FINAL

# Field Sampling Plan for the Radiological Final Status Survey of Building 4006

## Santa Susana Field Laboratory
## Ventura County, California

Contract Number 114579

***Prepared for:***

BOEING

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April 2008

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## List of Acronyms, Abbreviations, and Units of Measurement

| | |
|---|---|
| Boeing | The Boeing Company |
| CABRERA | Cabrera Services, Inc. |
| CDPH | California Department of Public Health |
| $cm^2$ | square centimeters |
| Cs | cesium (e.g., $^{137}Cs$) |
| DOE | U. S. Department of Energy |
| dpm | disintegrations per minute |
| DQOs | Data Quality Objectives |
| EDA | exploratory data analysis |
| EPA | U. S. Environmental Protection Agency |
| ETEC | Energy Technology Engineering Center |
| FSP | field sampling plan |
| FSS | final status survey |
| HASP | health and safety plan |
| IDW | investigation-derived waste |
| $m^2$ | square meters |
| MARSSIM | Multi-Agency Radiation Survey and Site Investigation Manual |
| MDC | minimum detectable concentration |
| ml | milliliter |
| Mn | manganese (e.g., $^{54}Mn$) |
| N/A | not applicable |
| NELAP | National Environmental Laboratory Accreditation Program |
| NIST | National Institute of Standards and Technology |
| PPE | personal protective equipment |
| QC | quality control |
| RAM | radio active material |
| SOP | Standard Operating Procedure |
| SSFL | Santa Susana Field Laboratory |
| U | uranium (e.g., $^{234}U$) |
| U.S. | United States |
| U.S.C. | Unites States Code |
| ZnS (Ag) | zinc sulfide (silver-activated) |
| μR/hr | microroentgen per hour |

## EXECUTIVE SUMMARY

This field sampling plan (FSP) describes the radiological final status survey (FSS) of Building 4006 at the Santa Susana Field Laboratory (SSFL) in Ventura County, California. Radiological data will be collected in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (EPA, 2000) to verify that the building meets the *Approved Sitewide Release Criteria for Remediation of Radiological Facilities at the SSFL* (Rocketdyne, 1999). These criteria for release to unrestricted use have been approved by the U.S. Department of Energy (DOE) and California Department of Public Health (CDPH).

Building 4006 is centrally located in Area IV and was operated as a non-nuclear sodium laboratory. Its principal function was research and development for sodium systems and components. While the building was predominantly a non-radiological facility, there are records of minor uses of radioactive materials.

Building 4006 is identified in the *Historical Site Assessment of Area IV, Santa Susana Field Laboratory, Ventura County, California* (Sapere, 2005) as a Class 3 impacted area, meaning it has a potential for residual radioactivity from historical activities, but where no radioactivity is expected to be detected above background. The radionuclides of concern that may be present as residual radioactivity in Building 4006 are uranium-234 ($^{234}$U), $^{235}$U, $^{238}$U, cesium-137 ($^{137}$Cs), manganese-54 ($^{54}$Mn), and tritium.

Scan and static measurements of alpha- and beta-emitting surface residual radioactivity, smear samples analyzed for gross alpha and beta radioactivity and tritium, and gamma exposure rate measurements will be collected from exposed, accessible surfaces in each survey unit. Accessible surfaces in air handling systems and drain lines will be surveyed. Inaccessible surfaces in these and other systems will not be surveyed unless indications of possible contamination are identified.

Exploratory data analysis (EDA) will be performed on the data to identify radionuclide distribution trends and potential outliers. EDA will include visual inspection of measurement results using time-series plots, posting plots, cumulative frequency distributions, probability plots, and histograms, as required, and calculation of statistical quantities including mean, median, standard deviation, and range. EDA of survey results will be performed in the field, as necessary, for the data sets in each survey unit to evaluate whether an investigation or additional survey data collection are warranted. EDA will include investigation of spatial or temporal distribution, outliers, and data population distributions.

The results of the data analysis and interpretation will be summarized and conclusions regarding the radiological status of the building and its suitability for release for unrestricted use will be documented in a survey report.

# 1.0 INTRODUCTION

This field sampling plan (FSP) describes the radiological final status survey (FSS) of Building 4006 at the Santa Susana Field Laboratory (SSFL) in Ventura County, California. Radiological data will be collected in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)* (EPA, 2000) to verify that the building meets U. S. Department of Energy (DOE) and California Department of Public Health (CDPH) approved criteria for release for unrestricted use. Cabrera Services, Inc. (CABRERA) has been contracted by The Boeing Company (Boeing) to perform this work.

Boeing operates Area IV of the SSFL for the DOE. Under the authority of the Atomic Energy Act [42 United States Code (U.S.C.) 201 et seq.]DOE is responsible for establishing a comprehensive health, safety, and environmental program for managing facilities. As an Agreement State under the Atomic Energy Act, the State of California through the CDPH has jurisdiction over non-DOE radiological activities at the SSFL.

## 1.1 Historical Background and Radiological Overview

In the late 1940s, North American Aviation acquired land in the Simi Hills between the Simi and San Fernando Valleys. That land, now known as SSFL, was used primarily for the testing of rocket engines. Atomics International, a division of North American Aviation, was formed in 1955 and part of Area IV at SSFL was set aside and used for nuclear reactor development and testing. In 1984 Atomics International merged with Rocketdyne. Boeing purchased Rocketdyne in 1996. Area IV of the SSFL is used for DOE-sponsored activities. Boeing, the National Aeronautics and Space Administration, and the Department of Defense have used the balance of the SSFL for rocket and laser testing.

Activities in Area IV started in the mid 1950s. Until 1964, these activities were primarily related to sodium-cooled nuclear power plant development and development of space power systems with sodium and potassium as coolants. The Energy Technology Engineering Center (ETEC, originally known as the Liquid Metal Engineering Center) was formed in the mid 1960s as an Atomic Energy Commission (now DOE) laboratory for the development of liquid metal heat transfer systems in support of the Liquid Metal Fast Breeder Reactor Program. Nuclear operations at Area IV included 10 nuclear research reactors, seven critical facilities, the Hot Laboratory, the Nuclear Materials Development Facility, and various test and nuclear material storage areas. All nuclear operations ended in 1988. Since that time DOE-funded activities have focused on decontamination and decommissioning of the ETEC facilities.

The *Historical Site Assessment of Area IV, Santa Susana Field Laboratory, Ventura County, California* (Sapere, 2005) describes the history and use of Building 4006. Building 4006 is centrally located in Area IV and was operated as a non-nuclear sodium laboratory. Its principal function was research and development for sodium systems and components. While the building was predominantly a non-radiological facility, there are records of minor uses of radioactive materials, including encapsulated cylinders of uranium oxide powder, components activated with manganese-54 ($^{54}$Mn), tritiated titanium foils in gas chromatographs and sodium loop level gauges possibly employing cesium-137 ($^{137}$Cs) sources. Several minor radiation surveys have been performed in the past related to these activities. No radioactivity was detected. In addition, soil sampling following removal of the building septic tank and leach-field did not detect any contamination. The building is not a designated or posted radiological facility.

Building 4006 is shown in Figure 1-1. It was constructed with a steel frame and walls and measures 1,234 square meters ($m^2$). The building is oriented length-wise on a northwest to southeast axis. It was closed for operations in 1999.

**Figure 1-1 Building 4006**

*(southeast end of building; view from south corner)* *(northeast side of building; view from south corner)*

## 1.2 Release Criteria

The criteria for releasing Building 4006 for unrestricted use is found in the *Approved Sitewide Release Criteria for Remediation of Radiological Facilities at the SSFL* (Rocketdyne, 1999), specifically the surface contamination and ambient gamma exposure rate guidelines presented in Sections 4 and 5, respectively. These criteria have been approved by the DOE and CDPH.

Based on the *Historical Site Assessment* (Sapere, 2005), the radionuclides of concern that may be present as residual radioactivity in Building 4006 are uranium-234 ($^{234}$U), $^{235}$U, $^{238}$U, $^{137}$Cs, $^{54}$Mn, and tritium. The surface residual radioactivity guidelines for these radionuclides are given in Table 1-1. The ambient gamma exposure rate guideline is 5 microroentgen per hour (μR/hr) above natural background, measured at one meter above the surface. The guideline values are from the *Approved Release Criteria* (Rocketdyne, 1999).

**Table 1-1 Surface Residual Radioactivity Guidelines for SSFL Facilities**

| ***Radionuclide*** | ***Type of Radiation*** | ***Average over 1 m$^2$ (dpm/100 cm$^2$)*** | ***Maximum over 100 cm$^2$ (dpm/100 cm$^2$)*** | ***Removable (dpm/100 cm$^2$)*** |
|---|---|---|---|---|
| uranium ($^{234}$U, $^{235}$U, $^{238}$U) | alpha | 5,000 | 15,000 | 1,000 |
| mixed fission products ($^{137}$Cs) | beta, gamma | 5,000 | 15,000 | 1,000 |
| activation products ($^{54}$Mn) | beta, gamma | 5,000 | 15,000 | 1,000 |
| tritium | beta | --- | --- | 10,000 |

Since both alpha- and beta/gamma-emitting surface residual radioactivity may be present, the sum of fractions rule will be applied by summing the concentration of each type of radiation divided by the average surface residual radioactivity guideline. The release criterion for surface residual radioactivity is met where the sum of fractions is less than or equal to unity.

# 2.0 DATA QUALITY OBJECTIVES

Data Quality Objectives (DQOs) were developed to define the purpose of the radiological survey, clarify what data should be collected to satisfy the purpose, and specify the performance requirements for the quality of information to be obtained from the data.

## 2.1 Step 1 – State the Problem

### 2.1.1 Problem Description

Building 4006 is identified in the *Historical Site Assessment* (Sapere, 2005) as radiologically impacted. Radiological data are needed to verify that the building meets the guidelines in the *Approved Release Criteria* (Rocketdyne, 1999) for release of the building for unrestricted use.

### 2.1.2 Planning Team Members

CABRERA is responsible for developing this work plan and providing the necessary materials, consumables, and qualified personnel, including qualified radiation survey technicians, to conduct the radiological survey. Boeing provides information on current and past activities in the form of historical radiological data.

### 2.1.3 Primary Decision Maker

The primary decision maker is the Boeing Project Manager.

### 2.1.4 Available Resources and Relevant Deadlines

Sufficient resources have been allocated for CABRERA to develop and implement this work plan. The radiological FSS will be performed once the FSP is approved. Upon completion of the radiological FSS, a report will be prepared summarizing the survey data and documenting the conclusion regarding the suitability of Building 4006 for release for unrestricted use.

## 2.2 Step 2 – Identify the Decision

### 2.2.1 Principal Study Question

The principal study question is: "Do the levels of residual radioactivity in Building 4006 meet the guidelines in the *Approved Release Criteria* (Rocketdyne, 1999)?"

### 2.2.2 Alternative Actions

The following alternative actions will result from resolution of the principle study question:

- If the levels of residual radioactivity meet the guidelines (see Section 1.2), then the building will be considered suitable for release for unrestricted use.
- If the levels of residual radioactivity do not meet the guidelines, then the primary decision maker or designee will be consulted to determine further action. Such action may include recommendations for remediation, additional survey data collection, and/or the calculation of incremental risk or dose.

### 2.2.3 Decision Statement

Based on the principal study question and the alternative actions listed above, the decision statement is: Determine whether or not the levels of residual radioactivity in Building 4006 meet the guidelines for release for unrestricted use.

## 2.3 Step 3 – Identify Inputs to the Decision

### 2.3.1 Radionuclides of Concern

The radionuclides of concern that may be present as residual radioactivity in Building 4006 are $^{234}U$, $^{235}U$, $^{238}U$, $^{137}Cs$, $^{54}Mn$, and tritium.

### 2.3.2 Potentially Affected Media

The potentially affected media are the interior and exterior building surfaces, which primarily consist of the following materials: corrugated metal, structural steel, sheet metal, concrete, sheetrock, linoleum, carpet, and acoustical ceiling tile.

### 2.3.3 Action Levels

Action levels, shown in Table 2-1, have been established that will cause further evaluation of identified areas of elevated surface residual radioactivity.

The action level for the detection of alpha- and beta-emitting surface residual radioactivity by scanning is a z-score greater than 3.0. A z-score greater than 3.0 represents a probability greater than 99% that the scan data may not belong to the same population as the rest of the data set (i.e., potentially represents surface contamination rather than background radioactivity). A mean and standard deviation of the collected data set are calculated. The difference between each scan data point and the mean is divided by the standard deviation to convert the measurement to multiples of the standard deviation above or below the population mean (i.e., z-score). These data are used to create a contour map. The contouring process involves creating a regularly spaced grid and assigning values to every spot on the grid using a weighted average based on the inverse square law. The inverse square law is generally used to describe how radiation levels drop off with distance from a source. Once the grid is complete, contours are created from grid node values within the specified ranges of values. The contouring process tends to smooth over single data points with z-score values slightly above 3.0 while accentuating clustered areas or single locations with z-score values significantly above 3.0. This is the desired effect which aids in the data analysis by focusing attention on those areas most likely to have elevated residual radioactivity. Contour areas with a z-score greater than 3.0 may have dissimilar radiological characteristics and should be investigated.

The action levels for static and removable measurements of alpha- and beta-emitting surface residual radioactivity are given in units of disintegrations per minute per 100 square centimeters (dpm/100 cm$^2$) and are based on one-half the surface residual radioactivity guidelines for average and removable residual radioactivity given in Table 1-1.

**Table 2-1 Action Levels**

| ***Action Levels***[a] | | |
|---|---|---|
| ***Scan Measurements*** | ***Static Measurements*** | ***Removable Measurements***[b] |
| z-score > 3.0 | 2,500 dpm/100 cm$^2$ | 500 dpm/100 cm$^2$ |

Note:
(a) Values given are distinguishable from background for both alpha and beta radiation.
(b) Does not apply to tritium measurements.

The action level for gamma exposure rate measurements is 5 μR/hr above background, based on the *Approved Release Criteria* (Rocketdyne, 1999). There is no action level for removable measurements of tritium surface residual radioactivity since this type of radioactivity cannot be reliably measured in the field.

#### 2.3.4 Measurement Inputs

Static measurements of alpha- and beta-emitting surface residual radioactivity, smear samples analyzed for gross alpha and beta radioactivity and tritium, and gamma exposure rate measurements will be used as quantitative inputs to the principal study question. Scan measurements of alpha- and beta-emitting surface residual radioactivity will be used as qualitative inputs to the principal study question.

### 2.4 Step 4 – Define the Study Boundaries

#### 2.4.1 Define the Target Population

The target population is the surface residual radioactivity concentrations of the radionuclides of concern and ambient gamma exposure rates.

#### 2.4.2 Spatial Boundaries of the Decision Statement

Survey data will be collected from exposed, accessible floor, wall, and ceiling surfaces in each survey unit. Biased survey data will also be collected equipment, systems, and components inside and outside the building such as roof vents, conduit, piping, ductwork, and entry doors, which are considered to have been susceptible to radioactive contamination from building activities.

#### 2.4.3 Scale of Decision Making

Decisions will be made on two fundamental levels:

- Localized areas – a decision to collect additional data will be made for discrete areas where measurement results exceed one or more action levels.
- Survey unit – a decision will be made for each survey unit as to the suitability of the survey unit for release for unrestricted use or, alternatively, the need for remediation, additional data collection, and/or calculation of incremental risk or dose.

### 2.5 Step 5 – Develop a Decision Rule

The decision statement results in the decision rules, listed in Table 2-2. No action is required where the logical alternative to the action given in Table 2-2 is not listed.

**Table 2-2 Decision Rules**

<table>
<tr><th>Parameter</th><th>IF</th><th>THEN</th></tr>
<tr><td>Scan Measurements</td><td>Areas identified with z-scores greater than 3.0,</td><td>Select one or more biased measurement locations in each identified area; collect:<br>▪ alpha and beta static measurements, and<br>▪ alpha/beta smear samples.</td></tr>
<tr><td>Static Measurements</td><td>Residual radioactivity exceeds 2,500 dpm/100 $cm^2$ alpha or beta,</td><td rowspan="2">Perform 100% scan coverage (if not already done) of 4 $m^2$ area around measurement; select four biased measurement locations; collect:<br>▪ alpha and beta static measurements, and<br>▪ alpha/beta smear samples.<br>Step out as needed to define area; compare results to Table 1-1 values.</td></tr>
<tr><td>Smear Samples</td><td>Residual radioactivity exceeds 500 dpm/100 $cm^2$ alpha or beta,</td></tr>
<tr><td>Surface Residual Radioactivity</td><td>Average, maximum, or removable levels exceed allowable values in Table 1-1,</td><td>Consult Boeing Project Manager to determine further action, if any.</td></tr>
</table>

## 2.6 Step 6 – Specify Limits on Decision Errors

False positive (Type I) and false negative (Type II) decision error rates associated with the calculation of instrument minimum detectable concentrations (MDCs) and the number of static measurements will also be set at 0.05 (5%). Deterministic release criteria will be applied to the data themselves (see Section 1.2).

# 3.0 SURVEY DESIGN

Outputs from the DQO process were used to develop a survey design for data collection. The survey design integrates both probability-based (random and random-start, systematic) and judgmental (biased) methods to data collection, as described in *MARSSIM* (EPA, 2000) to achieve the project DQOs.

## 3.1 Classification

The *Historical Site Assessment* (Sapere, 2005) identified Building 4006 as a Class 3 impacted area, meaning it has a potential for residual radioactivity from historical activities, but where no radioactivity is expected to be detected above background. There are no Class 1 areas, which are areas where radiological remediation has occurred or radioactive contamination has been identified above established DCGLs; and no Class 2 areas, which are areas where the processing, physical measurement, or storage of radioactive materials is known to have occurred and contamination exists or existed but below DCGLs.

## 3.2 Survey Units

A summary of the Building 4006 survey units, their class, size, and material types is shown in Table 3-1. Each survey unit will have similar physical characteristics and potential for residual radioactivity. Data evaluation and statistical analysis will be performed and a separate decision will be made for each survey unit as to its suitability for release (see Section 5.0). Additional survey units may be created based on field implementation of the survey design considering factors such as accessibility, material types, surface area, etc.

**Table 3-1 Summary of Building 4006 Survey Units**

| *Survey Unit Description* | *Survey Unit Class* | *Approximate Floor Area ($m^2$)* | *Predominant Surface Materials* |
|---|---|---|---|
| Main Bay | 3 | 310 | corrugated metal, structural steel, concrete |
| Lab Area | 3 | 713 | linoleum, sheetrock, acoustical tile |
| Balance of Interior | 3 | 211 | carpet, sheetrock, acoustical tile |
| Exterior Roof | 3 | 1,234 | corrugated metal, component steel |
| Exterior Walls | 3 | N/A | corrugated metal, sheet metal |

## 3.3 Survey Data

Scan and static measurements will be performed and smear samples will be collected from exposed, accessible surfaces in each survey unit. Accessible surfaces in air handling systems and drain lines will be surveyed. Inaccessible surfaces in these and other systems will not be surveyed unless indications of possible contamination are identified. Measurements will be performed and samples will be collected in accordance with the decision rules in Table 2-2 and as prescribed in this section. The survey methods are described in Section 4.3.

### 3.3.1 Scan Measurements

Alpha and beta scan measurements will be performed to locate radiation anomalies that might indicate areas with elevated residual radioactivity where further data collection is warranted. Scan coverage will be based on historical knowledge and include approximately 10% of accessible surfaces biased toward those areas with the highest potential for residual radioactivity, based on professional judgment.

#### 3.3.2 Static Measurements

Alpha and beta static measurements will be collected at 15 measurement locations in each survey unit. The number of measurement locations was calculated using the methodology described in Section 5.5.2 of *MARSSIM* (EPA, 2000) and is based on the design goals and constraints described in Appendix A. A random-start systematic pattern will be used to select measurement locations. The starting location will be determined by a random selection process. Subsequent measurement locations will be distributed around the starting location in a systematic pattern across the survey unit area.

#### 3.3.3 Exposure Rate Measurements

Exposure rate measurements will be collected at each static measurement location.

#### 3.3.4 Smear Samples

Alpha/beta smear samples will be collected at each static measurement location. The alpha/beta smear samples will be analyzed on-site. A limited number of tritium smear samples (approximately five samples per survey unit) will be collected at selected static measurement locations and sent off-site for analysis.

### 3.4 Survey Investigations

Investigations will be performed of locations identified with residual radioactivity above one or more action levels given in Table 2-2. Additional data will be collected and the Boeing Project Manager consulted as prescribed by the decision rules in Table 2-2. Professional judgment will be used to investigate adjacent areas in order to provide reasonable assurance that other undiscovered areas of elevated residual radioactivity do not exist within the survey unit.

#### 3.4.1 Scan Measurements

Areas identified from scan measurements with z-scores greater than 3.0 will be investigated. One or more biased measurement locations in each identified area will be selected. Static measurements of alpha- and beta-emitting surface residual radioactivity will be performed and a smear sample analyzed for gross alpha and beta radioactivity will be collected at each biased measurement location.

#### 3.4.2 Static Measurements

Random-start, systematic and biased static measurement locations with alpha- or beta-emitting surface residual radioactivity above 2,500 dpm/100 $cm^2$ will be investigated. Scan measurements will be performed over a 4 $m^2$ area centered around the measurement location, if not already performed. Four biased measurement locations will be selected within the 4 $m^2$ area equidistant from one another and the measurement location being investigated. Alpha and beta static measurements will be performed and an alpha/beta smear will be collected at each biased measurement location. Additional step-outs will be performed as necessary to define the area. The results will be compared to the values in Table 1-1.

#### 3.4.3 Gamma Exposure Rate Measurements

Measurement locations with gamma exposure rate measurements greater than 5 μR/hr above background will be investigated in the same manner described above for static measurements.

#### 3.4.4 Smear Samples

Measurement locations with removable alpha- or beta-emitting surface residual radioactivity above 500 dpm/100 $cm^2$ will be investigated in the same manner described above for static measurements.

### 3.5 Consultation with Boeing Project Manager

The Boeing Project Manager will be consulted regarding areas where the residual radioactivity exceeds the allowable average, maximum, or removable surface residual radioactivity levels given in Table 1-1 to determine further actions, if any. Actions may include remediation to reduce residual radioactivity to acceptable levels, additional survey data collection, and/or the calculation of incremental risk or dose.

Where remediation is performed, the survey data collected from the remediated area will be designated as historical and the area will be resurveyed. The scan coverage of the remediated area will be 100%. Alpha and beta static measurements will be performed and an alpha/beta smear will be collected at each random-start, systematic and biased measurement location within the remediated area.

### 3.6 Reference Coordinate System

A reference coordinate system will be used to facilitate the selection of measurement locations and to provide a mechanism for referencing a measurement to a specific location. Scale drawings, maps, or photographs of the survey unit will be prepared and oriented according to the reference coordinate system.

### 3.7 Background Reference Areas

Representative measurements of background will be performed where material background radioactivity is the suspect cause for alpha and beta/gamma static measurements above the action levels. Measurements will be performed from one or more background reference areas selected from non-impacted areas that have similar radiological and physical characteristics as the survey unit with which their measurements will be compared. Only static measurements will be collected in the background reference areas. The static measurements will be randomly distributed within the background reference area, as recommended by *MARSSIM* (EPA, 2000). The same number of static measurements will be collected in the background reference area as in the corresponding survey unit.

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## 4.0 SAMPLING AND ANALYSIS

Field measurements and samples will be collected in accordance with DQOs established for the project.

### 4.1 Survey Preparation

A walk-down will be performed prior to the start of survey data collection to assess the physical state of the surfaces to be surveyed and to identify actions needed to prepare for data collection. General area exposure rate measurements will also be performed as described in the *Health and Safety Plan for the Radiological Final Status Survey of Building 4006* (HASP, CABRERA, 2008). Support activities necessary to conduct the survey, such as needed housekeeping, scaffolding, interference removal, and electrical tag-outs, will be identified. A hazard evaluation will be performed to identify and quantify the health and safety hazards associated with the project, and to evaluate the risks to workers. A review will be performed of the potential for generating investigation derived waste (IDW), if any, and how it will be handled. Where available, previously collected radiological data will be reviewed and locations identified where historically any contamination has been found.

### 4.2 Instrumentation

Commercially available instrumentation will be used. A project file will be kept on the portable instrumentation (and radioactive calibration and check sources) used for survey data collection. The file will be maintained on-site for review and inspection.

#### 4.2.1 Instrument Selection

Radiation detection and measurement instrumentation will be selected based on reliable operation, detection sensitivity, operating characteristics, and expected performance in the field. Typical instrumentation that may be used is identified in Table 4-1.

**Table 4-1 Typical Survey Instrumentation**

| Measurement Type | Detector Type | Effective Detector Area and Window Density | Instrument Model | Detector Model |
|---|---|---|---|---|
| Alpha/Beta Scan | Gas flow proportional | 582 $cm^2$<br>3.4 $mg/cm^2$ aluminized mylar | Ludlum 2360 | Ludlum 239-1F |
| Alpha/Beta Static | Dual phosphor scintillation | 100 $cm^2$<br>1.2 $mg/cm^2$ aluminized mylar | Ludlum 2360 | Ludlum 43-93 |
| Exposure Rate | Tissue-equiv. scintillation | Not Applicable (N/A) | Bicron MicroRem® | N/A |
| Alpha/Beta Smears | ZnS(Ag) scintillation | 2” (5.1cm) diameter<br>0.4 $mg/cm^2$ | Ludlum 2929 | Ludlum 43-10-1 |

#### 4.2.2 Calibration and Maintenance

Instrumentation will be maintained to manufacturer’s specifications and calibrated for the radiation types and energies of interest using National Institute of Standard Technology (NIST) traceable sources. Instrumentation will be inspected prior to use to ensure its proper working condition, and properly protected against inclement weather conditions in the field. Sufficient instrumentation redundancy will be maintained to preclude the requirement for repair and maintenance capability. Maintenance and/or repair of equipment will be performed by the equipment manufacturer or authorized representative under contract or purchase order.

Calibration/maintenance records will include the following information:

- Type of instrument
- Instrument name and identification number (e.g., model and serial number)
- Manufacturer
- Date of calibration
- Calibration due date
- Name of person performing the calibration

#### 4.2.3 Response Checks

Instrument response checks will be conducted to assure constancy in instrument response, to verify the detector is operating properly, and to demonstrate that measurement results are not the result of detector contamination. Instrument response will be checked before instrument use each day. Portable instruments will also be checked after instrument use each day. A check source will be used that emits the same type of radiation (i.e., alpha, beta, and/or gamma) as the radiation being measured and that gives a similar instrument response. The check source will not necessarily use the same radionuclide as the radionuclide being measured. The response check will be performed at a set location using a specified source-detector alignment that can be easily repeated. Corrective action will be taken for instruments exhibiting response outside the acceptance criteria and the instrument will not be used until corrected. Measurements made between the last acceptable response check and the failed check will be evaluated and discarded, if appropriate.

Instrument response acceptance criteria will be established for each instrument prior to initial use. Ten one-minute counts will be collected using a source representative of the radiation types and energies of interest, and the mean of the source counts calculated. The source response acceptance criterion is ± 20% of the mean of the source counts. Ten one-minute counts will also be collected with the source removed to determine expected instrument response to ambient background. The background response acceptance criterion is ± 20% of the mean of the background counts.

Daily response checks will be monitored using a control chart. Background will be monitored qualitatively to assess daily variations that may impact the instrument's MDC. Records of daily response checks will be maintained, along with any control charts or logs associated with each instrument.

#### 4.2.4 Minimum Detectable Concentration

The MDC will be determined for each instrument and technique that is used for survey data collection. The MDC is the concentration that a specific instrument and technique can be expected to detect 95% of the time under actual conditions of use. The methodology for determining scan and static MDCs is given in Appendix B.

If the site specific MDC of the scanning technique is not sufficient to project action levels for residual radioactivity, the number of static measurements may need to be adjusted (see Appendix B).

### 4.2.5 Detection Sensitivity

The nominal detection sensitivities of typical instrumentation are shown in Table 4-2. The results shown are based on representative count times, background counts, and instrument efficiencies. Instrument-specific values based on actual field conditions will be used to establish *a priori* MDC values prior to instrument use

**Table 4-2 Typical Detection Sensitivities**

| Detector Model | Radiation of Interest | Count Time (min) | Back-ground (cpm) | Total Efficiency$^{(1)}$ (cpm/dpm) | Scan MDC$^{(2)}$ (dpm/100 cm$^2$) | Static MDC$^{(3)}$ (dpm/100 cm$^2$) |
|---|---|---|---|---|---|---|
| Ludlum 43-37 | Beta | N/A | 600 | 0.15 | 390$^{(4)}$ | N/A |
| Ludlum 43-93 | Alpha | 1 | 1 | 0.19 | N/A | 40$^{(6)}$ |
| Ludlum 43-93 | Beta | 1 | 140 | 0.12 | N/A | 480$^{(6)}$ |
| Ludlum 43-10-1 | Alpha | 1 | <1 | 0.34$^{(5)}$ | N/A | 19$^{(7)}$ |
| Ludlum 43-10-1 | Beta | 1 | 40 | 0.16$^{(5)}$ | N/A | 200$^{(7)}$ |

Notes:
(1) Total efficiency equals instrument efficiency times surface efficiency.
(2) Scan MDC is calculated per MARSSIM Equation 6-10 and assumes a surveyor efficiency of 0.5, and a value of 1.38 for acceptable false indications.
(3) Static MDC is calculated per MARSSIM Equation 6-7.
(4) Scan MDC assumes an observation interval of 1 second, which results from a scan speed of 15 cm (approximately one detector width) per second.
(5) 4π detection efficiency assumed.
(6) Static measurement action level for both alpha- and beta-emitting surface residual radioactivity is 2,500 dpm/100cm$^2$.
(7) Removable measurement action level for both alpha- and beta-emitting surface residual radioactivity is 500 dpm/100cm$^2$.

## 4.3 Survey Methods

Survey data will be collected as described by the following survey methods using approved CABRERA survey procedures (or their equivalent). Any changes made to the survey methods will be documented, including any field adjustments made to surface-to-detector distance, scan rate, or count time.

### 4.3.1 Scan Measurements

Scan measurements for the detection of alpha- and beta-emitting surface residual radioactivity will be performed using a Ludlum Model 43-37 582 cm$^2$ gas proportional detector (or equivalent) with a Ludlum Model 2360 alpha/beta data logger (or equivalent). Scan measurements will be performed by moving the detector approximately 2 cm above the surface of interest at a scan rate of 15 cm/s. The scan rate may be adjusted depending on the expected detector response. The Ludlum Model 44-9 15 cm$^2$ Geiger-Mueller (G-M) detector (or equivalent) with a Ludlum Model 4221 count rate meter/scaler (or equivalent) may be used for beta scanning small areas.

A posting plot or other spatial orientation tool, such as a Leica Total Station (or equivalent), will be used to record and document scan measurement locations with residual radioactivity above the action level. Hand drawn maps and digital images may also be used to document measurement locations.

#### 4.3.2 Static Measurements

Static measurements of alpha- and beta-emitting surface residual radioactivity will be performed using a Ludlum Model 43-93 100 $cm^2$ dual phosphor scintillation (or equivalent) with a Ludlum Model 2360 alpha/beta data logger (or equivalent). Static measurements will be performed by placing the detector on the surface to be measured, taking a one minute (or longer) scaler count, and recording the reading.

#### 4.3.3 Exposure Rate Measurements

Exposure rate measurements will be performed using a Bicron MicroRem® tissue-equivalent scintillation detector (or equivalent). The measurements will be taken using the “slow” response time constant setting. The detector will be positioned approximately 1 m from the surface of interest and allowed to stabilize prior to recording the measurement (approximately 30 seconds).

#### 4.3.4 Alpha/Beta Smear Samples

Alpha/beta smear samples will be collected over approximately 100 $cm^2$ and analyzed for gross alpha and beta radioactivity using a Ludlum Model 43-10-1 dual phosphor zinc sulfide (silver-activated) [ZnS(Ag)] alpha/beta scintillation detector (or equivalent) with a Ludlum Model 2929 alpha/beta scaler (or equivalent) using a one minute count time.

Prior to initial use, a minimum of 10 alpha and 10 beta background counts will be performed. The background counts will be used to calculate the MDC for the counter at various count times. The source counts will be used to calculate acceptance criteria for subsequent daily response checks. This calculation involves calculating the mean and standard deviation of both the alpha and beta source counts. The acceptance criteria for each channel will then be set at $\pm 2\sigma$ or $3\sigma$ from the mean.

Daily alpha and beta response checks will be performed and evaluated against these acceptance criteria. If an alpha/beta counting system channel falls outside $2\sigma$ of the mean but is within $3\sigma$ of the mean, the source check may be repeated. If the result is still outside $2\sigma$ or if a single response check falls outside $3\sigma$, the system will be removed from service. Results of both alpha and beta daily response checks will be plotted on individual instrument control charts.

#### 4.3.5 Tritium Smear Samples

Tritium smear samples will be collected over approximately 100 $cm^2$ using a moistened paper smear. The smear will be placed in 20 milliliters (ml) liquid scintillation counter vials provided by the offsite laboratory containing 5 ml of de-ionized water and sent to an analytical laboratory to be analyzed by liquid scintillation counting.

When sample custody is transferred (e.g., when samples are sent for laboratory analysis), a sample tracking record will accompany the sample for tracking purposes. The sample tracking (or chain of custody) record will document the custody of the sample from the point of measurement or collection until final results are obtained. Any special handling requirements identified in the field will be communicated to the laboratory performing the analysis using the sample tracking record. The samples will be properly packed to ensure their safe arrival at the analytical laboratory. Samples will be shipped in accordance with applicable state and federal regulations.

A unique sample identification number will be assigned to each sample collected and tracked in a master log to ensure there is no duplication. The sample identification number, date and time of sample collection, and the name of the sample collector will be recorded in the master sample log and on the sample label. Sample labels will be completed with a permanent marker or computer generated label and affixed securely to the sample container.

### 4.4 Analytical Laboratory

The analytical laboratory will be certified by a state that is authorized to provide National Environmental Laboratory Accreditation Program (NELAP) certification. The analytical laboratory will have the necessary quality assurance (QA) program and procedures and will be responsible for sample laboratory quality control (QC) analyses.

QC samples will be analyzed to evaluate laboratory performance. For every twenty samples analyzed, there will be one duplicate, one laboratory control sample, and one reagent blank analyzed for QC purposes. The analysis of duplicate samples will evaluate the effectiveness of sample preparation techniques. Laboratory control samples will evaluate the accuracy of the measurements. Reagent blank samples will evaluate the potential for laboratory contamination.

The analytical laboratory will provide a summary of QC performance during analysis of project samples.

### 4.5 Investigation-Derived Waste

Waste may be classified as IDW or non-investigative waste. Solid and liquid IDW will be stored in a designated secure location, and labeled "IDW, Potential Radioactive Contamination, Awaiting Analysis." IDW containers will identify Boeing as the generator and include emergency contact information. All IDW will be turned over to Boeing for analysis and subsequent disposition.

IDW will be properly containerized and surveyed during temporary storage. Depending on the radionuclides of concern, fencing or other special marking may be required. The number of containers will be estimated on an "as-needed" basis. Acceptable containers will be sealed, DOT-approved steel, 55-gallon drums or small dumping bins with lids. The containers will be transported in such a manner to prevent spillage or particulate loss to the atmosphere. To facilitate handling, the containers will be no more than half full when moved. The IDW will be segregated where it was generated according to matrix (solid or liquid), and origin (drill cuttings, drilling fluid, decontamination fluids, and purged water). Each container will be properly labeled with site identification, sampling point, depth, matrix, constituents of concern, and other pertinent information for handling.

Solid materials (e.g., gloves, booties, disposable personal protective equipment [PPE], rags, wipes, brooms, brushes, trowels, bowls) will be surveyed for loose and fixed radioactive material (RAM) and evaluated based on the limits provided in Table 1.1. Liquid IDW (e.g., cleaning solutions, rinse water) will be sampled and analyzed at the on-site or off-site laboratory for radioactive contamination. Liquid IDW analytical results will be compared to local limits for liquid effluents, if available, or to the drinking water limits listed in 40 CFR 141 (i.e., 30 microgram/liter total uranium). If no radioactive contamination is identified, the solid IDW will be disposed of as trash and liquid IDW will be disposed of in the sanitary sewer.

## 4.6 Data Management

Project data will be recorded in project data logbooks, on approved survey forms (e.g., sample tracking records, maps, photographs, survey audit reports), or in electronic data files. Project documentation will be maintained for at least five years.

### 4.6.1 Project Data Logbooks

Project data logbooks will be maintained during survey data collection activities. For survey activities, sample data listed below will be collected at each measurement location and recorded by survey team personnel in project data logbooks:

- Time and date of sample acquisition
- Sample type
- Instrumentation used
- Location descriptor
- Sample collection personnel

Project data logbooks will be permanently bound and the pages will be numbered. Pages will not be removed from logbooks under any circumstances. Logbook entries will be in permanent ink, legible, factual, detailed, and complete and will be signed and dated by the individual(s) making the entries. Completed forms will be legible, detailed, factual, and signed and dated by the individual completing the form. If a mistake is made in a log or on a form, the error will be denoted by placing a single line through the erroneous entry and initialing the correction. Under no circumstances will any previously entered information be completely obliterated. Use of whiteout in data logbooks or on forms will not be permitted for any reason.

### 4.6.2 Survey Documentation

Forms, such as sample collection forms, direct measurement forms, and photographic log sheets, will be provided as needed to survey teams. Actions taken to review, approve, transfer, copy, duplicate, backup, store or secure project data will be noted in a project data logbook. Other survey documentation will include, as needed, survey logbooks, maps, equipment use/calibration logs. Each completed form (a copy or original, depending on the type of form) will be maintained on-site until the completion of the survey activity.

#### *4.6.2.1. Maps/Sketches*

Copies of maps or sketches will be used by the survey teams to record key site conditions and to show approximate locations of building features and other appropriate site location information.

#### *4.6.2.2. Corrections to Documentation*

Measurements made and samples collected will be recorded. Survey personnel will initial each page as it is completed. Corrections will be made by drawing a single line through the incorrect entry and writing in the correct entry. The person making the correction will date and initial the correction. There will be no erasures or deletions from the survey logs. Additionally, no correction fluid will be used.

#### *4.6.2.3. Photographic Records*

Photographs of sample collection and measurement activities taken during the survey operations will be documented in a project logbook or using approved forms. Descriptions of photographs will include orientation information relevant to the photograph to correlate location.

### 4.6.3 Electronic Data Backup and Security

Project electronic data will be downloaded from its collection device on a daily basis. Electronic files will be labeled with unique file identification numbers. At the conclusion of each day's survey activities, electronic data collected that day will be backed up to appropriate removable media (e.g., compact disk, zip disk, or equivalent) and the backup will be removed from the site. The backup will not be stored in the same building in which the original project electronic data are stored.

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# 5.0 DATA EVALUATION

The data inputs collected according to project DQOs and survey data collection requirements will be quantitative and qualitative in nature. The data will be reviewed, verified, and validated during and after collection. Data will be quantitatively analyzed for direct comparison to action levels and qualitatively reviewed to determine further investigation during the project.

## 5.1 Data Validation and Verification

Survey data will be reviewed to verify they are authentic, appropriately documented, and technically defensible. The review criteria for data acceptability are:

- The instruments used to collect the data were capable of detecting the radiation types and energies of interest at or below the action levels.
- The calibration of the instruments used to collect the data was current and radioactive sources used for calibration were NIST traceable.
- Instrument response was checked before and, where required, after instrument use each day data were collected.
- The MDCs and the assumptions used to develop them were appropriate for the instruments and the survey methods used to collect the data.
- The survey methods used to collect the data were appropriate for the media and types of radiation being measured.
- The custody of samples collected for laboratory analysis was tracked from the point of collection until final results were obtained.

Where one or more criteria are not met, the discrepancy will be reviewed and the reasons for acceptability of the data or the corrective actions taken to restore data acceptability will be documented.

## 5.2 Exploratory Data Analysis

Exploratory data analysis (EDA) will be performed on the data to identify radionuclide distribution trends and potential outliers. EDA will include visual inspection of measurement results using time-series plots, posting plots, cumulative frequency distributions, probability plots, and histograms, as required, and calculation of statistical quantities including mean, median, standard deviation, and range. EDA of survey results will be performed in the field, as necessary, for the data sets in each survey unit to evaluate whether an investigation or additional survey data collection are warranted. EDA will include investigation of spatial or temporal distribution, outliers, and data population distributions.

## 5.3 Documentation

The results of the data analysis and interpretation will be summarized and conclusions regarding the radiological status of the building and its suitability for release for unrestricted use will be documented in a survey report. Analytical data will be appended or otherwise provided in its entirety and will be transmitted in an electronic format. The number of significant figures reported will be consistent with the limits of uncertainty inherent in the analytical method.

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# 6.0 PROJECT MANAGEMENT

## 6.1 Project Organization and Responsibilities

The responsibilities of key project personnel are described below.

### 6.1.1 Program Manager

The Program Manager will be responsible for overall project objectives, scope, budget, and quality of submittals. Duties will include:

- Planning, coordinating, integrating, monitoring, and managing project activities.
- Ensuring adequate corporate resources are made available to the project
- Providing senior technical review and project support.
- Ensuring compliance with all contractual requirements.

The Program Manager communicates directly with Boeing and project stakeholder personnel, as necessary.

### 6.1.2 Project Manager

The Project Manager will report to the Program Manager and will serve as the primary client interface. The Project Manager will be responsible for:

- Planning, coordinating, integrating, monitoring, and managing project activities.
- Ensuring proper implementation of this plan.
- Performing day-to-day management and monitoring of the project budget, schedule, and scope.

### 6.1.3 Health and Safety Coordinator

The Health and Safety (H&S) Coordinator will report to the Project Manager and will serve as the project safety officer. The H&S Coordinator or an on-site designee will be responsible for:

- Implementing the project HASP in accordance with site-specific safety protocols, including any project-specific health and safety programs.
- Performing ongoing hazards assessment, including reviewing survey conditions and authorizing appropriate changes to the HASP.
- Conducting daily safety meetings to review the day's work plan, associated activities, and any anticipated hazards.
- Imposing proper health and safety procedures and halting unsafe work activities.
- Addressing project health and safety concerns.

### 6.1.4 Quality Assurance/Quality Control Coordinator

The QA/QC Coordinator will report to the Project Manager. The QA/QC Coordinator will be responsible for:

- Performing ongoing oversight of QA/QC activities, including ensuring procedure compliance and conducting audits, as necessary.
- Imposing proper QA/QC procedures and halting activities detrimental to data quality.

- Addressing project QA/QC concerns.

#### 6.1.5 Survey Team Leader

The Survey Team Leader will report to the Project Manager and will serve as the project radiation safety officer. The Survey Team Leader will be responsible for:

- Organizing, scheduling, and supervising survey data collection activities.
- Implementing the FSP with regards to survey data collection activities (i.e., ensuring proper collection and documentation of survey data by the survey team).
- Working closely with the QA/QC Coordinator and H&S Coordinator to ensure proper implementation of QA/QC and HASP requirements with regards to survey team activities.
- Serving as the primary on-site point of contact for project activities.

#### 6.1.6 Survey Team

The Survey Team will report to the Survey Team Leader. The Survey Team will be responsible for properly collecting survey data and documenting its collection using appropriate logbooks, forms, and electronic data capture.

#### 6.1.7 Project Subcontractors

Project subcontractors report to the Project Manager. Project subcontractors provide analytical laboratory capability and survey support, such as excavation work.

### 6.2 Quality Assurance/Quality Control

The objective of QA/QC is to ensure survey data are of the type and quality such that decisions regarding the buildings can be made with sufficient confidence. Data collection activities will be performed in a controlled, deliberate manner as described in this plan. Surveys will be performed by trained individuals with calibrated instruments following written procedures and/or protocols. Data will be recorded and reviewed, and documentation will be auditable.

Where identified, problems or questions about survey or analytical data quality will be documented and appropriate corrective actions taken to address them. The Project Manager and QA/QC Coordinator will be notified immediately of QA/QC situations requiring immediate corrective action.

### 6.3 Training

On-site project personnel, including contractors, subcontractors, and visitors, will be required to be familiar with this plan and applicable site standard operating procedures (SOPs). Project personnel who may be exposed to hazardous conditions will have received the following training:

- 40-Hour OSHA HAZWOPER
- HAZWOPER supervisor training (supervisory personnel only)
- Radiation Worker

Copies of training certificates will be provided to Boeing prior to commencement of field work and will be maintained on-site.

## 7.0 REFERENCES

The following works were consulted in preparing this FSP.

CABRERA, 2008. *Health and Safety Plan for the Radiological Final Status Survey of Building 4006*, Cabrera Services, Inc., Draft, April 2008.

DOE 1993. *Radiation Protection of the Public and the Environment*, United States Department of Energy, Order DOE 5400.5, Change 2, January 1993.

EPA, 2000. *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, 402-R-97-016, Revision 1, U. S. Environmental Protection Agency, August 2000.

NRC, 1995. *Minimum Detectable Concentrations with Typical Radiation Survey Instruments for Various Contaminants and Field Conditions*, United States Nuclear Regulatory Commission, NUREG-1507, August 1995.

NRC 1997. *A Proposed Nonparametric Statistical Methodology for the Design and Analysis of Final Status Decommissioning Surveys*, NUREG-1505, U.S. Nuclear Regulatory Commission, 1997.

Rocketdyne, 1999. *Approved Sitewide Release Criteria for Remediation of Radiological Facilities at the SSFL*, Report No. N001SRR140131, prepared by Rocketdyne for the U.S. Department of Energy, February 18, 1999.

Sapere, 2005. *Historical Site Assessment of Area IV, Santa Susana Field Laboratory, Ventura County, California*, Sapere Consulting, Inc., and The Boeing Company, May 2005.

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# Appendix A
# Minimum Number of Samples

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# APPENDIX A

## MINIMUM NUMBER OF SAMPLES

A minimum number of samples is needed to obtain sufficient statistical confidence that conclusions drawn from a sample population are sound. The method described in Section 5.5.2 of *MARSSIM* (EPA, 2000) for determining the number of samples necessary to assure a population of sufficient size for statistical analysis is summarized here in the manner it is applied to Building 4006. The minimum number of samples is dependent on the variability in the data, the width of the gray region, and acceptable decision error rates discussed below.

Relative Shift (Δ/σ)

The number of samples needed depends on a ratio involving the concentration to be measured relative to the variability in the concentration. The ratio is called the relative shift, denoted by Δ/σ. It is defined as follows (Section 5.5.2.3 of *MARSSIM*):

$$\Delta/\sigma = \frac{\text{UBGR - LBGR}}{\sigma}$$

where:

UBGR = upper bound of gray region

LBGR = lower bound of gray region

σ = standard deviation

*MARSSIM* (EPA, 2000) states that relative shift values greater than 3.0 will not result in significant changes in the number of samples required to support a decision. Therefore, the survey design goal for the relative shift is 3.0.

Gray Region

The gray region is the range of uncertainty regarding the true concentration of the sample population. The width of the gray region is calculated as the difference between the upper bound of the gray region (UBGR) and the lower bound of the gray region (LBGR). The UBGR is set equal to the release criteria (see Table 1-2). The LBGR is set equal to background, or zero.

Standard Deviation (σ)

The standard deviation, denoted by σ, represents the spatial variability in the concentration of the sample population. Since all of the other terms of the relative shift equation are set, the equation can be solved to determine the acceptable standard deviation. Solving the equation, the survey design goal for the standard deviation is the action level divided by the relative shift (1/3 times the action level), or 1,667 dpm/100 $cm^2$. The actual standard deviation of the sample population must be compared to the *a priori* value to verify the survey design goal value is representative. Where the actual standard deviation is larger than the *a priori* value, the number of samples may need to be increased.

Acceptable Decision Errors

The acceptable decision error rates are selected based on the consequences of making an incorrect decision or selecting an incorrect course of action. If the initial assumption (i.e., null hypothesis) is that the radioactivity in the survey area is equal to background (i.e., LBGR) there are two possible decision errors: deciding the true concentration is above the LBGR when it is actually is not; and deciding the true concentration is at the LBGR when it is actually above.

The consequence of incorrectly deciding the true concentration is at the LBGR is failing to investigate areas with elevated levels of radioactivity. This type of decision error is designated Type I. A decision error rate of 5% is assigned at the LBGR, which means there is at least 95% confidence that areas with radionuclide concentrations greater than the LBGR will be investigated.

The consequence of incorrectly deciding the true concentration is above the LBGR is performing additional investigations in areas with radioactivity consistent with background. This type of decision error is designated Type II. A decision error rate of 5% is also assigned at the LBGR, which means there is at least 95% confidence that areas with radioactivity consistent with background will not require additional investigation.

The use of statistical methods allows for controlling the probability of making decision errors in regard to the evaluation of survey units.

Minimum Number of Samples

Tables 5.3 and 5.5 in *MARSSIM* provide the number of samples required to support decisions based on the relative shift and acceptable decision error rates assuming either the statistical Wilcoxon Rank Sum test or Sign test is used. Using 15 as the minimum number of samples provides a statistically sufficient number of samples to support a decision, regardless of the statistical test applied.

The release criteria for Building 4006 are deterministic in nature and 100% of the survey data must meet those criteria. While no statistical test will be applied to the survey data collected from Building 4006, the conclusion that 15 samples is statistically sufficient remains sound.

# Appendix B
# Minimum Detectable Concentrations

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# APPENDIX B

## MINIMUM DETECTABLE CONCENTRATIONS

The MDC will be determined for each instrument and technique that is used for survey data collection. The MDC is the concentration that a specific instrument and technique can be expected to detect 95% of the time under actual conditions of use.

Beta Scan MDC for Structure Surfaces

The MDC for scanning structure surfaces will be calculated using *MARSSIM* Equation 6-10:

$$MDC_{scan} = \frac{(1.38)\sqrt{B}}{\sqrt{p}\; E_i\, E_s\, (A/100)\, t}$$

where:

| | | |
|---|---|---|
| $MDC_{scan}$ | = | minimum detectable concentration for scanning surfaces (dpm/100 $cm^2$) |
| 1.38 | = | scan performance criteria (see *MARSSIM*, Section 6.7.2.1) |
| B | = | number of background counts in time interval t (cnts) |
| p | = | surveyor efficiency, 0.5 (see *NUREG-1507*, Section 6.6) |
| $E_i$ | = | instrument efficiency for emitted radiation (cpm/dpm) |
| $E_s$ | = | surface efficiency for emissions/disintegration |
| A | = | area of detector ($cm^2$) |
| t | = | time interval of observation while detector passes over the source (min) |

Alpha/Beta Static MDC for Structure Surfaces

The MDC for static measurements will be calculated using *MARSSIM* Equation 6-7:

$$MDC_{static} = \frac{3 + (4.65)\sqrt{B}}{E_i\, E_s\, (A/100)\, t}$$

where:

| | | |
|---|---|---|
| $MDC_{static}$ | = | minimum detectable concentration for static counting (dpm/100 $cm^2$) |
| B | = | background counts during measurement time interval t (counts) |
| $E_i$ | = | instrument efficiency for emitted radiation (cpm/dpm) |
| $E_s$ | = | surface efficiency for emissions/disintegration |
| A | = | area of detector ($cm^2$) |
| t | = | measurement counting time interval (minutes) |

Alpha/Beta MDC for Smears of Structure Surfaces

The MDC for the smear counter will be calculated as described above with the $E_i$ and $E_s$ terms replaced by the detector's calculated $4\pi$ detection efficiency (cpm/dpm).