



TETRA TECH

April 22, 2011

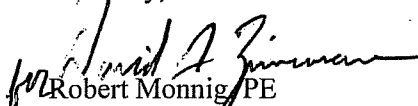
Mr. Roy Crossland
START Project Officer
U.S. Environmental Protection Agency, Region 7
901 North 5th Street
Kansas City, Kansas 66101


Subject: Quality Assurance Project Plan
Removal Action at Radiation – Kelley Instruments, Wichita, Kansas
CERCLIS ID: KSN000706130
U.S. EPA Region 7 START 3, Contract No. EP-S7-06-01; Task Order No. 0229
Task Monitor: James Johnson, On-Scene Coordinator

Dear Mr. Crossland:

Tetra Tech EM Inc. is submitting the attached Quality Assurance Project Plan for a Removal Action at the Radiation – Kelley Instruments site in Wichita, Kansas. If you have any questions or comments, please contact the project manager at (816) 412-1775.

Sincerely,


Robert Monnig, PE
START Project Manager


Ted Faile, PG, CHMM
START Program Manager

Enclosures

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X9004.11.0229.000

**QUALITY ASSURANCE PROJECT PLAN
FOR A REMOVAL ACTION AT THE
RADIATION – KELLEY INSTRUMENTS SITE
WICHITA, KANSAS**

CERCLIS ID: KSN000706130

**Superfund Technical Assessment and Response Team (START) 3 Contract
Contract No. EP-S7-06-01, Task Order 0229**

Prepared For:

U.S. Environmental Protection Agency
Region 7
Superfund Division
901 N. 5th Street
Kansas City, Kansas 66101

April 22, 2011

Prepared By:

Tetra Tech EM Inc.
415 Oak Street
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Region 7 Superfund Program
Addendum to the QAPP for Superfund Integrated Site Assessment and Targeted Brownfields Assessment Activities (July 2007)
for the Radiation – Kelley Instruments Site

Project Information:

Project Name: Radiation – Kelley Instruments		County: Sedgwick	State: KS
EPA Project Manager: James Johnson		START Project Manager: Rob Monnig	
Approved By: <i>[Signature]</i>	Title: START Project Manager	Date: 4/22/11	Prepared For: EPA Region 7 Superfund Division
Approved By: <i>[Signature]</i>	Title: START Program Manager	Date: 4/22/11	
Approved By: <i>[Signature]</i>	Title: START QA Manager	Date: 4/22/11	
Approved By:		Prepared By: Rob Monnig	
Title: EPA Project Manager		Date: April 2011	
Approved By:		Tetra Tech START Project Number:	
Title: EPA Region 7 QA Manager		X9004.11.0229.000	

1.0 Project Management:

1.1 Distribution List

EPA—Region 7: James Johnson, EPA Project Manager
Diane Harris, EPA Region 7 QA Manager

Tetra Tech START: Rob Monnig, Project Manager
Kathy Homer, QA Manager

1.2 Project/Task Organization

James Johnson, of the EPA Region 7 Superfund Division, will serve as the EPA project manager for the activities described in this QAPP. Rob Monnig, of Tetra Tech EM Inc., will serve as the START project manager for field activities.

1.3 Problem Definition/Background:

Description: This site-specific Quality Assurance Project Plan form is prepared as an addendum to the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007), and contains site-specific data quality objectives for the sampling activities described herein.

- ☒ Description attached.
- ☐ Description in referenced report: _____
- Title Date

1.4 Project/Task Description:

- ☐ CERCLA PA
☐ CERCLA SI
☐ Brownfields Assessment
☒ Removal Action
- ☐ Other (description attached):
☐ Pre-CERCLIS Area Screening
☐ Removal Site Evaluation

Other Description:

Schedule: Field work is anticipated to begin during the week of May 2, 2011, and is anticipated to take 1 week to complete.

- ☐ Description in referenced report: _____
- Title Date

1.5 Quality Objectives and Criteria for Measurement Data:

- | | |
|------------------------|---|
| a. Accuracy: | <input checked="" type="checkbox"/> Identified in attached table. |
| b. Precision: | <input checked="" type="checkbox"/> Identified in attached table. |
| c. Representativeness: | <input checked="" type="checkbox"/> Identified in attached table. |
| d. Completeness*: | <input checked="" type="checkbox"/> Identified in attached table. |
| e. Comparability: | <input checked="" type="checkbox"/> Identified in attached table. |

Other Description:

*A completeness goal of 100 percent has been established for this project. However, if the completeness goal is not met, EPA may still be able to make decisions based on any or all of the remaining validated data.

1.6 Special Training/Certification Requirements:

- ☒ OSHA 1910
☒ Special Equipment/Instrument Operator (describe below):
☐ Other (describe below):

Along with the training listed above, familiarization with radiation screening instrumentation and procedures will be necessary for the Tetra Tech START team.

1.7 Documentation and Records:

- ☒ Field Sheets
☒ Daily Log
☒ Trip Report
☒ Area Maps
☐ Video
- ☒ Chain of Custody
☒ Health and Safety Plan
☐ Letter Report
☒ Photos

☒ Sample documentation will follow EPA Region 7 SOP 2420.05.

☒ Other: Analytical information will be handled according to procedures identified in Table 2.

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2.0 **Measurement and Data Acquisition:**

2.1 Sampling Process Design:

- | | | | |
|--|---|--|---|
| <input type="checkbox"/> Random Sampling | <input type="checkbox"/> Transect Sampling | <input checked="" type="checkbox"/> Biased/Judgmental Sampling | <input type="checkbox"/> Stratified Random Sampling |
| <input type="checkbox"/> Search Sampling | <input checked="" type="checkbox"/> Systematic Grid | <input type="checkbox"/> Systematic Random Sampling | <input type="checkbox"/> Definitive Sampling |
| <input type="checkbox"/> Screening w/o Definitive Confirmation | | <input checked="" type="checkbox"/> Screening w/ Definitive Confirmation | |
| <input checked="" type="checkbox"/> Sample Map Attached | | | |

- ☒ Other (Provide rationale behind each sample): See Appendix A for additional sampling information.

Real-time field sampling will be judgmental, in accordance with the *Guidance for Performing Site Inspections Under CERCLA*, OSWER Directive #9345.1-05, September 1992, and *Removal Program Representative Sampling Guidance, Volume 1: Soil*, OSWER Directive 9360.4-10, November 1991. Judgmental sampling is the subjective (biased) selection of sampling locations based on historical information, visual inspection, and the best professional judgment of the sampler(s). Surface and subsurface soil will be field screened for gamma radiation with real-time instruments.

A final status radiological survey following removal activities will be conducted using a systematic grid, in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM)*, Revision 1, August 2000. Soil samples will be submitted for laboratory radionuclide analysis.

See Appendices A through D for additional site-specific information and maps.

Sample Summary Location	Matrix	# of Samples*	Analysis
Exterior Areas	Soil	13	Radionuclides (gamma spectrometry, radium-226)

*NOTE: Four background/QC samples are not included with these totals. See Table 1 for a complete sample summary.

2.2 Sample Methods Requirements:

Matrix	Sampling Method	EPA SOP(s) or other Method
Soil	Soil samples will be collected from 0 to 2 inches below ground surface using disposable stainless steel spoons, and transferred to appropriate sample containers.	SOP 4231.2012

- ☐ Other Description:

2.3 Sample Handling and Custody Requirements:

- ☒ Samples will be packaged and preserved in accordance with procedures defined in Region 7 EPA SOP 2420.06.
- ☒ COC will be maintained as directed by Region 7 EPA SOP 2420.04.
- ☐ Samples will be accepted according to Region 7 EPA SOP 2420.01.
- ☒ Other (Describe): Samples will be accepted according to procedures established by the START-contracted laboratory.

2.4 Analytical Methods Requirements:

- ☒ Identified in attached table.
- ☒ Rationale: The requested analyses have been selected based on historical information about the area and program experience with similar types of sites.
- ☐ Other (Describe):

2.5 Quality Control Requirements:

- ☐ Not Applicable
- ☒ Identified in attached table.
- ☒ In accordance with the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007).
- ☒ Field QC Samples: For this investigation, no field QC samples will be required to obtain valid data for removal action purposes.
- ☐ Other (Describe):

2.6 Instrument/Equipment Testing, Inspection, and Maintenance Requirements:

- ☐ Not Applicable
- ☒ In accordance with the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007).
- ☒ Testing, inspection, and maintenance of analytical instrumentation will proceed in accordance with the previously referenced SOPs and/or manufacturers' recommendations. Testing, inspection, and maintenance of field instruments (radiation screening instruments, GPS units, etc.) will proceed in accordance with manufacturers' recommendations.

2.7 Instrument Calibration and Frequency:

- ☐ Not Applicable
- ☒ In accordance with the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007).
- ☒ Calibration of laboratory equipment will be performed as described in the previously referenced SOPs and/or manufacturers' recommendations.
- ☒ Other (Describe): Calibration of field instruments (radiation screening instruments, etc.) will be conducted in accordance with manufacturers' recommendations.

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2.8 Inspection/Acceptance Requirements for Supplies and Consumables:

- ☐ Not Applicable
- ☒ In accordance with the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007).
- ☒ All sample containers will meet EPA criteria for cleaning procedures for low-level chemical analysis. Sample containers will have Level II certifications provided by the manufacturer in accordance with pre-cleaning criteria established by EPA in *Specifications and Guidelines for Obtaining Contaminant-Free Containers*.
- ☐ Other (Describe):

2.9 Data Acquisition Requirements:

- ☐ Not Applicable
- ☒ In accordance with the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007).
- ☒ Previous data or information pertaining to the area (including other analytical data, reports, photos, maps, etc., that are referenced in this QAPP) has been compiled by EPA and/or its contractor(s) from other sources. Some of that data has not been verified by EPA and/or its contractor(s); however, that unverified information will not be used for decision-making purposes by EPA without verification by an independent professional qualified to verify such data or information.
- ☐ Other (Describe):

2.10 Data Management:

- ☐ All laboratory data acquired will be managed in accordance with Region 7 EPA SOP 2410.01E.
- ☒ Other (Describe): All laboratory data acquired will be managed according to procedures established by the EPA-approved laboratory.

3.0 Assessment and Oversight:

3.1 Assessment and Response Actions:

- ☒ Peer Review ☒ Management Review ☐ Field Audit ☐ Lab Audit
- ☒ Assessment and response actions pertaining to analytical phases of the project are addressed in Region 7 EPA SOPs 2430.06 and 2430.12.
- ☐ Other (Describe):

3.1A Corrective Action:

- ☒ Corrective actions will be at the discretion of the EPA project manager whenever problems appear that could adversely affect data quality and/or resulting decisions affecting future response actions pertaining to the area.
- ☐ Other (Describe):

3.2 Reports to Management:

- ☐ Audit Report ☐ Data Validation Report ☐ Project Status Report ☐ None Required
- ☒ A letter report describing the sampling techniques, locations, problems encountered (with resolutions to those problems), and interpretation of analytical results will be prepared by START and submitted to the EPA.
- ☒ Reports will be prepared in accordance with the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007).
- ☐ Other (Describe):

4.0 Data Validation and Usability:

4.1 Data Review, Validation, and Verification Requirements:

- ☐ Identified in attached table.
- ☒ Data review and verification will be performed in accordance with the Generic Quality Assurance Project Plan for Superfund Integrated Assessment and Targeted Brownfields Assessment Program (updated July 2007).
- ☐ Data review and verification will be performed by a qualified analyst and the laboratory's section manager as described in Region 7 EPA SOPs 2430.06 and 2430.12.
- ☒ Other (Describe): Data review and verification will be performed in accordance with procedures established by the EPA-approved laboratory.

4.2 Validation and Verification Methods:

- ☐ Identified in attached table.
- ☐ The data will be validated in accordance with Region 7 EPA SOPs 2430.06 and 2430.12.
- ☒ The EPA project manager will inspect the data to provide a final review. The EPA project manager will review the data, if applicable, for laboratory spikes and duplicates, laboratory blanks, and field blanks to ensure the data are acceptable. The EPA project manager will also compare the sample descriptions with the field sheets for consistency, and will ensure appropriate documentation of any anomalies in the data.
- ☒ Other (Describe): The data will be validated in accordance with procedures established by EPA-approved laboratory.

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for the Radiation – Kelley Instruments Site

4.3 Reconciliation with User Requirements:

- ☐ Identified in attached table.
- ☒ If data quality indicators do not meet the project's requirements as outlined in this QAPP, the data may be discarded, and re-sampling or re-analysis of the subject samples may be required by the EPA project manager.
- ☐ Other (Describe):

Region 7 Superfund Program Addendum to the QAPP for Superfund Integrated Site Assessment and Targeted Brownfields Assessment Activities (July 2007) for the Radiation – Kelley Instruments Site							
Table 1: Sample Summary							
Project Name: Radiation – Kelley Instruments Site				Location: Wichita, Kansas; see Appendix B, Figure 1			
START Project Manager: Rob Monnig				Activity/ASR #: Not Applicable (START contracted lab)			Date: April 2011
No. of Samples	Matrix	Location	Purpose	Depth or other Descriptor	Requested Analysis	Sampling Methods	Analytical Method
13	Soil	Within excavated areas	To determine whether the site can be released for unrestricted use following cleanup activities	Surface soils (0-2 inches)	Radionuclides (gamma spectrometry, radium-226)	EPA SOP 4231.2012	See below
4	Soil	Collected from non-impacted areas on or near the site.	To determine background concentrations of radionuclides.	Surface soils (0-2 inches)	Radionuclides (gamma spectrometry, radium-226)	EPA SOP 4231.2012	See below

Note:

Analytical methods are as follows: gamma spectrometry (DOE HASL 300 4.5.2.3); radium-226 (by bismuth ingrowth and gamma spectrometry using method DOE EML HASL 300 4.5.2.3).

Region 7 Superfund Program Addendum to the QAPP for Superfund Integrated Site Assessment and Targeted Brownfields Assessment Activities (July 2007) for the Radiation – Kelley Instruments Site									
Table 2: Data Quality Objective Summary									
Project Name: Radiation – Kelley Instruments Site				Location: Wichita, Kansas; See Appendix B, Figure 1					
START Project Manager: Rob Monnig				Activity/ASR #: Not Applicable (START contracted lab)				Date: April 2011	
Analysis	Analytical Method	Data Quality Measurements					Sample Handling Procedures	Data Management Procedures	
		Accuracy	Precision	Representativeness	Completeness	Comparability			
SOIL									
Radionuclides (gamma spectrometry, radium-226)	see Table 1	per analytical method	per analytical method	Systematic sampling in accordance with the <i>Multi-Agency Radiation Survey and Site Inspection Manual</i> (MARSSIM). See Appendix C.	100%	Standardized procedures for sample collection and analysis will be used.	See Section 2.3 of QAPP form.	See Section 2.10 of QAPP form.	

APPENDIX A

SITE-SPECIFIC INFORMATION FOR THE RADIATION – KELLEY INSTRUMENTS SITE

INTRODUCTION

The Tetra Tech EM Inc. (Tetra Tech) Superfund Technical Assessment and Response Team (START) has been tasked by the U.S. Environmental Protection Agency (EPA) Region 7 Superfund Division to assist with a removal action (RA) to be conducted at the Radiation – Kelley Instruments (Kelley Instruments) site in Wichita, Kansas. An aircraft instrument repair shop operated on the property from as early as 1971 to as late as 1990 under the name Kelley Instruments, Inc., (Kansas Department of Health and Environment [KDHE] 2007). Results of an investigation that KDHE conducted at the Kelley Instruments site in March and May 2007 indicated the presence of radium-226 in soil at the site (KDHE 2007).

RA activities will include excavation of radium-impacted soil and collection of post-removal soil samples for laboratory analysis for radionuclides. This quality assurance project plan (QAPP) identifies site-specific features and addresses elements of the sampling strategy and analytical methods proposed for this investigation. Post-removal data will be analyzed in accordance with the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) to determine if the area can be released for unrestricted use (EPA 2000).

AREA LOCATION/DESCRIPTION

KDHE reports that the former Kelley Instruments radium dial shop facility had a license to operate at 1024 S. Santa Fe Street in Wichita, Kansas, but also indicates that dial shop activities may have also occurred at 1008 S. Santa Fe prior to licensing (KDHE 2007). Findings of the KDHE investigation and the investigation by EPA and START (reported herein), have identified radium-impacted soil on three contiguous properties: 1008, 1024, and 1032 S. Santa Fe (see Appendix B, Figure 1). Three buildings are located on the properties. The northernmost building, located on 1008 S. Santa Fe, is currently occupied by Commerce Construction Services, Inc. Two buildings to the south, located on 1024 and 1032 S. Santa Fe, are occupied by Engineered Door Products, Inc. The site is in the northwest quarter of Section 28, Township 27 South, Range 1 East. Geographic coordinates of its approximate center are 37.673860 degrees north latitude and 97.329940 degrees west longitude (KDHE 2007). The Kelley Instruments site is located in a predominantly commercial/industrial area.

PREVIOUS INVESTIGATIONS

Results of a KDHE investigation at the Kelley Instruments site in March and May 2007 indicated the presence of radium in soil at the site. KDHE identified one area of elevated gamma activity on the facility near the southeast corner of the 1008 S. Santa Fe building. According to KDHE, the highest

field-measured surface reading showed 103 microRoentgens per hour ($\mu\text{R/hr}$) using a Ludlum model 44-2, with a 1- by 1-inch-diameter sodium iodide T1 scintillator probe (KDHE 2007). KDHE also collected and submitted soil samples to a laboratory for radium-226 analysis. The highest radium-226 concentration measured in soil was 102 picoCuries per gram (pCi/g) detected in a soil sample collected from 6 inches below ground surface (bgs) (KDHE 2007).

In 2010, EPA tasked START to conduct a Removal Site Evaluation (RSE) to determine the extent of radium contamination (and associated radionuclides) in surface and subsurface soils at the site. RSE activities at the site in May and November 2010 included a surface soil gamma survey and collection of surface and subsurface soil samples. START collected 23 soil samples from potential areas of concern and three samples from background areas. Six soil samples collected from the site contained radium-226 activity that exceeded the EPA health-based standard of 5 pCi/g above background, including samples collected from 1008, 1024, and 1032 S. Santa Fe.

Based on the results of the March and May 2007 KDHE assessment and the May and November 2010 RSE, a RA was determined warranted to reduce the risk to occupants of the site. EPA has established a time-critical RA level for Ra-226 of 5 pCi/g above background in surface soil. Based on analysis of the background samples, the estimated Ra-226 background concentration in soil is approximately 1.6 pCi/g . Figure 1 depicts the areas where surface soils are estimated to exceed the EPA-determined action level.

SAMPLING STRATEGY AND METHODOLOGY

Under this task order, START will conduct real-time monitoring in the study area to delineate the extent of impacted surface soil and to guide the removal efforts. The proposed real-time sampling scheme for this activity is judgmental (based on the best professional judgment of the sampling team), in accordance with the *Removal Program Representative Sampling Guidance*, Volume 1: Soil, Office of Solid Waste and Emergency Response (OSWER) Directive 9360.4-10, November 1991. After soil excavation activities are complete, a final status radiological survey will be conducted in accordance with the MARSSIM, Revision 1, August 2000 (EPA 2000). Soil samples collected during this survey will be submitted for laboratory radionuclide analysis.

Field procedures will follow standard operating procedures (SOP) outlined in the QAPP. Field activities will include real-time monitoring of surface soils and collection of soil samples for laboratory analysis. In addition, air monitoring will be conducted during the surface soil excavation activities. Descriptions of the sampling strategy and procedures are presented below.

Real-Time Monitoring of Soils

START will conduct a survey of surface soils at the site for gross gamma activity prior to excavation activities. The survey will be conducted by scanning the surface soil in a serpentine pattern. The detector will be held above the ground surface at approximately 6 inches while the surveyor moves the detector at approximately 1 to 2 feet per second. These scanning measurements, along with measurements obtained during previous investigations, will be used to guide excavation of contaminated surface soils.

Excavation of surface soils will continue until scanning measurements of gross gamma activity indicate that the EPA-established action level of 5 pCi/g above background for Ra-226 has been achieved. When the final depth of excavation is reached, START will conduct a Final Status Survey (FSS) as described below.

Final Status Radiological Survey

A FSS following removal activities will be in accordance with MARSSIM guidance (EPA 2000). An FSS is performed to demonstrate that residual radioactivity in each survey unit satisfies the predetermined criteria for release for unrestricted use or, where appropriate, for use with designated limitations. The survey provides data to demonstrate that each radiological parameter does not exceed the established derived concentration guideline level (DCGL) for average concentration over a wide area (DCGL_w). The DCGL_w for the site is the action level of 5 pCi/g above background for Ra-226. The FSS plan includes a reference coordinate system, the survey units, the number and location of samples, scanning survey procedures, and the calculation of the minimum detectable concentration for the scanning survey. A FSS sampling design plan is included in Appendix C.

The FSS survey will include both a real-time scanning survey and collection of soil samples on a systematic grid for laboratory analysis. Before the FSS survey begins, the site will be divided into individual survey units, and each survey unit will be classified as a Class 1, Class 2, or Class 3 area based on the potential for residual contamination. The survey units will be classified based on the site operating history and previous survey and sampling data. The purpose of classifying the survey units is to establish the level of survey coverage needed for a particular area based on the potential for residual contamination. MARSSIM provides the follow descriptions for Class 1, 2, and 3 areas.

- Class 1 areas: Areas that have, or had prior to remediation, a potential for radioactive contamination (based on site operating history) or known contamination (based on previous radiological surveys). Examples of Class 1 areas include: (1) site areas previously subjected to remedial actions, (2) locations where leaks or spills are known to have occurred, (3) former burial or disposal sites, (4) waste storage sites, and (5) areas with contaminants in discrete solid pieces

of material with high specific activity. Areas containing contamination in excess of the DCGL_W prior to remediation should be classified as Class 1 areas.

- Class 2 areas: Areas that have, or had prior to remediation, a potential for radioactive contamination or known contamination, but are not expected to exceed the DCGL_W. To justify changing an area's classification from Class 1 to Class 2, the existing data (from scoping surveys, or characterization surveys) should provide a high degree of confidence that no individual measurement would exceed the DCGL_W. Examples of areas that might be classified as Class 2 for the final status survey include: (1) locations where radioactive materials were present in an unsealed form (e.g., process facilities), (2) potentially contaminated transport routes, (3) areas downwind from stack release points, (4) upper walls and ceilings of some buildings or rooms subjected to airborne radioactivity, (5) areas where low concentrations of radioactive materials were handled, and (6) areas on the perimeter of former contamination control areas.
- Class 3 areas: Any impacted areas not expected to contain any residual radioactivity, or expected to contain levels of residual radioactivity at a small fraction of the DCGL_W, based on site operating history and previous radiological surveys. Examples of areas that might be classified as Class 3 include buffer zones around Class 1 or Class 2 areas, and areas with very low potential for residual contamination but insufficient information to justify a non-impacted classification.

Following removal activities, EPA and START will divide the site into survey units and classify each unit. It is anticipated that one Class 1 survey unit will be established that includes all areas where soil was excavated. In addition, it is anticipated that one Class 3 survey unit will be established as a buffer zone around the Class 1 survey unit.

Following removal activities, a 100-percent scan of soils within the Class 1 survey unit will be performed to verify that no areas of elevated activity remain. If an area of elevated activity is detected within the Class 1 survey area and is suspected to contain contamination exceeding the DCGL_W, additional actions will be conducted to remove the suspected contamination and the area will be scanned again. Within the Class 3 survey unit, scanning will be performed at random areas and in areas with the greatest potential for residual contamination based on professional judgment (such as within drainage areas or areas downwind of the Class 1 survey unit). If an area of elevated activity is detected, the area will be flagged, investigated further, and all or part of the Class 3 survey unit will be reclassified as a Class 1 or 2 area. The FSS sampling design plan describes the procedures and equipment for conducting the scanning surveys (see Appendix C).

Following the scanning survey, soil samples will be collected from the Class 1 survey unit for laboratory analysis. In Class 3 areas, MARSSIM guidance allows for direct measurement using field instruments in lieu of soil sampling and laboratory analysis if the contamination is associated with gamma emitting radionuclides (because contamination is readily detected with field instruments). Because radium-226, a

significant gamma emitter, is associated with the contamination at the site, direct measurements using field instruments will be conducted within the Class 3 survey unit in lieu of laboratory analysis.

The soil sampling locations within the Class 1 survey unit will be collected from locations established by a systematic grid. The number of sampling locations has been predetermined based on the application of a statistical method described in MARSSIM and is independent of the size of the survey unit (see Appendix C). Because the number of sampling locations is predetermined, the grid spacing will be calculated in the field by dividing the number of pre-determined sampling locations by the area of the Class 1 survey unit. Per MARSSIM guidance, the Class 1 survey unit (or units) will be limited in size to 2,000 square meters or less to ensure that each area is assigned an adequate number of data points. Following the MARSSIM guidance and using the following assumptions, collection of 13 soil samples within the Class 1 survey unit is expected in order to complete the FSS. That number of soil samples was determined via the following example calculation:

1. The Lower Boundary of the Gray Region (LBGR) is set at 75% of the $DCGL_w$ (5 pCi/g): thus 3.75 pCi/g.
2. Calculation of the shift (Δ) is according to: $\Delta = DCGL_w - LBGR$; thus, $\Delta = 5 \text{ pCi/g} - 3.75 \text{ pCi/g} = 1.25 \text{ pCi/g}$.
3. The standard deviation (σ) of the data is anticipated at approximately 0.625 pCi/g.
4. Calculation of the relative shift thus proceeds as:
Relative shift = $\Delta / \sigma = 1.25 \text{ pCi/g} / 0.625 \text{ pCi/g} = 2.0$.
5. Calculation of the number of samples (n) per MARSSIM Table 5.3 (for contaminant present in the background) for a relative shift of 2.0 and Type I and Type II decision errors of 0.05 leads to a result of 13 samples.

Per MARSSIM guidance, if the survey unit area is relatively small (less than 100 square meters), the number of data points obtained from the statistical test may be unnecessarily large and not appropriate for the size of the survey unit. In this case, the number of samples collected may be based on judgment, rather than on statistical techniques presented in MARSSIM.

Soil samples collected for laboratory radionuclide analysis will be collected from 0 to 2 inches bgs using a disposable stainless steel spoon, homogenized in a disposable aluminum pie pan, and placed in clean resealable plastic bags.

Air Monitoring

Air monitoring to determine airborne concentrations of radioactive material will be conducted during the excavation activities using two RADeCO[®] Model H-810 high-volume air samplers and a Ludlum[®] Alpha/Beta Sample Counter Model 3030. Air samples will be collected daily while excavation activities are occurring. The air samplers will be positioned upwind and downwind of the excavation activities. The samplers will be operated at flow rates of 4 to 6 liters per minute for approximately 8 hours each day. One paper filter sample will be collected from each air sampler daily and will be analyzed on site for radiological contamination by START using the Ludlum[®] Alpha/Beta Sample Counter Model 3030. Measurements obtained from the Ludlum[®] Model 3030 will be used to estimate an exposure rate. These rates will be estimated using a spreadsheet provided by EPA (see Appendix D). In addition to monitoring airborne particles for radioactivity, real-time air monitoring for gamma radiation will be conducted throughout the site using a Ludlum[®] Model 192.

ANALYTICAL METHODS

Appropriate containers and collection techniques will be employed during the field activities to help verify acquisition of representative analytical results. Samples will be submitted to a START-contracted laboratory for analysis according to the SOPs and methods referenced or described in the QAPP.

REFERENCES

Kansas Department of Health and Environment (KDHE). 2007. Unified Focus Assessment Report, Kelley Instruments, Inc. (Former), 1024 South Santa Fe Avenue, Wichita, Kansas. June.

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

APPENDIX B

FIGURE



Legend

Gamma Survey Location

- < 27,073 cpm
Below Investigation Level
- 27,073 - 31,039 cpm
Investigation Level to 2x Background
- 31,039 - 46,559 cpm
2x Background to 3x Background
- 46,559 - 62,079 cpm
3x Background to 4x Background
- > 62,079 cpm
> 4x Background

Anticipated Area of Excavation

Parcel Boundary

cpm - counts per minute

Notes: Measurements were collected using a Ludlum 3x3 detector.

The Investigation Level is the mean of background readings plus 5 times the standard deviation of the background readings. Areas that exhibited gamma activity above the Investigation Level were subjected to additional investigation following the initial surface soil gamma survey.

0 23 46

Feet

Note: The Environmental Protection Agency does not guarantee the accuracy, completeness, or timeliness of the information shown, and shall not be liable for any injury or loss resulting from the reliance upon the information shown.

Source: RAT System Survey, May 2010
i³ Imagery Prime World 2D, 2010

Radiation - Kelley Instruments
Wichita, Kansas

Figure 1
Gamma Survey Results and
Anticipated Areas of Excavation



APPENDIX C

FINAL STATUS SURVEY SAMPLING DESIGN PLAN

**FINAL STATUS SURVEY SAMPLING DESIGN PLAN
RADIATION – KELLEY INSTRUMENTS
WICHITA, KANSAS**

Introduction

The United States Environmental Protection Agency (EPA) has directed the Tetra Tech EM Inc. (Tetra Tech) Superfund Technical Assessment and Response Team (START) to conduct a Final Status Survey (FSS) of surface soil at the Radiation – Kelley Instruments (Kelley Instruments) site located in Wichita, Kansas, to determine if the surface soil can be released for unrestricted use. This FSS sampling design plan addresses collection of assessment data for this task.

Data Quality Objectives

The data quality objectives (DQO) process, as set forth in the EPA documents *Data Quality Objectives Process for Hazardous Waste Site Investigations* (EPA QA/G-4HW, January 2000, EPA/600/R-00/007) and *Guidance for the Data Quality Objectives Process* (EPA QA/G-4, August 2000, EPA/600/R-96/055) was followed to establish the data quality objectives for this FSS sampling design plan. An outline of the process and the outputs for this FSS sampling design plan are included below.

Step 1 - State the Problem

Problem

Results of the Removal Site Evaluation (RSE) and a previous Kansas Department of Health and Environment investigation indicate that surface soils at the site are impacted with radium-226 (Ra-226). Based on these results, areas of the site have been classified as Class 1 and Class 3 survey units in accordance with Multi-Agency Radiation Survey and Site Investigation Manual (MARSSIM) guidance. The objective of this investigation is to conduct a FSS to determine if the area can be released for unrestricted use following removal activities.

Step 2 - Identify the Decision

Principal Study Questions

Is the mean residual surface soil contamination in the survey unit below the Derived Concentration Guideline Level-Average (DCGL_W) of 5.0 picocuries per gram (pCi/g) for Ra-226? Are all measurements in the survey unit below the Derived Concentration Guideline Level-Elevated Measurement Concentration (DCGL_{EMC})?

Alternative Actions

If a survey unit fails to meet the release criteria, further investigations and remediation will be conducted. If a survey unit meets the release criteria, the survey unit will be released for unrestricted use. After remediation, the area will be reinvestigated to confirm that each survey unit meets the release criteria.

Decision Statement

Determine if each soil survey unit meets the release criteria.

Step 3 - Identify Inputs to the Decision

Information Required to Resolve the Decision Statement

1. Release criteria based on the $DCGL_W$ and $DCGL_{EMC}$.
2. Location and classification of each survey unit.
3. Location of reference areas and background levels.
4. The number of samples for each survey unit.
5. Appropriate measurement techniques with a minimum detectable concentration (MDC) at or below the release criteria, the $DCGL_W$ and $DCGL_{EMC}$.
6. Scanning data results from a 100% and 50% scanning survey over each Class 1 and Class 2 survey unit, respectively.
7. Posting plot of gamma radiation measurements.
8. Soil sample results for concentrations of Ra-226.
9. The spatial location of samples and measurements in each survey unit.
10. Data analysis of sample results for each survey unit to determine if the data pass the statistical tests for compliance with the $DCGL_W$.
11. Data analysis of scanning measurements for each survey unit to determine if measurements are less than the $DCGL_{EMC}$.

Sources of Information

Data and documentation generated during this investigation.

Information Needed to Establish the Action Levels

For this site, EPA has established a $DCGL_W$ of 5.0 pCi/g for Ra-226.

Confirm That Appropriate Methods Exist to Provide the Necessary Data

A laboratory has been arranged to perform the radioassay for the soil samples. Data generated will be definitive level quality. Field portable radiation instrumentation available in the EPA inventory can generate the required data for scanning surveys. Data will be field screening level quality.

Step 4 - Define the Study Boundaries

Characteristics that Define the Population of Interest

Activity of Ra-226 in pCi/g and gross gamma radiation measurements.

Spatial Boundaries of the Decision Statement

The boundaries of this investigation are defined as surface soil, from ground surface to 5 centimeters below ground surface. The total area of the Class 1 survey units is anticipated to be approximately 300 square feet (ft²).

Temporal Boundaries of the Decision Statement

Completion of this investigation is anticipated within a one-week period.

Scale of Decision Making

The scale of decision making corresponds to the data collected from on-site surface soil samples and all gross gamma radiation measurements during scanning surveys.

Practical Constraints on Data Collection

No practical constraints exist for this investigation.

Step 5 - Develop a Decision Rule

Statistical Parameter that Defines the Population of Interest

Individual activity of Ra-226 and gross gamma radiation measurements will be used instead of a statistical parameter.

The Action Level for the Decision

For this site, EPA has established a $DCGL_w$ of 5 pCi/g for Ra-226.

Confirm the Action Level Exceeds Measurements Detection Limits

The action levels exceed detection limits for radioassay of soil samples and for gross gamma radiation measurements during scanning surveys that will be used during the investigation.

Decision Rule

Principal Study Questions for soil samples analyzed by the analytical laboratory:

If all samples are less than the $DCGL_w$, the survey unit will be released for unrestricted use.

If any sample equals or exceeds the $DCGL_w$, the data results will be evaluated based on the Wilcoxon Rank Sum (WRS) statistical test to determine if the survey unit can be released for unrestricted use. If a Class 1 survey unit fails the WRS statistical test, the survey unit data will be reevaluated to determine the appropriate actions. If a Class 2 survey unit fails the WRS statistical test, the survey unit classification will be reevaluated and if reevaluation of survey data indicates that the survey unit should be reclassified as a Class 1 survey unit, the survey unit will be assessed as a Class 1 survey unit.

Principal Study Questions for gross gamma radiation measurements:

If all surveyed locations in the survey unit are less than the $DCGL_w$, the survey unit is released for unrestricted use.

If any surveyed location in the survey unit equals or exceeds the $DCGL_w$, then determine the extent of contamination of the elevated area and reevaluate the classification of the survey unit if necessary. If reevaluation of survey data indicates that the survey unit should be reclassified as a Class 1 survey unit, the survey unit will be assessed in accordance with MARSSIM.

Step 6 - Specify the Limits on Decision Errors

Separate limits on decision errors for the $DCGL_w$ criteria and for the gross gamma radiation criteria were developed as detailed below.

$DCGL_w$ for Radium-226

Determine the Possible Range of the Parameter of Interest

The activity of Ra-226 contamination ranges from background (approximately 2 pCi/g) to approximately 12,700 pCi/g.

Define Both Types of Decision Errors and Establish the True Nature for Each Decision Error

Decision Statement: Decision Errors Types I and II

Type I: Decide that a datum is less than the release criteria when, in fact, it is not.

Type II: Decide that a datum is above the release criteria when, in fact, it is not.

The first decision error occurs when the investigation results are erroneously reported below action levels, or observations and judgments are made that the true hazardous nature of the data does not warrant further action. This decision error could result from measurement error (i.e., errors in field screening such as an improper calibration, calculation errors, malfunction of instrument), monitoring or sampling error (i.e., incorrect use of instrument, improper sample handling, sample collection errors), and/or from judgment errors.

The second decision error occurs when the investigation results are erroneously reported above action levels or observations, and judgments are made that the true hazardous nature of the data does warrant further action. This decision error could result from measurement error (i.e., errors in field screening such as an improper calibration, calculation errors, malfunction of instrument), monitoring or sampling error (i.e., incorrect use of instrument, improper sample handling, sample collection errors), and/or from judgment errors.

The Type I and Type II decision errors are set at 0.05. The following calculations are used to determine the number of samples that must be collected and analyzed to obtain sufficient data to meet the decision errors. The following is a sample calculation. A new calculation will be conducted following removal activities, and the actual survey unit area as determined in the field will be used in the calculation.

1. The Lower Boundary of the Gray Region (LBGR) is set at 75% of the $DCGL_w$ (5 pCi/g), thus 3.75 pCi/g.
2. Calculate the shift. $\text{Shift } (\Delta) = DCGL_w - LBGR$; thus $5 \text{ pCi/g} - 3.75 \text{ pCi/g} = 1.25 \text{ pCi/g}$.
3. The standard deviation (σ) of the data is anticipated at approximately 0.625 pCi/g.

4. Calculate the relative shift. Relative shift = Δ/σ ; thus 1.25 pCi/g / 0.625 pCi/g = 2.0.
5. Select the number of samples (n) per MARSSIM Table 5.3 (for contaminant present in the background) for a relative shift of 2.0 and Type I and Type II decision errors of 0.05. This is 13 samples.
6. Calculate the grid length for a triangular grid for 13 samples.

$$GridLength(L) = \sqrt{\frac{A}{0.866n_{EA}}}$$

“A” is the survey unit area and n_{EA} is the number of samples.

Thus the square root of [300 square feet (ft²) / (0.866 * 13)] = 5.2 feet

Consequences of the Decision Errors

Decision Statement: Decision Errors Types I and II

Type I: This decision error could result in a threat to human health and the environment.

Type II: This decision error could result in unnecessary expenditures for investigations or remediation.

Establish Which Decision Error Has the More Severe Consequences Near the Action Level

Decision Error Type I:

Decision error Type 1 has more severe consequences near the action levels, because the public or workers could be exposed to hazardous conditions potentially damaging to human health.

Define the Baseline Condition

Decision Error Type I:

H_o = Data exceed the release criteria and the survey unit will be reclassified as a Class 1 survey unit.

H_a = Data do not exceed the release criteria and the survey unit can be released for unrestricted use.

The null hypothesis is when data exceed the release criteria and the survey unit will be reclassified as a Class 1 survey unit. A false positive decision error occurs when the null hypothesis is falsely rejected. In this case, a false positive occurs if the decision maker decides that data do not exceed the release criteria, and that individual does not reclassify the survey unit as Class 1, when, in fact, it should be. A false negative occurs when the null hypothesis is falsely accepted.

Range of Possible Parameters Where the Consequence of a False Negative Decision Error is Relatively Minor (Grey Region)

A grey region of 75-100% of the action levels is acceptable for this investigation.

Tolerable Probability for Decision Errors

The decision error limits for this investigation are summarized in Table D-1.

Table D-1 Decision Error Limits for Radium

True Exposure (% of Action Level)	Decision Error Probability Goal	Type of Decision Error
<50	0.01	False Rejection
50-74	0.05	False Rejection
75-100	Grey Area	Grey Area
101-150	0.05	False Acceptance
>150	0.01	False Acceptance

Gross gamma radiation*Determine the Possible Range of the Parameter of Interest*

Gross gamma radiation ranges from 9,000 counts per minute (cpm) (background) to approximately 100,000 cpm using a Ludlum 2x2 sodium iodide (NaI) detector.

*Define Both Types of Decision Errors and Establish the True Nature for Each Decision Error***Decision Statement: Decision Errors Type 1 and Type 2**

Decision Error Type 1: Decide that a datum is less than the release criteria when, in fact, it is not.

Decision Error Type 2: Decide that a datum is above the release criteria when, in fact, it is not.

A Type 1 decision error occurs when the investigation results are erroneously reported below action levels, or observations and judgments are made that the true hazardous nature of the data does not warrant further action. This decision error could result from measurement error (i.e., errors in field screening such as an improper calibration, calculation errors, malfunction of instrument), monitoring or sampling error (i.e., incorrect use of instrument, improper sample handling, sample collection errors), and/or from judgment errors.

A Type 2 decision error occurs when the investigation results are erroneously reported above action levels or observations, and judgments are made that the true hazardous nature of the data does warrant further action. This decision error could result from measurement error (i.e., errors in field screening such as an improper calibration, calculation errors, malfunction of instrument), monitoring or sampling error (i.e., incorrect use of instrument, improper sample handling, sample collection errors), and/or from judgment errors.

The Type 1 and Type 2 decision errors are 0.05. Individual measurements will not be collected. Gross gamma radiation will be measured by scanning the soil survey unit at a specific scan speed. Gamma measurements will fluctuate rapidly. The technician will determine if any location exceeds the $DCGL_{EMC}$ by observing the instrument meter dial.

Consequences of the Decision Errors

Decision Statement: Decision Errors 1 & 2

- 1: This decision error could result in a threat to human health and the environment.
- 2: This decision error could result in unnecessary expenditures for investigations or remediation.

Establish Which Decision Error Has the More Severe Consequences Near the Action Level

Decision Error 1:

Decision error 1 has more severe consequences near the action levels because the public or workers could be exposed to hazardous conditions potentially damaging to human health.

Define the Baseline Condition

Decision Error 1:

- H_0 = Data exceed the release criteria and the survey unit will be reclassified as a Class 1 survey unit.
- H_a = Data do not exceed the release criteria and the survey unit can be released for unrestricted use.

The null hypothesis is when data exceed the release criteria and the survey unit will be reclassified as a Class 1 survey unit. A false positive decision error occurs when the null hypothesis is falsely rejected. In this case, a false positive occurs if the decision maker decides that data do not exceed the release criteria and that individual does not reclassify the survey unit as Class 1, when in fact, it should be. A false negative occurs when the null hypothesis is falsely accepted.

Range of Possible Parameters Where the Consequence of a False Negative Decision Error Are Relatively Minor (Grey Region)

A grey region of 75-100% of the action levels is acceptable for this investigation.

Tolerable Probability for Decision Errors

The decision error limits for this investigation are summarized in Table D-2.

Table D-2. Decision Error Limits for Gamma Radiation

True Exposure (% of Action Level)	Decision Error Probability Goal	Type of Decision Error
<50	0.01	False Rejection
50-74	0.05	False Rejection
75-100	Grey Area	Grey Area
101-150	0.05	False Acceptance
>150	0.01	False Acceptance

Step 7 - Optimize the Design for Obtaining Data

All sampling, analytical, and quality assurance activities will proceed under an EPA-approved Quality Assurance Project Plan (QAPP). The QAPP will be completed and approved prior to sample collection. Sampling activities and deviations from the QAPP will be documented in a field log book. Prior to sample collection, START personnel should review sampling procedures and relevant quality assurance and quality control required for the selected methods.

Sampling Design

The sampling design has been developed to generate the appropriate data to determine if the surface soil survey unit can be released for unrestricted use. The generated data will be analyzed by an appropriate statistical methodology in accordance with MARSSIM. The sampling design consists of two activities, collecting samples for laboratory analysis and performing scanning surveys. The combination of sampling and scanning provides an integrated FSS design as discussed in MARSSIM. The sampling and analysis results will be compared to the release criterion, i.e., the $DCGL_W$. A systematic sampling grid and the statistical test of the results are based on the assumption that the contamination is uniformly distributed throughout the survey unit.

Scanning survey measurements are collected for compliance with the $DCGL_{EMC}$. This survey is performed to determine if elevated areas of contamination are located in the survey unit. By scanning the survey unit, small areas of contamination can be detected.

Scanning Survey

MARSSIM recommends performing a scanning survey over 100% of a Class 1 survey unit and between 10% and 100% for Class 2 survey units. The key component to the design of a scanning survey is the determination of the scanning rate, based on achieving a specified scan minimum detectable concentration (MDC). MARSSIM discusses the determination of the scan MDC for gamma emitting radioisotopes in soil (Section 6.7.2.1, MARSSIM 2000).

Site specific variables used in the determination of the scan minimum detectable concentration (MDC) are as follows:

- Radionuclide = Ra-226
- Diameter of elevated area = 50 cm
- Depth of elevated area = 5 cm
- Detector = Ludlum Model 44-10, 2" by 2" sodium iodide scintillator
- Detector background = 9,000 cpm (exact value will be determined in field)
- Ra-226 $DCGL_W$ = 5.0 pCi/g
- Background Ra-226 = 2.0 pCi/g
- Detector count rate to exposure rate ratio = 900 cpm per $\mu R/h$ for Cs-137
- Detector relative response for 700 KeV gamma peak = 0.9
- Approximate gamma energy for Ra-226 plus daughters = 700 KeV
- Scan rate = 0.25 m/s (10 in/s)
- Index of sensitivity (d') = 1.38
- Surveyor efficiency (p) = 0.5
- Observational interval = 2 sec
- Distance of detector from the ground = 15 cm

- Instrument efficiency (ϵ_i) = determined by calculating the detector exposure rate at 7.0 pCi/g (DCGL_w plus background)
- Surface efficiency (ϵ_s) = 1 (no reduction for gamma radiation)

Based on site specific variables, the scan MDC calculations are as follows for a Class 2 survey unit.

Step 1. Calculate the expected background counts (b_i) in the observation interval (i). The equation is as follows:

$$b_i = \text{background rate} \times i \times 1 \text{ min}/60 \text{ sec}$$

The equation is solved with example site specific variables as follows:

$$b_i = 9,000 \text{ counts/min} \times 2.0 \text{ sec} \times 1 \text{ min}/60 \text{ sec} = 300 \text{ counts}$$

Step 2. Calculate the minimum detectable number of net source counts (s_i) using the following equation:

$$s_i = d' \times \%b_i$$

The equation is solved with the site specific variable as follows:

$$\begin{aligned} s_i &= 1.38 \times \%300 \text{ counts} \\ &= 23.9 \text{ counts} \end{aligned}$$

Step 3. Calculate the minimum detectable count rate (MDCR) using the following equation:

$$\text{MDCR} = s_i \times 60 \text{ sec/min} \times 1/i$$

The equation is solved with the site specific variables as follows:

$$\begin{aligned} \text{MDCR} &= 23.9 \text{ counts} \times 60 \text{ sec/min} \times 1/2.0 \text{ sec} \\ &= 717 \text{ cpm} \end{aligned}$$

Step 4. Calculate the MDCR_{surveyor} using the following equation:

$$\text{MDCR}_{\text{surveyor}} = \text{MDCR} / \%p$$

The equation is solved with the site specific variables as follows:

$$\begin{aligned} \text{MDCR}_{\text{surveyor}} &= 717 \text{ cpm}/\%0.5 \\ &= 1,014 \text{ cpm} \end{aligned}$$

Step 5. Calculate the dose coefficient for exposure to contaminated soil at a depth of one centimeter (cm) for Ra-226 and daughters using Federal Guidance Report No. 12, External Exposure to Radionuclides in Air, Water, and Soil (EPA-402-R-93-081).

Step 5a. Calculate the total dose coefficient for significant gamma emitting daughter products of Ra-226.

The significant gamma emitting daughter products of Ra-226 are lead (Pb)-214 and bismuth (Bi)-214. The dose coefficients are:

$$\text{Pb-214} = 1.57 \times 10^{-18} \text{ Sv/s per Bq/m}^3$$

$$\text{Bi-214} = 9.15 \times 10^{-18} \text{ Sv/s per Bq/m}^3$$

The total dose coefficient is:

$$\begin{aligned} \text{Total dose coefficient} &= 1.57 \times 10^{-18} \text{ Sv/s per Bq/m}^3 + 9.15 \times 10^{-18} \text{ Sv/s per Bq/m}^3 \\ &= 1.072 \times 10^{-17} \text{ Sv/s per Bq/m}^3 \end{aligned}$$

Step 5b. Convert the units to conventional units (mrem/yr per $\mu\text{Ci/g}$) using the conversion factor of 1.868×10^{23} (soil density independent).

$$\begin{aligned} \text{Total dose coefficient} &= 1.072 \times 10^{-17} \text{ Sv/s per Bq/m}^3 \times 1.868 \times 10^{23} \text{ mrem/year per } \mu\text{Ci/g} \\ &\quad / \text{ Sv/s per Bq/m}^3 \\ &= 2,002,496 \text{ mrem/yr per } \mu\text{Ci/g} \end{aligned}$$

Step 5c. Convert the total dose coefficient to conventional units for soil concentration (pCi/g) and to conventional exposure rate units of mrem/hr as follows:

$$\begin{aligned} \text{Total dose coefficient} &= 2,002,496 \text{ mrem/yr per } \mu\text{Ci/g} \times 1 \mu\text{Ci}/10^6 \text{ pCi} \times 1 \text{ yr}/8,760 \text{ hrs} \\ &= 0.0002286 \text{ mrem/hr per pCi/g} \end{aligned}$$

Step 5d. Calculate the exposure rate at the DCGL_W (5.0 pCi/g) plus background (2.0 pCi/g) as follows:

$$\begin{aligned} \text{Exposure rate} &= 0.0002286 \text{ mrem/hr per pCi/g} \times 7.0 \text{ pCi/g} \\ &= 0.00160 \text{ mrem/hr} \end{aligned}$$

Step 5e. Convert the exposure rate to conventional exposure rate units for field portable detectors ($\mu\text{R/hr}$) as follows:

$$\begin{aligned} \text{Exposure rate} &= 0.00160 \text{ mrem/hr} \times 1,000 \mu\text{R/hr per mrem/hr} \\ &= 1.60 \mu\text{R/hr} \end{aligned}$$

Step 6. Calculate the detector response to Ra-226 and daughters in equilibrium. Ra-226 and daughter have an approximate gamma radiation energy of 700 KeV. Ludlum reports the detector response to Cs-137 at 900 cpm per $\mu\text{R/hr}$ with a response curve that indicates a 0.9 relative response for 700 KeV. Thus the detector response for RA-226 plus daughters is as follows:

$$\begin{aligned} \text{Detector response} &= 900 \text{ cpm per } \mu\text{R/hr} \times 0.9 \\ &= 810 \text{ cpm per } \mu\text{R/hr} \end{aligned}$$

Step 7. Calculate the detector response for the exposure rate determined in Step 5 as follows:

$$\begin{aligned}\text{Detector response} &= 810 \text{ cpm per } \mu\text{R/hr} \times 1.60 \mu\text{R/hr} \\ &= 1,296 \text{ cpm}\end{aligned}$$

Step 8. Compare the detector response to Ra-226 surface contamination with the MDCRsurveyor determined in Step 4 (1,014 cpm).

Detector response of 1,296 cpm is greater than the MDCRsurveyor value of 1,014 cpm thus a Ludlum Model 44-10 can detect 7.0 pCi/g Ra-226 in surface soil.

Step 9. Calculate the scan MDC.

Step 9a. Calculate the detector response ($\mu\text{R/hr}$) for the MDCRsurveyor. The equation is as follows:

Detector response = MDCRsurveyor / detector response for Ra-226 plus daughters
The equation is solved with example site specific variables as follows:

$$\begin{aligned}\text{Detector response} &= 1,014 \text{ cpm} / 810 \text{ cpm per } \mu\text{R/hr} \\ &= 1.25 \mu\text{R/hr}\end{aligned}$$

Step 9b. Calculate the scan MDC using the following equation:

Scan MDC = (DCGL_w + Ra-226 background) x detector response (Step 9a) / exposure rate (Step 5c)

The equation is solved with example site specific variables as follows:

$$\begin{aligned}\text{Scan MDC} &= 7.0 \text{ pCi/g} \times 1.25 \mu\text{R/hr} / 1.60 \mu\text{R/hr} \\ &= 5.48 \text{ pCi/g}\end{aligned}$$

For Class 1 survey units, the scan MDC is determined as described above with one additional step. The area factor for the survey unit is used to determine the DCGL_{EMC}. The area factor is calculated from the RESRAD, Version 6.3 program for Ra-226. The 30 year total dose per year for an area of contamination of 10,000 square meters (m²) is compared to the 30 years total dose per year for an area of contamination based on the sampling grid used in the survey unit. The area of contamination is determined by the following equation:

$$A = 0.866 \times L^2$$

Where A = area of the contamination between sampling points in m²
L = length of grid, for a triangular grid in meters

The dose for the 10,000 m² area is divided by the dose calculated based on the area of contamination between sampling points (as described above) which is equal to the area factor. The DCGL_{EMC} is then calculated based on the following equation:

$$\text{DCGL}_{\text{EMC}} = \text{DCGL}_w \times \text{area factor}$$

For example, the 30 year total dose per year for 10,000 m² for Ra-226 is 0.3753 mrem/year. The 30 year total dose per year for 30 m² for Ra-226 is 0.2188, thus the area factor is determined as follows:

$$\begin{aligned}\text{Area factor} &= 0.3753 / 0.2188 \\ &= 1.7\end{aligned}$$

Then the DCGL_{EMC} is determined as follows:

$$\begin{aligned}\text{DCGL}_{\text{EMC}} &= 5.0 \text{ pCi/g} \times 1.7 \\ &= 8.5 \text{ pCi/g}\end{aligned}$$

The scan MDC for a Class 1 survey can be determined based on the DCGL_{EMC}; i.e. the scanning survey is designed to measure contamination below the DCGL_{EMC} instead of the DCGL_W.

Background Determination

The contaminant, Ra-226, is naturally occurring in background surface soil. Therefore, background activity for Ra-226 and gross gamma radiation will be established from areas not affected by site operations. Background samples were collected during the RSE and were analyzed for Ra-226 and gross gamma radiation.

Posting Plot

A primary assumption of the design of the FSS Sampling Design Plan is that the contamination is uniformly distributed throughout the survey unit. To document that the assumption is valid, a posting plot will be created. A posting plot is a graphic illustration of measurements in a survey unit. A posting plot may be conducted by collecting static measurements along evenly spaced transects (e.g., 1 meter apart) using a Ludlum Model 2241-2 ratemeter with a Ludlum Model 44-10 NaI scintillation detector coupled with a Trimble GPS unit. The ratemeter/GPS sampling platform will help establish the horizontal extent of radionuclide contamination through the display of real-time survey data in a XYZ coordinate format. The posting plot will provide a graphical illustration of the contamination distribution throughout the area of investigation.

Data Assessment

Two criteria must be met before the survey unit is released for unrestricted use. The soil sample results must comply with the DCGL_W, and all EMCs must have been addressed. The evaluation of the data generated from each investigation activity is treated according to MARSSIM requirements.

The first step in the data analysis is to determine if the survey unit meets the release criteria for the DCGL_W. If soil sample results, without background subtracted, are less than the DCGL_W of 5.0 pCi/g, the null hypothesis is rejected and the survey unit is released for unrestricted use without further data analysis using the Wilcoxon rank sum (WRS) statistical test. If any results exceed the DCGL_W, the WRS test will be performed. If W_r , the sum of the adjusted reference area ranks from the WRS test, is greater than the critical value, the mean concentration of Ra-226 in soil is less than the DCGL_W and the null hypothesis is rejected. However, if the W_r is less than the critical value, the mean concentration of Ra-226 in soil is greater than the DCGL_W, the null hypothesis is accepted, and the survey unit is not released. In this case, the survey unit would be investigated further to delineate the areas of contamination with subsequent remediation.

The critical value (W_c) is a function of the Type I error tolerance, which is 0.05 for this investigation, the number of reference area samples (3), and the number of the survey unit samples (13). The W_c is calculated by the following equation:

$$W_c = m(n + m + 1) / 2 + z \sqrt{nm(n + m + 1) / 12}$$

where,

m = number of reference area samples

n = number of survey unit samples

z = (1- α) percentile of a standard normal distribution (MARSSIM Table I.1)

Therefore,

$$W_c = 3(13 + 3 + 1) / 2 + 1.645 \sqrt{(13)(3)(13 + 3 + 1) / 12}$$

$$= 38$$

Whether or not the null hypothesis is rejected (survey unit is released) or accepted (further remediation is required), the power of the WRS should be assessed to determine if the DQOs were achieved. A retrospective power curve will be constructed to evaluate the number of samples collected with respect to the standard deviation of the sample set. The correct number of samples collected can then be validated. If the retrospective power curve indicates that insufficient samples were collected, two possible actions can be taken. The LBGR can be adjusted to change the relative shift that corresponds to the actual number of samples collected, assuming that the mean of the results is not greater than the LBGR or additional samples can be collected.

The second step in data assessment is the review of scanning measurements. Any detection of an EMC during scanning or from the discrete sampling will require further investigations to delineate the contamination. The contamination will be remediated and the survey unit will be reclassified as a Class 1 survey unit. If less than a 100% scan had been performed, remaining portions of the survey unit would require scanning surveys. Since the surface soil survey unit will be scanned at 100%, additional scanning surveys would not be required after the EMCs were confirmed remediated. However, no additional sampling would be required if the survey unit met the DCGL_w release criterion.

The final review of data will involve a visual interpretation of the posting plot to determine if any patterns in the gross gamma radiation levels indicate a non-homogenous distribution of contamination. Locations that exceed the EMC release criteria will be flagged for further investigation.

APPENDIX D

AIR MONITORING SPREADSHEET

LLD Calculation [This verifies that the count times used for the samples are within the LLD for the action level.]

LLD (uCi/mL)= **2.01E-13**

Ra-226 action level (uCi/mL)= **9.0E-13**

[10CFR20 App B, Table 2, Col 1] [100 mrem public dose limit]
(this would be the dose for an entire year at this concentration
and has additional factors to protect sensitive populations)

R _B	1	Background Count Rate (cpm) - [for alpha drawer ~1 cpm]
t _b	1	The count time of the Background result above, in minutes
t _s	1	Sample count time in minutes
	1800.0	Sample Volume from the Radeco (ft ³)
	5.10E+07	Volume conversion to mL (28,320.6 mL per ft ³)
	0.36	Efficiency of the alpha drawer counter (~37% for 4-pi)
	0.9	Self absorption correction factor
	0.9997	Filter collection efficiency
	2.22E+06	conversion factor for dpm per micro-Curie

$$MDA = \frac{2.71 + 3.29 \sqrt{R_B t_s \left[1 + \frac{t_s}{t_B} \right]}}{t_s E}$$

$$LLD = \frac{2.71 + 3.29 \sqrt{R_B t_s \left[1 + \frac{t_s}{t_B} \right]}}{(t_s)(E_D)(E_F)(FF)(SAF)(Vol_{CC})(2.22E6)}$$

Calculating Detection Limits: MDA & LLD
Jim Mitchell, EPA R5

"Approximation" of radium concentration
derived from 2 counts taken at 4 hours and
24 hours following the end of the air sample

This approximation accounts for the buildup of radon decay products on the sample filter and gives an
estimate of the concentration of non-radon decay products on the filter. It should be similar to the final
results once all radon decay products have decayed away (approx 4.5 days).

5.13E-13 uCi/mL
14 cpm

11/1/07 7:00 AM	Begin air sampling (mm/dd/yy hh:mm) [enter as military time]
11/1/07 4:30 PM	End air sampling (mm/dd/yy hh:mm) [enter as military time]
1200.0	Sample Volume from the Radeco (ft ³)
3.40E+07	Volume conversion to mL (28,320.6 mL per ft ³)
9:30	Calculated sample time (hh:mm)

$$C = \frac{C_2 - C_1 \exp(-0.0654 * \Delta T)}{(1 - \exp(-0.0654 * \Delta T))}$$

0.37	Efficiency of the alpha drawer counter (~37% for 4-pi) (counts recorded per actual disintegrations occurring, ie cpm/dpm)
4.5045E-07	Conversion Factor (dpm to uCi) ((dpm x 1E6 uCi/Ci) / (60 sec/min * 3.7E10 Ci/dps))

C ₁	300	(cpm) Results of Count #1 (Ludlum 3030 Alpha Drawer value). Take about 4 hours after sampling.
	11/1/07 8:00 PM	Time of Count #1 (mm/dd/yy hh:mm) [enter as military time]
	3:30	Elapsed time in (hours:minutes) between end of sample and Count #1. (This should be at least 4 hours!)

C ₂	100	(cpm) Results of Count #2 (Ludlum 3030 Alpha Drawer value). Take about 24 hours after sampling.
	11/2/07 2:25 PM	Time of Count #2 (mm/dd/yy hh:mm) [enter as military time]

ΔT	18:25	Calculated elapsed time between Count #1 and Count #2 (hh:mm) (This should be about 20 hours!)
	18.42	Delta T (decimal format)

Post Radon Decay - Final Concentration Calculation

Final Count from Air Sample (above)

Must be counted 4.5 days after end of sample

3.22E-13 uCi/mL

9 (cpm) Results of final count (Ludlum 3030 Alpha Drawer)