FINAL

FINAL STATUS SURVEY REPORT

ALL AREAS EXCEPT 5th FLOOR AND 5th FLOOR ADDENDUM

National Urban Security Technology Laboratory

U.S. Department of Homeland Security

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JMC Project 2006-001

Submitted by:

CABRERA SERVICES
RADIOLOGICAL•ENGINEERING•REMEDIATION

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
ALARA	as low as reasonably achievable
ASHRAE	American Society of Heating, Refrigerating and Air Conditioning Engineers
BNL	Brookhaven National Laboratory
CABRERA	Cabrera Services, Inc.
CFR	Code of Federal Regulations
cpm	counts per minute
DCGL	Derived Concentration Guideline Level
DHS	U.S Department of Homeland Security
DOE	U.S. Department of Energy
dpm/100 cm^2	disintegrations per minute per 100 square centimeters
DQO	data quality objective
EMC	elevated measurement comparison
EML	Environmental Measurements Laboratory
EPA	U.S. Environmental Protection Agency
ERDA	Energy Research and Development Administration
FSS	Final Status Survey
FSSP	Final Status Survey Plan
GSA	General Services Administration
JMC	Joint Munitions Command
LBGR	Lower Bound Gray Region
LTR	License Termination Rule
m	meter
m^2	square meter
MARSSIM	Multi-Agency Radiation Survey and Site Investigation Manual
MeV	megaelectron volts
mrem/yr	millirem per year
NMSS	the Office of Nuclear Material Safety and Safeguards
NRC	U.S. Nuclear Regulatory Commission
NUSTL	National Urban Security Technology Laboratory
NYCDOH	New York City Department of Health
QA	Quality assurance
QC	Quality control
ROCs	radionuclides of concern
SU	Survey Unit
WRS	Wilcoxon Rank Sum
yr	year

EXECUTIVE SUMMARY

The U.S. Department of Homeland Security (DHS) National Urban Security Technology Laboratory (NUSTL, formerly Environmental Measurements Laboratory [EML]) leases space from the United States General Services Administration (GSA) building located in lower Manhattan at 201 Varick Street. NUSTL currently occupies less than half of the fifth floor of the building, and small areas in the first floor, basement, and roof. As EML, the Laboratory was formerly part of the U.S. Department of Energy (DOE), at which time it occupied the entire fifth floor and its operations included environmental radiochemistry. Currently, no handling of unsealed radioactive sources occurs within the facility. DHS wishes to achieve unrestricted release of the NUSTL and all of the areas that may have been impacted by its past operations. To this end, Cabrera Services, Inc. (CABRERA) has been contracted via U.S. Army Joint Munitions Command (JMC) to provide radiological remediation and characterization to facilitate release of the facility. A *Final Status Survey (FSS) Report* presenting the results for the FSS performed of the impacted areas on the 5th floor of the building was submitted in December 2008 under separate cover (CABRERA, 2008). The present *FSS Report* details the remediation, waste disposal, and FSS activities performed in the areas impacted by NUSTL past activities in the basement, 1st floor, 4th floor, and roof, and provides an addendum for the 5th floor FSS Report (CABRERA, 2008).

Areas outside of the 5th floor that were used by NUSTL/EML during their operations include rooms B-15 (including B15A and B15C) and B-8 in the basement, NUSTL's first floor space (including Laboratories #1 and #2 and dust collectors), and an air duct system on the roof. Over the course of EML operations, radioactive solutions were poured down the sink of a 5th floor laboratory (Room 544). Radioactive contamination was identified inside the drain pipe from that sink that ran down through the fifth floor and along the ceiling of the 4th floor. This pipe was removed and the areas on the 4th floor impacted as a result of the removal action were surveyed for residual radioactive contamination.

The impacted areas outside of the 5th floor were divided into 12 distinct survey units (SUs) which were surveyed for radiological contamination, remediated to acceptable levels (if required), and finally surveyed for compliance with the approved release criteria via Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) FSS protocols. The FSS included exposure rate measurements, alpha/beta scans, and fixed and removable alpha/beta activity measurements at systematic and biased survey locations.

The results of the FSS for each SU revealed no contamination above criteria set forth in the *FSSP* (CABRERA, 2007a). Survey data collected in this effort and contained in this report meet the criteria derived in the *FSSP* (CABRERA, 2007a) for supporting the unrestricted radiological release of the NUSTL areas in the basement, 1st floor, 4th floor, 5th floor, and roof of the building.

1.0 INTRODUCTION

This *Final Status Survey Report* presents results of the final status survey (FSS) conducted by Cabrera Services, Inc. (CABRERA) to support the radiological decommissioning of the basement, 1st floor, 4th floor, and roof space that were impacted by past operations performed by the Department of Homeland Security (DHS) National Urban Security Technology Laboratory (NUSTL, formerly Environmental Measurements Laboratory [EML]). NUSTL leases space from General Services Administration (GSA) in the building located at 201 Varick Street in lower Manhattan, New York. A *Final Status Survey Report* presenting the results for the FSS performed of the impacted areas on the 5th floor of the DHS-NUSTL building was submitted in December 2008 under separate cover (CABRERA, 2008). Activities described in that report and this present report were conducted in accordance with the *FSS Plan* (CABRERA, 2007a) and *Site Safety and Health Plan (SSHP) – Environmental Measurements Laboratory – Department of Homeland Security* (CABRERA, 2007b), presented in Annex A and Annex B, respectively. This report has been prepared by CABRERA for the United States Army Joint Munitions Command (JMC), under JMC Project Number *DHS 2006-001, contract W52P1J-06-D-0019.*

1.1 Site Description and Background

NUSTL is now part of DHS, but it was formerly part of DOE and DOE's predecessor organizations, the Atomic Energy Commission (AEC) and the Energy Research and Development Administration (ERDA). NUSTL is the third name in the laboratory's history, following the Health and Safety Laboratory (HASL, 1953–1977) and the Environmental Measurements Laboratory (1977–2009). HASL moved to 201 Varick Street in 1959.

NUSTL currently occupies less than half of the fifth floor of the GSA Building at 201 Varick Street, and small areas in the first floor, basement, and on the roof. As EML, the Laboratory occupied the entire fifth floor, and its operations included environmental radiochemistry. Currently, no handling of unsealed radioactive sources occurs within the facility.

Several areas of radiological contamination on the fifth floor of the site were remediated as documented in the FSS for the 5th floor (CABRERA, 2008).

Areas outside of the 5th floor where radionuclides were used or stored, or might have migrated to include rooms B-15 and B-8 in the basement, NUSTL's first floor space (including Laboratories #1 and #2), and an air duct system on the roof.

In the NUSTL area of the building basement, in room B-15, radium contamination was known to exist on the floor and walls. The removable contamination in this area was encapsulated by the Environmental & Waste Management Services Division of Brookhaven National Laboratory (BNL) in June of 2004 (Brookhaven, 2004) to prevent spreading of the contamination. CABRERA'S decontamination effort included removal of the encapsulated contamination.

CABRERA personnel found contamination in a sink drain in Room 544 during a radiological survey performed in 2007. Over the course of laboratory operations, radioactive solutions were poured down the sink drain, causing the downstream run of the drain pipe to become contaminated. The drain pipe ran down through the fifth floor and above the ceiling across Room D-66 and a Men's and a Women's Restroom on the 4th floor.

1.2 Radionuclides of Concern

Several radionuclides of concern (ROCs) were identified in the *FSSP* (CABRERA, 2007a) as the result of historical operational radiological safety surveys, a comprehensive survey of the EML chemistry laboratories performed by BNL (Brookhaven 2005), and the historical operational knowledge of personnel at the facility. In addition, other radionuclides were identified during the course of the project; these are H-3, C-14, Fe-55, Co-60, Ba-133, Th-230, U-234, Pu-241, Pu-242, Am-241, Am-243, Cm-143, and Cm-244. These additional radioisotopes were documented in a historic radioisotope inventory of radioactive materials used at the facility and corroborated by discussions with Paul Goldhagen and Ray Lagomarsino of DHS NUSTL. Table 1-1 is a list of ROCs specifically identified or those with any significant likelihood of what might have been remaining at the site. ROCs specifically denoted as being at the facility in significant quantities are listed. However, the potential exists for other nuclides with atomic numbers up to 92 to have been historically present at the site in environmental samples or radionuclide standard solutions during past operations under AEC, ERDA, or DOE. Isotopes with half-lives of less than 6 months are not likely to be present at the site in significant activity at the present time, and are not included in the list.

Table 1-1: Radionuclides of Concern

NUCLIDE	NAME	HALF-LIFE	PRINCIPAL EMISSIONS (MEV)	SOURCE OF RADIONUCLIDE
^{3}H	Hydrogen-3	12.32 yr	0.0186 beta	standard solution
^{14}C	Carbon-14	5,700 yr	0.157 beta	standard solution
^{55}FE	Iron-55	2.74 yr	0.006 gamma*	standard solution
^{60}CO	Cobalt-60	5.27 yr	1.173 gamma* 1.332 gamma*	standard solution
^{63}NI	Nickel-63	100.1 yr	0.067 beta	standard solution
^{90}SR/^{90}Y	Strontium / Yttrium-90	28.6 yr	2.280 beta*	standard solution
^{99}TC	Technetium-99	21.3E4 yr	0.293 beta	standard solution
^{133}BA	Barium-133	10.55 yr	0.356 gamma*	standard solution
^{137}CS/^{137M}BA	Cesium-137 / Barium-137m	30.08 yr	0.511 beta 0.662 gamma	standard solution
^{226}RA	Radium-226	1,600 yr	4.785 alpha 0.168 beta 0.186 gamma	standard solution
^{230}TH	Thorium-230	7.54E4 yr	4.687 alpha*	standard solution
^{232}TH	Thorium-232	1.4E10 yr	4.010 alpha*	standard solution
^{234}U	Uranium-234	2.46E5 yr	4.775 alpha*	standard solution
^{235}U	Uranium-235	7.04E8 yr	4.396 alpha* 0.014 beta* 0.186 gamma*	standard solution
^{238}U	Uranium-238	4.47E9 yr	4.196 alpha* 0.029 beta*	standard solution
^{238}PU	Plutonium-238	87.75 yr	5.499 alpha* 0.021 beta*	standard solution
^{239}PU	Plutonium-239	2.41E4 yr	5.157 alpha*	standard solution
^{240}PU	Plutonium-240	6,561 yr	5.168 alpha*	standard solution
^{241}PU	Plutonium-241	14.29 yr	0.0208 beta*	standard solution
^{242}PU	Plutonium-242	3.74E5 yr	4.902 alpha*	standard solution
^{241}AM	Americium-241	432.6 yr	5.486 alpha* 0.0595 gamma*	standard solution
^{243}AM	Americium-243	7,370 yr	5.275 alpha* 0.0522 gamma*	standard solution
^{243}CM	Curium-243	29.10 yr	5.785 alpha* 0.103 gamma*	standard solution
^{244}CM	Curium-244	18.11 yr	5.804 alpha*	standard solution

Notes:

MeV = megaelectron volts
* = most abundant
yr = year

2.0 DERIVED CONCENTRATION GUIDELINE LEVELS

The establishment of derived concentration guideline levels (DCGLs) that were used to guide site decommissioning activities is set forth in the *FSSP* (CABRERA, 2007a) and described in the *Final Status Survey Report: 5th Floor* (CABRERA, 2008). DCGLs, expressed for surface activity in dpm/100 cm^2, represent the residual radioactivity concentrations (above background) on surfaces that correspond to the allowable radiation dose limit, considering the collective risks to human health associated with anticipated potential exposure scenarios and pathways to a potential future site population. Demonstrating that residual radioactivity remaining at the site is statistically within site-specific DCGLs maintains compliance with acceptable risk to a potential future site population.

These DCGL values were used for FSS operations were identified as conservative values and are listed in Table 2-1 below.

Table 2-1: Surface Activity DCGLs for NUSTL Final Status Survey

Agency / Reference	Alpha		Beta/Gamma	
	Total (dpm/100cm^2)	Removable (dpm/100cm^2)	Total (dpm/100cm^2)	Removable (dpm/100cm^2)
Chosen DCGL For DHS NUSTL	***500***[1]	***20***[1]	***1,000***[1]	***200***[1]

Notes:
1. Averaged over 1 m^2, provided no 100 cm^2 area exceeds three times the specified limit

Compliance with the NRC License Termination Rule (LTR) presented in 10 CFR 20, Subpart E, which specifies an allowable dose limit of 25 millirem/year (mrem/yr) was performed for all survey units (SUs) at the site, including the 5th floor. A review was performed based on process knowledge to identify areas in which the most restrictive ROCs were utilized per the critical population (“P_{crit}”) 0.90 activity concentrations contained in Table 5.19 of NUREG/CR-5512 (NRC, 1999). Rooms at the site with the highest residual concentrations of radioactive material in direct comparison to the Table 5.19 concentrations upon completion of the FSS were evaluated to ensure compliance with the NRC limit of 25 millirem per year. Based on this review, evaluations were performed for Rooms B-8 and 544 on the 5th floor and are provided in Annex C.

3.0 FINAL STATUS SURVEY DESIGN

Decommissioning planning was conducted in accordance with guidance presented in NUREG-1757, *Consolidated NMSS* (the Office of Nuclear Material Safety and Safeguards) *Decommissioning Guidance, Volumes 1 and 2*, (NRC, 2003a and 2003b). This section summarizes the design of the FSS conducted at NUSTL, as described in the *FSSP* (CABRERA, 2007a). The survey design discussed below is based on the technical guidance and statistical methods presented in the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (NRC, 2000), as required by *NUREG-1757, Volumes 1 and 2*, (NRC, 2003a and 2003b).

3.1 Determine Impacted and Non-Impacted Areas

Following field surveys conducted in March and November, 2007, it was determined that all areas of the basement and first floor utilized by NUSTL should be classified as impacted. This determination was made after SU surfaces in the basement were found to have previously undocumented radiological contamination. Specific areas covered under this evaluation include the following:

1. Approximately 570 square meters [m^2] in the basement, consisting of Rooms B-15 (laboratory including a radium work area) B-15A (Source Storage Room), B-15C (storage), and B-8 (storage)

2. Approximately 186 m^2 on the first floor, consisting of Lab #1 (Soil Grinder Room), Lab #2 (Environmental Air Filter Sorting), and the area around the Dust Collector (note that the Dust Collector was removed following completion of release surveys performed by CABRERA)

3. Approximately 20 m^2 on the 4th floor, consisting of a men's bathroom (Room D-29), an adjoining women's bathroom, the area above a drop ceiling in an adjoining office (Room D-66), and a drainage pipe running along the ceiling in these areas and continuing downstream from Room D-29

4. Approximately 10 m^2 on the roof, consisting of a rooftop air duct system

3.2 Area Classification Based On Contamination Potential

Impacted areas in the basement and on the 1st floor were initially classified in the *FSSP* (CABRERA, 2007a) based on contamination potential as per guidance in MARSSIM sections 2.2, 4.4, 5.5.2, and 5.5.3 (NRC, 2000):

- Class 1: The area had been contaminated above the release criteria, and it is possible to find radioactivity above the release criteria;
- Class 2: The area had radioactive material use, but it is unlikely to have radioactivity above the release criteria;
- Class 3: The area had some use of radioactive material, but is unlikely to contain any residual radioactivity.

During the course of the radiological remediation and FSS, several areas were reclassified from the *FSSP* (CABRERA, 2007a) designations due to additional information obtained during field efforts such as newly identified surface contamination or the recovery of previously unidentified radiological sources. The final SU classifications are discussed in Section 3.5.

3.3 Statistical Tests

3.3.1 Sign Test

The Sign test is designed to detect uniform contamination above screening limits throughout a SU. It draws direct comparisons between SU data and the chosen release criteria (i.e., DCGL). The Null Hypothesis is assumed to be true unless the statistical test indicates that it should be rejected in favor of the alternative. The null hypothesis states that the probability of a measurement less than the DCGL is less than one-half (i.e. the 50th percentile (or median) is greater than the DCGL). With this in mind, SUs may meet the release criteria even though some measurements may be greater than some uncontaminated reference area measurements. The result of the hypothesis test determines whether or not the SU as a whole meets the release criteria.

If all of the sample results are less than the DCGL then no Sign test statistical evaluation is required.

3.3.2 Application of Sign Test for Multiple Surfaces

The typical approach for evaluating internal building surfaces using the MARSSIM protocol involves the Wilcoxon Rank Sum (WRS) test. The WRS test requires that an appropriate background (reference) unit be surveyed for each material type in a SU such that gross measurements may be used for evaluating survey results. However, application of the WRS test for complex buildings with many structural surfaces can be cumbersome, as a single SU may require several background reference areas for proper evaluation. To address situations like this, a method for applying the Sign test to multiple surfaces was developed. The procedures for this are described in Chapter 12 of NUREG-1505 (NRC 1998).

NUREG-1505 states " …the Sign test may be more appropriate when there are many different materials within what would otherwise logically be a single SU. As indicated at the beginning of this chapter (Chapter 12), to divide such a SU into separate parts, each requiring its own reference area is not only impractical, but may be inconsistent with the dose models used to determine the DCGLs." "Fortunately, there is a third option – to use the Sign test with paired observations. Each measurement in the SU is paired with an observation on a suitable reference material. The Sign test is then performed on the difference. The tradeoff is the higher variability of the differences compared to a single measurement."

To account for this potential increased variability in measurement standard deviation from multiple surfaces, the planning sigma values used in the determination of the number of sample points per SU were doubled from their observed values during the Scoping Survey. Details of the SU design are provided in Section 3.8.

Representative background values to be used in the paired observations were collected in un-impacted areas of the buildings on similar building materials. The selection and measurement of the background reference areas were done at the start of the each field effort so they could be applied directly. A minimum of five (5) 1-minute fixed-point measurements were collected with the average used for subtraction from each systematic measurement location prior to evaluation using the Sign test. These background values are tabulated and included in Annex D.

3.3.3 Performing the Sign Test

The Sign test is applied as outlined in the following five steps from Section 8.3.2 of the MARSSIM. Each measurement had the appropriate background reading subtracted and the difference would be subject to the Sign test, outlined in the steps below:

Step 1: List the SU measurements, X_i, $i = 1, 2, 3, \ldots, N$.

Step 2: Subtract each measurement, X_i, from the DCGL to obtain the differences:

$$D_i = DCGL - X_i,\ i = 1, 2, 3, \ldots, N.$$

Step 3: Discard each difference that is exactly zero and reduce the sample size, N, by the number of such zero measurements.

Step 4: Count the number of positive differences. The result is the test statistic (S+). Note that a positive difference corresponds to a measurement below the DCGL and contributes evidence that the SU meets the release criterion.

Step 5: Large values of S+ indicate that the null hypothesis (that the SU exceeds the release criterion) is false. The value of S+ is compared to the critical values in MARSSIM Appendix I, Table I.3. If S+ is greater than the critical value, *k*, the null hypothesis is rejected.

3.4 Elevated Measurement Comparison

If a measurement showed a location of elevated activity greater than the DCGL and further decontamination is not possible, then the area around the location would need to be surveyed per the elevated measurement comparison (EMC) procedure. The EMC was performed for both measurements obtained on the systematic/random sampling grid and for bias locations flagged by scanning measurements. Any measurement from the SU that was equal to or greater than an investigation level indicated an area of relatively high concentrations and was investigated, regardless of the outcome of the nonparametric statistical tests. Investigation levels selected for this FSS are described in Section 3.7.

During the course of the field effort, areas where radiation levels exceeded the investigation levels were decontaminated, removed, or otherwise remediated prior to performance of the FSS. In each instance, decontamination efforts were successful in reducing surface contamination levels to below DCGLs (refer to Section 4.0). As such, the EMC procedure was not implemented in the course of this FSS.

3.5 SU Breakdown

Identification of impacted areas were determined based primarily on the review of the *EML Facilities Historic Utilization Team Report, August 2006, Radiological Surveys of EML Laboratories, September 30, 2005, Brookhaven National Laboratories,* and results of contamination surveys performed by CABRERA personnel in 2007. Classification of impacted areas was based on the likelihood of contamination based on the historical presence of radioactive materials supplemented with results from contamination surveys. Survey unit boundaries were identified based on area classifications and physical restrictions (e.g., walls, doors).

SUs were labeled according to the following scheme: “Floor”-“Room”-“Room Breakdown”. For example, two SUs were identified for Room B-15; B-15-F for the floor and B-15-W for the walls. Locations of SUs are illustrated in figures provided in Annex A, Appendix B.

Impacted, Class 1 Areas:

Basement Room B-15 was identified in the *FSSP* (CABRERA, 2007a) as a Class 1 area. Two SUs were identified in Room B-15; B-15-F for the floor and B-15-W for the walls.

Basement Room B-15A was identified in the *FSSP* (CABRERA, 2007a) as a Class 1 area. Two SUs were identified in Room B-15A; B-15A-F for the floor and B-15A-W for the walls.

Basement Room B-8 was originally classified as Class 2 in the *FSSP* (CABRERA, 2007a) but was reclassified as Class 1 based on the results of the contamination surveys. Two SUs were identified in Room B-8; B-8-F for the floor and B-8-W for the walls.

Basement Room B-15C was originally classified as Class 2 in the *FSSP* (CABRERA, 2007a) but was reclassified as Class 1 based on the results of the contamination surveys. Room B-15C was further divided into two SUs; B-15C for the floor and walls and B-15C-S to investigate residual radioactivity associated with the large shelving units in B-15C.

	The 4th Floor Men's Bathroom (Room D-29) was originally identified as non-impacted in the *FSSP* (CABRERA, 2007a). Based on the 5th Floor FSS (CABRERA, 2008) contamination was identified in the drain from a sink in Room 544. The removal of the contaminated pipe resulted in Room D-29 being identified as a Class 1 area. One SU was identified in Room D-29.
Impacted, Class 2 Areas:	Lab #1 on the 1st Floor was identified as a Class 2 area in the *FSSP* (CABRERA, 2007a). One SU was identified in Lab #1; SU L1. Lab #2 on the 1st Floor was identified as a Class 2 Area in the *FSSP* (CABRERA, 2007a). One SU was identified in Lab #2; SU L2. The Dust Collector on the 1st Floor was identified as a Class 2 area in the FSSP. One SU was identified for the Dust Collector; SU 1-Dust.
Impacted, Class 3 Areas:	The remainder of the rooms occupied by NUSTL on the 1st Floor were identified as a Class 3 area in the *FSSP* (CABRERA, 2007a). One SU was identified for the 1st Floor Class 3 areas: SU 1-R3. The rooftop air duct system of 201 Varick Street was identified as an impacted area based on discussions with NUSTL personnel during performance of the contamination surveys and the 5th Floor FSS. The roof was identified as a Class 3 area and one SU was identified to assess this area as discussed in the *FSSP* (CABRERA, 2007a).
Non-Impacted Areas:	The remaining areas of 201 Varick Street were identified as non-impacted areas. Non-impacted areas include the building lobby, stairwells, pipe chases, and 1st Floor utility closets.

3.6 SU Coverage

The coverage of radiation measurements in each SU is dependent upon the survey class. The survey classes are defined in this manner in order to simplify administration of the survey and handling of the data. General specifications for each SU class are provided below.

Class 1

Floors, Lower Walls (< 2 meters [m]) and Fixtures)

Perform an alpha/beta scan survey of 100% of accessible surfaces. Collect fixed-point measurements at systematic locations using a triangular grid pattern. Floor areas limited to 100 m^2, where practical. Collect additional fixed-point measurements at biased locations based on scan survey results (Section 3.10.1) or professional judgment.

Upper Walls (> 2m) and Ceilings

Perform an alpha/beta scan survey on at least 25% of accessible walls above 2 m and at least 10% of accessible ceiling surfaces. Collect fixed-point measurements at biased locations using professional judgment.

Class 2

Floors, Lower Walls (< 2m and Fixtures)

Perform an alpha/beta scan survey of at least 25% of accessible surfaces. Collect fixed-point measurements at systematic locations using a triangular grid pattern. Floor areas limited to 1,000 m^2, where practicable. Collect additional fixed-point measurements at biased locations using professional judgment.

Upper Walls and Ceilings

Perform an alpha/beta scan on at least 10% of accessible surfaces on walls and ceilings above 2 m. Collect fixed-point measurements at biased locations using professional judgment.

Class 3

All Surfaces and Fixtures

Perform an alpha/beta scan survey of at least 10% of all surfaces. Collect fixed-point measurements at computer-generated, random locations. No floor area size limit enforced.

3.7 Investigation Levels

Investigation levels were selected for this FSS as follows:.

- Class 1: sustained and repeatable survey instrument response observed at or above the surface activity DCGL
- Class 2: sustained and repeatable survey instrument response observed at or above half of the surface activity DCGL
- Class 3: sustained and repeatable survey instrument response observed above the material-specific background

If an investigation level was exceeded in a Class 1 SU, the area was remediated as appropriate to reduce the levels of residual radioactivity. The complete FSS was performed after remediation.

If an investigation level was exceeded in a Class 2 or Class 3 area, the room was reclassified as a separate Class 1 SU. The SU was then remediated as appropriate to reduce the levels of residual radioactivity. The complete FSS was performed after remediation.

3.8 Sampling Grid Layout

3.8.1 Relative Shift

The relative shift describes the relationship of site residual radionuclide concentrations to the DCGL and is calculated using the following equation, found in Section 5.5.2.2 of MARSSIM (NRC, 2000):

$$\frac{\Delta}{\sigma} = \frac{DCGL - LBGR}{\sigma}$$

where:

σ	=	An estimate of the standard deviation of the concentration of residual radioactivity in the SU (which includes real spatial variability in the concentration as well as the precision of the measurement system). Sigma values for static measurements and smears were set doubled from their observed values during the Scoping Survey to account for potential added variability.
Δ	=	The width of the gray region, i.e., DCGL minus the lower bound of the gray region (LBGR). The gray region is defined as "the range of values of the parameter of interest for a SU where the consequences of making a decision error are relatively minor".
DCGL	=	The derived concentration guideline level (i.e., release limit).
LBGR	=	Concentration at the LBGR. The LBGR effectively becomes the survey's action level. For conservatism, the LBGR was set to 0.5 times the DCGL for this FSS.

3.8.2 Number of Sampling Points

The *FSSP* (CABRERA, 2007a) established the acceptable decision errors α=β=0.05. Based on these acceptable decision errors and the relative shift, the minimum number of measurement locations in each SU was calculated in accordance with MARSSIM Section 5 methodology.

Table 3-1 shows the MARSSIM-based statistical parameters used in a calculation of the target number of samples per survey area.

Table 3-1: Summary of MARSSIM Design Parameters for the Site FSS

MARSSIM Parameter	Alpha Static Measurement[1] (cpm)	Beta Static Measurement[1] (cpm)	Alpha Smear (dpm/100 cm^2)	Beta Smear (dpm/100 cm^2)
σ	30[1,2]	60[1,2]	6[2]	60[2]
DCGL	100[4]	200[3]	20	200
LGBR	50	100	10	100
Relative Shift (Δ/σ)	1.67	1.67	1.67	1.67
Pr (from MARSSIM Table 5.4)	0.95	0.95	0.95	0.95
N	14	14	14	14
N (including 20% overage)[5]	*17*	*17*	*17*	*17*

Notes:

1. Static counts to be performed with Ludlum 43-68 proportional detector. Count time = 1 min.
2. Sigma values for static measurements and smears were set doubled from their observed values during the Scoping Survey to account for potential added variability (reference Section 3.3.2)
3. 200 counts per minute (cpm) is equivalent to the beta DCGL of 1,000 disintegrations per minute per 100 centimeters squared (dpm/100 cm^2) assuming 20% efficiency for the Ludlum 43-68 probe.
4. 100 counts per minute (cpm) is equivalent to the beta DCGL of 500 disintegrations per minute per 100 centimeters squared (dpm/100 cm^2) assuming 20% efficiency for the Ludlum 43-68 probe.
5. MARSSIM Section 5.5.2.2 recommends that the calculated number of samples per SU (N) be increased by 20%to account for uncertainty in the values used to calculate N. Final N rounded up to nearest whole number.

The LGBR was chosen as one-half of the DCGL as per guidance provided in the MARSSIM. The standard deviation for static and smear measurements were set at 30% of the DCGL as per MARRSIM recommendation when site specific standard deviation data is not available.

The results show that all of the measurements are sufficiently sensitive to allow a relatively small number of MARSSIM-type systematic measurements to be performed in each SU (i.e., 17). Scans and biased measurements are also important in demonstrating that the residual radioactivity levels are less than the DCGLs.

3.8.3 SU Grid Spacing

Grid spacing and placement of fixed-point measurement locations within each SU was based on a relative coordinate system.

The spacing of the data points for Class 1 and Class 2 areas is determined by:

$$L = \sqrt{\frac{A}{0.866\,n}}$$

where:

L = grid spacing

A = SU area (including wall area)

n = number of data points

The starting point was randomly selected and the data points located within the SU using a triangular grid for Class 1 or Class 2 areas. The systematic locations for floor areas included the first 2 m of each wall. If a grid point fell on a fixture such as a countertop, then the fixture was measured and so noted in the documentation.

Locations of measurement locations in Class 3 SUs were determined by multiplying the east-west (Y) and the north-south (X) dimensions of each SU by a randomly generated number between 0 and 1 for each dimension. For consistency, the southwest corner of each SU was used as the origin for each SU. Sample locations were calculated using a computer to determine random numbers and plot data point locations on a survey map. To facilitate field measurements, the calculated coordinates were rounded to the nearest whole number of feet.

3.9 Background Survey Areas

Determination of background values is of the utmost importance in building decommissioning projects. Since ‘net’ residual contamination values, or the difference between a sample count rate and background, are used to assert whether a particular SU satisfies the criteria for unrestricted release, application of accurate and applicable background values is crucial to proper decision-making. In this light, background measurements were made in non-impacted areas on building surfaces during the FSS. The selection and measurement of the background reference areas was done at the start of the fieldwork for each mobilization. Representative measurements of various flooring and wall materials were collected with each detector used so an applicable background could be applied before direct comparison with a DCGL value or application of the Sign test. In order to account for instrument response to ambient background, which can change from location to location, instrument background measurements were performed on each material encountered. These background values are tabulated and included in Annex D.

3.10 Survey Methods and Instrumentation

The purpose of this section is to describe direct radiation measurement and sample collection and analysis techniques that were implemented during the Site FSS. Physical and performance characteristics of each detector probe are provided in Table 3-2.

Table 3-2: Final Status Survey Detector Probe Characteristics

Detector	Application	Detector Type	Radiation Sensitivity	Active Area (cm^2)
Ludlum 44-9	Building, system, equipment surfaces; personnel frisking	Geiger-Mueller	Beta, Gamma	15
Ludlum 43-68	Small area surfaces (bench tops, drawers)	Gas Proportional	Alpha, Beta	126
Ludlum 43-37	Large area surfaces (floors, walls, bench tops)	Gas Proportional	Alpha, Beta	582
Ludlum 239-1F Floor Monitor (43-37 detector)	Smooth floor surfaces	Gas Proportional	Alpha, Beta	582
Ludlum 2929 Dual Scaler (43-10-1 detector)	Removable Contamination (Smear) Counter	Dual Channel "Phoswich"	Alpha, Beta	N/A
Bicron MicroRem,	Gamma radiation scans and counts	Plastic Scintillator	Gamma	N/A

3.10.1 Surface Alpha/Beta Radioactivity Scans

Applicability:

Impacted areas that have the potential for alpha-emitting and beta-emitting radionuclide surface contamination were scanned as described in this section. For the DHS NUSTL survey, this includes all impacted areas. Floors, walls, bench tops, and cabinet interiors wee scanned as described in Section 3.6.

Instrumentation:

The following detectors were used per the judgment of the survey supervisor:

- Gas proportional detector (Ludlum 43-68, Ludlum 43-37, or equivalent) for any large surfaces

- Geiger Mueller (Ludlum 44-9 or equivalent) for small surfaces or other hard-to-reach places

Scan measurement sensitivities are presented in Annex A, Appendix C (*FSSP*, CABRERA, 2007a).

Technique:

The surfaces were scanned for alpha and beta contamination by moving the probe in straight paths with spacing that ensured that at least the required minimum surface area was covered, as determined by the SU's classification. The rate meter was set to alarm at a preset level indicating that contamination was present at levels approaching a screening value, and the technician was familiar with detecting an audible or visible increase in count rate over the action level. Two scans were performed – once in alpha detection mode, and once in beta detection mode (for the 43-68 and 43-37 detectors).

If background response varied greatly during scan survey activities, instrument background measurements were performed at representative measurement locations.

The scan survey action level was a sustained instrument response above the ambient level. Action levels were calculated in "gross counts per minute (cpm)" for a given area with an asserted background level. If a survey resulted in locations above the action level, the following additional data were also collected:

- A 60 second static measurement at the location ("biased count") for alpha/beta;
- A "biased" smear sample to be analyzed for alpha/beta, or sent for isotopic analysis as the need was determined.

Data Recording:

Any biased measurements resulting from an elevated scan reading were recorded, including location, count or count rate reading, and a description of the object of interest.

A field scan sheet was completed for each area of the SU recording maximum and average count rates.

3.10.2 Fixed-Point Measurements

Applicability:

Fixed-point measurements were defined as static counts performed with a portable instrument. They were performed as part of the statistical survey or as biased measurements to investigate elevated scan readings.

Instrumentation:

A Ludlum 43-68 probe was used to perform and document fixed-point measurements.

Technique:

Fixed-point measurements were one-minute in duration with the instrument placed in scaler mode.

The fixed-point (static) survey action level was the DCGL plus the average background specific to the material type being evaluated.

Data Recording:

Fixed point measurements were recorded, including location (grid point or recognizable object), count rate (or exposure rate) reading, distance from the object of interest (if gamma reading), and a description of the object of interest as applicable.

3.10.3 Smear Sample Collection and Analysis

Applicability:

Selected building surfaces had smear samples taken to assess the presence of removable contamination. These smears were taken at every location that a fixed-point measurement was taken and at any other locations deemed necessary based on visual inspections and professional judgment.

Technique:

Smear samples were collected by wiping the 100 cm^2 area with a dry filter while applying moderate pressure. Smears were counted on-site using a Ludlum 2929 alpha/beta dual-scaler.

Data Recording:

Smear samples were recorded, including location (grid point or recognizable object), and a description of the object of interest as applicable.

3.10.4 Exposure Rate Surveys

Prior to conducting the alpha/beta scan surveys in each SU, an exposure rate survey was performed. The objective of the exposure rate survey was to determine the amount of time technicians were allowed to work in specific areas to minimize radiological exposure. The results of the exposure rate measurements were not used to evaluate compliance with any regulatory requirements and were not intended to support decisions regarding future use of the building. No exposure rates elevated above twice background were encountered during the course of the project.

4.0 REMEDIATION ACTIVITIES

As a result of surveys conducted, residual radiological surface contamination was identified in rooms B-15, B-8, B-15A, and B-15C. Affected SUs were decontaminated via surface activity removal efforts including minor wiping, scrubbing or mechanical grinding, and disassembly and removal of contaminated objects such as electrical conduit and shelves. Sections of a contaminated pipe were removed from the men's bathroom, women's bathroom, and room D-66 on the fourth floor. All contaminated materials including investigation derived waste (IDW) from remediation efforts were wrapped and stored in "B-25" waste containers while awaiting off-site disposal ("B-25" waste containers are comprised of steel and feature a 90 cubic foot capacity). Remediation activities generated a total of 16 B-25 waste containers of low-level radioactive waste and three 55-gallon drums of surface contaminated lead. Areas where IDW was stored had a Class 1 FSS performed following removal of the waste containers. All field operations were implemented in compliance with the *Site Safety and Health Plan* (*SSHP*, CABRERA, 2007b) (presented in Annex B).

4.1 Room B-15 and B-15A

In Room B-15 and B-15A, radium contamination was known to exist on the floor and walls (Brookhaven, 2004). The floor tiles, which contain asbestos, were contaminated and were peeled up and removed by JVN Restoration, Inc., a company certified to remediate asbestos-containing materials (ACM). After removing the floor tiles, fixed contamination was found on the floors and walls of B-15 and B-15A.

Several floor areas were decontaminated within Room B-15 by applying spray cleaner and scrubbing with scrub pads to remediate hotspots, and scabbling discrete areas of contamination as necessary where contamination had penetrated into the concrete. Scabbling was performed on twelve discrete floor spots; the largest scabbled area measured approximately two feet by two feet, and the remaining eleven scabbled areas measured one foot by one foot or smaller. Wall surfaces were decontaminated as necessary by removing contaminated paint, and scabbling discrete areas of contamination as necessary. Scabbling was performed on three discrete wall spots, each measuring one foot by one foot or smaller. Within Room B-15A, scabbling was performed on one discrete floor spot and one discrete wall spot, each measuring approximately one foot by one foot.

Decontamination efforts successfully reduced radiation levels on all surfaces and the Class 1 FSS was performed. Results of the FSS are discussed in Section 5.0.

4.2 Room B-15C

This room was used to store radiological materials. The rubber mat below the shelving units was contaminated above screening limits in two locations. The contaminated rubber mat sections were cut out and disposed of as radiological waste. Contamination was also found on a removable metal shelf. The shelf was removed and disposed of as radiological waste. Decontamination efforts successfully reduced radiation levels on all surfaces and the Class 1 FSS was performed. Results of the FSS are discussed in Section 5.0.

4.3 Room B-8

A number of contaminated materials from the 5th floor were temporarily stored in Room B-8 while the FSS of the 5th floor was being performed. Such items included: sections of contaminated lab benches, a glove box, and contaminated lead pigs. Several drums and barrels of solid materials, sampling equipment, instruments, and hundreds of soil/sediment samples were also stored in B-8. All equipment was surveyed for fixed and removable contamination and removed from room B-8 so the room could be surveyed.

A large area of fixed and removable alpha contamination (approximately 18 m^2) was found on the floor after the removal of materials and equipment. Floor surface areas were decontaminated by scabbling and/or light scrubbing or brushing. Decontamination efforts successfully reduced radiation levels on all surfaces and the Class 1 FSS was performed. Results of the FSS are discussed in Section 5.0.

The 16 B-25 containers of LLRW and the three 55-gallon drums of surface contaminated lead were staged in Room B-8 prior to disposal. Once the waste was removed from Room B-8, the floor was re-surveyed as a Class 1 area. These remedial support surveys are included in Annex E.

A small box containing four jars of uranium compounds sealed in plastic bags and a contaminated lead block wrapped in plastic shrink wrap was located on a shelf in Room B-8 following the removal of the 16 B-25s and drums of contaminated lead. These materials were removed and the shelf was surveyed. This remedial support survey is included in Annex E.

4.4 Room D-66, Men's Bathroom, and Women's Bathroom

A pipe containing alpha contamination was connected to a sink in Room 544 and ran down through the 5^{th} floor to the ceiling of the 4^{th} floor into Room D-66, and then horizontally into the men's and then women's restrooms. Samples were collected from the sink and the pipe below and sent offsite for radiological analysis to ALS. Sample results were elevated for Plutonium-238 (^{238}Pu). The sink sample ^{238}Pu result was 27,700 picocuries per gram (pCi/g), and the pipe sample ^{238}Pu result was 1,580 pCi/g. The contaminated section of the pipe on the 4^{th} floor was removed and disposed of as radiological waste. Remedial action support radiological surveys were performed in both bathrooms and in the ceiling above Room D-66 to ensure that there was no residual radioactivity due to removal of the contaminated pipe. The surveys did not find any radioactivity above background levels (refer to Annex D). A Class 1 FSS was performed in the men's bathroom where the majority of remediation was performed. Results are presented in Section 5.0.

4.5 Waste Characterization, Transportation, and Disposal, First Mobilization

The first mobilization for waste disposal was to remove the 16 B-25 boxes and three 55-gallon drums. An inventory of wastes added to each B-25 container was maintained to assist in waste characterization. B-25 containers were counted using an *In-Situ Object Counting System* (ISOCS), which consists of a High Purity Germanium liquid-nitrogen-cooled gamma spectroscopy detector, to support the identification of gamma emitting radionuclides (if any) present in the remediation waste and assist in providing total radioactivity estimates for each B-25. The radioactivity total in one B-25 (B-25 serial number 001) and in the 55-gallon drums of surface contaminated lead were estimated based on fixed and removable measurements from various items that were placed in these containers for disposal. These results were used to properly characterize the samples for waste disposal at Energy Solutions in Clive, Utah and are summarized in the Waste Manifests transmitted with the B-25s (reference Annex F).

Composite samples were also collected from 12 of the 16 B-25s and sent offsite to ALS for waste disposal characterization analyses (only the B-25s containing legacy radioactive soil samples and soil-like materials were sampled). The two samples from the sink and connected pipe in Room 544 (described in Section 4.4) and 12 representative waste samples from the B-25 containers were sent offsite for radiological analyses. The waste samples were also analyzed for hazardous constituents as shown in Table 4-1. Off-site analytical laboratory data is included in Annex G.

Table 4-1: Disposal Characterization Sample Analyses

Analysis	Method(s)
TCLP RCRA VOCs	SW8260B
TCLP RCRA SVOCs	SW8270C
TCLP RCRA Metals (+zinc)	EPA 6010B & 7470A
RCRA Pesticides	SW-846 EPA 8081A
RCRA Herbicides	SW-846 EPA 8151A
PCBs	SW8082
Ignitability	SW1010
Corrosivity (pH)	SW9045
Reactivity	SW846_7.3.1/SW846_7.3.2
Paint filter (free liquids)	SW9095

Notes:

1. TCLP = toxicity characteristic leaching procedure
2. RCRA = Resource Conservation and Recovery Act
3. VOCs = volatile organic compounds
4. SVOCs = semi-volatile organic compounds
5. PCBs = polychlorinated biphenyls

The 16 B-25s of LLRW and the three 55-gallon drums of surface contaminated lead were removed from the site on December 1 and 2, 2011. The B-25s were disposed of at Energy Solutions in Clive, Utah, and the drums of surface contaminated lead were disposed of at TOXCO Materials Management Center in Oak Ridge, Tennessee. Certificates of disposal for these waste streams were not yet available at the time this document was completed.

4.6 Waste Characterization, Transportation, and Disposal, Second Mobilization

CABRERA remobilized to pick up and dispose of the small box containing four jars of uranium compounds and the additional, contaminated lead block discovered on a shelf in Room B-8 following the removal of the 16 B-25s and drums of contaminated lead (removal of the B-25s and resurvey of the staging area is discussed in Section 4.3, and refer to Section 4.5 for disposal of these B-25s). As stated in Section 4.3, these materials were removed and the shelf was surveyed. A box containing seven miscellaneous soil samples was discovered on the 5th floor following completion of FSS surveys. The activities of the lead and the soil samples were estimated based on a gamma spectroscopy measurement performed by DHS NUSTL personnel. The activity concentrations of these soil samples and the contamination potential associated with them was low enough that a survey of the area where the soils were located was not warranted. The Waste Manifest transmitted with these materials is included in Annex F.

5.0 FINAL STATUS SURVEY RESULTS

The basement and first floor rooms occupied by the NUSTL consisted of laboratories, building service/equipment rooms, and storage areas. An area on the 4th floor was impacted by remedial activities associated with a laboratory drain originating on the 5th floor. An air duct system on the roof was also identified as an impacted area. The impacted areas included in this report include 9 Class 1 SUs, 2 Class 2 SUs, and 2 Class 3 SUs as described in Section 3.5 and listed in Table 5-1.

Table 5-1: Survey Units

Survey Unit	Area	MARSSIM Class	Notes
B-15-F	Room B-15 Floors	1	NUSTL-identified area, BNL Survey (2004)
B-15-W	Room B-15 Walls	1	NUSTL-identified area, BNL Survey (2004)
B-15A-F	Room B-15A Floors	1	NUSTL-identified area, BNL Survey (2004)
B-15A-W	Room B-15A Walls	1	NUSTL-identified area, BNL Survey (2004)
B-15C-FW	Room B-15C Floors and Walls	1	Contamination found during CABRERA survey
B-15C-S	Room B-15C Shelves	1	Contamination found during CABRERA survey
B-8-F (1)	Room B-8 Floors	1	Contamination found during CABRERA survey
B-8-W	Room B-8 Walls	1	Surveyed after finding contamination on floors
4-D29	Men's Bathroom	1	Contamination found during CABRERA survey
1-L1+L2	Laboratories #1 and #2	2	NUSTL-identified area, History Utilization Team report
1-Dust	Dust Collector (2)	2	NUSTL-identified area, History Utilization Team report
1-R3	All remaining 1st floor NUSTL areas	3	NUSTL-identified area, History Utilization Team report
Roof-1	Rooftop Air Duct System	3	NUSTL-identified area, BNL Survey (2004)

Notes:

(1) The floor of B-8 was separated into two SUs.

(2) The Dust Collector was removed following completion of release surveys performed by CABRERA.

The impacted rooms consisted of floors, walls, ceilings, and building fixtures. Building fixtures are considered to be permanently mounted components, such as lab benches and countertops, sinks, ventilation hoods, heating and ventilating ductwork, filtering housings, and building system piping and conduit. The Dust Collector was located against the wall on the loading dock of the first floor NUSTL area and was approximately 2 m long by 3 m wide; the Dust Collector was removed following completion of release surveys performed by CABRERA.

5.1 Scan Survey Results

Gross alpha and beta scans were performed separately over building and fixture horizontal and vertical surfaces at a scan density in accordance with the MARSSIM classification of the specific room or SU in the *FSSP* (CABRERA, 2007a). Floors and other large-area surfaces were scanned for surface contamination utilizing Ludlum Model 43-37 large-area (582 cm² active window area) gas proportional detectors coupled to Ludlum Model 2360 scaler/rate meters. Smaller surfaces, such as shelves or drawers, were scanned with Ludlum Model 43-68 gas proportional detectors (126 cm² active window area) coupled to Ludlum Model 2224 or Model 2360 scaler/rate meters. Survey results are listed on each field scan information sheets presented in Annex H(note: field scan information sheets for Survey #033 describe Room B-15 East, which is referred to elsewhere as Room B-15A). Scans were performed and biased measurements collected where appropriate at additional locations based on initial scan results and professional judgment. Certain locations with clearly elevated activity were decontaminated/removed and resurveyed until acceptable results were achieved in accordance with the ALARA concept. All final alpha and beta scan results were less than the DCGLs for each SU.

5.2 Surface Activity Measurements

Final Status Survey measurements were collected from building and fixture surfaces in accordance with the *FSSP* (CABRERA, 2007a). All FSS measurements represent the final, post-remediation (where necessary) surfaces and materials. Final Status Survey data consisted of Systematic and Biased static integrated alpha and beta measurements for fixed surface activity, and smear measurements for transferable alpha and beta activity. The distinctions between these are:

Systematic measurements:

- Are collected from a random start, systematic grid at the minimum number of survey locations within a SU as prescribed in the *FSSP* (CABRERA, 2007a);

- Must conform to the statistical tests required to demonstrate DCGL compliance; and
- Must conform to $DCGL_{EMC}$ requirements.

Biased measurements:

- Are collected to investigate in-process field measurements or as post-remediation samples to determine the effectiveness of remedial action:
- Are compared to DCGL requirements; and
- Must conform to $DCGL_{EMC}$ requirements.

The statistical tests applied to interpret survey data in regard to the DCGL were in accordance with MARSSIM for a radionuclide contaminant not present in background, and are:

1) If all measurements within a SU were less than the DCGL the unit met the release criteria.
2) If the SU average of all measurements was greater than the DCGL the unit did not meet the release criteria.
3) If the SU average was less than the DCGL but any individual measurement was greater, a Sign Test and elevated measurement comparison were conducted.

The Sign Test, a nonparametric statistical test, is designed to detect uniform failure of compliance with release criteria for systematic surface samples throughout a SU. The Sign test assumes that the contaminants are not present in background or are present in such small fractions of the DCGL as to be considered insignificant. Therefore, ROC activity concentrations are normally compared directly to the DCGL. However, for the DHS NUSTL FSS with the potential for high variability of background due to the many different building materials, a Sign test with paired observations was used. Each measurement in the SU was paired with an observation on a suitable reference (background) material (these background values are tabulated and included in Annex D). The Sign test is then performed on the net activity above background. The tradeoff is the higher variability of the differences compared to a single measurement.

To account for this potential increased variability in measurement standard deviation from multiple surfaces, the planning sigma values used in the determination of the number of sample points per SU were doubled from their observed values during the Scoping Survey. Details of the SU design are provided in Section 3.0.

In addition to the DCGL evaluation, results for each FSS sample location were evaluated to ensure that none exceeded the $DCGL_{EMC}$ investigation level (Section 3.7). If a measurement would have exceeded an investigation level, additional investigation would have been performed at least locally, to determine the actual extent of the elevated activity concentration. The use of investigation levels provided additional assurance that unusually large measurements were identified and received proper attention regardless of the outcome of the Sign Test. No FSS results exceeded the investigation levels.

All FSS results and forms are presented in Annex H. All FSS analyses (e.g., DCGL evaluations, Sign Tests) are presented in Annex D. Final Status Survey instrumentation calibrations and certificates are presented in Annex I.

5.2.1 Systematic Measurements

There were a total of 182 systematic total and removable surface activity measurements collected from the impacted areas at 201 Varick Street outside of the 5th Floor. All total and removable surface activity measurement results from the FSS were below the residual surface activity DCGLs presented in Table 2-1.

5.2.2 Biased and Property Measurements

Biased fixed-point and removable surface activity measurements were also collected from the fifth floor. All biased total and removable surface activity measurement results were below the relevant residual surface activity DCGLs presented in Table 2-1. Total and removable surface activity measurements were also collected from various pieces of property (e.g., lead bricks, laboratory instruments, laboratory equipment, etc.) located throughout the rooms in the basement and 1st floor. Pieces of property with elevated activity were either decontaminated or removed for disposal as radioactive waste.

5.3 MARSSIM-Based Evaluation of Final Status Survey Results

Final Status Survey results were evaluated in accordance with MARSSIM guidance. No final survey results exceeded the DCGL for each ROC and therefore comparison to the DCGL elevated measurement criteria, $DCGL_{EMC}$, was not required.

No survey measurement in the FSS exceeded the DCGL, accounting for material-specific background, the application of Sign Tests were not required.

Based on the results of these FSS activities, each SU in the basement, 1st floor, 4th floor, and roof meets the screening criteria of NUREG-1757, Vol. 1, Appendix B, release criteria of NYCDOH 175.03 *Release of Materials or Facilities*, and the release criteria of DOE 10 CFR 835, Appendix D as presented in Table 2-1 in Section 2.0. According to the *FSSP* (CABRERA, 2007a) decision methodology, these areas meet the criteria for unrestricted release.

5.4 Verification of Data Quality Objectives

In order to verify that the data quality objectives (DQOs) for the survey have been met, data from the SUs is used to back-calculate the actual relative shift for each SU. As discussed in Section 3.8 and as provided in Table 3-1, the relative shift (Δ/σ) describes the relationship of site residual radionuclide concentrations to the DCGLs. Based on the assumptions used during the design phase of the FSS, the relative shift was estimated to have a value of 1.67 for each type of measurement. The actual standard deviation and median concentration of residual radioactivity in each SU for each measurement type now replaces the estimated standard deviation and LBGR (respectively) to ensure the data quality objectives have been met. A calculated relative shift greater than 1.67 would reflect that additional measurements are warranted to support the statistical basis for disposition decisions for the SU; a calculated relative shift less than 1.67 reflects that sufficient measurements have been collected to support disposition decisions for the SU. The relative shift is well above 1.67 for all measurement types in all SUs. These data are presented below in Table 5-2 (total radioactivity) and Table 5-3 (removable radioactivity).

Verification that the DQOs have been met is also performed by preparing a retrospective power curve for each SU (refer to Annex D). The minimum number of systematic measurement locations required in each SU for the Sign statistical test was determined using Table 5.4 in *MARSSIM* (NRC, 2000) at 17 systematic measurement locations per SU. Compliance with *MARSSIM* (NRC, 2000) is demonstrated for SUs where fewer than 17 measurements were collected by calculating the median concentration and preparing a retrospective power curve for the data from each SU. Based on the retrospective power curve, we can establish the concentration in each SU at which the rate of making a decision error is less than 1% (i.e., the probability that the SU passes exceeds 99%, in excess of the 95% target of the FSS design, i.e., the retrospective power approaches 1 or 100%). The median concentration is well below the concentration at which the rate of making a decision error is less than 1% for all measurement types in all SUs. These data are presented below in Table 5-2 (total radioactivity) and Table 5-3 (removable radioactivity).

Table 5-2: Verification of DQOs: Total Radioactivity

	Relative Shift (unitless)		Alpha Static Measurements (DPM/100 cm^2)		Beta Static Measurements (DPM/100 cm^2)	
Survey Unit	**Alpha Static Measurements**	**Beta Static Measurements**	**Median**	**Power <1 (1)**	**Median**	**Power <1 (1)**
B8-F (1), Class 1	20.9	12.7	-5.5	468.6	-220.3	875.2
B8-F (2), Class 1	4.3	11.5	35.6	359.2	-120.6	873.4
B8-W, Class 1	43.2	6.3	8.2	485.2	-385.1	716.2
B15-F, Class 1	17.2	9.8	8.2	462.9	26.9	871.3
B15-W, Class 1	30.6	9.4	8.2	479.1	-176.9	837.7
B15A-F, Class 1	64.3	6.0	-5.5	489.8	-29.5	776.7
B15A-W, Class 1	18.2	62.3	8.2	464.9	-172.6	975.5
B15C-FW, Class 1	38.3	4.9	-9.6	482.7	15.6	738.8
B15C-S, Class 1	34.1	19.4	5.5	481.1	74.6	937.9
L1+L2, Class 2	48.1	7.0	15.6	486.9	-98.6	797.4
1-Dust, Class 1	45.5	6.5	21.1	486.3	192.8	838.3
1-R3, Class 1	294.7	53.8	-7.7	497.8	-14.2	975.5
4-D29, Class 1	42.3	5.1	-8.2	484.4	11.3	748.8
Roof-1, Class 3	42.0	2.5	2.5	484.6	242.5	600.2

Notes:

(1) The "Power <1" column reflects the activity concentration where the retrospective power equals 99%; this concentration is compared to the median concentration in each SU. A median activity concentration greater than the "Power <1" value indicates a retrospective power less than 99% and would reflect that additional measurements are warranted to support the statistical basis for disposition decisions for the SU. A median activity concentration less than the "Power <1" value indicates a retrospective power exceeding 99% and reflects that sufficient measurements have been collected to support disposition decisions for the SU. Refer to the Retrospective Power Curves contained in Annex D for expanded presentation of these data.

Table 5-3: Verification of DQOs: Removable Radioactivity

	Relative Shift (unitless)		Alpha Smears (DPM/100 cm^2)		Beta Smears (DPM/100 cm^2)	
Survey Unit	**Alpha Smears**	**Beta Smears**	**Median**	**Power <1 (1)**	**Median**	**Power <1 (1)**
B-8F (1), Class 1	12.2	6.7	-1.3	17.7	-37.7	153.9
B-8F (2), Class 1	13.0	7.2	-1.3	17.9	-48.3	155.0
B-8W, Class 1	13.6	6.7	-1.3	18.0	-37.7	153.9
B-15F, Class 1	7.8	8.1	-1.8	16.4	-23.2	164.0
B-15W, Class 1	11.0	7.2	-1.8	17.4	19.0	167.4
B-15A-F, Class 1	12.9	8.6	-1.4	17.8	-9.5	168.3
B-15A-W, Class 1	15.1	5.9	-1.4	18.2	6.3	157.5
B-15C, Class 1	10.4	5.1	-0.7	17.4	1.8	149.6
B-15C-S, Class 1	6.2	5.8	2.1	16.3	12.3	157.7
1-L1+2, Class 2	9.2	7.3	-1.0	17.0	6.6	165.7
1-Dust, Class 2	9.5	6.6	1.9	17.5	-17.4	156.9
1-R3, Class 3	14.4	14.6	0.0	18.2	-30.3	179.4
4-D29, Class 1	10.7	5.8	-1.4	17.4	-10.7	152.9
Roof-1, Class 3	9.4	6.8	-0.4	17.2	5.2	162.5

Notes:

(1) The “Power <1” column reflects the activity concentration where the retrospective power equals 99%; this concentration is compared to the median concentration in each SU. A median activity concentration greater than the “Power <1” value indicates a retrospective power less than 99% and would reflect that additional measurements are warranted to support the statistical basis for disposition decisions for the SU. A median activity concentration less than the “Power <1” value indicates a retrospective power exceeding 99% and reflects that sufficient measurements have been collected to support disposition decisions for the SU. Refer to the Retrospective Power Curves contained in Annex D for expanded presentation of these data.

5.5 Compliance with the NRC License Termination Rule

As described in Section 2.0, Rooms B-8 and 544 on the 5th floor were selected for evaluation to ensure compliance with the NRC LTR of 25 mrem/yr (10 CFR 20, Subpart E). These evaluations are provided in Annex C.

6.0 QUALITY ASSURANCE/QUALITY CONTROL

Field activities conducted as part of the decommissioning effort were performed in accordance with written procedures and/or protocols in order to ensure consistent, repeatable results. Data generated during the FSS met the Quality Assurance (QA)/Quality Control (QC) requirements outlined in the *FSSP* (CABRERA, 2007a).

6.1 Survey Instrumentation Quality Control

The CABRERA Project Health Physicist was responsible for determining the instrumentation required to complete the requirements of this FSS. Only instrumentation approved by the CABRERA Project Health Physicist was used to collect radiological data. The CABRERA Project HP was responsible for ensuring individuals were appropriately trained to use project instrumentation and other equipment, and that instrumentation met the required detection sensitivities. Instrumentation was operated in accordance with either a written procedure or manufacturers' manual, as determined by the CABRERA Project Health Physicist. The procedure and/or manual provided guidance to field personnel on the proper use and limitations of the instrument.

6.1.1 Calibration Requirements

Instruments used during project performance had current calibration and maintenance records on site for review and inspection. The records included the following:

- name of the equipment
- equipment identification (model and serial number)
- manufacturer
- date of calibration
- calibration due date

Instrumentation was maintained and calibrated to manufacturers' specifications to ensure that required traceability, sensitivity, accuracy and precision of the equipment/instruments were maintained. Instruments were under current calibration. The calibration records for each instrument used during this characterization survey are presented in Annex I.

6.1.2 Instrument QC Source Checks

Prior to daily use, project instrumentation was QC checked by comparing instrument response to a benchmark response. Prior to the commencement of field operations, site reference locations were selected for performance of these checks; subsequent QC checks were performed at these locations. QC source checks consisted of a one-minute integrated count with the designated source positioned in a reproducible geometry performed at the reference location. Prior to the start of initial surveys, this procedure was repeated ten times to establish average instrument response. The QC results for each instrument used during this characterization survey are presented in Annex I.

6.1.3 Direct Radiation Measurement Instrumentation QC

Instrument responses to designated QC check sources were recorded and evaluated against the average established at the start of the field activities. An acceptance criterion of ± 20% was required for direct measurement detectors. A QC count outside the respective screening limit would require informing the Project Manager, or designee, a detector evaluation, and could have resulted in the detection system being removed from service for corrective action. Direct measurement detectors that were used during field activities passed QC evaluations daily. The QC results for each instrument used during this characterization survey are presented in Annex I.

7.0 HEALTH AND SAFETY

Health and safety measures were employed during conduct of FSS activities, in accordance with the project *SSHP* (CABRERA, 2007b) (presented in Annex B).

7.1 General Health and Safety Measures

Daily health and safety activities were performed in accordance with the project *SSHP*, including conducting Daily Safety meetings, prior to the performance of survey activities each day. These daily safety meetings allowed for discussion of daily safety measures required based on the activities planned for each day. The *SSHP* was reviewed by CABRERA project personnel prior to the performance of characterization survey activities. No reported injuries took place during the characterization survey field effort.

7.2 Radiological Health and Safety Measures

General radiological health and safety measures were performed in accordance with the project *SSHP* (CABRERA, 2007b) and CABRERA Standard Operating Procedures.

8.0 SUMMARY OF RESULTS AND CONCLUSIONS

Final Status Surveys were conducted at NUSTL in accordance with MARSSIM guidance using 10 CFR 835 Appendix D criteria for final release. None of the final FSS fixed or removable survey results, as presented in Annex D, Annex E, and Annex H, exceeded the corresponding DCGLs. The evaluations performed for Rooms B-8 and 544 on the 5th floor demonstrate compliance with the NRC LTR of 25 mrem/yr (10 CFR 20, Subpart E) (refer to Annex C). Data obtained from this FSS effort support the release of the NUSTL areas in the basement, 1st floor, 4th floor, 5th floor, and roof for unrestricted use.

9.0 REFERENCES

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Annex A

Final Status Survey Plan

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Annex B

Site Specific Health and Safety Plan

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Annex C

RESRAD-BUILD Evaluation

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Annex D

Final Status Survey Analysis – Sign Test Forms

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Annex E

Remediation Support Surveys

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Annex F

Waste Manifests

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Annex G

Off-Site Laboratory Analytical Data

Refer to Attached CD

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Annex H

Final Status Survey Results and Forms

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Annex I

QA/QC Records

Refer to Attached CD