deviation (σ), referred to as sigma, is initially calculated from characterization samples/survey data with activity at or below the approved DCGL since this value is what is expected to remain after necessary remediation has been completed. The sigma values used in the BMRC FSS design will be calculated using post-demolition surveys of the bedrock for the Class 1 areas. The sigma values for the Class 2 and Class 3 areas will be calculated from characterization data.

3.5.6 Wilcoxon Rank Sum (WRS) Test Sample Size

The number of data points to be obtained from each reference area/survey unit pair may be determined using the Table 5.3 in the MARSSIM. The table includes the recommended 20% adjustment to ensure an adequate sample size. An alternative method is to use Formula 5-1 to directly calculate the required number of data points. Using the formula will require an adjustment for a recommended 20% surplus of data points.

MARSSIM Formula 5–1:

$$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{3(P_r - 0.5)^2}$$

Where:

$Z_{1-\alpha}$ = desired Type I error

$Z_{1-\beta}$ = desired Type II error

P_r = probability associated with the relative shift from Table 5.1 (see below) in the MARSSIM

Table 3-3: MARSSIM Table 5.1

Relative Shift	Probability	Relative Shift	Probability
0.1	0.528182	1.4	0.838864
0.2	0.556223	1.5	0.855541
0.3	0.583985	1.6	0.871014
0.4	0.611335	1.7	0.885299
0.5	0.638143	1.8	0.89842
0.6	0.66429	1.9	0.910413
0.7	0.689665	2.0	0.921319
0.8	0.714167	2.3	0.944167
0.9	0.73771	2.5	0.961428
1.0	0.760217	2.8	0.974067
1.1	0.781627	3.0	0.983039
1.2	0.801892	3.5	0.993329
1.3	0.820978	4.0	0.997658

If relative shift > 4.0, use Pr = 1.0

3.5.7 Sign Test Sample Size

The number of data points to be collected may be determined from Table 5.5 in the MARSSIM and includes the recommended 20% adjustment to ensure an adequate sample size. As with the WRS sample size discussed above, an alternative method is to use Formula 5-2 in the MARSSIM. Calculating the number of data points by using the formula will require an adjustment for a recommended 20% surplus of data points.

MARSSIM Formula 5–2: $$N = \frac{(Z_{1-\alpha} + Z_{1-\beta})^2}{4(SignP - 0.5)^2}$$

Where:

$Z_{1-\alpha}$ = desired Type I error
$Z_{1-\beta}$ = desired Type II error
SignP = value from Table 5.4 (see below) in the MARSSIM associated with the relative shift

Table 3-4: MARSSIM Table 5.4

Relative Shift	Sign p	Relative Shift	Sign p
0.1	0.539828	1.2	0.88493
0.2	0.57926	1.3	0.903199
0.3	0.617911	1.4	0.919243
0.4	0.655422	1.5	0.933193
0.5	0.691462	1.6	0.945201
0.6	0.725747	1.7	0.955435
0.7	0.758036	1.8	0.96407
0.8	0.788145	1.9	0.971284
0.9	0.81594	2	0.97725
1	0.841345	2.5	0.99379
1.1	0.864334	3	0.99865

Note: If relative shift > 3.0, use Sign p = 1.0

3.6 Instruments and Detection Limits

3.6.1 Scan Surveys

The FSS will consist of walkover surveys with gamma scintillation detectors, and soil sampling with off-site analysis, scans and direct measurements with floor monitors. The instruments proposed for use during the FSS and their applications are provided in Table 3-5. If necessary, the DOC may substitute comparable instruments.

All instruments will be calibrated using NIST-traceable standards. Instruments will be checked at the beginning of each day to ensure they are operating properly. The daily check also reassures the validity of the previous day's measurements. The daily checks will include a background measurement and a source check. Instrument records, including dates of use, efficiencies, calibration due dates and source traceability, will be maintained in accordance with established procedures.

In Table 6.4 of NUREG-1507 (Reference 7.6), the minimum detectable Co-60 concentration in soil for scanning measurements (MDC_{scan}) i.e. a walk-over survey with a 2x2 NaI detector is approximately 3.4 pCi/g. For cesium-137, the MDC_{scan} is approximately 6.4 pCi/g. Therefore, based on the gamma photon energies of these isotopes and the other gamma-emitting isotopes of concern, the walk-over

surveys should be capable of identifying the presence of residual contamination at levels below the DCGLs.

For additional verification, the Co-60 DCGL (3.8 pCi/g) was modeled using Microshield© with an infinite slab source geometry, and is consistent with the analysis reported in Section 6.8.2 of Reference 7.6. This analysis, presented in Attachment 9.1, shows that the expected exposure rate for soil containing 3.8 pCi/g Co-60 would be 11 µR/hr. Using the conversion factor of 430 counts per minute (cpm) per µR/hr from Reference 7.6, the required minimum detectable count rate (MDCR) to measure 3.8 pCi/g of Co-60 would be approximately 4,730 cpm.

Microshield was used in the same way to model Ag-108m. This analysis, presented in Attachment 9.2, shows that the expected exposure rate for soil containing 8.2 pCi/g Ag-108m would be 20.9 µR/hr. Based off the Microshield evaluation, the average weighted energy of Ag-108m is ~50 keV. The 2x2 NaI has detection sensitivity at that energy range of approximately 3,600 cpm per µR/hr (Reference 7.7), therefore the required MDCR to measure 8.2 pCi/g of Ag-108m would be approximately 75,200 cpm.

The MDCR is determined by first determining the minimum detectable net source counts using Formula 6-8 from the MARSSIM as below.

Minimum number of detectable source counts: $s_i = d'\sqrt{b_i}$

Where:

d' = value taken from Table 6.5 in the MARSSIM for applicable true and false positive rates

b_i = Number of background counts in a given time interval

The MDCR is calculated from Formula 6-9 in the MARSSIM:

Minimum detectable count rate: $MDCR = s_i * \frac{60}{i}$

Where:

i = Observed time interval

Finally, applying the detection efficiency correction results in an MDC_{scan} in standardized units (DPM/100-cm^2) from this formula:

Scan MDC:

$$MDC_{scan} = \frac{MDCR}{\sqrt{\rho} * \varepsilon_i * \varepsilon_s * \frac{probearea}{100cm^2}}$$

Where:

ρ = Surveyor efficiency (value from a range between 0.5 and 0.75)
ε_i = Instrument efficiency
ε_s = Surface efficiency
probearea = active area of the detector face in cm^2

The value for ρ was developed in Draft NUREG/CR-6364 and NUREG-1507, it is a percentage estimate of the likelihood a surveyor will reliably detect an elevated count rate. A value of 0.5 will be used for the Surveyor Efficiency.

Using the MDCR equation above and estimating a background count rate of 8,000 cpm the expected MDCR is 1,352 net cpm (841 cpm less than the required MDCR) or approximately 9,350 gross cpm (depending on the true background rate on site). Using the MDC_{scan} (pCi/g) equation above, this MDCR correlates to an expected MDC_{scan} of about 3.1 pCi/g for Co-60 contamination in the soil.

MARSSIM protocols also recommend the derivation of a DCGL for elevated measurements comparison ($DCGL_{emc}$). For this derivation, an outside Area Factor is needed. To estimate the Area Factor, the area of each square grid must be approximated based on the size of the survey unit and the number of sampling points.

Using Table 5-6 from MARSSIM (Reference 7.2), the Area Factor can be approximated for Co-60, the primary contaminant of concern, for the grid area of 22.5 m^2. Interpolating between 10 m^2 and 30 m^2, the area factor is 1.8. The $DCGL_{emc}$ (or required MDC_{scan}) is equal to the DCGL times the Area Factor, or 5.6 pCi/g for Co-60. Since the expected MDC_{scan} (from Table 6.4 of Reference 7.6) are less than the $DCGL_{emc}$ (required MDC_{scan}), the survey approach and the number of samples is statistically acceptable.

Table 3-5: FSS Instrumentation

Instrument	Detector Type	Radiation Detected	Calibration Source	Use
Ludlum Model 2221	Ludlum Model 43-68 Gas Proportional ($126\ cm^2$ area)	Beta/Gama	Tc-99	Surface Static Measurements; Beta/Gamma scan measurements
Ludlum Model 2360	Ludlum Model 43-68 Gas Proportional ($126\ cm^2$ area)	Alpha/Beta	Th-230/Tc-99	Alpha/Beta static measurements
Ludlum Model 2360	Ludlum Model 43-89 ZnS coated Plastic Scintillator ($126\ cm^2$ area)	Alpha/Beta	Th-230/Tc-99	Alpha/Beta static measurements
Ludlum Model 3030E	Ludlum Model 43-10-1 ZnS internal detector	Alpha/Beta	Th-230/Tc-99	Swipe/smear counting
Ludlum Model 19	Internal NaI	Gamma	Cs-137	General area exposure rates

3.6.2 Minimum Detectable Concentration

The minimum detectable concentration (MDC) is the concentration of radioactivity that an instrument can be expected to detect at a 95 percent confidence level. For instruments performing direct measurements and for laboratory analyses, the MDC goal is 10-50 percent of applicable release criteria.

For static (direct) surface measurements, with conventional detectors, the MDC was calculated using the formula:

$$\text{MDC (dpm/100cm}^2\text{)} = \left[\frac{3 + 3.29\sqrt{(R_b)(T_s)(1 + T_s / T_b)}}{(T_s)(\varepsilon_t)} \right]$$

Where:

R_b = Background count rate (cpm)
T_b = Background count time (min)
T_d = Sample Run Time (min)
T_s = Sample Count Time (min)
ε = Total Instrument Efficiency (MARSSIM section 6.6.1)

The data used to calculate the MDC for the instrumentation is from data collected during the BMRC characterization process. The a priori MDC is listed in Table 3-6.

Table 3-6: Instrumentation MDC

Instrument	Detector Type	Radiation Detected	Typical Scan MDC (dpm/100 cm^2)	Typical Static MDC (dpm/100 cm^2)
Ludlum Model 2221	Ludlum Model 43-68	Beta	1736	271
Ludlum Model 2360	Ludlum Model 43-68	Alpha	N/A	59
		Beta	2981	393
Ludlum Model 2360	Ludlum Model 43-89	Alpha	N/A	47
		Beta	4292	612
Ludlum Model 3030E	Ludlum Model 43-10-1	Alpha	N/A	12
		Beta	N/A	159
Ludlum Model 19	Internal NaI	Gamma	N/A	N/A

3.7 Daily Instrument and Background Measurements

Daily instrument checks will be made according to written procedures. These measurements will be made in non-impacted areas using radioactive check sources. These measurements will be recorded for the purpose of ensuring that instruments are operating properly. An instrument control log will be used for each instrument to keep track of background counts and response checks.

Daily background measurements will also be made according to written procedures. These measurements will be made in non-impacted areas. Single background measurements used to estimate the mean background will be made for a minimum of 10 minutes for scaling instruments (scalers).

3.8 Reference Area Measurements

The radionuclides of concern at the BMRC fall into two distinct categories:

1) The DCGL is low and the radioisotope is generally not detectable in background samples (cobalt, silver, and europium), and

2) The DCGL is high compared to the expected background concentration (remaining isotopes)

Therefore, to simplify matters, the site release statistical tests will assume that none of the radioisotopes of concern are present in background. Based on this assumption, MARSSIM recommends the Sign Test for statistical comparisons. No reference area measurements are required for the Sign Test to release the site based on the soil sample results.

3.9 Projected Survey Units

The projected survey units and associated classes are shown in Table 3-7

Table 3-7: Survey Units

Survey Unit	Unit #	Class	Area (m^2)	Relative Shift	Required Data Points
N16	1	1	90	1.5	14
Tank Farm	2	1	105	1	29
Sub-Basement	3	1	300	1	29
Containment	4	1	420	1	29
Side slopes	5	2	1,230	3.0	14
Cooling Tower	6	2	105	1	29
Remainder	7	3	>2,000	3.0	14

3.9.1 Class 1 Survey Units

3.9.1.1 N16 Tank Area - Survey Unit 1

The N16 tank is known to have radioactivity greater than NRC and NYS Screening values for Co-60. Additionally, Ag-108m was elevated and has a high potential to be greater than the release criteria (Reference 7.5). The N16 tank area encompasses approximately 90 m^2.

A summary of the characterization data for the detected radionuclides of interest for this area is shown in the table below. This data summary excludes sample results greater than the relevant DCGL in order to properly calculate the relative shift.

Table 3-8: N16 Tank Area Characterization Results Summary

Radionuclide	LBGR	Standard Deviation	DCGL (pCi/g)	Calculated Relative Shift
Ag-108m	4.9	2.2	8.2	1.5
Co-60	2.54	0.84	3.8	15
Cs-137	1.86	1.75	11	5.2
Eu-152	0.54	0.86	6.9	7.3
Eu-154	0.34	0.37	8	20.7
H-3	4.8	2.4	110	43.8
Ni-63	33.7	25.1	2,100	82.3
Sr-90	0.14	0.13	1.7	12

The lowest relative shift calculated from this data is 1.5 which correlates to a minimum of 14 samples to meet MARSSIM data requirements.

3.9.1.2 Tank Farm Area – Survey Unit 2

The Tank Farm lies in the subsurface adjacent to the containment building and extends towards the southwest of the containment building. Sub-surface soil borings taken in the bordering areas of the tank farm do not indicate residual radioactive materials. The tank farm survey unit is approximately 105 m^2.

Data collection was not possible for the areas beneath the tank farm during the characterization process due to the risk of puncturing a tank. This results in insufficient data to calculate relative shift. As such, a relative shift of 1.0 is assumed which requires 29 survey locations to meet MARSSIM data requirements. Gross beta scan and static surface measurements will be performed in this area.

3.9.1.3 Sub-Basement – Survey Unit 3

The sub-basement area encompasses approximately half of the area beneath the administrative wing of BMRC directly adjacent to the containment structure. The sub-basement survey unit is approximately 300 m^2.

No data of the subsurface for this area was collected during the characterization. Therefore, a relative shift of 1.0 is assumed which requires 29 survey locations to meet MARSSIM data requirements. Gross beta scan and static surface measurements will be performed in this area.

3.9.1.4 Containment – Survey Unit 4

Concrete cores taken during the site characterization did not indicate the presence of radioactive materials greater than the DCGL, however a leak in the primary cooling piping at the point where the pipe penetrates the reactor pool tank has been noted providing historical knowledge of possible presence of residual radioactive materials beneath the floor of the neutron deck. The area of the containment is approximately 420 m^2.

More conclusive data collection was not possible during the characterization process in order to gather sufficient data to calculate relative shift. As such, a relative shift of 1.0 is assumed which requires 29 survey locations to meet MARSSIM data requirements. Gross beta scan and static surface measurements will be performed in this area.

3.9.2 Class 2 Units

There are two class 2 survey units identified for this FSSP. They total approximately 1,230 m^2. Table 3-9 summarizes the characterization data for the entire class 2 area.

Table 3-9: Class 2 Soil Characterization Results Summary

Radionuclide	LBGR	Standard Deviation	DCGL (pCi/g)	Calculated Relative Shift
Ag-108m	2.57E-02	1.23E-02	8.2	681.1
Co-60	4.22E-02	1.73E-02	3.8	221.0
Cs-137	9.95E-02	3.59E-02	11	302.8
Eu-152	1.01E-01	5.64E-02	6.9	121.4
Eu-154	4.75E-02	2.36E-02	8	331.3
H-3	4.12E+00	9.58E-01	110	110.2
Ni-63	1.19E+01	2.03E+00	2,100	1028.6

Because the lowest calculated relative shift is greater than 3, the survey design will use a relative shift of 3 to calculate the appropriate number of data locations to meet MARSSIM requirements. This means that a minimum of 14 locations will be designated for each identified survey unit.

3.9.2.1 Side Slopes – Survey Unit 5

The side slopes of the excavation surround the Class 1 units. The table below provides a summary of the characterization results. In order to properly calculate the relative shift, the LBGR shown is the maximum value detected in the soils samples. Volumetric sampling at a minimum of 14 locations will be performed in this area to determine the final radiological status.

3.9.2.2 Cooling Tower, Sewer, Tank Farm Piping – Survey Unit 6

The area encompassing the former cooling tower area also contains sewer lines and the discharge lines from the tank farm. This area is conservatively segregated as its own single class 2 area to determine the final radiological conditions present. Gross beta scan and static surface measurements at a minimum of 14 will be performed in this area.

3.9.3 Class 3 Unit

3.9.3.1 Remaining Area – Survey Unit 7

The class three survey unit comprises the remainder of the project area. Characterization data of soils for the class 2 area is sufficient for use in determining the required quantity of data locations for the class 3 unit. This means using a relative shift of 3.0 which requires 14 data locations to meet MARSSIM data requirements. Volumetric sampling will be performed in this area to determine the final radiological status.

3.10 Volumetric Sample Collection

Volumetric samples (e.g. the side slopes of the excavation area) will be collected. These samples are to be representative of surface soil conditions up to 15 centimeters deep (i.e. ~6 inches). In order to maintain safe access to the excavation, the construction contractor will be required to either slope or bench the sides in accordance with OSHA regulations. Regardless of either method, collection of the soil samples will be the same and should result in approximately one kilogram of soil placed into a clean container. Procedures detailing sample collection methodology have been developed.

Volumetric samples will be analyzed for the radionuclides listed in Table 3-1 at an approved off-site laboratory using an appropriate combination of gamma spectroscopy, alpha spectroscopy and liquid scintillation as presented in Table 3-10.

Table 3-10: Analysis Methods for Volumetric Samples

Radionuclide	Analysis Method
Ag-108m	Gamma spectroscopy
Am-241	Gamma spectroscopy
C-14	Liquid scintillation
Co-60	Gamma spectroscopy
Cs-137	Gamma spectroscopy
Eu-152	Gamma spectroscopy
Eu-154	Gamma spectroscopy
H-3	Liquid scintillation
Ni-63	Liquid scintillation
Pu-238	Alpha spectroscopy
Pu-239/240	Alpha spectroscopy
Sr-90	Liquid scintillation

3.11 Investigation Levels and Elevated Areas Test

During survey unit measurements, levels of radioactivity may be identified by an increase in count rate or an elevated sample result which warrants investigation. Elevated measurements may result from discrete particles, a distributed source, or a change in background activity. In any case, investigative actions should be implemented.

Depending on the investigation results, the survey unit may require:

- No action
- Remediation
- Reclassification and resurvey

3.11.1 Investigation Levels

Table 5.8 in the MARSSIM provides guidance on investigation levels for scan surveys. In addition to investigation levels for scan surveys, direct measurement survey investigation levels may be used. These additional investigation levels include a conservative value for Class 3 survey units and are provided in Table 3-11.

Table 3-11: Measurement Result Investigation Levels

Classification	Investigation Level
Class 1	Result >$DCGL_{emc}$
Class 2	Result >DCGL
Class 3	Result >50% DCGL

3.11.2 Investigation Process

Technicians respond to all audibly detectable elevated count rates while surveying. Upon observing a count rate above the IL (MDCR), the technician stops and resurveys the suspect area to verify the count rate elevation and determine the areal extents of the elevated count rate. Technicians are cautioned, in training, about the importance of the elevated count rate and the verification survey. They are given specific direction regarding the extent and scan speed of the verification survey. If the elevated count rate is verified, the technician marks the area. Each marked area will receive an additional documented survey which requires a re-scan of the area and one or more direct measurements and removable contamination wipes. Results of each investigation are discussed and reported in the FSS Report.

The size and average activity level in the elevated area will be defined to determine compliance with the area factors. If any location in a Class 2 area exceeds the DCGL, scanning coverage is increased in order to determine the extent and level of the elevated reading(s). If any location in a Class 2 area exceeds the $DCGL_{emc}$, the area will be reclassified as a Class 1 area. If the elevated reading occurs in a Class 3 area, the scanning coverage is increased and the area may be reclassified, if necessary.

Investigations should consider:

- The assumptions made in the survey unit classification
- The most likely or known cause of the contamination
- The possibility that other areas within the survey unit may have elevated areas of activity that may have gone undetected

Depending on the results of the investigation, a portion of the survey unit may be reclassified if there is sufficient justification. The results of the investigation process are documented in the survey area Release Record. See Section 3.11.4 for additional discussion regarding potential reclassification of the survey unit.

3.11.3 Elevated Measurement Comparison DCGL

The $DCGL_{emc}$ is not expected to be used during this FSS based upon site characterization data. Should scan measurements of these soils exceed the investigation levels, use of the elevated measurement comparison $DCGL_{emc}$will be considered. The EMC DCGL ($DCGL_{emc}$) provides assurance that unusually large measurements receive the proper attention and that any area having the potential for significant dose contribution is identified and not averaged out over a large area. As stated in the MARSSIM, the EMC is intended to flag potential failures in the remediation process and should not be considered the primary means to identify whether or not a survey unit meets the release criterion.

Locations identified by scan with levels of residual radioactivity which exceed the $DCGL_{emc}$ or static measurements with levels of residual radioactivity which exceed the $DCGL_{emc}$ are subject to additional surveys to determine compliance with the EMC. The size of the area containing the elevated residual radioactivity and the average level of residual activity within the survey unit are determined. The initial $DCGL_{emc}$ is established during the survey design and is calculated as follows:

$DCGL_{emc}$ determination: $$DCGL_{emc} = AF * DCGL$$

Where:
AF = Area Factor corresponding to the size of the elevated area
DCGL = Derived Concentration Guideline Limit

The area factor is a multiple of the DCGL that is permitted for the area of elevated residual radioactivity without remediation. The area factor is related to the size of the area over which the elevated activity is distributed. That area is generally bordered by levels of residual radioactivity below the DCGL and is determined by the investigation process.

The area assumed for the NRC screening values is unlimited based on the setting for the DandD code. To calculate the $DCGL_{emc}$, the DandD code was run for the radionuclides at the default values except the area of contamination was changed to 1 square meter. For small areas of radioactivity, the DCGL values calculated from the modified DandD run (listed in Table 3-12 below) were used to calculate the area factors and then the most conservative factor (i.e., 5 for tritium) was selected to be used for all radionuclides.

Table 3-12: DCGLemc Values

Radionuclide	Default DCGL (pCi/g)	$DCGL_{emc}$ (pCi/g)	Area Factor
	Unlimited Area	1 m^2	
Cobalt 60	3.80	27	7
Tritium	110	554	5
Europium 152	7.0	62	9

The actual area of elevated activity is determined by investigation surveys and the area factor is adjusted for the actual area of elevated activity. The product of the adjusted area factor and the DCGL determines the actual $DCGL_{emc}$. If the $DCGL_{emc}$ is exceeded, the area is remediated and resurveyed. Should the EMC be used during this FSS, investigation surveys and the EMC evaluation shall be described in detail in the FSS report.

The results of the elevated area investigations in a given survey unit that are below the $DCGL_{emc}$ limit are evaluated using the equation below. If more than one elevated area is identified in a given survey unit, the unity rule can be used to determine compliance. If the formula result is less than unity, no further elevated area testing is required and the EMC test is satisfied.

Elevated area evaluation:

$$\frac{\delta}{DCGL_w} + \frac{C_{avg} - \delta}{(AF)(DCGL_w)} < 1$$

Where:

δ = average residual activity in the survey unit
C_{avg} = average concentration of the elevated area
AF = Area Factor corresponding to the size of the elevated area

When calculating δ for use in this inequality, measurements falling within the elevated area may be excluded provided the overall average in the survey unit is less than the DCGL.

Compliance with the soil $DCGL_{emc}$ is determined using gamma spectroscopy results and a unity rule approach. These general methods are also applied to other materials where sample gamma spectroscopy is used for FSS. The application of the unity rule to the EMC requires that area factors and a corresponding $DCGL_{emc}$ be calculated separately for any gamma emitters of reactor origin identified during FSS.

3.11.4 Remediation and Reclassification

Areas of elevated residual activity above the $DCGL_{emc}$ within any classification are remediated to reduce the residual radioactivity to acceptable levels. Whenever an investigation confirms activity above an action level applicable to the classification, an evaluation of the operational history, design information, and sample results is performed to assure the area was classified properly. The evaluation considers:

- The elevated area location, dimensions, and sample results.
- An explanation of the potential cause and extent of the elevated area in the survey unit.
- The recommended extent of reclassification, if considered appropriate.
- Any other required actions.

If an individual scan or static location measurement within a survey unit exceeds the applicable investigation level listed in Table3-8, the survey unit or a portion of it may be reclassified and the survey redesigned and re-performed accordingly. Instrument performance, background fluctuation, surveyor performance, ambient radiological conditions, and other variables should be considered to avoid unnecessary reclassification.

3.11.5 Reclassification and Resurvey

Following an investigation, if a survey unit is reclassified or if remediation activities occur, a resurvey will be performed. If the average value of Class 2 direct survey measurements was less than the DCGL, the MDC_{scan} was sensitive enough to detect the $DCGL_{emc}$ and there were no areas greater than the $DCGL_{emc}$, the survey redesign may be limited to obtaining a 100% scan without having to re-perform the direct measurements. This condition assumes that the sample density meets the requirements for a Class 1 area. If the Class 2 area had contamination greater than the DCGL, but the MDC_{scan} was not sensitive enough to detect the $DCGL_{emc}$, the affected area is reclassified as Class 1 and resurveyed with the sample density determined for the new classification. Class 3 areas are treated in a similar manner, using 50% DCGL as the investigation limit. If a Class 3 area had activity in excess of 50% DCGL, but less than the DCGL and the MDC_{scan} was sensitive enough to detect the $DCGL_{emc}$, then the expansion of scan survey coverage to 100% will be sufficient. If activity is detected above the DCGL, or the MDC_{scan} was not

sensitive enough, the area is increased to the appropriate classification as determined by the activity detected and the survey redesigned. Reclassification of a survey area will be detailed in the FSS Report.

4.0 DATA QUALITY OBJECTIVES

The Data Quality Objective (DQO) process provides systematic procedures for defining the criteria that the FSS survey design should satisfy. The following DQOs are quantitative and qualitative statements derived from the output of the DQO process.

- Data quality will be assessed through a combination of on-site analysis of duplicate samples, replicate on-site analyses, and replicate off-site analyses and is further described in the Quality Assurance Project Plan.
- The Null Hypothesis (H_0) selected is that the residual activity in the survey unit is assumed to exceed the release criteria.
- The LBGR is defined as the average of the characterization data for results that meet the appropriate DCGL.
- Relative shift will be between 1 and 3. Adjustment of the LBGR, standard deviation, or both are acceptable to achieve a relative shift between 1 and 3 as is selection of a lower than calculated relative shift.
- The Type I and Type II decision error probabilities for determining the number of samples per survey unit for comparison tests are both 5%. The Type II decision error may be increased so long as it does not affect the quality of the data.
- Off-site soil sample analysis MDC should be less than 25% of the DCGL.
- The MDC_{scan} will be less than 100% of the $DCGL_{emc}$.
- Survey measurements will be documented and controlled as quality documents.
- Data collection locations in Class 1 and Class 2 survey units will be established using a triangular grid pattern with a random starting location.
- Data collection locations in the class 3 survey unit will be random.

DQOs may be adjusted during the course of the project, such as changing the Type II error rate, or slightly altering the limits of the MDCs with respect to the DCGL may be done as long as the modifications do not alter the quality of the FSS survey data.

5.0 FSS REPORT

Survey results are documented in the FSS Report. Survey results will be described in written reports to the NRC. The FSS report provides a summary of the survey results and the overall conclusions which demonstrate that the BMRC site meets the radiological criteria for release. Information such as the number and type of measurements, basic statistical quantities, and statistical analysis results are included in the report. The level of detail is sufficient to clearly describe the FSS program and to certify the results. The basic outline of the final reports will be:

1.0 Executive Summary
2.0 Introduction

- Purpose and Objective
- Project Background
- Decommissioning Activities

3.0 Final Status Survey Methodology

- Release Criteria
- Classification and sample size
- Types and Methods of Surveys
- Survey Instrumentation

4.0 Final Status Survey Results

- Number of measurements taken
- Survey maps
- Sample concentrations
- Statistical evaluations, including power curves
- Judgmental and miscellaneous data sets
- Elevated Measurement Comparisons (if used)

5.0 Conclusions
6.0 References

6.0 QUALITY ASSURANCE

It is important to maintain the integrity of the data collected during the final status survey. The DOC shall operate under a strict quality assurance (QA) program that includes the elements described in Chapter 9 of MARSSIM and Section 1.2.4 of the DP. QA protocols cover items such as document control, control of measurement and test equipment, chain-of-custody, and data validation and verification.

6.1 Training and Qualification

Personnel performing FSS measurements will be trained and qualified. At a minimum, training will include the following topics:

1. Procedures governing handling FSS data such as, but not limited to, document control, records retention, and chain of custody.
2. Operating field and laboratory instrumentation used for FSS.
3. Performing FSS measurements and collecting samples.

The extent of training and qualification will be commensurate with the education, experience and proficiency of the individual and the scope, complexity and nature of the activity. Training records will be maintained as quality records.

6.2 Measurement/Data Acquisition

6.2.1 Survey Design

The site will be divided into survey areas. Each survey area will contain one or more survey units. A survey package specifies the type and number of measurements required for a survey unit based on the classification and known characterization data results. Each survey unit will have a survey package.

6.2.2 Written Procedures

To assure proper performance, acquisition, consistency and overall quality of the data and measurements used in the Final Status Survey, sampling and survey tasks are performed in accordance with approved, written procedures. Procedures describe and delineate the methods and techniques used for the sampling, survey and data acquisition and evaluation tasks and each includes a section describing the QA/QC goals and methods specific to that procedure.

6.2.3 Sampling Methods

Samples are collected and placed into new containers using either new tools or tools that have been thoroughly decontaminated and double-rinsed with clean water from two sources, i.e., two separate dip tanks. Surface abrasion of the tools may be necessary to dislodge adhered media from previous samples. This may entail using a stiff-bristled brush in the first dip tank. Tools will be air- or towel-dried prior to reuse.

6.2.4 Chain of Custody

Responsibility for custody of samples from the point of collection through the determination of the final survey results is established by procedure. When custody is transferred, a chain of custody will accompany the sample for tracking purposes. Secure storage is provided for archived samples until such time it is determined to no longer be necessary, i.e. license termination for samples utilized for FSS.

6.2.5 Survey Documentation

Each FSS measurement will be identified by date, instrument, location, type of measurement, and mode of operation. Generation, handling and storage of the original FSS design and data packages will be controlled. The FSS records have been designated as quality documents and will be maintained in accordance with document control procedures.

6.3 Volumetric Analyses

For soil samples, Quality Control will consist of requiring the vendor analytical laboratory to meet or exceed the qualifications 10CFR50 Appendix B, the National Environmental Laboratory Accreditation Program (NELAP), or the National Voluntary Laboratory Accreditation Program (NVLAP). However, as an additional quality measure, randomly selected samples may be subjected to blank sample, blind duplicate, split, recount, or third party analyses. The acceptance criterion for blank samples is that no plant-derived radionuclides are detected to the required MDA. The criterion for blind duplicates, split, recount, and third party analyses is that the two measurements are within ±20% of each other. Samples that fail the above criterion shall be investigated and corrective action taken as necessary.

6.4 Instrument Selection, Calibration and Operation

Proper selection and use of instrumentation ensure sensitivities are sufficient to detect radionuclides at specified MDCs. An overview of the required capabilities is presented in Section 3.0. These requirements help assure the validity of the collected survey data. Instrument calibrations are performed with NIST-traceable sources using approved procedures.

6.5 Data Management

Survey data control from the time of collection through evaluation is specified by procedure. All survey and data analysis records pertaining to the final radiological status of the BMRC are considered quality records and are maintained by the University in accordance with applicable document control procedures.

6.6 Data Validation

Survey data are reviewed prior to evaluation or analysis for completeness and for the presence of outliers. Comparisons to investigation levels are made and measurements exceeding the investigation levels are evaluated.

6.7 Confirmatory Measurements

It is anticipated that the NRC and other regulatory agencies will choose to conduct confirmatory measurements in accordance with applicable laws and regulations. The NRC may take confirmatory measurements to make a determination in accordance with 10 CFR 50.82(a)(11) that the final radiation survey and associated documentation demonstrate that the facility and site are suitable for release in accordance with the criteria for decommissioning in 10 CFR Part 20, Subpart E. Confirmatory measurements taken by the NRC and other regulatory agencies are based on the same DCGLs. Timely and frequent communications with these agencies ensure that they are afforded sufficient opportunity for these confirmatory measurements prior to any difficult to reverse decommissioning actions.

7.0 REFERENCES

7.1 Enercon Services, Inc, "Decommissioning Plan Buffalo Materials Research Center",

7.2 U.S. Nuclear Regulatory Commission, "Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)", NUREG-1575, Revision 1, August 2001.

7.3 U.S. Nuclear Regulatory Commission, "Supplemental Information on the Implementation of the Final Rule on Radiological Criteria for License Termination", Federal Register, Volume 63, Number 222. November 18, 1998.

7.4 Code of Federal Regulations, Chapter 10, Part 20 (10 CFR 20), Subpart E, Radiological Criteria for License Termination.

7.5 Enercon Services, Inc, "Site Characterization Report Buffalo Materials Research Center", July 2011

7.6 U.S. Nuclear Regulatory Commission, "Minimum Detectable Concentrations With Typical Radiation Survey Instruments for Various Contaminants and Field Conditions", NUREG-1507, June 1998.

7.7 Ludlum Measurements, Inc, "Energy Response for Ludlum Model 44-10"

8.0 ATTACHMENTS

8.1 Microshield Analysis for MDC_{scan} Determination for Co-60

8.2 Microshield Analysis for MDC_{scan} Determination for Ag-108m

Attachment 8.1

Filename	Run Date	Run Time	Duration
Co-60.msd	April 19, 2012	2:35:59 PM	00:00:00

Project Info

Case Title	BMRC Co-60
Description	Inf. Slab 3.8 pCi/g
Geometry	16 - Infinite Slab

Source Dimensions

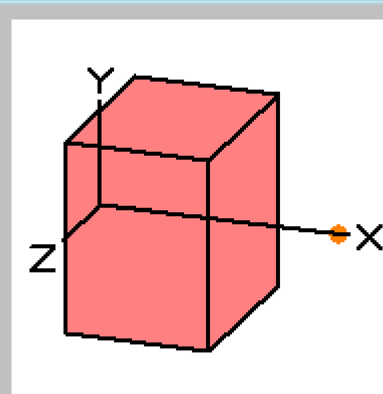
Thickness	15.0 cm (5.9 in)

Dose Points

A	X	Y	Z
#1	25.0 cm (9.8 in)	0.0 cm (0 in)	0.0 cm (0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Air Gap		Air	0.00122



Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Co-60	6.0800e-006	2.2496e-001

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.6	3.670e-05	8.138e-05	2.946e-04	1.588e-07	5.750e-07
1.0	2.250e-01	1.022e+00	2.626e+00	1.884e-03	4.841e-03
1.5	2.250e-01	1.817e+00	3.654e+00	3.057e-03	6.148e-03
Totals	**4.500e-01**	**2.839e+00**	**6.281e+00**	**4.941e-03**	**1.099e-02**

Attachment 8.2

Filename	Run Date	Run Time	Duration
Ag-108m.msd	April 19, 2012	2:37:49 PM	00:00:00

Project Info	
Case Title	BMRC Ag-108m
Description	Inf. Slab 8.2 pCi/g
Geometry	16 - Infinite Slab

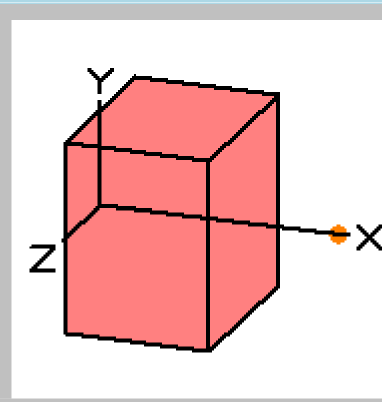
Source Dimensions	
Thickness	15.0 cm (5.9 in)

Dose Points

A	X	Y	Z
#1	25.0 cm (9.8 in)	0.0 cm (0 in)	0.0 cm (0 in)

Shields

Shield N	Dimension	Material	Density
Source	Infinite	Soil	1.6
Air Gap		Air	0.00122



Source Input: Grouping Method - Standard Indices
Number of Groups: 25
Lower Energy Cutoff: 0.015
Photons < 0.015: Included
Library: Grove

Nuclide	µCi/cm³	Bq/cm³
Ag-108m	1.3100e-005	4.8470e-001

Buildup: The material reference is Air Gap
Integration Parameters

Results

Energy (MeV)	Activity (Photons/sec)	Fluence Rate MeV/cm²/sec No Buildup	Fluence Rate MeV/cm²/sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	2.612e-02	1.503e-04	1.692e-04	1.289e-05	1.451e-05
0.02	3.179e-01	4.701e-03	6.381e-03	1.628e-04	2.210e-04
0.03	1.029e-07	3.976e-09	9.220e-09	3.941e-11	9.137e-11
0.08	3.435e-02	5.348e-03	6.065e-02	8.463e-06	9.598e-05
0.4	4.357e-01	5.520e-01	2.772e+00	1.076e-03	5.401e-03
0.6	4.381e-01	9.717e-01	3.518e+00	1.897e-03	6.866e-03
0.8	4.386e-01	1.454e+00	4.352e+00	2.766e-03	8.278e-03
Totals	**1.691e+00**	**2.988e+00**	**1.071e+01**	**5.923e-03**	**2.088e-02**