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October 4, 2006

David Everhart
US Nuclear Regulatory Commission
Region 1
475 Allendale Road
King of Prussia, PA 19406

SUBJECT: 71 SHELTON AVENUE, NEW HAVEN, CT

Dear Mr. Everhart,

Attached please find our Final Status Survey Plan for the Former UNC Manufacturing Facility, New Haven, Connecticut. We have incorporated your previous comments from your letter to me dated April 19,2006.

We look forward to your review and approval, so that work can proceed at the site. Please contact me if you have any question regarding this submittal.

Sincerely,

Robert Bonito / BRT

Robert F. Bonito
General Manager of Operations
UNC Naval Products

Attachments

cc:
John M. Uruskyj, GE Corporate Environmental Programs
Ronald R. Bellamy, USNRC Division of Nuclear Materials Safety (w/o attachments)

REC'D IN LAT 10/10/06

NMSS/RGNI MATERIALS-C02

Final Status Survey Plan for the Former UNC Manufacturing Facility, New Haven, Connecticut

UNC Naval Products

Report No. 2002020/G6315

Final Status Survey Plan for the Former UNC Manufacturing Facility, New Haven, Connecticut

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Report No. 2002020/G-6315
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1 INTRODUCTION

1.1 Project Background

The site that is the subject of this plan is located at 71 Shelton Avenue, New Haven, Connecticut, and consists of a building identified as 3H and 6H, its environs, and a connected sewer system which is inactive. A utility trench is located on the south side of both buildings and extends past the southeast edge of the property. The site is located at the edge of an industrial park, and the building is used primarily as a warehouse. It is enclosed by a chain link fence.

The site was decontaminated and decommissioned (D&D) from 1973 through 1976, after the work performed there was transferred to a new facility located in Montville, Connecticut. The New Haven site was officially removed from License SNM-368 on April 22, 1976.[1] License SNM-368 was terminated by the NRC eighteen years later, on June 8, 1994, following UNC's successful D&D of the Montville facility.[2] Additional characterization was completed at New Haven in 1996 and 1997.[3,4] The analysis of soil samples showed that a small number of local areas of soil and sediments contained enriched uranium exceeding the soil acceptance criteria established by the NRC in 1981.[5] UNC prepared a Decommissioning Plan in order to remediate the areas identified during the sampling effort; it was submitted to the NRC for approval in 1998.[6] UNC completed additional subsurface characterization in 2003 to supplement the work that was performed in 1997; these results were submitted to the NRC.[7] The sampling was conducted to determine the lateral and vertical extent of the enriched uranium in the identified areas of concern. The decommissioning plan was revised by UNC in order to incorporate the results of the characterization effort submitted to the NRC.[8]

1.2 Purpose

The objectives of the Final Status Survey are to verify survey unit classifications and to collect sufficient information to demonstrate, to a reasonable degree of statistical certainty, that the

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[1] Letter, NRC (W.T. Crow) to United Nuclear Corporation (Robert J. Pyzel) dated April 22, 1976.

[2] Letter, NRC (John H. Austin) to UNC Naval Products (Robert F. Bonito) dated June 8, 1994.

[3] NRC Inspection No. 070-00371/96-001, dated July 26, 1996.

[4] NRC Inspection No. 070-00371/97-001, dated February 12, 1997

[5] NRC Branch Technical Position "Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations", published in the October 23, 1981 Federal Register.

[6] UNC Naval Products, *Decommissioning Plan for the Previously Licensed Facility in New Haven, CT*, August 14, 1998.

[7] AAA/IEM, *Radiological Characterization of the Former UNC Manufacturing Facility, New Haven, Connecticut*, IEM Report 2002020/G-1269, May 31, 2005.

[8] UNC Naval Products, *Decommissioning Plan for the Previously Licensed Facility in New Haven, CT*, Revision 1, June 7, 2005.

concentrations of radiological constituents at the site do not exceed the release criteria following the remedial activities described in the Decommissioning Plan. Upon evaluation of the survey data, UNC will demonstrate that the requirements for unrestricted release have been met.

The purpose of this Final Status Survey Sampling Plan (FSSSP) is to detail the survey and sampling efforts that will be performed at the site, with the intent of establishing unrestricted release. This FSSSP also serves as the Field Sampling Plan (FSP) and the Performance Standard Verification Plan (PSVP) for the Final Status Survey. This FSSSP has been prepared in accordance with the protocols and methods established in the *Multi-Agency Radiation Survey Site Investigation Manual* (MARSSIM) and the Decommissioning Plan for this site.[9,10] The Final Status Survey will be conducted in conformance with the Decommissioning Plan and this FSSSP. The Final Status Survey Report will be prepared and submitted to the USNRC for review.

1.3 Project Organization

The decommissioning activities at the site will be implemented, on behalf of UNC, by a team of engineering consultants, construction managers, and contractors who possess the necessary qualifications and experience to perform the specific component(s) of the work to which they have been assigned responsibility. The Decommissioning Project Team is identified in the Decommissioning Plan.

The overall supervision of the project will be provided by AAA Environmental and Integrated Environmental Management, Inc. (AAA/IEM). These assignments include the overall project management and the coordination of all subcontractors.

1.4 Radiation Safety Procedures

Health and safety procedures will be followed to permit the decommissioning and Final Status Survey activities to be conducted without adverse impacts on worker health and safety. These procedures will comply with applicable portions of the Health and Safety Plan for Decommissioning Activities at this site as well as the Radiation Safety Program that was described in the Decommissioning Plan.

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[9] US Nuclear Regulatory Commission, *Multi-Agency Radiation Survey And Site Investigation Manual*, NUREG-1575, Revision 1, August, 2000.

[10] UNC Naval Products, *Decommissioning Plan for the Previously Licensed Facility in New Haven, CT*, Revision 1, June 7, 2005.

2 CLASSIFICATION OF SURVEY UNITS

The operating history for various areas of the site resulted in different levels of potential exposure to radioactivity. Therefore, these areas require different levels of survey coverage to confirm that residual levels of radiation are below the release criteria (30 pCi/g) deemed acceptable by the USNRC. In the Decommissioning Plan, the areas of the site subject to decommissioning were placed into three categories: subfloor soils, indoor residues and sewer residues. Each of these three areas are classified as Class 1 areas as defined by MARSSIM. Class 1 areas have the greatest potential for contamination because, prior to decommissioning field activities, they were areas that had known contamination greater than the release criteria. Class 2 areas are those areas that have a potential for radioactive contamination, but are not expected to contain radiation greater than the release criteria. Class 3 areas are those that are not expected to contain residual radioactivity above the release criteria. Class 1 areas will receive the highest degree of survey effort for the Final Status Survey, followed by the Class 2 areas. A list of the classifications for the New Haven facility is provided in Table 1.

In 1996, the NRC recorded biased exposure rate, fixed contamination, and removable contamination measurements on accessible surfaces at the site. This inspection report stated "All measured exposure rates were consistent with the background radiation exposure rate of 12-14 μR/hr" and "All fixed and removable measurements met NRC release criteria as described in *Guidelines for Decontamination*, revised in 1982."[11] Consequently, no additional building surface surveys are necessary according to this NRC report. The building and equipment release criteria for fixed and removable contamination are the same as they were in 1976, when the buildings were extensively surveyed by UNC and accepted by the NRC for unrestricted use.[12]

2.1 Class 1 Survey Units

There are three Class 1 survey units at the site: subfloor soils, indoor residues and sewer residues. The subfloor soils are located under the concrete floor in the decon pit, x-ray read room and the rectifier room. As defined in the Decommissioning Plan, the impacted soil will be excavated and packaged for disposal. The subsurface areas are specifically described in the Characterization Report including the dimensions of each area.[13] The indoor residues are located in the South trench extending through Building 3H and 6H. The South trench was previously used as a utility trench which enclosed steam piping as well as electrical utilities. Samples collected from the floor of the trench indicated the presence of uranium in excess of release criteria. The stormwater sewer line, south of Buildings 3H and 6H, contains residues that exceed the release criteria.

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[11] US Nuclear Regulatory Commission, *Inspection Report*, Report Number 070-00371/96-001, July 26, 1996.

[12] U.S. Nuclear Regulatory Commission, *Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material*, July, 1982.

[13] AAA/IEM, *Radiological Characterization of the Former UNC Manufacturing Facility, New Haven, Connecticut*, IEM Report 2002020/G-1269, May 31, 2005.

The Final Status Survey for the subsurface areas, the floor of the South trench and the sewer line will include soil scanning and sampling, following the remediation of the impacted residues. Direct measurements as described in Section 7 of this Plan will be completed as well as analysis of discrete samples to verify the remaining areas satisfy the release criteria.

2.2 Class 2 Survey Units

There is one (1) Class 2 area at this facility. The soil surrounding the sewer tile outside of Building 3H and 6H is potentially impacted if the sewer tile was breached or at some time leaked into the surrounding soil. While no samples were collected during the characterization effort in 2003, the potential of leakage will be investigated during remedial activities.

The Final Status Survey for the soil outside of the sewer line will include soil sampling, following the remediation of the impacted residues. The discrete samples will be collected adjacent to the sewer line by boring a vertical hole to a depth below the sewer line and collecting a discrete sample. The analysis of soil samples is described in Section 8 of this Plan.

2.3 Class 3 Survey Units

The subsurface areas in the Decon pit, rectifier room and the Xray reading room were excavated and backfilled with clean soil during the remediation by UNC in 1973. The backfill is considered to be Class 3 areas as defined by MARSSIM. The soil will be excavated and segregated while the impacted soil is removed. The Final Status Survey for the segregated soil will include soil scanning and sampling, following the remediation of the impacted soil. Direct measurements as described in Section 7 of this Plan will be completed as well as analysis of discrete samples to verify the remaining areas satisfy the release criteria.

2.4 Background Radioactivity

Background will be established as defined in MARSSIM, Chapter 4. The samples will be collected from areas to establish background concentrations and establish distribution of measurement data necessary to identify and evaluate contributions attributable to the facility. The results of the analysis will be used to compare the conditions determined in specific survey units. The analytical results will be summarized in order to calculate a mean and the 95 percent Upper Confidence Limit (UCL) above the mean for each radioisotope detected in each medium. Background samples were collected in 1993 at the Montville facility. The value determined for the UNC Naval Products Montville facility was summarized by Oak Ridge Institute of Science and Engineering (ORISE) in their report on the New Haven facility in 1997. This value is 3.43 pCi/g.[14] At least sixteen (16) discrete samples will be collected and analyzed to represent background.

[14] Figure H-2.3, UNC Naval Products Final Site Decontamination Report, dated 3/12/93.

3 RELEASE CRITERIA

The Final Status Survey data, for the radionuclides of concern, will be compared with the release criteria presented in this section, using the statistical tests described in Section 4. The key isotopes likely to be encountered at the New Haven facility are provided in Table 2 and 3. The criteria were established by the NRC in 1981.[15] Specifically, the limit for processed enriched uranium in soil was less than 30 pCi/g enriched Uranium averaged over an area of 100 m^2. As specified in the NRC Branch Technical Position, the criteria may be modified for "hot spots" or areas that exhibit localized concentrations of uranium over an area smaller than 100 m^2. The criteria are limited by the formula

$$ElevatedMeasuremtCriteria = 30pCi / g \times (100 / A)^{1/2}$$

where A is the area of the location with the impacted soil, measured in square meters (m^2). No single value greater than 90 pCi/g is permitted for unrestricted release.

Selected concrete surfaces in the South Trench will be remediated and surveyed for release. The USNRC established the release criteria for total and removable activity on surfaces during the 1996 final status survey.[16,17] Specifically, the limit for total uranium on surfaces is less than an average of 5,000 disentegrations per 100 square centimeters (dpm/100 cm^2) and a maximum of 15,000 dpm/100cm^2. Removable activity is limited to less than 1,000 dpm/100cm^2. The release criteria is provided in the Attachment to this survey plan.

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[15] USNRC Branch Technical Position, *Disposal or Onsite Storage of Thorium or Uranium Wastes from Past Operations*, SECY 81-576, October 23, 1981.

[16] US Nuclear Regulatory Commission, *Inspection Report*, Report Number 070-00371/96-001, July 26, 1996.

[17] U.S. Nuclear Regulatory Commission, *Guidelines for Decontamination of Facilities and EquipmentPrior to Release for Unrestricted or Termination of Licenses for Byproduct, Source or Special Nuclear Material,* July, 1982.

4 SURVEY OBJECTIVES

This section describes the statistical tests that will be used to determine the number of discrete soil samples to be collected in each survey unit, and to evaluate the data that is collected as part of the Final Status Survey. Several parameters must be set to ensure that the survey will meet the statistical evaluations needed to support the radiological release of the facility. In addition to the release criteria, which are presented in Section 3, these parameters include the Data Quality Objectives; the acceptable decision errors; and the Relative Shift. These parameters are used to determine the number of required survey measurements per survey unit.

4.1 Statistical Tests

Because the radionuclides of concern at the New Haven facility (uranium and decay progeny) exist in the natural background, all measurement results acquired during the Final Status Survey will be compared with the release criteria established for the site plus background, using the Wilcoxon Rank Sum test, as described in MARSSIM. If an area exhibits residual radioactivity in excess of the applicable criterion, either additional decommissioning actions will be implemented in that area, or a technical justification for no further action will be developed and included in the Final Status Survey Report. If additional field decommissioning activities are necessary, follow-up measurements will be performed to demonstrate their effectiveness.

4.1.1 Data Quality Objectives

The final status survey design process begins with the development of data quality objectives (DQOs).[18] The DQOs are used in conjunction with the radiological conditions at the site to calculate the number and locations of measurement and sampling points to demonstrate compliance with the release criterion. Survey techniques and analytical methodologies are selected to generate the required analytical data. Once the analytical data are received from the laboratory and validated, they are evaluated using statistical techniques to test the hypothesis stated in this section.

Statement of Cleanup Objective

After decommissioning is completed, residual radioactivity in subfloor soil, sewer residue and residue in the South trench at the New Haven facility will be less than 30 pCi/gram of enriched uranium. As necessary, obstacles, such as the concrete floor covering the potentially impacted soil and piping in the trench, will be removed before the final status survey is initiated.

Hypothesis to be Tested

Following remediation of each of the areas identified in the Decommissioning Plan, it must be determined whether the site-specific cleanup guideline has been met, or if further remediation is required. Therefore, the decision to be made is: "Do the soil and residues contain radiation less than the release criteria described in Section 3 of this Final Status Survey Sampling Plan?" The null

[18] U. S. Environmental Protection Agency, *Guidance For Planning For Data Collection In Support Of Environmental Decision Making Using The Data Quality Objectives Process*, EOA QA/G-4, September 1994.

hypothesis (HO) for the statistical test is that the site does not meet the release criteria, as outlined in MARSSIM: "The concentration in the survey unit exceeds the concentration in the reference area by more than the release criteria."[19]

Inputs to the Decision

Inputs to the decision include the type, quality, and quantity of data that will be sufficient to make decisions. The type refers to the radiological data needed for the survey unit soil. Quality refers to various aspects of the analytical data collected, such as precision, accuracy, representativeness, comparability, completeness, required and achieved detection limits, and data validation documentation requirements. Validation that the resulting data meet these values will ensure the quality of the information and allow the results to be used in testing the site cleanup hypothesis. Quantity refers to the amount of data necessary to confirm compliance with the release criteria, and is determined as part of the design process. Data quality requirements are provided below.

Precision

Precision refers to the level of agreement among repeated measurements of the same parameter. The overall precision of a piece of data is a mixture of sampling and analytical factors. The analytical precision is much easier to control and quantify because the laboratory is a controlled, and therefore a measurable environment. Laboratory sampling precision will be checked by obtaining a minimum of one replicate sample for every 20 physical soil samples collected in a given survey unit. Precision will be evaluated by calculating the relative percent difference (RPD) for each replicate pair. The soil field replicate pairs are expected to have RPDs in the range of 50 percent. At a minimum, one replicate sample or the recount of a previously sampled location will be performed for every sample batch. A sample batch is defined as a group of samples that behave similarly with respect to the sampling or testing procedures being employed. For quality control (QC) purposes, a group of 20 samples of similar physical media collected within 1 work week, or all such samples collected in a work week (if less than 20), whichever occurs first, is considered a batch. The RPD for each analytical parameter will be calculated and compared with a method-specific precision criteria derived from historical performance data. If these criteria are not met, a careful examination of the sampling techniques, sample media, and analytical procedure will be conducted to identify the cause of the high RPD and to define the usability of the data.

Accuracy

Accuracy refers to the difference between a measured value for a parameter and the true value for the parameter. It is an indicator of the bias in the measurement system. Field instrument accuracy will be evaluated by comparing the static count measurement at each soil sample location with the laboratory result.

Representativeness

Representativeness is a measure of the degree to which the measured results accurately reflect the medium being sampled and the overall situation at the site. It is a qualitative parameter that is

[19] US Nuclear Regulatory Commission, *Multi-Agency Radiation Survey And Site Investigation Manual*, NUREG-1575, Revision 1, August, 2000.

addressed through the proper design of the sampling program in terms of sample location, number of samples, selection, preparation, and handling of the samples.

Comparability
Comparability expresses the confidence with which one data set can be compared with another. When comparing data, it is important to compare data collected under the same set of conditions. Seasonal trends, depth of sample collection, analytical protocol, method detection limits, and any other sampling/analytical variables must be taken into account when comparing data sets. This will be accomplished using standardized methods for collecting the samples.

Completeness
Completeness is a measure of the amount of information that must be collected during the Final Status Survey to allow for successful achievement of the project objectives. A certain amount and type of data must be collected for each Final Status Survey unit to be valid. The statistically-derived number of samples will be calculated in accordance with MARSSIM. Missing data may reduce the precision of estimates or introduce bias, thus lowering the confidence level of the conclusions. The completeness goal for each Final Status Survey will be 95 percent (areal) for the field sampling and 95 percent (number) for the laboratory analyses. The importance of any lost or suspect data will be evaluated in terms of the sample location, analytical parameter, nature of the problem, decision to be made, and the consequence of an erroneous decision. Critical locations or parameters for which data are determined to be inadequate may be resampled.

Sensitivity
Sensitivity refers to the ability to detect a minimal amount of a substance, and is typically expressed as the Method Detection Limit, Practical Quantitation Limit, or Reporting Limit. A description of the direct reading radiation survey instruments is provided in Tables 4 and 5. Radiological analyses must indicate if the soil remaining at the site has met the cleanup criteria. Therefore, the required off-site analytical laboratory minimum detectable level (MDL) has been set at 5 pCi/g of U 238. A description of the analytical methods is provided in Table 7.

4.1.2 Decision Rules
If the concentrations of residual U 238, U-235, and radioactive progeny of the parents in the soil of a given survey unit are below the concentrations listed in Section 3 of this Plan, the survey unit is in compliance with the release criteria. The MARSSIM process specifically includes the use of elevated measurements as a component of radiation surveys and site investigations. Areas with elevated levels of radioactivity should be rare because remediation activities will be rigorously conducted. "Hot spot criteria" will be a multiple of the cleanup criteria; no single sample may contain more than 90 pCi/gram of enriched uranium. Section 3 defines the derivation of the "Hot Spot criteria". Any such "hot spots" identified during the gamma scanning of the final excavation surface will be plotted on survey unit maps. All survey unit maps will be evaluated to identify areas that may require additional evaluation based on spatial distribution of the elevated measurements.

Acceptable Decision Errors

The data evaluation approach described in MARSSIM specifies that failure to meet the release criteria should be assumed as the null hypothesis; the data are then analyzed to demonstrate that the release criteria are met. The null hypothesis can be stated thus: "The median concentration in the survey unit exceeds that in the reference area by more than the release criteria." The data then are analyzed to demonstrate that the null hypothesis is false. Site measurement data are used to estimate the actual site conditions within a specified margin of error. The sample collection and data analysis process described in MARSSIM attempts to control decision error by defining the types of errors and incorporating them into the interpretation of survey results. The possible types of decision errors include the following:

- Type I errors (a) - Concluding that residual radiological contamination does not exceed the cleanup criteria when it actually exceeds the criteria; and
- Type II errors (b) - Concluding that residual radiological contamination exceeds the cleanup criteria when it actually is below the criteria.

Type I and Type II errors can have distinct consequences. Type I errors may have human health consequences, political consequences (state and federal officials may face undue pressure if it is discovered that the site may not have been adequately cleaned up), and cost consequences (the cost of excavating selected portions of the site after remediation is complete would be significant). On a preliminary basis, the probability of a Type I error will be less than 5 percent ($\alpha<0.05$).

Type II errors do not have residual risks, but rather have cost and resource consequences (the manpower, equipment, and disposal costs associated with excavating and disposing material that already meets the cleanup criteria are unnecessary expenses). On a preliminary basis, the probability of a Type II error will be less than 25 percent ($\beta<0.25$).

4.1.3 Relative Shift

The Relative Shift is defined as Δ/σ, where "Δ" is the release criteria minus the LBGR (lower bound of the gray region) and the "σ" is the standard deviation of the contaminant distribution. In order to calculate the Relative Shift, two assumptions must be made to estimate the LBGR and the standard deviation of the measurement distribution. MARSSIM suggests that, initially, the LBGR be set at 50 percent of the release criteria.

For the purpose of the Final Status Survey at this site, the LBGR will be set at 0.5 x release criteria. The standard deviation may be estimated or may be calculated from preliminary survey data, prior surveys of similar areas and materials, or the standard deviation of a reference area. However, it is important to note that the "σ" represents the standard deviation of the set of measurements collected in a survey area when all area decontamination is thought to be complete.

For the purpose of the Final Status Survey at this site, the standard deviation will initially be set at 0.3 x release criteria. The Relative Shift is calculated, as follows:

$$RelativeShift = \Delta/\sigma = (1.41 - (0.5 \times 1.41))/(0.3 \times 1.41) = 1.67 \approx 1.7$$

4.2 Number of Discrete Soil Sample Locations

The number of discrete soil samples to be collected in any single excavation (or less than 2,000 m^2 on the floors and walls of the excavation) depends on the nonparametric statistics that are used to test the null hypothesis, acceptable decision errors, and the Relative Shift. In order to satisfy the nonparametric statistics discussed in Subsection 4.1 (i.e., a Type I error of 0.05, a Type II error of 0.25, and a Relative Shift of 1.7), Table 5.3 of MARSSIM indicates that 8 samples are needed for 100 percent coverage of a 2,000 m^2 survey area. This is the minimum sampling intensity for all Class 1 survey units.

A smaller survey unit will be established for the concrete building surfaces in the South trench; a single survey unit will be no larger than 100 m^2 in area. In accordance with MARSSIM, the grids for building surfaces are smaller in area than those established for excavated soil. No discrete soil samples will be collected from the concrete surface of the South trench floor; radiation surveys will be performed on accessible surfaces as defined in 5.3 of this Plan.

In accordance with MARSSIM, UNC will provide up to 33 percent coverage for discrete soil sampling in the Class 2 survey units (i.e. soil surrounding the sewer tile). In other words, UNC will collect discrete soil samples in the Class 2 survey units at a sampling density of more than three (3) samples per 2,000 m^2. If a survey unit, as defined in this FSSSP, is larger than 2,000 m^2, MARSSIM requires that the survey unit be subdivided into approximately 2,000 m^2 grids for the purpose of the Final Status Survey.

5 SURVEY DESIGN and IMPLEMENTATION

The Final Status Survey activities for exposed soil will include surface scanning and discrete soil sampling (0-6 inches). The Final Status Survey for the floor of the South trench and the walls of the excavations will include direct measurements of radiological activity on the exposed surfaces. The project team will perform the activities according to this FSSSP, which has been prepared in accordance with MARSSIM. Specifically, the following approach will be used:

1. Survey instrumentation will be set up and source-checked to verify proper operation. The Radiation Safety Officer (RSO) will perform preliminary inspections of the areas to identify additional specific survey requirements, if any.
2. The project team will use appropriate calibrated instruments and perform daily source and background checks before each day's work.
3. The project team will grid the survey areas and mark or map the survey locations as applicable.
4. The project team will take survey measurements and collect discrete soil samples for analysis by the radiochemistry laboratory (Outreach Laboratory in Broken Arrow, Oklahoma).

The RSO will review the survey results to identify any areas that may exhibit elevated radiation levels. This review will also verify that the data are recorded in a consistent manner, and are suitable for inclusion in the Final Status Survey Report.

The scanning coverage and the number of discrete measurements have been developed in accordance with MARSSIM. The number of discrete measurements for each survey unit are based on the Data Quality Objectives and the statistical parameters detailed in Section 4.

5.1 Preparation for Surveys

As necessary, equipment and materials that may restrict access to the survey unit will be relocated. A grid system will be established in Class 1 survey units and each Class 2 survey unit to facilitate systematic reproducible selections of measuring/sampling locations, to provide a mechanism for referencing a measurement/sample so that the same survey point can be relocated, and to assist in the detection of discrete areas of elevated activity. This grid system will be recorded on survey maps and provided in the final report. The grid will consist of a system of intersecting lines, referenced to a fixed site location or benchmark. The grid lines will be arranged in a perpendicular pattern, dividing the survey location into rectangles or blocks of roughly equal area. Grids will be marked by wooden/metal stakes or flags that will be driven into the ground surface at grid line intersections. Where surface coverings prevent installation of stakes, the grid intersection may be marked by painting. Where possible, grid locations will be left in place to facilitate resampling and/or confirmatory surveys.

5.2 Survey Design - Subfloor Soils

The walls of each excavation will be exposed after the impacted soil and the backfill is excavated and segregated. A Class 1 area will be established for the walls and floor of each excavation as described in MARSSIM; the maximum area of any survey unit is less than 2,000 m^2. The survey activities for each survey unit will begin with surface scans, conducted over 100 percent of each grid area, in a systematic manner. The surface scan data will be evaluated to determine if any measurements exceed the release criteria.

Assuming the surface scan data pass the release criteria, UNC will proceed with the collection of discrete soil samples. UNC will collect eight (8) discrete soil samples from each excavation for the Final Status Survey in this area. If the surface scan results, or the discrete soil sample results, in one or more of the 2,000 m^2 grids do not pass the release criteria, the grid(s) will be remediated and additional measurements will be collected, in accordance with MARSSIM.

5.3 Survey Design - Trench Residues

Following remediation of the South Trench, direct radiation measurements will be completed on accessible concrete surfaces. UNC will conduct surface scans over 100 percent of the survey units, in accordance with MARSSIM. If the surface scan results in either of the survey units do not pass the release criteria, additional remediation will be performed in the survey unit, and additional measurements will be collected in accordance with MARSSIM.[20]

5.4 Survey Design - Sewer

The final status survey of the sewer will be initiated after the remedial activities are completed. If the sewer tile is excavated during the remediation, radiation surveys and soil samples will be collected on the floor and walls of the excavation. The excavation will be classified as a Class 1 area and sampled in accordance with MARSSIM guidance. Eight (8) samples will be collected for the excavation, representing less than 2,000 m^2. In the event that the excavation exceeds 2,000 m^2, additional survey units will be established and sampled as described. In the event that the sewer tile is remediated and left in place, discrete samples will be collected from each of the manholes providing access to the sewer. Direct measurements will be made on exposed surfaces inside each manhole. If the surface scan results, or the discrete soil sample results, in any of the survey units do not pass the release criteria, the survey unit will be remediated and additional measurements will be collected, in accordance with MARSSIM. The sewer tile may be excavated from Argyle Street. In this case, no samples will be collected from inside the sewer tile and samples will be collected from the walls of the excavation, in accordance with MARSSIM guidance.

5.5 Survey Design - Soil Surrounding the Sewer Tile

Sampling will occur after remediation is complete. In the event that the sewer tile is remediated and left in place, sampling will be performed from the surface, along the outside edge of the sewer tile. The soil surrounding the sewer tile is not expected to be impacted and consequently is classified as a Class 2 survey unit. Discrete soil samples will be collected from specific locations adjacent to the sewer tile. The location of the samples will be determined during the remedial activities. The

[20] The release criteria for the concrete surfaces are described in Section 3 of this Plan.

contractor will collect at least two samples (i.e. one sample on each side of the sewer tile) every fifty (50) feet along the length of the sewer tile from Building 3H to Shelton Avenue.

5.6 Survey Design - Backfill Soil

Each of the subsurface areas in the Decon pit, the rectifier room and the Xray reading room were previously remediated by UNC in 1973. Clean backfill was placed in the excavation and the concrete floor was replaced. The backfill soil will be excavated and segregated from the impacted soil. Three (3) discrete soil samples will be collected for each survey unit and analyzed to verify that the concentration of enriched uranium is less than the release criteria described in Section 3 of this Plan. Direct radiation measurements (i.e. walk over surveys) will be performed on at least fifty percent (50%) of the soil after it is placed in the storage pile. Soil that satisfies the release criteria will be returned to the excavation after impacted soil is removed.

6 RADIATION SAFETY INSTRUMENTS

All instrumentation used for the Final Status Survey, including scanning measurements, will be appropriate for the type of radiation expected, of sufficient sensitivity and accuracy to detect the radioactive materials of interest, and of sufficient quantity to support planned activities. The following subsections provide additional project-specific details.

6.1 Selection Criteria

The selection of appropriate radiation detectors will depend upon the type of survey, the surface contour, and the survey area's size. Table 4 provides a list of the instrument types that will be used for the Final Status Survey, along with the types of radiations they detect, and the necessary calibration sources. Table 5 describes the sensitivity of the direct reading instruments.

For surface soil, the project team will use a 2-inch by 2-inch sodium iodide (NaI) gamma scintillator, such as a Ludlum Model 44-10, or equivalent. For concrete surfaces, the project team will typically use a plastic scintillator detector of approximately 100 square centimeters in area, such as a Ludlum Model 43-93 or equivalent, for direct alpha measurements. In areas where the Ludlum Model 43-93 will not fit, a 15 square centimeter Geiger-Mueller (GM) detector, such as a Ludlum Model 44-9 or equivalent, will be used. An appropriate ratemeter will be attached to the detector, sufficient to provide the required voltage and if required, a scaler to accumulate total counts in a specified time period. A ratemeter such as a Ludlum Model 2224 or Model 3, or equivalent, may be selected.

6.2 Instrument Response Check

The sensitivity of each counting system and instrument for each medium and radionuclide will be determined prior to the start of the measurement campaign, with the results documented in the Final Status Survey Report. For all counting systems and instruments used as part of the analyses, at a minimum, the following QA/QC principles will be applied:

- Counting systems and instruments will be used in accordance with approved procedures. Each day that a counting system and instrument is used, the response will be checked using an appropriate radiation source before use. Additional response checks may be necessary depending on the counting system used, for example:
  - For laboratory counting systems, source check acceptance criteria (e.g., $\pm 2\sigma$ of the average response determined after the most recent calibration, or otherwise linking the response to the current calibration) will be established prior to using the counting system. Control charts will be used to evaluate the data.
  - For field instrumentation, source check acceptance criteria (e.g., $\pm 2\sigma$ for direct [integrated] measurements and ±20 percent for rate measurements) will be established prior to beginning the project.
- All source check results will be documented. Failed source checks will be repeated. Consecutive failure will result in additional testing of the counting system, in

accordance with the applicable procedure, and ultimately in removing the counting system from service.

- Survey data acquired prior to an instrument failing a source check will be reviewed by the Radiation Safety Officer to determine the validity of the data. This review will be documented.
- All instrument failures in the field will be followed by an investigation by the Project Manager of suspect data. All investigations will be documented.

6.2.1 Background Determination

On each day that an analysis is performed, the ambient background radiation will be determined and documented at least once, depending on the counting system and instrument used and the variability in the background.

6.2.2 Calibration

All counting systems and instruments will be calibrated with a National Institute of Standards and Technology (NIST) traceable source at intervals not exceeding 12 months for laboratory counting systems and at intervals not exceeding 6 months for portable field survey instruments. The source used will be appropriate for the type and the energy of the radiation to be detected. All calibrations will be documented and will include the source data.

6.2.3 In Situ Measurement Instrumentation Description

No in situ measurements of radionuclide concentration in soil will be made during this decommissioning effort. Instead, samples will be collected and forwarded to a commercial analytical laboratory for analysis.

6.2.4 Analytical Instrument Description

Prior to submitting any samples to a commercial analytical laboratory, a letter of specification will be sent to the laboratory. This letter will include the necessary measurement results and relevant detection sensitivities. At that time, the laboratory will be asked to declare the analytical methods and measurement devices they intend to use in order to meet UNC specifications.

Each commercial laboratory that provides analytical results as part of the decommissioning effort will be asked to provide a copy of their quality assurance documents, including quality assurance procedures designed to ensure that the necessary calibrations and detection sensitivity requirements are met.

In addition to the analytical requirements, the letter of specification will describe the following criteria:

- Sample disposition - turnaround time required to support the project; and proper maintenance, storage, and archiving of samples after transfer to laboratory.
- Analytical QC - the number of samples for a specific laboratory analysis that will be submitted for the purposes of QA/QC, as specified in the QAPP. These QC samples will include duplicate samples and spiked samples with site media containing a known quantity of one or more radionuclides. Samples selected for QC analyses will

be determined by the Project Manager. The results of these QA/QC samples will be reviewed by the Project Manager to assess the accuracy and precision of the laboratory counting system as follows:

- The results of duplicate samples, equipment rinsate samples, and spiked samples will be reviewed against the original analysis results.
- The results of the background analysis will be reviewed against the desired Minimum Detectable Concentrations (MDCs) for the specified radionuclides. The MDCs reported should be less than the desired MDCs. The results of the QC samples and their review will be included in the Final Status Survey Report.

6.3 Calibration Sources

In addition to the daily response checks, all portable instrumentation will be calibrated on an annual basis using National Institute of Standards and Technology (NIST) traceable sources and calibration equipment. Calibration labels showing the instrument identification number, calibration date, and calibration due date will be attached to all portable field instruments, and calibration records will be captured in the Final Status Survey Report.

Calibration will include the following:

- High-voltage calibration;
- Discriminator threshold calibration; and
- Scaler calibration verification.

The calibration of detectors will include the determination of the operating voltage and the calibration constant.

All sources used for instrument calibration, daily checks, or efficiency determinations for the survey will be representative of the instrument's response to the identified radionuclides and are traceable to NIST. These sources will include ^{99}Tc, ^{230}Th, ^{137}Cs, and mixed gamma sources. Direct alpha measurements will be collected using a detector calibrated with thorium 230 (^{230}Th). This isotope is adequate for calibration because the alpha energy (approximately 4.6 Mev) is similar to the alpha energies from the radionuclides associated with thorium and uranium, and their decay chains. The gamma scintillator will be checked with a ^{137}Cs source with a gamma energy of approximately 670 keV. Health physics technicians will control the use and storage of the radiation sources used for instrument response checks and efficiency determination.

6.4 Detection Limits

Minimum Detectable Concentration (MDC) is defined as the smallest amount or concentration of radioactive material that will yield a net positive count with a 5 percent probability of falsely interpreting background responses as true activity. The MDC is dependent upon count times, geometry, sample size, detector efficiency, and background, and for scanning, the scanning rate and the efficiency of the surveyor. Nominal detection sensitivities were calculated using the guidance

provided by NUREG 1507, and are summarized in Table 5.[21] Instruments will be selected to achieve detection sensitivities of less than the release criteria for both scanning and direct, static measurements.

6.4.1 Surface Soil

The minimum detectible concentration (MDC) was calculated using guidance provided by MARSSIM, to ensure that walk-over surveys of land areas are sufficiently sensitive (Section 6.7, MARSSIM). The minimum detectible count rate (MDCR) for a surveyor using a two-inch by two-inch NaI detector was calculated as shown below. For a surveyor scanning at a speed of 1 foot per second, with a background of 8,000 cpm, as found during the previous surveys at the site, an index of sensitivity of 1.38 (consistent with a false-positive proportion of 0.6 and a true-positive proportion of 0.95) and a surveyor efficiency (p) of 0.5, the following results:

$$B_i = \frac{8{,}000 counts}{\text{min}} \times \frac{1\,\text{min}}{60\,\text{sec}} \times 1\,\text{sec} = 133 counts$$

$$MDCR = 1.38 \times \sqrt{133} \times \frac{60\,\text{sec}}{\text{min}} = \frac{956 counts}{\text{min}}$$

$$MDCR_{surveyor} = \frac{956}{\sqrt{0.5}} = \frac{1{,}352 counts}{\text{min}}$$

The MDCR of 1,352 counts per minute (cpm) is converted to an exposure rate using the detection sensitivity in Table 6. Consequently, the surveyor is capable of achieving a scan MDC of approximately 1.6 μR/hour above background.

The scan MDC value in μR/hour can be converted to pCi/g for specific radionuclides using a conversion factor derived from guidance provided in MARSSIM and the shielding code Microshield. Examples of the conversion factors are provided in Table 6. As demonstrated in the table, the scan of surface soil is adequately sensitive to detect concentrations of uranium below the release criteria. The results of the surface scan will be used to identify areas of elevated radiation; the results of the laboratory analysis of discrete soil samples will be used to verify compliance with the release criteria.

6.4.2 Concrete Surfaces

For the survey of the concrete surface in the South trench and the manholes of the sewer, the detection limit for surface activity measurements (counts) acquired over a pre-set time period was determined by the following methodology:

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[21] U.S. Nuclear Regulatory Commission, *Minimum Detectable Concentrations With Typical Radiation Survey Instruments For Various Contaminants And Field Conditions*, NUREG-1507, December 1997.

$$MDA = \frac{\left(2.71 + 4.65\sqrt{BKG_{avg} \times t}\right)}{t \times E \times \frac{A}{100}}$$

where:

MDA = the activity level (dpm/100 cm^2),
BKG_{avg} = the background count rate for this measurement type (cpm),
E = instrument efficiency,
t = the measurement duration (min),
A = the area of the detector (cm^2).

The MDA for an instrument operating in the ratemeter mode was determined by:

$$MDA = \frac{4.65\sqrt{\frac{BKG_{avg}}{2t_c}}}{E \times \frac{A}{100}}$$

where:

t_c = the meter time constant (min).

Alternatively, the detection limits for scanning measurements were approximated, based upon an audibly discernible increase in count rate by the following methodology:

$$MDA = \frac{R_a \times BKG_{avg}}{E}$$

where:

R_a = the audibly discernible increase in instrument response by the individual surveyor.

6.5 Measurement Uncertainty

The rate of radioactive decay is not constant with time and is therefore described by a Poisson probability distribution. Based on such a distribution, the best estimate of the standard deviation (s) on a number of counts © is the square root of the counts. Likewise, the standard deviation in a count rate over the count time (t) is:

$$s_r = \frac{\sqrt{c}}{t}$$

For the measurements conducted during the survey, the number of counts due only to background will be a significant portion of the total counts. The uncertainty associated with the background will be taken into account by:

$$s_r = \sqrt{\frac{c}{t^2} + \frac{BKG_{avg} \times t_{bkg}}{\left(t_{bkg}\right)^2}}$$

where

t_{BKG} = the time period over which the background counts were determined.

Each reported measurement value will include an assessment of the uncertainty associated with that value. To ensure a 95 percent confidence level, each value of sr will be multiplied by a factor of 1.96.

7 PROTOCOL FOR RADIATION SURVEYS

7.1 Procedure and Data Conversion for Soil Scanning

7.1.1 Procedures

Instruments used to acquire measurement data will be appropriate for the type of radiation expected, of sufficient sensitivity and accuracy to detect the radioactive materials found at the site, and of sufficient quantity to support the activities. Each instrument will be labeled with a unique identifier (e.g., serial number of detector and ratemeter) to enable traceability between instrument and survey records. Tables 4 and 5 contain a listing of each instrument type, its anticipated use during performance of the survey, and its nominal background response, detection efficiency, and detection sensitivity.

An area will be scanned according to the area classification. Scanning coverage will range from 0 to 100 percent. When scanning soil, the detector will be held close to the ground, within 6 centimeters (< 3 inches), and will be moved in a serpentine pattern. A scan rate of 0.5 meter per second is standard for scanning gamma emitters in surface soil. The scan rate may be adjusted by the Radiation Safety Officer according to the required scan MDC. Additional factors that may reduce the effectiveness of scanning (e.g., increased moisture content of the soil or depth of contamination) will be considered when establishing a scan rate in the field. In the scanning mode, the audio response will be used to improve the likelihood of detection of an elevated area and avoid a false-negative response resulting from the lag time of the meter (analog needle) response. If the health physics technician detects elevated activity in a particular location, the technician will pause and obtain a count rate in that area. Any area exhibiting residual radioactivity that is distinguishable from background will be identified with a flag, and will be subject to further investigation.

Exposure rate measurements will be conducted at a height of 1 meter above the ground surface. Measurements will be made at grid points and/or those locations of elevated radiation identified during scanning.

7.1.2 Data Conversion

Ambient gamma exposure rates from the walk-over survey will be converted to units of net exposure rate by the following methodology:

$$R_{net} = \left(R_{gross} - BKG_{avg}\right) \times CF$$

where

R_{net} = the net measured exposure rate (cpm),
R_{gross} = the gross measured exposure rate (μR/hr or cpm),
BKG_{avg} = the mean background exposure rate applicable to the survey (μR/hr or cpm),

CF = an optional conversion factor to convert count rate instrument readings into units of "μR/hr" if instrument read-outs were in "counts per minute."

7.2 Procedures and Data Conversion for Measurements on Concrete Surfaces

7.2.1 Procedures

Total contamination will be measured by direct survey with portable radiation survey instruments sensitive to alpha radiation. For these measurements, the instrument will be turned on and permitted to stabilize (approximately 30 seconds) before proceeding further. In addition, preoperational checks to ensure functionality will be completed.

Static surveys will be conducted by placing the detector in contact with the surface of interest. A timed count of biased areas will be performed with the Ludlum 2224/43-93 probe in alpha mode. During the surveys, the count rate in each area will be recorded on the survey form, along with any comments and notations that may be necessary for interpretation of the results. Care will be taken to ensure that surfaces monitored will be free of material (e.g., dust, grease, etc.) having the potential to interfere with alpha monitoring.

7.2.2 Data Conversion

Total (fixed plus removable) contamination data will be converted to units of activity by the following methodology:

$$A_{total} = \frac{cpm - BKG_{avg}}{E} \times \frac{100}{A}$$

where

A_{total} = the total surface activity (dpm/100 cm^2),
cpm = the counts per minute measured by direct survey,
BKG_{avg} = the average background count rate for this measurement methodology (cpm),
E = detection efficiency of the instrument used (counts per disintegration),
A = the active surface area of the detector (cm^2).

8 PROTOCOL FOR DISCRETE SOIL SAMPLING

8.1 Soil Sampling Locations

The discrete soil sampling locations will be selected to ensure even coverage over each Survey Unit, as follows:

- As with the scanning surveys, a reference system will be established using a grid system placed over the area; and
- The location strategy will utilize a stratified systematic unaligned sampling protocol.[22]

Quality Control (QC) sampling will include the collection of duplicate samples at a frequency of one for every ten environmental samples and matrix spike/matrix spike duplicate (MS/MSD) samples at a frequency of one for every twenty environmental samples. Replicates will be prepared by homogenizing a sample in a precleaned, dedicated bowl, then removing separate aliquots for the duplicate sample or the MS/MSD sample. Additional sample volume will be collected, as necessary.

8.2 Sampling Procedures

For each discrete soil sample, approximately 500 grams to 1 kilogram of soil will be collected to a depth of 6 inches (15 cm) at each sampling location, using a clean scoop. The soil sample will be placed into a 1 gallon plastic bag and sealed, or into a wide-mouth jar and covered.

8.3 Sample Designation

Samples will be assigned a unique alpha-numeric sample descriptor identifying the survey unit and sample number. The plastic bag containing each sample, and the field notes and maps depicting the sampling location, will be labeled. The sample designations for subsurface survey units may not include a survey grid number because these survey units are expected to be less than 2,000 m^2 in area. In addition to the unique alpha-numeric sample descriptor, each plastic bag will be labeled with the sampler's initials and the time and date of sample collection, in the format of MM/DD/YYYY.

8.4 Sample Shipping

The samples will be placed in a suitable container for transportation, and shipped via overnight courier (preferably Federal Express) to Outreach Laboratory in Broken Arrow, Oklahoma, for radiological analysis. The hold time for radionuclides is 6 months.

8.5 Chain-of-Custody Procedures

The sampler will be responsible for sample custody from the time of sample collection to receipt at the laboratory, or until samples are shipped by commercial carrier. A sample is considered to be under custody under the following circumstances:

- The sample is in a person's possession;

[22] Toohey R.E., W. Brown, and J.H. Stebbings, *Random geographic sampling with UTM coordinates*, Argonne National Laboratory, 1987.

- The sample is in that person's view after being in his or her possession;
- The sample was in that person's possession and then placed in a secured location; or
- The sample is in a designated secure area.

Sample containers that are shipped together in a group of coolers will be assigned a Chain-of-Custody Record, which will be included in one of the coolers sent to the laboratory.

A signed copy of the Chain-of-Custody Record will be retained by the field sampler before the coolers are shipped to the laboratory. A copy of the Chain-of-Custody Record with its assigned sample numbers will be kept in the laboratory to help identify samples that might become separated from the discrete sample delivery group. The shipment air bill will be kept as Chain-of-Custody documentation.

8.6 Analytical Parameters and Procedures

All discrete soil samples will be analyzed by the methodology of gamma spectroscopy, using Method DOE GA-01-R, which is an equivalent method to HASL 300. Selected samples will be analyzed via alpha spectroscopy for isotopic uranium and thorium, using Method DOE A-01-R, which is an equivalent method to LANL ER290. The radionuclide concentrations will be reported in units of "picocuries per gram." Analytical parameters, methods, and contract-required detection limits are provided in Table 7.

8.7 Decontamination Procedures and Management of Investigation-derived Waste

Soil sampling equipment will be decontaminated after each sample to minimize the spread of contamination from one sample to another. The visible debris will be removed and the tools will be rinsed with clean water. The tools and collection bowls will be surveyed for the presence of total radioactivity.

9 DATA VALIDATION AND COMPARISON WITH RELEASE CRITERIA

9.1 Data Assessment

Data will be reviewed to verify that the requirements stated in this FSSSP are implemented as prescribed and that the results of the data collection activities support the objectives of the survey, or permit a determination that these objectives should be modified. Specifically, the data will be reviewed to determine if the data are of the appropriate type, quality, and quantity to demonstrate compliance with the release criteria. The review will check that the appropriate number of samples were taken from the correct locations and that they were analyzed with measurement systems having the appropriate sensitivity. After the data are analyzed, a sample estimate of the data variability, namely the sample standard deviation (σ) and the actual number of valid measurements, will be used to determine that the sampling design provides adequate power to conclude that the objectives of the survey design are met.

9.2 Preliminary Data Review

The Project Manager will review the QA/QC reports, prepare graphs of the data, and calculate basic statistical quantities to analyze the structure of the data, and to identify patterns, relationships, or potential anomalies. The survey data will be reviewed as they are collected. The preliminary data examination will include the following:

- Evaluation of data completeness;
- Verification of instrument calibration;
- Verification of sample identification and traceability to sampling location;
- Measurement of analytical precision using duplicate samples;
- Measurement of analytical bias using spiked samples;
- Assessment of adherence to method specifications and QC limits;
- Evaluation of method specifications and QC limits;
- Evaluation of method performance in the sample matrix;
- Applicability and validation of analytical procedures for site-specific measurements; and
- Assessment of external QC measurement results and QA assessments.

9.3 Investigation Levels

The Project Manager will use radionuclide-specific investigation levels to determine when additional investigations may be necessary. Investigation levels will also serve as a QC check to assess whether a measurement process is beginning to get out of control. A measurement that exceeds the investigation level may indicate that the survey unit has been improperly classified, or it may indicate a failing instrument. When an investigation level is exceeded, the first step will be to confirm that the initial measurement/sample actually exceeds the particular investigation level. This may involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the resulting dose or risk meets the release criterion. Depending on the results of the investigation actions, the survey unit may require reclassification, additional field decommissioning activities, and/or resurveying.

If the data suggest that the survey unit was improperly classified, then the original DQOs will be redeveloped for the proper classification. The sampling design and data collection documentation will be reviewed for consistency with the DQOs.

9.4 Data Evaluation and Conversion

9.4.1 Conversion of Data to Release Criteria Units

For comparison of survey data with release criteria, the survey data from field and laboratory measurements will be converted to appropriate units (i.e. pci/gram). The Project Manager will ensure that data measurements retain traceability to NIST and that conversion factors are appropriate for the radiation quantity. The preliminary data reports will be reviewed to ensure that adequate measurement sensitivity is being achieved and to resolve any detector sensitivity problems.

An evaluation will be made to confirm that the data are consistent with the underlying assumptions made for survey plan statistical procedures. The basic statistical quantities that will be calculated for the survey unit are as follows:

- Mean;
- Standard deviation;
- Median;
- Minimum; and
- Maximum.

The value of the sample standard deviation will be used to determine if a sufficient number of samples were collected to achieve the desired power of the statistical test. A verification that the sample sizes determined for the tests are sufficient to achieve the DQOs set for the Type I (α) and Type II (β) error rates will be completed. If an insufficient number of samples was collected, another survey will be performed. A resurvey will be performed only if the sample size must be increased by more than 20 percent, since MARSSIM Tables 5.3 and 5.5 include a correction factor of 20 percent to allow for loss or unusable data. If it is not possible to show that the DQOs were met with reasonable assurance, then a resurvey will be performed.

9.4.2 Data Analysis

During the Final Status Survey, the survey data will be evaluated to determine whether the levels of radioactivity in each medium in a survey unit are greater than the levels of radioactivity in the corresponding medium in the background area. Data evaluation will be performed using the tests specified in MARSSIM, as summarized in Table 8.

Wide-Area Measurements

Wide-area measurements will be performed in which the mean measurement for a survey unit will be compared with the mean background plus the release criteria. The release criteria is the criteria to be used for statistical tests. In a "hot spot," Elevated Measurement Comparisons (EMCs) will be performed where specific measurements exceed the release criteria. The release criteria for a "hot spot" is derived separately in Section 3 of this Plan. No single sample is allowed to exceed 90 pCi/gram of enriched uranium.

The first level of comparison will be to assess whether the difference between the maximum value in the survey unit and the minimum value in the reference area is less than the release criteria. If the difference is less than the release criteria, then the unit passes. A second level of comparison is to assess whether the difference between the mean of the values in the survey unit and the mean of the values in the reference area is greater than the release criteria. If the difference is greater than the release criteria, then the unit fails. In the intermediate case, where the maximum difference is greater than the release criteria, but the difference of the means is less than the release criteria, the Wilcoxon Rank Sum (WRS) test will be used. The WRS test will be used because all of the analytes of concern are present in background. The WRS test is a nonparametric test that can used to determine if the mean concentration in the survey unit is significantly greater than the mean concentration in the background.

Areas with Isolated Elevated Measurements

Both the measurements at discrete locations and the scans will be subject to the Elevated Measurement Comparison (EMC). The result of the EMC will be used as a trigger for further investigation. If a measurement at any location exceeds the release criteria for a "hot spot", the investigation may involve taking further measurements to determine that the area and level of the elevated residual radioactivity are such that the resulting dose or risk meets the release criteria. The investigation will provide adequate assurance, using the process outlined in MARSSIM, that there are no other undiscovered areas of elevated residual radioactivity in the survey unit that might otherwise result in a dose or risk exceeding the release criteria. In some cases, this may lead to reclassifying all or part of a survey unit, unless the results of the investigation indicate that reclassification is not necessary.

10 PROJECT DOCUMENTATION

10.1 Field Records

All records pertinent to this Final Status Survey will be maintained pursuant to IEM RSP 004, "Radiation Protection Records" or equivalent.[23] This Section provides an overview of record keeping procedures for the Final Status Survey. All records associated with the Final Status Survey will be maintained until authorized for destruction by the USNRC.

Field records will contain the following, at a minimum:

- A description of the purpose of the survey;
- The name of the surveyor(s) and the surveyor's qualifications;
- A description of the survey methodology;
- A complete and unambiguous record of the radiological status of the areas that were surveyed in the buildings and on Argyle Street;
- Sufficient information and data to enable an independent re-creation and evaluation of survey activities and results at some future date; and
- Copies of all Radiological Survey Forms, instrument check sheets, and calculation forms as required in RSP-008, "Instrumentation" and RSP-018, "Surveillance," or equivalent.

Survey maps will designate the location being surveyed, as well as the name of the surveyor and other pertinent survey information. Both direct field measurements and laboratory analytical results for radiological monitoring and soil testing will be documented. The results for each survey measurement and/or each sample analysis will be listed in tabular form along with the corresponding grid block or coordinate location. All survey data will be recorded in a verifiable manner and reviewed for accuracy and consistency.

Data acquired during the implementation of the Final Status Survey will be captured as part of a data management system. Data management personnel will ensure that chain-of-custody and data management procedures are followed.

10.2 Final Status Survey Report

The Final Status Survey Report will be a stand-alone document, with the amount of information incorporated by reference being kept to a minimum. The report will be reviewed and approved by personnel capable of evaluating all aspects of the report prior to its release. The required report elements are as follows:

- Site description
- Site conditions at the time of the survey
- Survey objectives
- Release Criteria
- Classification of areas

[23] Integrated Environmental Management, Inc., *Radiation Protection Records*, IEM RSP-004, January12, 2005.

- Selection of instruments and survey techniques
- Survey plan and procedures
- Determination of background
- Scanning survey measurements
- Discrete samples
- Detection sensitivity
- Sample collection and analysis
- Data interpretation

The following construction-related items will be included in the report as well:

- A brief description of the outstanding construction items from the final inspection and an indication that the items were satisfactorily resolved;
- A synopsis of the work defined in the Decommissioning Plan and certification that this work was performed;
- An explanation of any changes to the work defined in the decommissioning work plan, including as-built drawings of the constructed facilities, and why the changes were necessary or beneficial for the project; and
- Certification that the decommissioning activities are complete.

Additionally, the Final Status Survey Report will contain the following:

- A discussion of any field modifications that were made in the implementation of the Final Status Survey from what was described in the FSSSP or other submittals;
- A description of the method by which the number of samples was determined for each survey unit; and
- A summary of the values used to determine the number of samples and a justification for these values.

Furthermore, the survey results reported for each survey unit will include the following, as applicable:

- The number of samples collected from the survey unit;
- A drawing of the survey unit showing the reference system and random start systematic sample locations for Class 1 and 2 survey units and random locations shown for Class 3 survey units and reference areas;
- The measured sample concentrations;
- The statistical evaluation of the measured concentrations;
- Judgmental and miscellaneous sample data sets reported separately from those samples collected for performing the statistical evaluation;
- A discussion of anomalous data, including any areas of elevated direct radiation detected during scanning that exceeded the investigation level or measurement;
- Locations in excess of the release criteria; and
- A statement that a given survey unit satisfied the release criteria and the elevated measurement comparison if any sample points exceeded the release criteria.

Finally, the Final Status Survey Report will contain the following, as necessary:

- A description of any field modifications made to initial survey unit assumptions relative to the extent of residual radioactivity;
- If a survey unit fails, a description of the investigation conducted to ascertain the reason for the failure and a discussion of the impact that failure has on the conclusion that the facility is ready for final radiological surveys; and
- If a survey unit fails, a discussion of the impact that the reason for the failure has on other survey unit information.

TABLES

Table 1 - Classification of Survey Units

Former UNC Manufacturing Facility
New Haven, Connecticut

ROOM	CLASSIFICATION	DESCRIPTION
Decon Pit	1	Subsurface soil
Rectifier Room	1	Subsurface soil
Xray Reading Room	1	Subsurface soil
Fill Soil in Previous Excavations	3	Fill Soil in each excavation
Chemistry Lab	1	Residue in South Trench
Building 3H and 6H	1	Residue in South Trench
Sewer Residues	1	Impacted residue in the sewer
Soil Outside of the Sewer	2	Soil surrounding the sewer system

Table 2 - Uranium Series Decay Chain

Former UNC Manufacturing Facility
New Haven, Connecticut

NUCLIDE	HALF LIFE	MAJOR RADIATION ENERGIES (MeV) AND DECAY BRANCHING RATIO (%)					
		ALPHA		BETA(E_{MAX})		GAMMA	
Uranium 238	4.51×10^9 years	4.15 4.20	23% 77%				
Thorium 234	2.41×10^1 days			0.10 0.19	19% 73%	0.063 0.928	4% 3%
Protactinium 234m	1.7×10^0 minutes			2.29	98%	1.00	1%
Uranium 234	2.44×10^5 years	4.72 4.77	27% 72%			0.053	0.1%
Thorium 230	7.7×10^4 years	4.62 4.68	28% 76%			0.067	0.4%
Radium 226	1.6×10^3 years	4.60 4.78	60% 94%			0.186	3%
Lead 210	2.22×10^1 years			0.063	20%	0.046	4%

Table 3 - Actinium Series Decay Chain

Former UNC Manufacturing Facility
New Haven, Connecticut

NUCLIDE	HALF LIFE	MAJOR RADIATION ENERGIES (MeV) AND DECAY BRANCHING RATIO (%)					
		ALPHA		BETA(E_{MAX})		GAMMA	
Uranium 235	7.1×10^8 years	4.37 4.40	18% 57%			0.143 0.185	11% 54%
Protactinium 231	3.3×10^4 years	5.01 5.02	24% 23%			0.027	6%
Actinium 227	2.16×10^1 years	4.95	1%	0.043	99%	0.07	<1%
Thorium 227	18.2 days	5.98 6.04	24% 23%			0.237	15%
Radium 223	11.4 days	5.61 5.71	26% 54%			0.149 0.27	10% 10%

Table 4 - Radiation Survey Instruments

Former UNC Manufacturing Facility
New Haven, Connecticut

Make	Ratemeter Model	Detector Model	Detector Type	Radiation Detected	Calibration Source	Use
Ludlum	2241	44-10	Sodium Iodide (NaI)	Gamma	^{137}Cs (γ)	Scanning surface soil
Ludlum	2224	43-93	Dual scintillation	Alpha or beta	^{230}Th (α) ^{99}Tc (β)	Direct alpha surveys on solid surfaces
Ludlum	3	44-9	Geiger-Mueller	Beta	^{99}Tc (β)	Direct beta surveys; beta scans on solid surfaces
Ludlum	2929	43-10-1	Dual scintillation	Alpha or beta	^{230}Th (α) ^{99}Tc (β)	Removable activity on wipe tests
Bicron	Microrem	--	Sodium Iodide (NaI)	Gamma	^{137}Cs (γ)	Whole body radiation exposure

Table 5 - Nominal Detection Sensitivities

Former UNC Manufacturing Facility
New Haven, Connecticut

INSTRUMENT MODEL	DETECTOR	USE	NOMINAL BACKGROUND	DETECTION EFFICIENCY	DETECTION SENSITIVITY
Ludlum Model 2241 scaler/ratemeter	Ludlum Model 44-10 (2x2 sodium iodide)	Walk over survey	5,000 - 8,000 cpm	N/A	900 cpm/μR/hr
Ludlum Model 2224 ratemeter	Ludlum Model 43-93	Contamination survey	0-3 cpm alpha	13-19%	N/A
Ludlum Model 2929 scaler	Ludlum Model 43-10-1	Smear counting	50-80 cpm beta 0-3 cpm alpha	30-40%	N/A
Bicron Microrem	Internal (Sodium Iodide)	Walk over survey	3-8 μrem/hr	N/A	N/A

Table 6 - Example Conversion Factors to Convert from Scanning Results

Former UNC Manufacturing Facility
New Haven, Connecticut

Radionuclide	Detection Sensitivity cpm/μR/hour	Conversion Factor pCi/g/μR/hr
Radium-226	760	1.41
Uranium-238	830	0.99
Natural uranium and progeny	3,990	211

Table 7 - Analytical Parameters, Methods and MDCs

Former UNC Manufacturing Facility
New Haven, Connecticut

Parameter	Matrix	Method	Contract Required Detection Limit
Isotopic uranium	Soil	Alpha Spectroscopy DOE A-01-R	0.1 pCi/g
Gamma emitting progeny of uranium and actinium	Soil	Gamma Spectroscopy DOE GA-01-R	5.0 pCi/g

Table 8 - Summary of Statistical Tests for Analytes that are Present in Background

Former UNC Manufacturing Facility
New Haven, Connecticut

Survey Result	Conclusion
Difference between largest survey unit measurement and smallest reference area measurement is less than release criteria	Survey unit meets release criterion
Difference of survey unit average and reference area average is greater than release criteria	Survey unit does not meet release criterion.
Difference between any survey unit measurement and any reference area measurement is greater than release criteria and the difference of survey unit average and reference area average is less than release	Conduct WRS test and elevated measurement comparison

FIGURES

Figure 1 - 71 Shelton Avenue, New Haven Connecticut

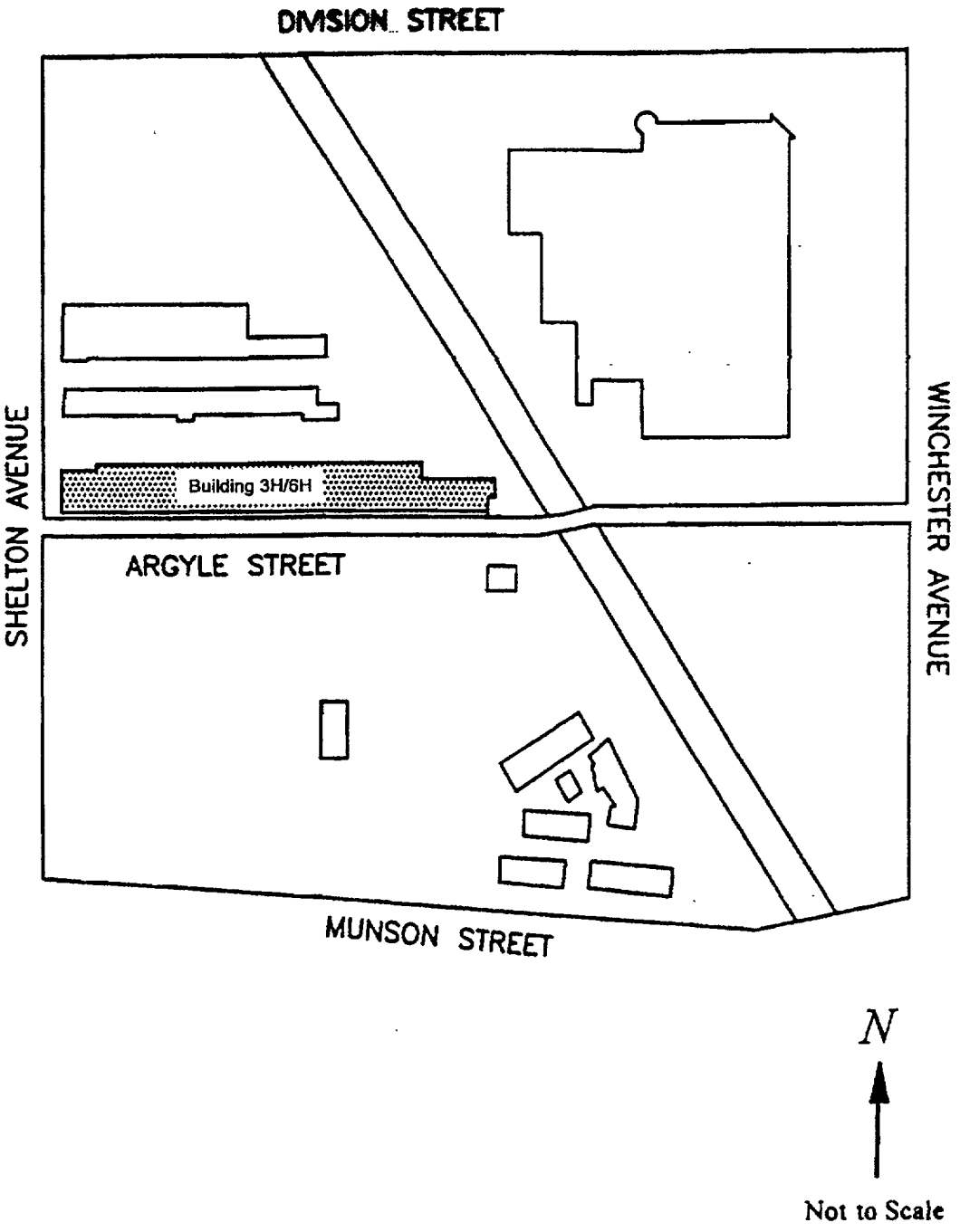


Figure 2 - Buildings 3H and 6H

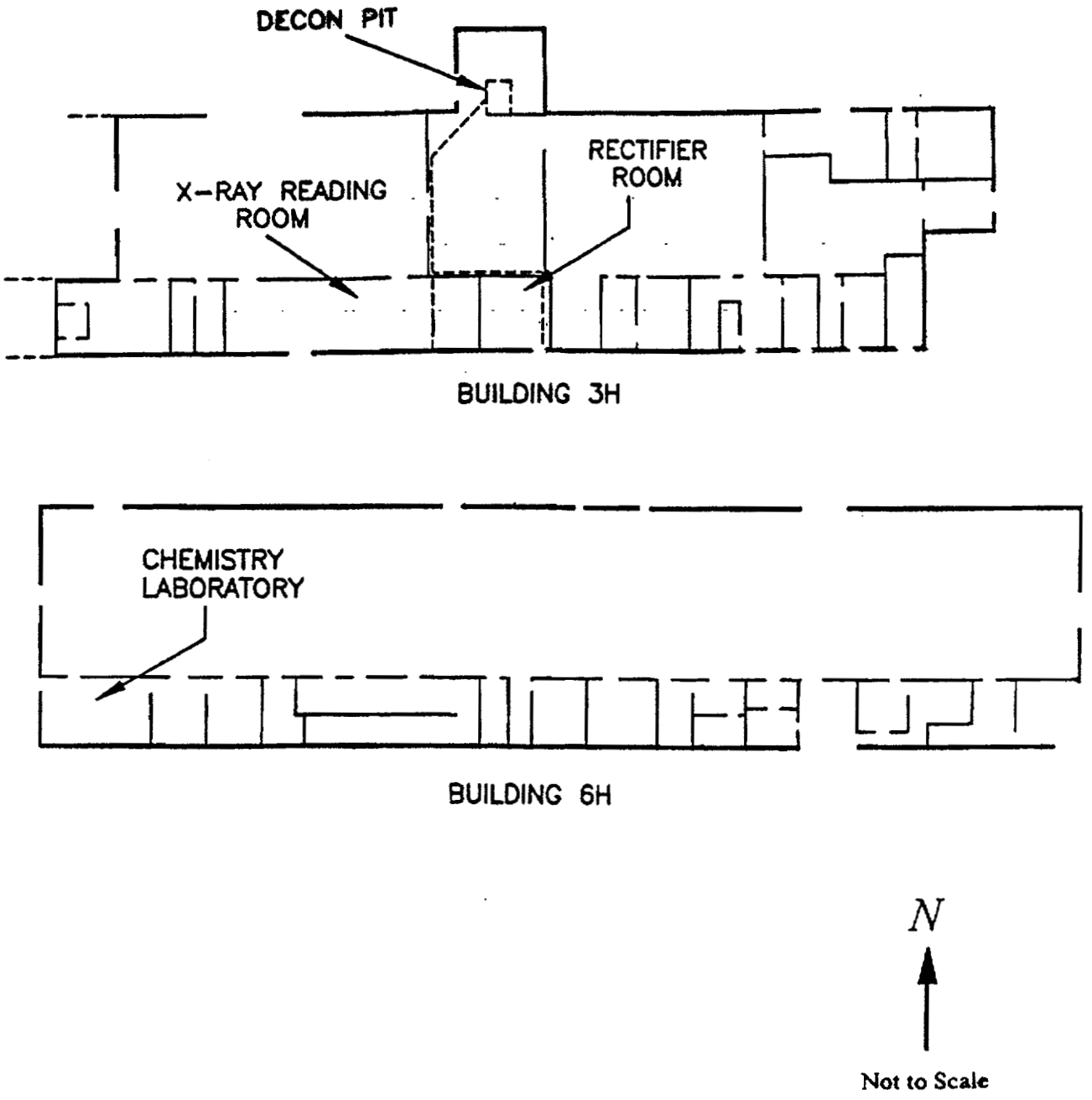
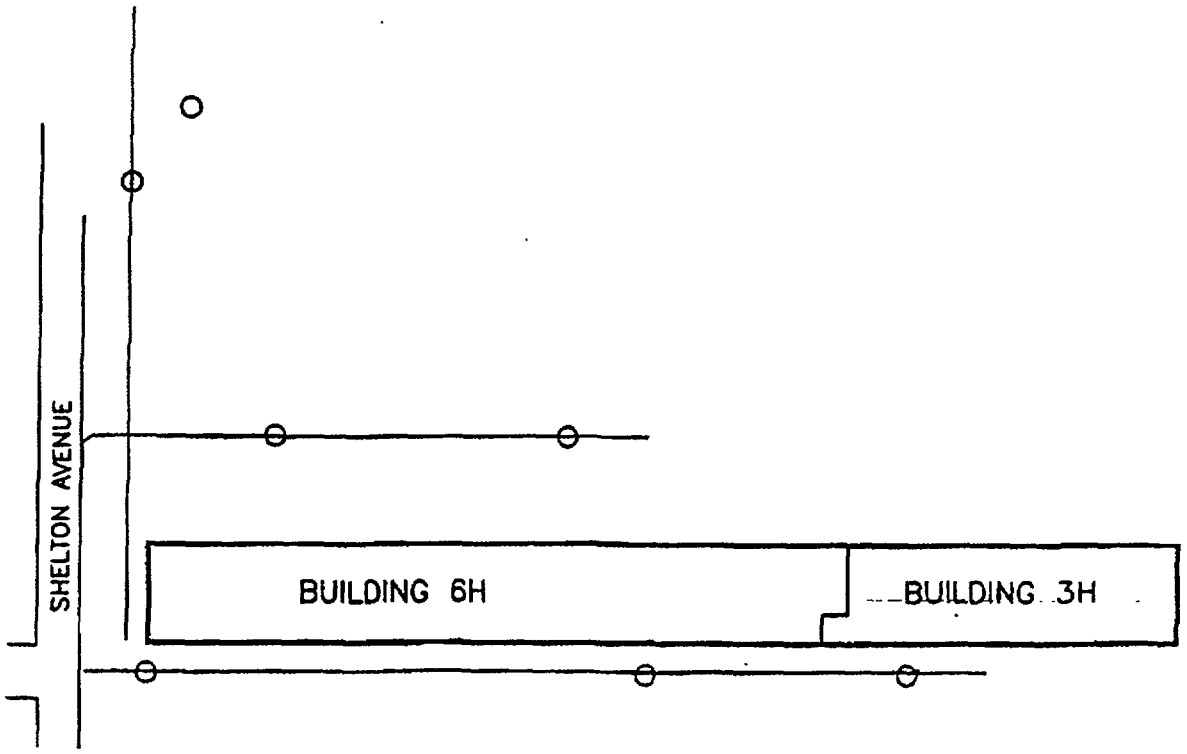


Figure 3 - Storm Water Sewer System, Argyle Street



Manhole

N

Not to Scale

APPENDICES

Appendix A - USNRC Guidelines for Decontamination of Facilities and Equipment Prior to Release for Unrestricted Use or Termination of Licenses for Byproduct, Source, or Special Nuclear Material

GUIDELINES FOR DECONTAMINATION OF FACILITIES AND EQUIPMENT PRIOR TO RELEASE FOR UNRESTRICTED USE OR TERMINATION OF LICENSES FOR BYPRODUCT. SOURCE, OR SPECIAL NUCLEAR MATERIAL

U.S. Nuclear Regulatory Commission
Division of Fuel Cycle & Material Safety
Washington, D.C. 20555

July 1982

[UNC Note - The original document was derived from NRC Regulatory Guide 1.86. It was published in November 1976, included as Appendix I in NRC NUREG/CR-2082 - Monitoring for Compliance With Termination Survey Criteria, and the contents were incorporated into UNC's NRC license as Condition 11.]

The instructions in this guide, in conjunction with Table 1, specify the radionuclides and radiation exposure rate limits which should be used in decontamination and survey of surfaces or premises and equipment prior to abandonment or release for unrestricted use. The limits in Table 1 do not apply to premises, equipment, or scrap containing induced radioactivity for which the radiological considerations pertinent to their use may be different. The release of such facilities or items from regulatory control is considered on a case-by-case basis.

1. The licensee shall make a reasonable effort to eliminate residual contamination.

2. Radioactivity on equipment or surfaces shall not be covered by paint, plating, or other covering material unless contamination levels, as determined by a survey and documented, are below the limits specified in Table 1 prior to the application of the covering. A reasonable effort must be made to minimize the contamination prior to use of any covering.

3. The radioactivity on the interior surfaces of pipes, drain lines, or ductwork shall be determined by making measurements at all traps, and other appropriate access points, provided that contamination at these locations is likely to be representative of contamination on the interior of the pipes, drain lines, or ductwork. Surfaces or premises, equipment, or scrap which are likely to be contaminated but are of such size, construction, or location as to make the surface inaccessible for purposes of measurement shall be presumed to be contaminated in excess of the limits.

4. Upon request, the Commission may authorize a licensee to relinquish possession or control of premises, equipment, or scrap having surfaces contaminated with materials in excess of the limits specified. This may include, but would not be limited to, special circumstances such as razing of buildings, transfer of premises to another organization continuing work with radioactive materials, or conversion of facilities to a long-term storage or standby status. Such requests must:

   a. Provide detailed, specific information describing the premises, equipment or scrap, radioactive contaminants, and the nature, extent, and degree of residual surface contamination.

   b. Provide a detailed health and safety analysis which reflects that the residual amounts of materials on surface areas, together with other considerations such as prospective use of the premises, equipment or scrap, are unlikely to result in an unreasonable risk to the health and safety of the public.

5. Prior to release of premises for unrestricted use, the licensee shall make a comprehensive radiation survey which establishes that contamination is within the limits specified in Table 1. A copy of

the survey report shall be filed with the Division of Fuel Cycle and Material Safety, USNRC, Washington, D.C. 20555, and also the Administrator of the NRC Regional Office having jurisdiction. The report should be filed at least 30 days prior to the planned date of abandonment. The survey report shall:

a. Identify the premises.

b. Show that reasonable effort has been made to eliminate residual contamination.

c. Describe the scope of the survey and general procedures followed.

d. State the findings of the survey in units specified in the instruction.

Following review of the report, the NRC will consider visiting the facilities to confirm the survey.

TABLE 1

ACCEPTABLE SURFACE CONTAMINATION LEVELS

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

a. Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.
b. As used in this table, dpm (disintegratlons per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.
c. Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each such object.
d. the maximum contamination level applies to an area of not more than 100 cm^2.
e. The amount of removable radioactive material per 100 cm^2 of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.
f. The average and maximum radiation levels associated with surface contamination resulting from beta-gamma emitters should not exceed 0.2 mrad/h at 1 cm and 1.0 mrad/h at 1 cm, respectively, measured through not more than 7 milligrams per square centimeter of total absorber.

This report was prepared under the direction of
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by

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