Nevada
Environmental
Management
Operations Activity

DOE/NV--1548

National Nuclear Security Administration

# Closure Report for Corrective Action Unit 412: Clean Slate I Plutonium Dispersion (TTR) Tonopah Test Range, Nevada

Controlled Copy No.: ___
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August 2016

UNCLASSIFIED

/s/ Joseph P. Johnston 08/22/2016
Joseph P. Johnston, Navarro CO Date

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# CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 412: CLEAN SLATE I PLUTONIUM DISPERSION (TTR) TONOPAH TEST RANGE, NEVADA

U.S. Department of Energy, National Nuclear Security Administration
Nevada Field Office
Las Vegas, Nevada

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August 2016

**CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 412:**
**CLEAN SLATE I PLUTONIUM DISPERSION (TTR)**
**TONOPAH TEST RANGE, NEVADA**

Approved by: /s/ Tiffany A. Lantow Date: 08/22/2016

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Soils Activity Lead

Approved by: /s/ Robert F. Boehlecke Date: 08/22/2016

Robert F. Boehlecke
Environmental Management Operations Manager

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## List of Acronyms and Abbreviations

| | |
|---|---|
| Ag | Silver |
| ags | Above ground surface |
| Al | Aluminum |
| Am | Americium |
| ASTM | ASTM International |
| bgs | Below ground surface |
| BMP | Best management practice |
| CA | Contamination area |
| CAA | Corrective action alternative |
| CAI | Corrective action investigation |
| CAS | Corrective action site |
| CAU | Corrective action unit |
| CD | Certificate of Disposal |
| CFR | *Code of Federal Regulations* |
| CLP | Contract Laboratory Program |
| cm | Centimeter |
| Cm | Curium |
| Co | Cobalt |
| COC | Contaminant of concern |
| COPC | Contaminant of potential concern |
| cpm | Counts per minute |
| CR | Closure report |
| CSI | Clean Slate I |
| CSM | Conceptual site model |
| DOE | U.S. Department of Energy |
| DOELAP | U.S. Department of Energy Laboratory Accreditation Program |

## List of Acronyms and Abbreviations *(Continued)*

| | |
|---|---|
| dpm/100 $cm^2$ | Disintegrations per minute per 100 square centimeters |
| DQA | Data quality assessment |
| DQI | Data quality indicator |
| DQO | Data quality objective |
| EPA | U.S. Environmental Protection Agency |
| Eu | Europium |
| FAL | Final action level |
| FD | Field duplicate |
| FFACO | *Federal Facility Agreement and Consent Order* |
| FIDLER | Field instrument for the detection of low-energy radiation |
| GPS | Global Positioning System |
| GT | Ground troops |
| GZ | Ground zero |
| HCA | High contamination area |
| hr/day | Hours per day |
| hr/yr | Hours per year |
| IA | Industrial area |
| in. | Inch |
| LCS | Laboratory control sample |
| LLW | Low-level waste |
| m | Meter |
| $m^2$ | Square meter |
| MDC | Minimum detectable concentration |
| M&O | Management and operating |
| MOB | Multiples of background |
| mrem | Millirem |

## *List of Acronyms and Abbreviations* *(Continued)*

| | |
|---|---|
| mrem/GT-yr | Millirem per Ground Troops year |
| mrem/IA-yr | Millirem per Industrial Area year |
| mrem/yr | Millirem per year |
| N/A | Not applicable |
| NAC | *Nevada Administrative Code* |
| NAD | North American Datum |
| Nb | Niobium |
| NDEP | Nevada Division of Environmental Protection |
| NIST | National Institute of Standards and Technology |
| NNSA/NFO | U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office |
| NNSS | Nevada National Security Site |
| Np | Neptunium |
| NSTec | National Security Technologies, LLC |
| PAL | Preliminary action level |
| pCi/g | Picocuries per gram |
| PI | Preliminary investigation |
| PSM | Potential source material |
| Pu | Plutonium |
| QA | Quality assurance |
| QAP | Quality Assurance Plan |
| QC | Quality control |
| RBCA | Risk-based corrective action |
| RPD | Relative percent difference |
| RRMG | Residual radioactive material guideline |
| RWMC | Radioactive Waste Management Complex |
| SAFER | Streamlined Approach for Environmental Restoration |

# *List of Acronyms and Abbreviations* *(Continued)*

| | |
|---|---|
| SCL | Sample collection log |
| Sr | Strontium |
| Tc | Technetium |
| TED | Total effective dose |
| Th | Thorium |
| TLD | Thermoluminescent dosimeter |
| TTR | Tonopah Test Range |
| U | Uranium |
| UCL | Upper confidence limit |
| UR | Use restriction |
| USAF | U.S. Air Force |
| UTM | Universal Transverse Mercator |
| UXO | Unexploded ordnance |
| $yd^3$ | Cubic yard |

# *Executive Summary*

This Closure Report (CR) presents information supporting the clean closure of Corrective Action Unit (CAU) 412: Clean Slate I Plutonium Dispersion (TTR), located on the Tonopah Test Range, Nevada. CAU 412 consists of a release of radionuclides to the surrounding soil from a storage–transportation test conducted on May 25, 1963. This CR complies with the requirements of the *Federal Facility Agreement and Consent Order* (FFACO) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management. CAU 412 consists of one corrective action site, TA-23-01CS, Pu Contaminated Soil.

Corrective action investigation (CAI) activities were performed in April and May 2015, as set forth in the *Streamlined Approach for Environmental Restoration (SAFER) Plan for Corrective Action Unit 412: Clean Slate I Plutonium Dispersion (TTR), Tonopah Test Range, Nevada*; and in accordance with the *Soils Activity Quality Assurance Plan*. The purpose of the CAI was to fulfill data needs as defined during the data quality objectives process. The CAU 412 dataset of investigation results was evaluated based on a data quality assessment. This assessment demonstrated the dataset is complete and acceptable for use in fulfilling the data needs identified by the data quality objectives process.

This CR provides documentation and justification for the clean closure of CAU 412 under the FFACO without further corrective action. This justification is based on historical knowledge of the site, previous site investigations, implementation of the 1997 interim corrective action, and the results of the CAI. The corrective action of clean closure was confirmed as appropriate for closure of CAU 412 based on achievement of the following closure objectives:

- Radiological contamination at the site is less than the final action level using the ground troops exposure scenario (i.e., the radiological dose is less than the final action level).
- Removable alpha contamination is less than the high contamination area criterion.
- No potential source material is present at the site, and any impacted soil associated with potential source material has been removed so that remaining soil contains contaminants at concentrations less than the final action levels.
- There is sufficient information to characterize investigation and remediation waste for disposal.

The CAI confirmed that further corrective action is not required at CAU 412. Based on the interim corrective action implemented in 1997, clean closure of the site is complete; the closure objectives established in the SAFER Plan have been achieved; and no further corrective action at the site is required.

The corrective action of clean closure meets all applicable federal and state regulations for closure of the site under the FFACO. Based on the implementation of these corrective actions, the DOE, National Nuclear Security Administration Nevada Field Office (NNSA/NFO) provides the following recommendations:

- No further corrective actions are necessary for CAU 412.
- The Nevada Division of Environmental Protection should issue a Notice of Completion to NNSA/NFO for closure of CAU 412.
- CAU 412 should be moved from Appendix III to Appendix IV of the FFACO.

# 1.0 Introduction

This Closure Report (CR) presents information supporting closure of Corrective Action Unit (CAU) 412, Clean Slate I Plutonium Dispersion (TTR), located on the Tonopah Test Range (TTR) (Figure 1-1). This document has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management.

CAU 412 consists of a release of radionuclides to the surrounding soil from a storage–transportation test conducted on May 25, 1963 (NNSA/NFO, 2015b). The test used a conventional explosives detonation to disperse plutonium and depleted uranium to the environment. A detailed discussion of the history of this CAU is presented in the *Streamlined Approach for Environmental Restoration (SAFER) Plan for Corrective Action Unit 412: Clean Slate I Plutonium Dispersion (TTR), Tonopah Test Range, Nevada* (NNSA/NFO, 2015a).

CAU 412 has previously undergone extensive investigation involving soil sampling, geophysical surveys, and radiation surveys. In 1997, highly contaminated soil and debris were removed from the site as an interim corrective action. A summary of previous investigations and the 1997 remediation is found in the CAU 412 SAFER Plan (NNSA/NFO, 2015a). The 1997 interim corrective action was implemented using a concentration-based action level. Following the interim corrective action, work on CAU 412 was suspended. An effort was made in 2004 to restart the project using the previous concentration-based cleanup level, but this effort stalled in negotiation with the Nevada Division of Environmental Protection (NDEP). A renewed effort to close the CAU 412 site was initiated in 2014, using a risk-based action level of 25 millirem per year (mrem/yr).

The CAU 412 dose estimates presented in this CR are intended to estimate the maximum potential dose that any receptor could reasonably receive under current and foreseeable future use of the contaminated area. These dose estimates were made using conservative values for site physical properties, contaminant properties, dose conversion properties, and exposure durations. While this conservatism results in dose estimates that are higher than actual expected doses, it provides protection against making a false-negative decision error (i.e., a decision that contamination

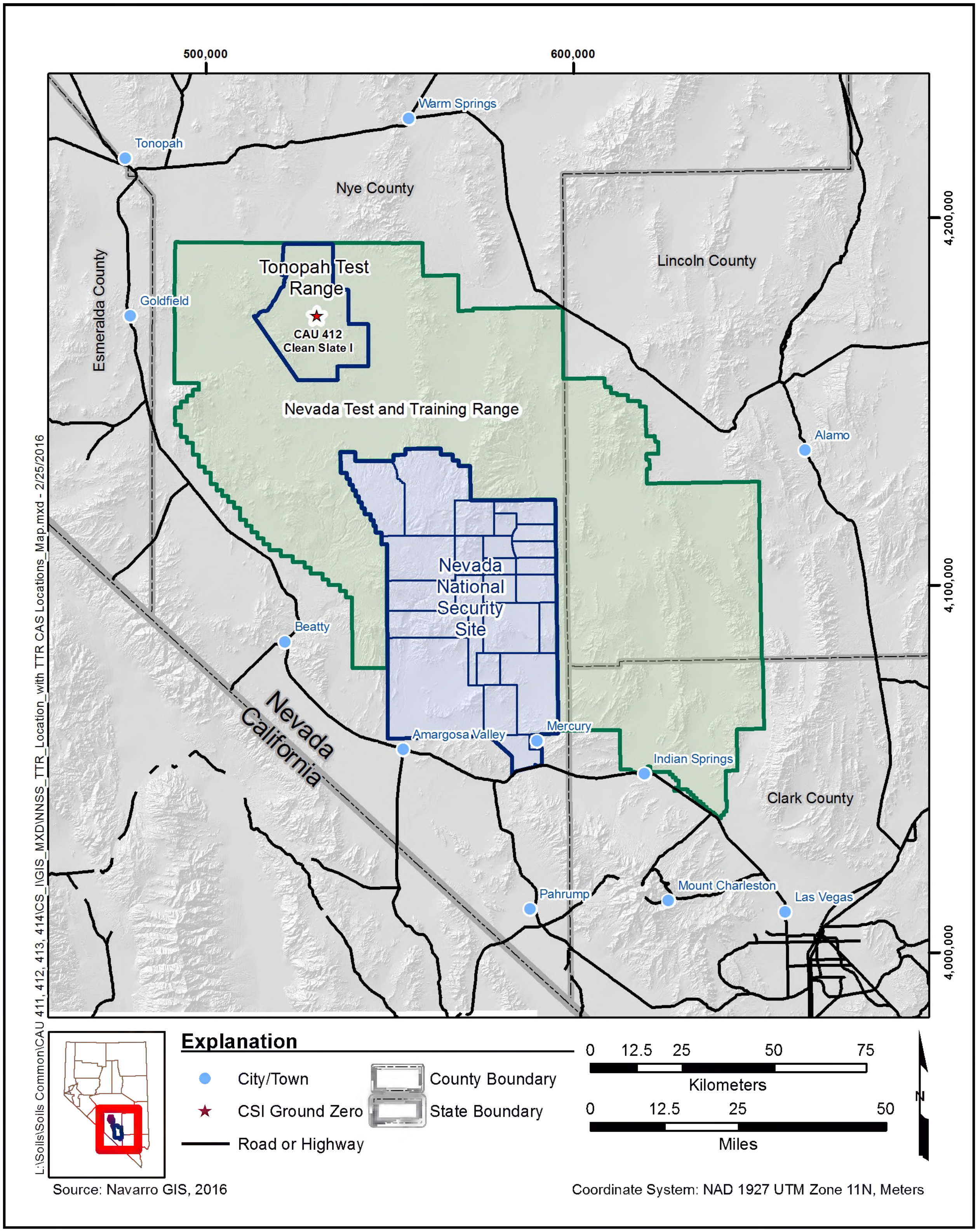


**Figure 1-1**
**CAU 412 Location**

exceeding final action levels (FALs) is not present when it actually is). CAU 412 consists of a single corrective action site (CAS), TA-23-01CS, Pu Contaminated Soil. Because the CAU has only one CAS, the CAS nomenclature is generally not used in this CR. Instead, the CAS is referred to as the Clean Slate I (CSI) site or CAU 412 throughout this document.

### 1.1 Purpose

This CR provides documentation and justification for the clean closure of CAU 412 under the FFACO without further corrective action. This justification is based on historical knowledge of the site, the 1997 interim corrective action, subsequent site investigations, and the results of the corrective action investigation (CAI). CAI activities were completed in accordance with the SAFER Plan (NNSA/NFO, 2015a) and the *Soils Activity Quality Assurance Plan* (QAP) (NNSA/NSO, 2012), which establishes requirements, technical planning, and general quality practices. The evaluation of investigation results and the risk associated with site contamination was conducted in accordance with the *Soils Risk-Based Corrective Action* (RBCA) *Evaluation Process* (NNSA/NFO, 2014). The CAI data support the confirmation of clean closure as the appropriate corrective action at CAU 412, as proposed in the SAFER Plan.

### 1.2 Scope

An interim corrective action was conducted at CAU 412 in 1997 in which the most highly contaminated soil and debris were removed from the site. The scope of the interim corrective action was to remove soil and debris that exceeded the concentration-based action level of 200 picocuries per gram (pCi/g) total transuranics in place at the time. Post-remediation radiation surveys of the site verified that remediation to the 1997 action level was achieved. In 2015, a CAI was conducted to determine the radiological conditions at the site in relation to the current risk-based action level. This CR includes an evaluation of the CAU 412 dataset using the risk-based action level to document and justify that clean closure is the appropriate corrective action for the site.

### 1.3 CR Contents

This CR is divided into the following sections and appendices:

- Section 1.0, "Introduction," summarizes the purpose, scope, and contents of this CR.

- Section 2.0, "Closure Activities," summarizes the closure activities, deviations from the SAFER Plan, the actual schedule, and the site conditions following completion of corrective actions.
- Section 3.0, "Waste Disposition," discusses the wastes generated and entered into an approved waste management system as a result of the corrective action.
- Section 4.0, "Closure Verification Results," summarizes verification activities and results.
- Section 5.0, "Conclusions and Recommendations," provides the conclusions and recommendations along with the rationale for their determination.
- Section 6.0, "References," provides a list of all referenced documents used in the preparation of this CR.
- Appendix A, *DQOs as Developed in the* SAFER *Plan,* references the data quality objectives (DQOs) as presented in Appendix B of the CAU 412 SAFER Plan.
- Appendix B, *Closure Certification*. This appendix is not applicable to CAU 412, because closure certification is only required for permitted or interim status hazardous waste facilities.
- Appendix C, *As-Built Documentation*. This appendix is not applicable to CAU 412, because the site was clean closed. In addition, the 1997 interim corrective action conducted at the site did not involve the construction of an engineered barrier or other structure for which as-built documentation is applicable.
- Appendix D, *Confirmation Sampling Test Results*, provides a description of the project objectives, confirmation sampling activities, and closure results.
- Appendix E, *Waste Disposition Documentation*, documents disposal of items removed or waste generated during closure activities.
- Appendix F, *Modifications to the Post-closure Plan*. This appendix is not applicable to CAU 412, because the site is being clean closed and a post-closure plan is not required.
- Appendix G, *Use Restrictions* (URs). This appendix is not applicable to CAU 412, because the site is being clean closed and FFACO URs are not required.
- Appendix H, *Risk Evaluation*, presents the risk evaluation results.
- Appendix I, *Evaluation of Corrective Action Alternatives* (CAAs). This appendix is not applicable to CAU 412, because the presumed corrective action of clean closure was proposed in the SAFER Plan and confirmed by the CAI.

- Appendix J, *Sample Location Coordinates*, presents the investigation sample location coordinates.

- Appendix K, *Nevada Division of Environmental Protection Comments,* contains NDEP comments on the draft version of this document.

### 1.3.1 Applicable Programmatic Plans and Documents

All CAI activities were performed in accordance with the following documents:

- SAFER Plan for CAU 412, Clean Slate I Plutonium Dispersion (TTR) (NNSA/NFO, 2015a)
- Soils Activity QAP (NNSA/NSO, 2012)
- Soils RBCA document (NNSA/NFO, 2014)
- FFACO (1996, as amended)

### 1.3.2 Data Quality Objectives Summary

The DQOs are presented in the SAFER Plan (NNSA/NFO, 2015a). The DQOs were developed to identify data needs, clearly define the intended use of the environmental data, and design a data collection program that will satisfy these purposes.

The problem statement for CAU 412 is as follows:

- "Existing information on the nature and extent of contamination is insufficient to determine whether site closure objectives have been achieved."

To address this problem, the resolution of two decision statements is required:

- **Decision I.** "Does any location exceed the FALs?" The radiological FAL is a dose-based action level based on the ground troops (GT) exposure scenario, as detailed in Appendix H.

The RBCA dose evaluation does not address the potential for removable radioactive contamination to be transported to other areas. A discussion of the risks associated with removable contamination is presented in the Soils RBCA document (NNSA/NFO, 2014). For removable contamination, it is assumed that if the high contamination area (HCA) criterion is exceeded, the dose-based FAL of 25 millirem per Ground Troops year (mrem/GT-yr) is also exceeded and corrective action is required. The HCA criterion and removable contamination are further discussed in Sections D.2.5.2 and H.1.4.

- **Decision II.** "Is there sufficient information to achieve closure objectives?" Sufficient information is defined to include the following:

  - The lateral and vertical extent of contaminant of concern (COC) contamination
  - The information needed to predict potential remediation waste types and volumes

As stated in the SAFER Plan (NNSA/NFO, 2015a), the closure objectives for CAU 412 are as follows:

- Radiological contamination at the site is less than the FAL using the GT exposure scenario (i.e., the radiological dose is less than the FAL).

- Removable alpha contamination is less than the HCA criterion.

- No potential source material (PSM) is present at the site, and any impacted soil associated with PSM has been removed so that remaining soil contains contaminants at concentrations less than the FALs.

- There is sufficient information to characterize investigation and remediation waste for disposal.

### *1.3.3 Data Quality Assessment Summary*

A data quality assessment (DQA) was conducted that evaluated the degree of acceptability and usability of the reported data in the decision-making process. This DQA is presented in Section 4.1. Using both the DQO and DQA processes helps to ensure that DQO decisions are sound and defensible.

Based on the DQA, the nature and extent of COCs at CAU 412 have been adequately identified to verify the corrective action of clean closure. Information generated during the investigation supports the conceptual site model (CSM) assumptions, and the data collected met the DQOs and support their intended use in the decision-making process.

# 2.0 Closure Activities

The SAFER Plan (NNSA/NFO, 2015a) identified the presumed corrective action for CAU 412 as clean closure. This presumption was based on implementation of the interim corrective action in 1997 and data collected during subsequent investigations. In order to supplement existing data and determine whether site closure objectives have been achieved, additional data were collected at CAU 412 as part of a CAI. A discussion of CAI activities and the calculated dose at CAU 412 is presented in Appendix D. The methods used to calculate dose are detailed in the SAFER Plan (NNSA/NFO, 2015a) and the Soils RBCA document (NNSA/NFO, 2014).

## 2.1 Description of Corrective Action Activities

CAI activities were conducted in April and May 2015. Investigation activities at CAU 412 included visual surveys, ground-based radiation surveys, collection of surface and subsurface soil samples, and placement of thermoluminescent dosimeters (TLDs). The purpose of the CAI was to provide the additional information needed to determine whether site closure objectives, defined in Section 1.3.2, have been achieved.

For DQO Decision I, sample locations were established judgmentally based on the presence of biasing factors (e.g., highest radiation survey values). Using the contamination levels from the judgmental locations of highest potential contamination provides a conservative estimate of the contaminant exposure a receptor could receive from working at the release site. Where soil samples were collected in sample plots, an additional level of conservatism was added by evaluating the judgmental sample results probabilistically using the 95 percent upper confidence limit (UCL) of the average sample result to resolve DQO Decision I. For DQO Decision II, data were evaluated against the four site closure objectives to determine whether clean closure is an appropriate corrective action for CAU 412.

Data to calculate radiological dose were provided by the analytical results of TLD samples for external radiological dose, where available, and soil samples for the calculation of internal radiological dose. The calculated total effective dose (TED) for each sample location is an estimation of the true radiological dose (true TED). The TED is defined in 10 *Code of Federal Regulations*

(CFR) Part 835 (CFR, 2016b) as the sum of the effective dose (for external exposures) and the committed effective dose (for internal exposures). Methods used for calculating internal, external, and total dose are presented in the Soils RBCA document (NNSA/NFO, 2014). Deviations from these methods are discussed in Section 2.2.

The dose to a receptor from site contamination is a function of the time the receptor is present at the site and exposed to the radioactively contaminated soil. In consultation with stakeholders, including NDEP; the U.S. Air Force (USAF); and DOE, National Nuclear Security Administration Nevada Field Office (NNSA/NFO), the GT exposure scenario was determined applicable to the CAU 412 site (USAF, 2014). The most exposed individual in this scenario is defined as an adult member of the military who spends 100 percent of his or her time onsite outdoors and engaged in activities that may include light, moderate, and hard physical labor and periods at rest. This scenario assumes that the individual bivouacs at the CAU 412 site. The maximum amount of time an individual ground troop could be deployed during any single mission or operation is 14 days, 24 hours per day (hr/day), and would participate in three such deployments a year. This results in a total of 1,008 hours per year (hr/yr) of potential exposure. As presented in Appendix H, the radiological FAL is based on this exposure scenario.

The RBCA dose evaluation does not address the potential for removable contamination to be transported to other areas. A discussion of the risks associated with removable radioactive contamination is presented in the Soils RBCA document (NNSA/NFO, 2014). It is assumed that corrective action is required for areas that exceed the HCA criterion even though the area may not present a potential radiation dose to a receptor that exceeds the FAL (25 mrem/yr). Therefore, in addition to comparing the TED to the FAL to determine the need for corrective action, removable contamination levels must be compared to the HCA criterion (i.e., removable contamination preliminary action level [PAL]). If this criterion is exceeded, it will be assumed that the radiological FAL is exceeded. Additional discussion of the HCA criterion is presented in Section D.2.5.

In accordance with the graded approach described in the Soils Activity QAP (NNSA/NSO, 2012), the dataset quality will be determined by its intended use in decision making. Data used to define the presence of COCs (Decision I) are classified as decisional and will be used to make corrective action decisions. Radiation survey data are classified as decision supporting and are not used, by themselves, to make corrective action decisions.

## 2.2 Deviations from SAFER Plan as Approved

All CAI activities were conducted in accordance with the SAFER Plan (NNSA/NFO, 2015a), with one exception. For sample locations where no TLD data exist (e.g., 2012 sample plots), the SAFER Plan states that external dose will be estimated using the methodology found in the Soils RBCA document (NNSA/NSO, 2014). However, an alternate method for deriving external dose at these locations was applied, as explained in Section D.2.4.2.

## 2.3 Corrective Action Schedule as Completed

Table 2-1 provides a timeline of major activities and associated documents that support closure of CAU 412.

**Table 2-1**
**Timeline of CAU 412 Closure Activities**

| Year | Activity | Associated Document/Reference |
|---|---|---|
| 1996 | Initial Site Characterization | *Clean Slate Corrective Action Investigation Plan* (DOE/NV, 1996) |
| 1997 | Interim Corrective Action | *Clean Slate 1 Corrective Action Plan* (DOE/NV, 1997) |
| 2012 | Preliminary Investigation | *Preliminary Investigation Results and Recommendations for CAUs 411, 412, 413, and 414, Nevada Test and Training Range and Tonopah Test Range, Nevada* (N-I, 2013) |
| 2015 | Corrective Action Investigation | *Streamlined Approach for Environmental Restoration (SAFER) Plan for Corrective Action Unit 412: Clean Slate I Plutonium Dispersion (TTR), Tonopah Test Range, Nevada* (NNSA/NFO, 2015a) |

## 2.4 Site Plan/Survey Plat

During the 1997 interim corrective action, approximately 5,420 cubic yard ($yd^3$) of soil was excavated from a 9-acre area within the contamination area (CA) fence (Sanchez et al., 1998). After the interim corrective action, a radiation survey using the KIWI system was conducted to verify that contamination had been removed to the target action level (which was 200 pCi/g transuranics at the time) (BN, 1998). The area excavated during the interim corrective action and the results of the KIWI survey are shown in Figure 2-1. These survey results were also used in selection of sample locations for the CAI (see Section D.2.3.1). As part of the CAI, a radiation survey using a field instrument for the detection of low-energy radiation (FIDLER) was completed. This survey, shown in Figure D.2-1, represents the current radiological conditions at CAU 412.

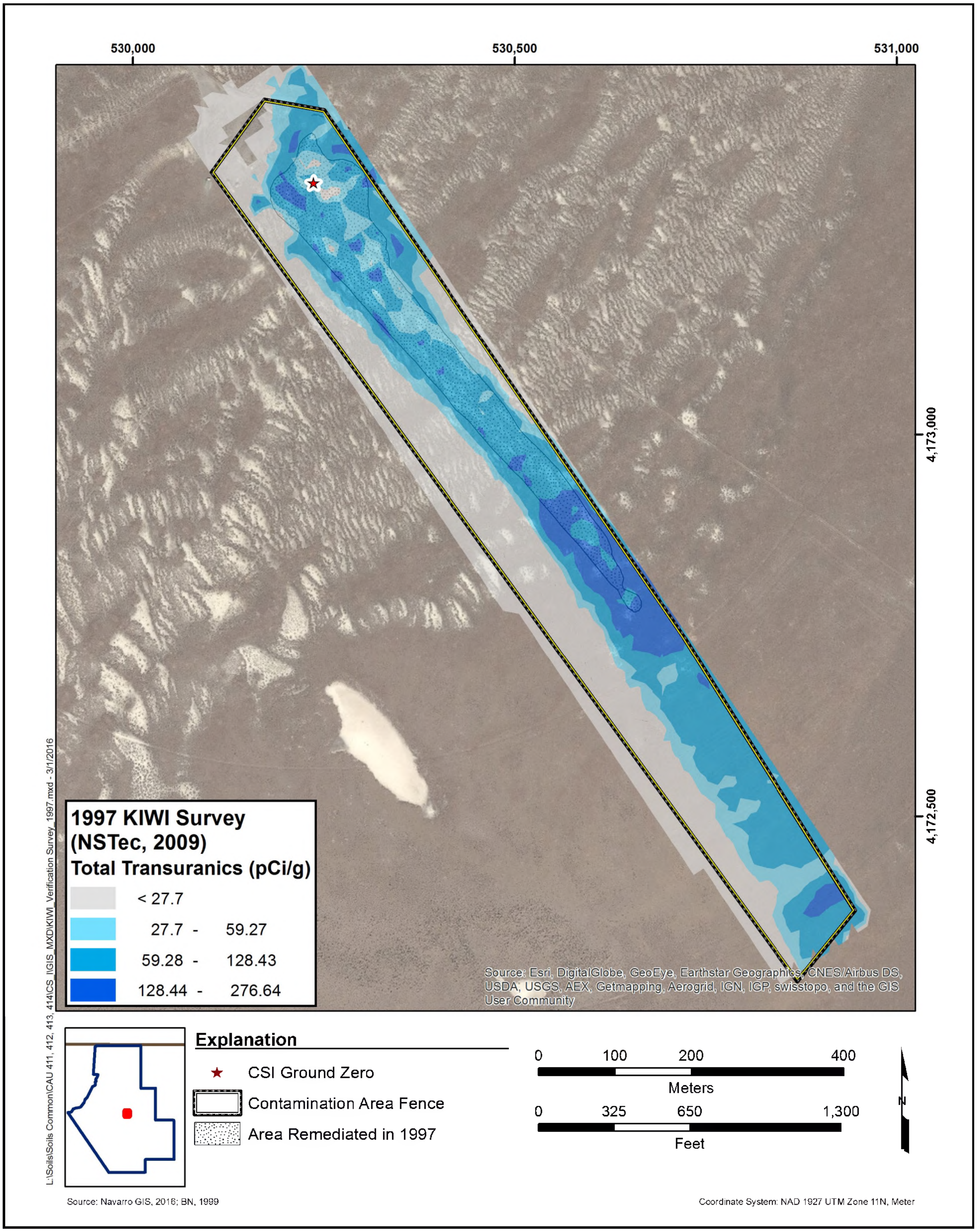


**Figure 2-1**
**Post-Interim Corrective Action Radiation Survey Results**

# 3.0 Waste Disposition

Remediation waste generated during the 1997 interim corrective action at CAU 412 included radiologically contaminated debris (e.g., concrete pieces, rebar, metal fragments); disposable personal protective equipment; and approximately 5,420 $yd^3$ of soil. All remediation waste was transported to the Nevada Test Site (now known as the Nevada National Security Site [NNSS]) for disposal.

This section addresses the characterization and management of investigation-derived wastes generated during the CAI; remediation waste was not generated as a result of the CAI. Waste management activities during the CAI were conducted as specified in the SAFER Plan (NNSA/NFO, 2015a).

## 3.1 Generated Wastes

Investigation-derived waste generated during the CAI at CAU 412 included personal protective equipment, a small volume of metal fragments and soil, and approximately 5 $yd^3$ of black hose. The wastes listed in Table E.1-1 of Appendix E were generated during CAI activities at CAU 412. Wastes were segregated to the greatest extent possible, and waste minimization techniques were integrated into the field activities to reduce the amount of waste generated. Controls were in place to minimize the use of hazardous materials and the unnecessary generation of hazardous and/or mixed waste. The amount, type, and source of waste placed into each container were recorded in waste management logs that are maintained in the CAU 412 file.

## 3.2 Waste Characterization and Disposal

Waste container 412B01 contains combined waste from CAUs 411, 412, 413, and 414; and was characterized using CAI soil sample results and radiological screening results. A direct waste characterization sample of this waste stream was not collected. The waste in this container was characterized as low-level waste (LLW). The waste shipping and disposal documentation for CAU 412 is in Attachment E-1.

# 4.0 Closure Verification Results

The SAFER Plan identified the presumed corrective action for CAU 412 as clean closure. This presumption was based on implementation of the interim corrective action in 1997 and data collected during subsequent investigations. Closure verification data were collected during the CAI to determine whether site closure objectives have been achieved. The CAI results are presented in Appendix D. Each of the closure objectives defined in the SAFER Plan was achieved as indicated below:

- *Radiological contamination at the site is less than the FAL using the GT exposure scenario (i.e., the radiological dose is less than the FAL).* No sample location exceeded the radiological dose FAL. See Section D.2.5.
- *Removable alpha contamination is less than the HCA criterion.* Removable alpha contamination at the site was less than the HCA criterion, so it is assumed that the dose associated with removable contamination is less than the radiological dose FAL. See Section D.2.5.2.
- *No PSM is present at the site, and any impacted soil associated with PSM has been removed so that remaining soil contains contaminants at concentrations less than the FALs.* No PSM was identified at CAU 412. See Section D.2.1.
- *There is sufficient information to characterize investigation and remediation waste for disposal.* Soil sample results and radiological survey data are sufficient to characterize the investigation waste generated during the CAI; no remediation waste was generated during the CAI. See Section 3.0.

CAU 412 sampling locations were accessible and sampling activities at planned locations were not restricted by buildings, storage areas, active operations, or aboveground and underground utilities.

## 4.1 Data Quality Assessment

The CAU 412 SAFER Plan identified the use of each dataset in making corrective action decisions (NNSA/NFO, 2015a). Aerial and ground-based radiological surveys were classified as decision-supporting data, for which limitations and data quality must be assessed. The quality of these datasets is discussed in Section 4.1.10. Analytical data from soil samples and TLD measurements were classified as decisional data, which require the highest level of quality assurance (QA)/quality control (QC). The DQA for the analytical dataset is discussed in Section 4.1.2.

The quality of TLD data is assessed by the management and operating (M&O) dosimetry contractor at the NNSS, who maintains a comprehensive QA program in accordance with 10 CFR 830 (CFR, 2016a). The TLDs placed at CAU 412 to measure external dose are the same as those used in the routine NNSS environmental monitoring program. TLDs were obtained from, and measured by, the M&O contractor. TLD data meet rigorous data quality requirements outlined in a comprehensive QA program. This program addresses management, training, and qualification requirements; quality improvement and work processes; record keeping; performance; and program assessment. The effectiveness of the QA program is demonstrated, in part, through satisfactory completion and maintenance of the U.S. Department of Energy Laboratory Accreditation Program (DOELAP) accreditation. In addition, dosimetry program operations are routinely reviewed and improved through the use of blind audits, DOELAP performance testing, onsite audits, and internal assessments. Dosimetry program documents are reviewed biennially and updated as necessary.

TLDs were analyzed using automated TLD readers that are calibrated and maintained by the contractor. QA requirements for the TLD readers include daily QC tests, reader calibration, reader linearity, reader crossover, and reader heating tests. Process variances and the necessary corrective actions are tracked, and activities are implemented to approve, evaluate, and resolve process variances and control nonconforming items until corrective actions are completed. Processes are reviewed and improved during the execution of the process and as a result of internal and external assessments.

The SAFER Plan (NNSA/NFO, 2015a) identified that the right type, quality, and quantity of data are needed to resolve the DQO decision statements. To verify that the dataset obtained as a result of the CAI supports the DQO decisions, a DQA was conducted. The DQA process is the scientific evaluation of the actual investigation results to determine whether the DQO criteria established in the SAFER Plan were met and whether DQO decisions can be resolved at the desired level of confidence. The DQO process ensures that the right type, quality, and quantity of data will be available to support the resolution of those decisions at an appropriate level of confidence. Using both the DQO and DQA processes helps to ensure that DQO decisions are sound and defensible.

The DQA involves five steps that begin with a review of the DQOs and end with an answer to the DQO decisions. These steps are briefly summarized as follows:

1. *Review DQOs and Sampling Design*. Review the DQO process to provide context for analyzing the data. State the primary statistical hypotheses; confirm the limits on decision errors for committing false-negative (Type I) or false-positive (Type II) decision errors; and review any special features, potential problems, or any deviations to the sampling design.

2. *Conduct a Preliminary Data Review*. A preliminary data review should be performed by reviewing QA reports and inspecting the data both numerically and graphically, validating and verifying the data to ensure that the measurement systems performed in accordance with the criteria specified, and using the validated dataset to determine whether the quality of the data is satisfactory.

3. *Select the Test*. Select the test based on the population of interest, population parameter, and hypotheses. Identify the key underlying assumptions that could cause a change in one of the DQO decisions.

4. *Verify the Assumptions*. Perform tests of assumptions. If data are missing or censored, determine the impact on DQO decision error.

5. *Draw Conclusions from the Data*. Perform the calculations required for the test.

### 4.1.1 Review DQOs and Sampling Design

This section contains a review of the DQO process presented in the SAFER Plan (NNSA/NFO, 2015a). The DQO decisions are presented with the DQO provisions to limit false-negative or false-positive decision errors. Special features, potential problems, and deviations to the sampling design are also presented, as applicable.

The PAL and FAL for radioactivity are based on an annual dose limit of 25 mrem/yr. This dose limit is specific to the annual dose a receptor could potentially receive from a CAU 412 release and is dependent upon the cumulative annual hours of exposure to site contamination. The dose-based PAL for radioactivity was established in the SAFER Plan based on a dose limit of 25 mrem/yr over an annual exposure time of 1,008 hours (i.e., the GT exposure scenario) (USAF, 2014). An additional decision criterion applicable at CAU 412 is related to the amount of removable alpha radiation at the site. For removable contamination, it is assumed that if removable contamination levels are above the numeric criterion for posting an HCA (i.e., 2,000 disintegrations per minute per 100 square centimeters [dpm/100 $cm^2$]), then the radiological FAL of 25 mrem/CW-yr is exceeded and corrective action is required. Additional discussion of how removable contamination levels at the site are addressed for the purposes of site closure may be found in Section D.2.5.2 and the Soils RBCA document (NNSA/NSO, 2014). The dose-based radiological FAL is established in Appendix H.

The chemical PALs presented in the SAFER Plan were based on the U.S. Environmental Protection Agency (EPA) Region 9 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2016). Because no chemical releases were identified at CAU 412, no chemical analyses were completed for samples collected during the CAI, with the exception of waste characterization samples. Thus, the establishment of chemical FALs for making DQO decisions was not necessary and is not included in this CR.

### *4.1.2 Decision I*

The Decision I statement presented in the SAFER Plan is as follows: "Does any location exceed the FALs?" Any contaminant that is present (or is assumed to be present) at concentrations exceeding its corresponding FAL will be defined as a COC. A COC may also be defined as a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk based on a multiple contaminant analysis (NNSA/NFO, 2014).

As the RBCA dose evaluation does not address the potential for removable contamination to be transported to other areas, a corrective action is assumed to be required for areas that exceed the HCA criterion (i.e., 2,000 dpm/100 $cm^2$), even though the area may not present a potential radiation dose to a receptor that exceeds the FAL.

As stated in the SAFER Plan, the dataset used to resolve DQO decisions for CAU 412 includes the data collected during the CAI and the soil sample data collected during the preliminary investigation (PI) conducted in 2012 (NNSA/NFO, 2015a). The resolution of Decision I determined that contamination at the site is not present at levels that require additional corrective action.

#### *4.1.2.1 DQO Provisions To Limit False-Negative Decision Error*

A false-negative decision error (when it is concluded that contamination exceeding FALs is not present when it actually is) was controlled by meeting the following criteria:

1a) For Decision I, having a high degree of confidence that sample locations selected will identify COCs if present anywhere within the CAU (judgmental sampling).

1b) Maintaining a false-negative decision error rate of 0.05 (probabilistic sampling).

2) Having a high degree of confidence that analyses conducted will be sufficient to detect any COCs present in the samples.

3) Having a high degree of confidence that the dataset is of sufficient quality and completeness.

Criteria 1b, 2, and 3, were assessed based on the entire dataset. Therefore, these assessments apply to both Decision I and Decision II.

##### *Criterion 1a (Confidence Judgmental Sample Locations Identify COCs)*

To resolve Decision I (determine whether the FAL is exceeded at any location), samples were collected in areas most likely to contain a COC. Soil sample plot locations were selected based on the areas of highest radioactivity identified in aerial and KIWI radiation surveys (see Section D.2.3.1). During the CAI field investigation, sample plot locations were further biased to areas of highest radioactivity using FIDLER survey data.

##### *Criterion 1b (Confidence in Probabilistic False-Negative Decision Error Rate)*

Control of the false-negative decision error for the probabilistic samples was accomplished by ensuring the following:

- The samples are collected from unbiased locations within the sample plots.
- A sufficient sample size was collected (see Table 4-1).
- A false rejection rate of 0.05 was used in calculating the 95 percent UCLs and minimum sample size.

Selection of the sample aliquot locations within a sample plot was accomplished using a random start, systematic triangular grid pattern. This permitted that all given locations within the boundaries of the sample plot would have an equal probability of being chosen. Although the TLD locations were not established at random locations (i.e., they were placed at the center of the sample plot), they provided three independent measurements of dose (per TLD) that integrate unbiased measurements from each sample location.

The minimum number of samples required for each probabilistic sample location was calculated for both the internal (soil samples) and external (TLD elements) dose samples. The minimum sample size (*n*) was calculated using the following EPA sample size formula (EPA, 2006):

$$n = \frac{s^2(z_{.95} + z_{.80})^2}{(\mu - C)^2} + \frac{z^2_{.95}}{2}$$

where

$s$ = standard deviation
$z_{.95}$ = z score associated with the false-negative rate of 5 percent
$z_{.80}$ = z score associated with the false-positive rate of 20 percent
$\mu$ = dose level where false-positive decision is not acceptable (12.5 mrem/yr)
$C$ = FAL (25 mrem/yr)

The use of this formula requires the input of basic statistical values associated with the sample data. Data from a minimum of three samples are required to calculate these statistical values and, as such, the least possible number of samples required to apply the formula is three. Therefore, in instances where the formula resulted in a value less than three, three is adopted as the minimum number of samples required. The results of the minimum sample size calculations and the number of samples collected are presented in Table 4-1. As shown in the table, the minimum number of sample plot and TLD samples was met or exceeded. The minimum sample size calculations were conducted for probabilistic sample locations as stipulated in the SAFER Plan (NNSA/NFO, 2015a) based on the following parameters:

- A false rejection rate of 0.05
- A false acceptance rate of 0.20
- The maximum acceptable gray region set to one-half the FAL (12.5 mrem/yr)
- The calculated standard deviation

**Table 4-1**
**Input Values and Determined Minimum Number of Samples for Sample Plots and TLDs**

| Sample Type | Sample Location | Standard Deviation | Minimum Sample Size | Number of Samples Collected |
|---|---|---|---|---|
| Plot | B01 | 0.2 | 3 | 4 |
| | B05 | 0.4 | 3 | 5 |
| | B09 | 0.3 | 3 | 4 |
| | B10 | 0.4 | 3 | 4 |
| | B11 | 0.1 | 3 | 4 |
| | B12 | 0.3 | 3 | 4 |
| | B13 | 0.1 | 3 | 4 |
| TLD | B09 | 0.2 | 3 | 3 |
| | B10 | 1.4 | 3 | 3 |
| | B11 | 0.9 | 3 | 3 |
| | B12 | 0.6 | 3 | 3 |
| | B13 | 0.9 | 3 | 3 |

Note: The actual required minimum number of samples calculated by the one-sample t-test (EPA, 2006; PNNL, 2007) was less than 3. The minimum number of samples required to calculate statistics is 3.

### *Criterion 2 (Confidence in Detecting COCs Present in Samples)*

To satisfy the second criterion, the dataset was assessed against the acceptance criterion for the data quality indicator (DQI) of sensitivity as defined in the Soils Activity QAP (NNSA/NSO, 2012). The sensitivity acceptance criterion is that analytical detection limits will be less than the corresponding FAL (NNSA/NFO, 2015a). For radionuclides, the criterion is that all detection limits are less than their corresponding GT internal dose RRMG. All of the analytical result detection limits for radionuclides were less than their corresponding RRMGs. Therefore, the DQI for sensitivity has been met for all contaminants, and no data were rejected due to sensitivity.

### *Criterion 3 (Confidence that Dataset is of Sufficient Quality and Complete)*

To satisfy the third criterion, the dataset was assessed against the acceptance criteria for the DQIs of precision, accuracy, comparability, completeness, and representativeness, as defined in the Soils Activity QAP (NNSA/NSO, 2012). The DQI acceptance criteria are presented in Table 6-1 of the SAFER Plan (NNSA/NFO, 2015a). The individual DQI results are presented in the following subsections.

*Precision*

Precision was evaluated as described in the SAFER Plan (NNSA/NFO, 2015a) and the Soils Activity QAP (NNSA/NSO, 2012). Precision was found to be equitable (less than 20 relative percent difference) for all samples within the dataset. Therefore, the dataset is determined to be acceptable for the DQI of precision.

*Accuracy*

Accuracy was evaluated as described in the SAFER Plan (NNSA/NFO, 2015a) and the Soils Activity QAP (NNSA/NSO, 2012). The DQI criteria for accuracy was met for all samples within the dataset, with the exception of plutonium (Pu)-241. As shown in Table 4-2, isotopic Pu-241 was qualified for accuracy in four samples; however, the dataset is within acceptable limits (i.e., greater than 80 percent within criteria). Therefore, the dataset for CAU 412 is acceptable for the DQI of accuracy.

**Table 4-2**
**Accuracy Measurements**

| Constituent | Analyses | Number of Measurements Qualified | Number of Measurements Performed | Percent within Criteria |
|---|---|---|---|---|
| Pu-241 | Plutonium | 4 | 41 | 90.2 |

*Representativeness*

The DQO process as identified in Appendix B of the SAFER Plan (NNSA/NFO, 2015a) was used to address sampling and analytical requirements for CAU 412. During this process, appropriate locations were selected that enabled the samples collected to be representative of the population parameters identified in the DQO (the most likely locations to contain contamination [judgmental sampling] or that represent contamination of the sample plot [probabilistic sampling]). The sampling locations identified in the Criterion 1a discussion meet this criterion.

Special consideration is needed for americium (Am) and Pu isotope concentrations related to representativeness. This is due to the nature of these contaminants in soil. These isotopes may be present in soil in the form of small particles that may or may not be captured in a small soil sample of 1 to 2 grams. As individual particles of these radionuclides can make a significant impact on analytical results, small soil samples taken from the same site can produce analytical results that are very different (i.e., poor accuracy). However, the Am and Pu isotopes are co-located (e.g., Am-241 is a daughter product of Pu-241), and the relative concentrations between different samples from the same site (i.e., the ratio of Am to Pu isotope concentrations) should be equal. Based on process knowledge and demonstrated by analytical results from previously sampled Soils Activity sites, the ratios between Am and Pu isotopes in soil contamination from any given source is expected to be the same throughout the contaminant plume at any given time. Therefore, if the ratios are known and one of these isotopic concentrations is known, the concentrations of the other isotopes can be estimated.

Am-241 is reported by the gamma spectrometry method as well as the isotopic Am method. As the gamma spectrometry measurement is based on a much larger soil sample (usually 1 liter), the particle distribution problem discussed above is greatly diminished and the probability of the result being representative of the sampled site is much improved. Therefore, the ratios between the Am and Pu isotopes will be established using the isotopic analytical results and these ratios will be used to infer concentrations of Pu isotopes using the gamma spectrometry results for Am-241. These inferred Pu values will be more representative of the sampled area than the isotopic results.

Based on the methodical selection of sample locations and the use of Am and Pu concentrations that are more representative of the sampled area, the analytical data acquired during the CAU 412 CAI are considered to adequately represent contaminant concentrations of the sampled population.

*Comparability*

Field sampling, as described in the SAFER Plan (NNSA/NFO, 2015a), was performed and documented in accordance with approved procedures that are comparable to standard industry practices. Approved analytical methods and procedures per DOE were used to analyze, report, and validate the data. These are comparable to other methods used not only in industry and government practices, but most importantly are comparable to other investigations conducted by the Soils Activity. Therefore, CAU 412 datasets are considered comparable to other datasets generated using these same standardized DOE procedures, thereby meeting DQO requirements. Also, standard, approved field and analytical methods ensured that data were appropriate for comparison to the investigation action levels specified in the SAFER Plan.

*Completeness*

The SAFER Plan (NNSA/NFO, 2015a) defines acceptable criteria for completeness to be that the dataset is sufficiently complete to be able to make the DQO decisions. This is initially evaluated as 80 percent of release-specific analytes identified in the SAFER Plan having valid results. All of the CAU 412 data have valid results; therefore, the dataset has met the criteria for completeness and may be used to make DQO decisions.

#### 4.1.2.2 DQO Provisions To Limit False-Positive Decision Error

The false-positive decision error was controlled by assessing the potential for false-positive analytical results. Laboratory QA/QC samples such as method blanks were used to determine whether a false-positive analytical result may have occurred. This provision is evaluated during the data validation process and appropriate qualifications are applied to the data when applicable. There were no data qualifications that would indicate a potential false-positive analytical result.

### 4.1.3 Decision II

Decision II as presented in the SAFER Plan (NNSA/NFO, 2015a) is as follows: "Is there sufficient information to achieve closure objectives?" Sufficient information is defined to include the following:

- The lateral and vertical extent of COC contamination
- The information needed to predict potential remediation waste types and volumes

As stated in the SAFER Plan (NNSA/NFO, 2015a), the closure objectives for CAU 412 are as follows:

- Radiological contamination at the site is less than the FAL using the GT exposure scenario (i.e., the radiological dose if less than the FAL).

- Removable alpha contamination is less than the HCA criterion.

- No PSM is present at the site, and any impacted soil associated with PSM has been removed so that remaining soil contains contaminants at concentrations less than the FALs.

- There is sufficient information to characterize investigation and remediation waste for disposal.

The resolution of Decision I determined that contamination at the site is not present at levels that require additional corrective action. Information presented in Section 3.0 demonstrate that sufficient information was available for the disposal of all wastes. Therefore, Decision II has been resolved by the achievement of all closure criteria.

### 4.1.4 Sampling Design

The SAFER Plan (NNSA/NFO, 2015a) stipulated that the following sampling processes would be implemented:

- Sampling of sample plots will be conducted by a combination of judgmental and probabilistic sampling approaches.

  **Result.** The location of the plots were selected judgmentally, and sample aliquots were collected within each plot probabilistically as described in Section D.2.3.

- Probabilistic samples will be collected of the surface and subsurface (interior) of each soil mound.

  **Result.** One surface and one subsurface sample were collected at each soil mound.

- Removable contamination samples will be collected at the locations of sample plots within the CA fence.

  **Result.** Removable contamination samples were collected at the four sample plots locations within the CA fence.

### *4.1.5 Conduct a Preliminary Data Review*

A preliminary data review was conducted by reviewing QA reports and inspecting the data. The contract analytical laboratories generate a QA nonconformance report when data quality does not meet contractual requirements. All data received from the analytical laboratories met contractual requirements, and a QA nonconformance report was not generated. Data were validated and verified to ensure that the measurement systems performed in accordance with the criteria specified in the Soils Activity QAP (NNSA/NSO, 2012). The validated dataset quality was found to be satisfactory.

### *4.1.6 Select the Test and Identify Key Assumptions*

The test for making DQO decisions for radiological contamination was the comparison of the TED to the FAL of 25 mrem/GT-yr. The dose-based radiological FAL is based on an exposure duration to a site worker using the GT exposure scenario. The test for removable contamination was the comparison of site conditions to the HCA criterion of 2,000 dpm/100 $cm^2$ alpha contamination.

Based on the results of TLD and soil samples, radiological dose at CAU 412 does not exceed 25 mrem/GT-yr at any location. The average and the 95 percent UCL TED values for the GT and the industrial area (IA) exposure scenarios for all sample locations are presented in Table D.2-9. An explanation regarding the use of the IA scenario is found in Section D.2.5.3.

The key assumptions that could impact a DQO decision are listed in Table 4-3.

**Table 4-3**
**Key Assumptions**

| | |
|---|---|
| **Exposure Scenario** | Ground Troops |
| **Affected Media** | Surface and subsurface soil |
| **Location of Contamination/Release Points** | Surface soil surrounding and downwind of GZ; surface/subsurface sediment in soil mounds |
| **Transport Mechanisms** | Potential transport mechanisms include surface water runoff, infiltration of precipitation, and wind |
| **Preferential Pathways** | Surface water runoff and wind are preferential pathways for lateral migration of contaminants. Due to high potential evapotranspiration in the area and the depth to groundwater, infiltration of precipitation is not expected to be a significant migration pathway. |
| **Lateral and Vertical Extent of Contamination** | Contamination, if present, is expected to be contiguous to the release points. Concentrations are expected to decrease with distance and depth from the source. Groundwater contamination is not expected. Lateral and vertical extent of COC contamination is assumed to be within the spatial boundaries. |
| **Groundwater Impacts** | None |
| **Future Land Use** | Military |

GZ = Ground zero

### *4.1.7 Verify the Assumptions*

The results of the investigation support the key assumptions identified in the CAU 412 DQOs and Table 4-3. All data collected during the CAI supported the CSM, and no revisions to the CSM were necessary.

### *4.1.8 Other DQO Commitments*

The SAFER Plan (NNSA/NFO, 2015a) made the following commitments:

- One TLD will be placed in the center of each sample plot and each soil mound.

  **Result:** One TLD was placed at each of the five sample plots established during the CAI, and one TLD was placed at the center of each of the three soil mounds.

- Revisit locations of surface features identified in previous investigations to determine whether a potential release is present based on biasing factors such as stains, spills, or debris.

  **Result.** No indication of release(s) was identified at any of the previously identified locations. In addition, no other PSM and/or potential releases were identified during the CAI.

### 4.1.9 Draw Conclusions from the Data

***Decision I***

Based on analytical results for samples collected during the 2012 PI and the CAI, radiological dose is not above the FAL of 25 mrem/GT-yr (see Section D.2.4.3).

Removable contamination samples indicate that the removable alpha contamination at CAU 412 is not above the HCA criterion of 2,000 dpm/100 $cm^2$. It is therefore assumed that the dose associated with removable contamination is not above the dose-based FAL of 25 mrem/GT-yr.

***Decision II***

In accordance with the SAFER Plan and based on achievement of the site closure objectives, the corrective action of clean closure was completed at CAU 412.

### 4.1.10 Data Quality for Decision-Supporting Data

The SAFER Plan identified aerial and ground-based radiological survey data as decision-supporting data (NNSA/NFO, 2015a). The following subsections discuss the quality of these datasets, including aerial, KIWI, and FIDLER, radiological surveys; and removable contamination surveys.

#### 4.1.10.1 Aerial Radiological Surveys

Aerial radiological surveys were conducted at CAU 412 in 1993 (EG&G, 1995) and 2006 (NSTec, 2007). An evaluation of aerial survey data was completed in 1995 (DOE/NV, 1995). The evaluation suggests that aerial surveys underestimate the intensity of highly localized radiation sources due to the wide field of view of the aerial system. The report also states that the method for processing survey data can impact sensitivity and/or spatial resolution. The report concludes that aerial survey data are useful for determining the general distribution of radionuclides at a site, but are not recommended for more precise mapping of individual radionuclide distributions.

A comparison of the quality of the 1993 and 2006 surveys concluded that the surveys are consistent with regard to contaminant distribution; however, the 2006 survey provides better spatial resolution (NSTec, 2007). Thus, the 2006 survey was used to guide the selection of sample locations for the 2012 PI and the CAI.

The radiological surveys provide quality spatial data, with the limitation that the field of view from the aerial platform is not as precise as a ground-based survey. When these aerial surveys are used in conjunction with ground-based surveys that provide very high spatial resolution (less than 1 square meter [$m^2$]) and the data are used qualitatively, the quality of the 2006 aerial survey data is sufficient for guiding the biasing of sample locations and meets the requirements as decision-supporting data.

#### *4.1.10.2 KIWI Radiological Surveys*

In 1999, a report containing a rigorous review of the KIWI system and data processing methodology was published (BN, 1999). This report found no obvious errors in the techniques or procedures, and concluded that the measurement of surface activity by the KIWI is reproducible. The limitation of the KIWI data is that the results are in gross gamma counts, which are not directly comparable to a soil concentration. When these data are used qualitatively, the quality of KIWI survey data is sufficient for guiding the biasing of sample locations and meets the requirements as decision-supporting data.

#### *4.1.10.3 FIDLER Radiological Surveys*

The FIDLER data meet the data quality requirements listed in Section 2.6.1 of the Soils QAP (NNSA/NSO, 2012) through the verification of acceptable instrument performance. This was accomplished through the use of control charts and daily operational tests (performing daily background and response checks). This assures that the instrument responds appropriately to higher levels of radiation with correspondingly higher readings. The FIDLER readings are used qualitatively to represent generally observed radiation levels relative to the nearby background radiation level. These are expressed in terms of multiples of the background radiation level (multiples of background [MOB]). The qualitative MOB values are used to distinguish a spatial pattern of where radioactivity is relatively higher and lower. These values become semi-quantitative if a relationship is established between MOB values and quantitative dose levels that meets the quality criterion defined in the Soils RBCA document (NNSA/NFO, 2014).

FIDLER data are also used qualitatively to guide the biasing of sampling locations. As used for these purposes, the quality of FIDLER survey data is sufficient to meet the requirements of decision-supporting data.

#### *4.1.10.4 Removable Contamination Surveys*

The removable contamination surveys conducted during the 2012 PI and CAI at CAU 412 used the "stomp and tromp" methodology. The survey method uses a tool to obtain a swipe sample of removable radioactive contamination from the ground surface. The sample is then analyzed by calibrated radiation instruments that undergo daily quality checks.

An assessment of this methodology was completed in 2000 (Tinney et al., 2000). The assessment concluded that the survey technique lacked verification and quality control, and was likely overly conservative in determining removable soil contamination. A qualitative assessment of the technique showed that the results of the surveys, averaged over large areas, appeared to be reproducible within ±30 percent. A correlation of the survey data to KIWI survey data resulted in a correlation coefficient of 0.75.

The results of the survey methodology are used as an indicator of the need to assume the radiological dose to an offsite receptor would exceed 25 mrem/yr. This assumption is necessary in the absence of a methodology to estimate the dose an offsite receptor could receive from the uncontrolled removal of removable contamination. The use of the removable contamination survey data is limited to only a qualitative indicator to implement the conservative assumption of the need for corrective action based on an unknown dose to an unknown receptor. When used in this manner, the quality of removable contamination survey data is sufficient to meet the requirements as decision-supporting data.

## *4.2 Use Restrictions*

For site closure under the FFACO, URs are required when contamination is left on site above action levels or as site-specific conditions warrant. Because no locations at CAU 412 exceed the FAL using the GT exposure scenario and site closure objectives have been achieved, no further corrective action is required, and FFACO URs are not necessary. As further explained in Section 5.0, if the exposure scenario or land use should change in the future, DOE will need to reevaluate site closure and the need for URs.

# 5.0 Conclusions and Recommendations

The CAI for CAU 412 verified that radiological contamination is not present at the site in excess of the FAL, and further corrective action is not required. Based on the interim corrective action implemented in 1997 and the CAI, clean closure of the site is complete and the closure objectives established in the SAFER Plan (NNSA/NFO, 2015a) have been achieved.

NNSA/NFO requests that NDEP issue a Notice of Completion for this CAU and approve transferring CAU 412 from Appendix III to Appendix IV of the FFACO. The DOE, under its regulatory authority for management of radioactive waste materials associated with environmental remediation activities, approves these actions (USC, 2012).

The closure of CAU 412 under the FFACO means that the selected corrective action has been accepted and approved by NDEP and other stakeholders. The closure of CAU 412 is based on an evaluation of both the GT and the IA exposure scenarios. The conservative estimates of dose at the locations of highest radioactivity were all below the FAL for both of these scenarios. If land use were to change that could result in potential exposures exceeding that of the IA exposure scenario (e.g., release of the property to the public), the closure of CAU 412 would need to be reevaluated. In the future, should the land custodian determine that a proposed mission use would not comport with the proposed closure of CAU 412, then NNSA/NFO will work with the custodian and NDEP to address and resolve cleanup issues associated with the proposed use or transfer/relinquishment. NNSA/NFO remains responsible for working with NDEP and other stakeholders as needed to revise or renegotiate any closure agreements, and remains liable for all costs associated with any future negotiation and/or remediation action for CAU 412, consistent with its responsibilities under applicable law.

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# Appendix A

# DQOs as Developed in the SAFER Plan

The DQOs are presented in Appendix B of the SAFER Plan (NNSA/NFO, 2015a).

# Appendix B

# Closure Certification

## B.1.0 Closure Certification

Certification of closure is required for permitted or interim status hazardous waste facilities, and is not applicable to CAU 412.

# Appendix C

# As-Built Documentation

# *C.1.0 As-Built Documentation*

This appendix is not applicable to CAU 412 because the site was clean closed. In addition, the 1997 interim corrective action conducted at the site did not involve the construction of an engineered barrier or other structure for which as-built documentation is applicable.

# Appendix D

# Confirmation Sampling Test Results

# D.1.0 Introduction

This appendix presents the CAI activities and the calculated dose for CAU 412, Clean Slate I Plutonium Dispersion (TTR). The methods used to calculate dose are detailed in the SAFER Plan (NNSA/NFO, 2015a) and the Soils RBCA document (NNSA/NFO, 2014). CAU 412 comprises one CAS: TA-23-01CS, Pu Contaminated Soil, and is located in Cactus Flat on the TTR (Figure 1-1). CAU 412 consists of a release of radionuclides to the surrounding soil from a storage–transportation test conducted on May 25, 1963 (NNSA/NFO, 2015b). An interim corrective action was conducted at CAU 412 in 1997 in which the most highly contaminated soil and debris was removed from the site. Additional information regarding the history of the site, previous site investigation efforts, the interim corrective action, and the scope of the CAI is presented in the CAU 412 SAFER Plan (NNSA/NFO, 2015a).

The objective of the CAI was to provide sufficient information to determine whether the following site closure objectives have been achieved:

- Radiological contamination at the site is less than the FAL using the GT exposure scenario (i.e., the radiological dose is less than the FAL).
- Removable alpha contamination is less than the HCA criterion.
- No PSM is present at the site, and any impacted soil associated with PSM has been removed so that remaining soil contains contaminants at concentrations less than the FALs.
- There is sufficient information to characterize investigation and remediation waste for disposal.

As indicated in the SAFER Plan, the corrective action of clean closure will be confirmed as appropriate for closure of CAU 412 if the above closure objectives have been achieved.

# D.2.0 Corrective Action Investigation

Field investigation and sampling activities for the CAU 412 CAI were conducted in April and May 2015. Investigation activities at CAU 412 included the following:

- Visual surveys, including debris removal
- Ground-based radiological surveys
- Collection of surface and subsurface soil samples
- Placement of TLDs

The investigation and sampling program adhered to the requirements set forth in the SAFER Plan (NNSA/NFO, 2015a) (except any deviations described herein) and in accordance with the Soils Activity QAP (NNSA/NSO, 2012), which establishes requirements, technical planning, and general quality practices. The evaluation of investigation results and the risk associated with site contamination was conducted in accordance with the SAFER Plan (NNSA/NFO, 2015a) and the Soils RBCA document (NNSA/NFO, 2014).

In accordance with the graded approach described in the Soils Activity QAP (NNSA/NSO, 2012), the quality required of a dataset will be determined by its intended use in decision making. The intended use of data collected in previous investigations at CAU 412 is presented in the SAFER Plan (NNSA/NFO, 2015a). CAI data used to calculate dose (i.e., soil sample and TLD data) are classified as decisional and will be used to make corrective action decisions. Radiation survey data are classified as decision supporting and are not used, by themselves, to make corrective action decisions.

## D.2.1 Visual Surveys

As stated in the SAFER Plan (NNSA/NFO, 2015a), the locations of previously-identified surface debris and surface features were to be reevaluated during the CAI to determine whether any biasing factors suggesting a release were evident. The surface debris identified during the 2012 PI included an active weather station, discarded black hose, and four inert unexploded ordnance (UXO) items. The weather station and UXO items were left in place as there were no visible indications of a release. The black hose, located inside the CA fence, was removed for disposal. There were no visible or radiological biasing factors present or any other indications of a release associated with the hose. The surface features identified during the 2012 PI included a concrete loading dock and three soil mounds. There were no biasing factors present at any of these features; however, soil samples were collected of the soil mounds in accordance with the SAFER Plan (see Section D.2.3.3). No additional potential release locations or surface debris/features were identified during the CAI. Table D.2-1 presents the locations surveyed and associated actions taken during the CAI.

**Table D.2-1**
**Visual Survey Results**

| Location Description | Action | Comments |
|---|---|---|
| Active weather station | None | No visible indication of release. |
| Concrete loading dock | None | No visible indication of release. |
| Black hose | Removed | No visible indication of release; FIDLER survey of material did not identify elevated radiation. See Section 3.0. |
| Inert UXO items | None | No visible indication of release. |
| Soil mounds | Investigated | Soil mounds were sampled. See Section D.2.3.3. |

### *D.2.2 Radiological Surveys*

An extensive FIDLER survey was completed at the site in 2012 during the PI at CAU 412 (N-I, 2013). During the CAI, FIDLER surveys were completed in the vicinity of all proposed soil sample plot locations to further bias the samples to the areas of highest FIDLER measurements. In 2016, additional FIDLER surveys were conducted at CAU 412 inside the CA fence. The objective of these surveys was to present the radiological conditions at the site at the time of closure. The entire area inside the CA fence was surveyed after several metal fragments identified near GZ during the CAI were removed for disposal (see Section 3.0). Figure D.2-1 presents a composite of FIDLER data collected in 2012 and 2016. The FIDLER data shown inside the CA fence are exclusively from the 2016 survey, which represents field conditions after the removal of some metal fragments during the CAI.

The FIDLER survey data presented in the SAFER Plan (NNSA/NFO, 2015a) were shown as discrete data points collected along the path that was walked/driven by the field technician. While these data are useful in identifying points of elevated radioactivity, they do not readily depict the contaminant

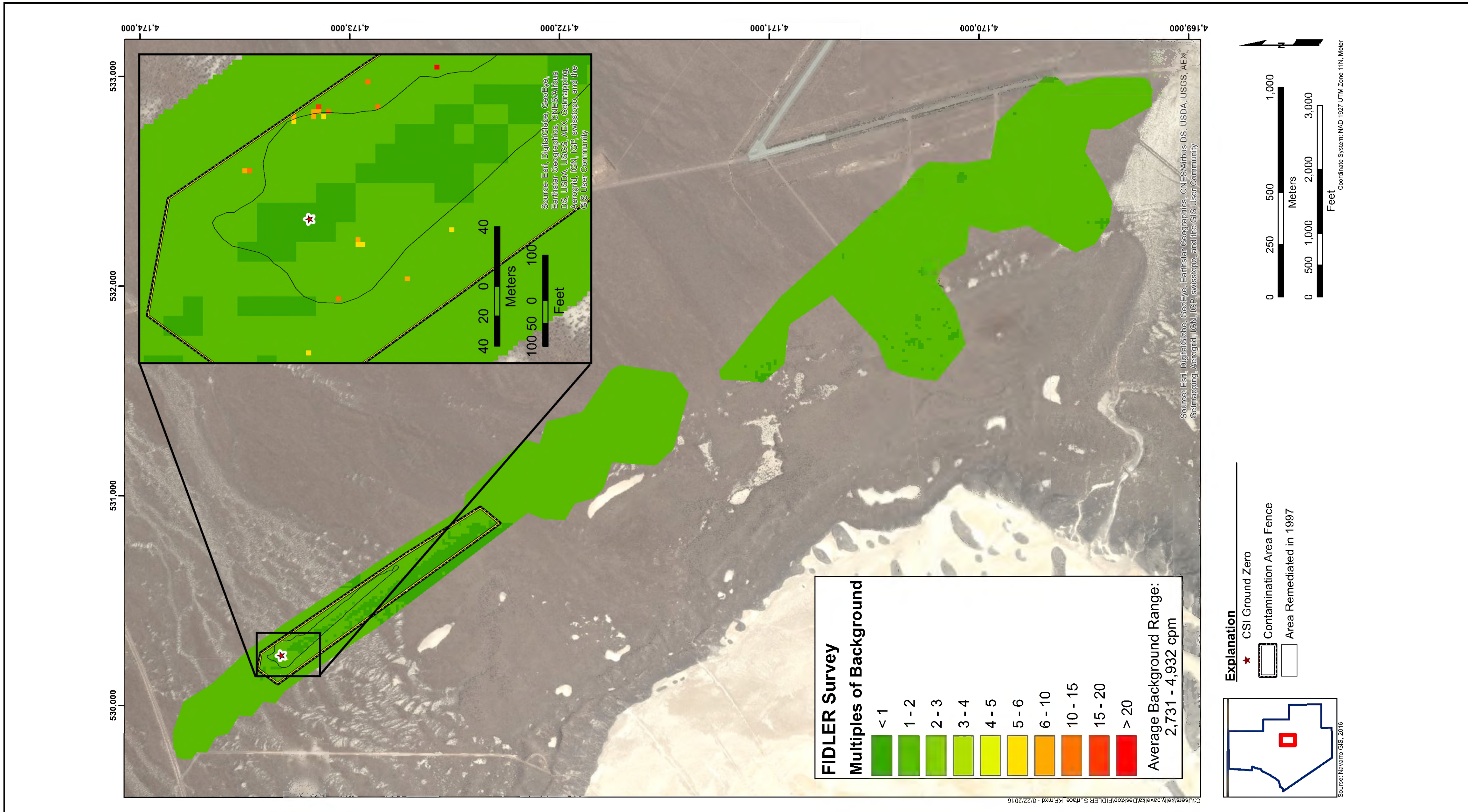


Figure D.2-1
FIDLER Survey Results (Composite of 2012 and 2016 Data)

distribution over the entire area surveyed. Using an inverse distance weighted interpolation technique, the discrete data points were processed to generate a continuous spatial distribution (i.e., interpolated surface), which is more easily compared to other datasets (e.g., soil sample data, aerial survey data). This interpolated surface maintains much of the variance inherent in the original point data, limiting the impact of averaging data over an area. The data variance is particularly important at sites where the contaminant distribution is heterogeneous, as at CAU 412. Another data processing technique was used to retain the intensity of radiation measured at point sources (e.g., metal fragments or isolated areas of soil with elevated radioactivity). This technique involved removing the point source data from the dataset before creating the interpolated surface and then overlaying the point source data on top of the surface. The combination of these two processes results in the display of both the general distribution of contamination and distinct areas of elevated radioactivity. Figure D.2-1 presents the interpolated surface for CAU 412.

### *D.2.3 Sampling Activities*

Sampling activities at CAU 412 during the CAI consisted of the collection of composite surface soil samples from soil sample plots, placement of TLDs, and the collection of composite surface and subsurface (mound interior) soil samples from soil mounds. All soil samples collected at CAU 412 were submitted for gamma spectroscopy; Pu-241; and isotopic uranium (U), Pu, and Am analyses. All sample locations and points of interest were surveyed with a Global Positioning System (GPS) instrument. Appendix J presents these GPS data in a tabular format. Tables D.2-2 and D.2-4 present the 2012 PI and 2015 CAI sample locations and the biasing factors used to select the locations. Additional information on the selection of sample locations and biasing factors is found in the SAFER Plan (NNSA/NFO, 2015a) and the PI report (N-I, 2013).

Soil sample plot locations for CAU 412 were selected judgmentally, using radiological survey results to bias locations to the highest readings. Soil samples collected at sample plots were collected following a probabilistic approach. Four composite samples were collected within each sample plot, and a TLD was placed at the center of each sample plot established during the CAI. The subsample aliquot locations for each sample were identified using a predetermined random-start, triangular grid pattern.

Probabilistic (i.e., random) sample locations at the soil mounds were selected based on the visual extent of each soil mound. Two six-point composite samples (one surface and one subsurface) were collected at each of the three soil mounds.

CAU 412 sampling locations were accessible and sampling activities at planned locations were not restricted. The complete field documentation and laboratory data—including field activity daily logs, sample collection logs (SCLs), analysis request/chain-of-custody forms, laboratory certificates of analyses, and analytical results—are retained in CAU 412 files as hard copy documents or electronic media.

### *D.2.3.1 Sample Plots*

A total of 28 soil samples from seven soil sample plots were collected at CAU 412. Two of the sample plots (B01 and B05) were sampled during the 2012 PI; and five plots (B09, B10, B11, B12, and B13) were sampled during the CAI. The seven soil sample plot locations are shown in Figure D.2-2 (see Figure 2-1 of the SAFER Plan [NNSA/NFO, 2015a]). Table D.2-2 lists the soil samples collected from sample plots at CAU 412 and the biasing factors used to select the sample locations.

The soil sample plot locations sampled during the 2012 PI were selected primarily based on a visual assessment of contamination distribution as shown in the 1997 post-remediation KIWI survey and the 2006 aerial radiation survey (N-I, 2013). Because the KIWI survey was limited to the inside of the CA fence, the KIWI data were used to guide selection of sample plots located inside the fence. The areas with the most elevated radioactivity (as defined by the survey) were identified and a 10-by-10-meter (m) (100-$m^2$) plot was oriented in such a way that the entire plot would be wholly contained within the area. The 2006 aerial survey data were used in a similar manner to select plot locations outside the fence. Calculated activities for individual radionuclides obtained by *in situ* gamma spectroscopy were also considered in sample plot selection (NSTec, 2011). The applicability of the *in situ* data, however, was limited to selection of plots outside the fence as no *in situ* measurements were collected inside the fence.

Sample plot locations for the CAI were also selected based on the 1997 KIWI and 2006 aerial surveys. For the CAI, however, these radiological survey data (aerial and KIWI) were modeled to produce average values over each 1,000-$m^2$ area of the site; the resulting model was then used to bias

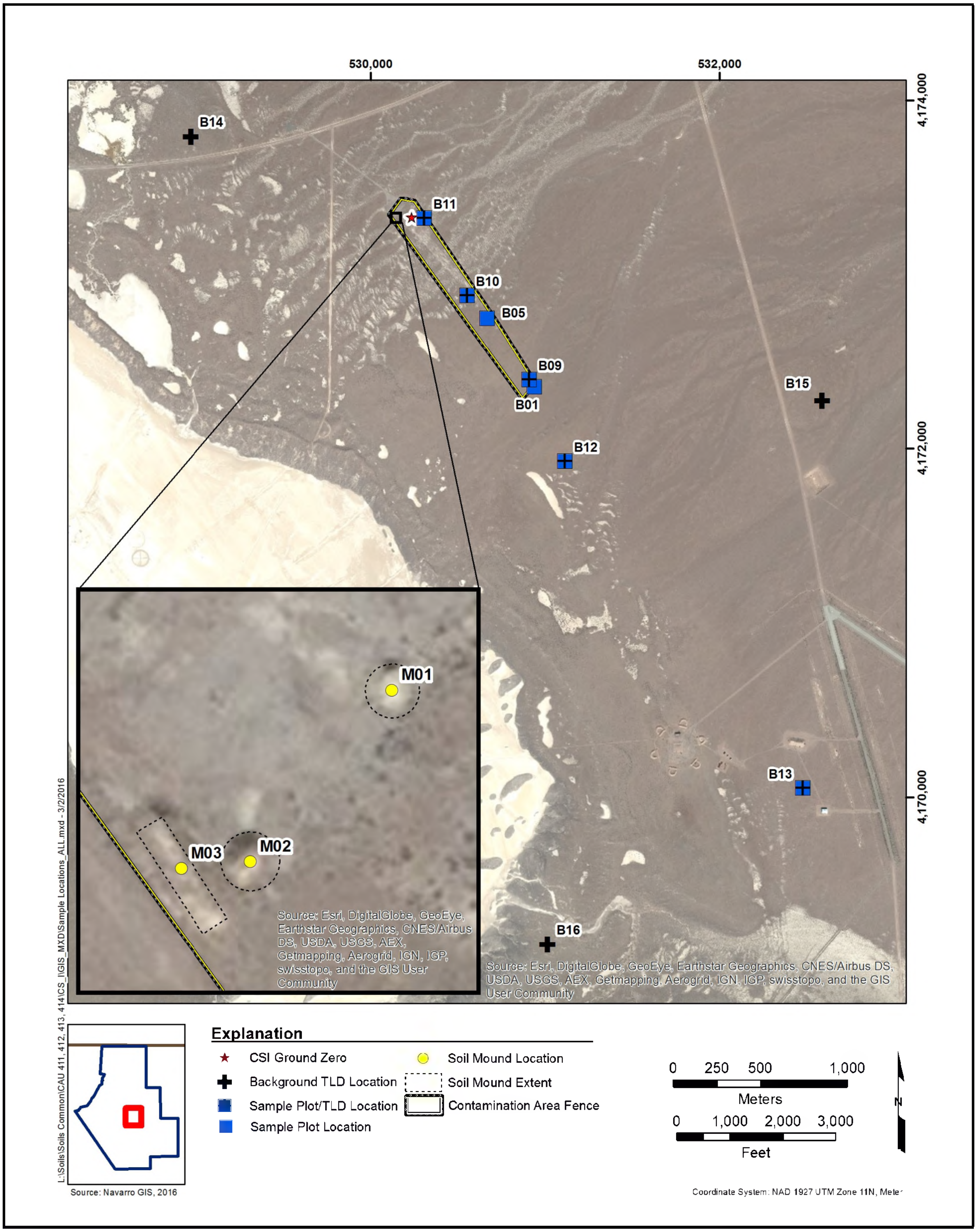


**Figure D.2-2**
**Sample and TLD Locations**

## Table D.2-2
## CAU 412 Sample Plot Soil Samples

| Location | Sample Number | Sample Date | Sample Location Biasing Factor | Depth (cm bgs) |
|---|---|---|---|---|
| B01 | AB2B601 | 05/24/2012 | 2006 Aerial Survey; FIDLER Field Measurements | 0 - 5 |
| | AB2B602 | | | |
| | AB2B603 | | | |
| | AB2B604 | | | |
| B05 | AB2B605 | 05/29/2012 | 1997 KIWI Survey; FIDLER Field Measurements | 0 - 5 |
| | AB2B606 (FD) | | | |
| | AB2B607 | | | |
| | AB2B608 | | | |
| | AB2B609 | | | |
| B09 | AB2B610 | 04/15/2015 | 1997 KIWI Survey; FIDLER Field Measurements | 0 - 5 |
| | AB2B611 | | | |
| | AB2B612 | | | |
| | AB2B613 | | | |
| B10 | AB2B622 | 05/06/2015 | 1997 KIWI Survey; FIDLER Field Measurements | 0 - 5 |
| | AB2B623 | | | |
| | AB2B624 | | | |
| | AB2B625 | | | |
| B11 | AB2B626 | 05/06/2015 | 1997 KIWI Survey; FIDLER Field Measurements | 0 - 5 |
| | AB2B627 | | | |
| | AB2B628 | | | |
| | AB2B629 | | | |
| B12 | AB2B614 | 04/23/2015 | 2006 Aerial Survey; FIDLER Field Measurements | 0 - 5 |
| | AB2B615 | | | |
| | AB2B616 | | | |
| | AB2B617 | | | |
| B13 | AB2B618 | 04/23/2015 | 2006 Aerial Survey; FIDLER Field Measurements | 0 - 5 |
| | AB2B619 | | | |
| | AB2B620 | | | |
| | AB2B621 | | | |

bgs = Below ground surface
cm = Centimeter
FD = Field duplicate

the selection of the sample locations to the areas of highest radioactivity. Three sample plots were located inside the CA fence at the three most elevated areas identified by the KIWI survey, and two plots were located outside the CA fence at the two most elevated areas identified by the 2006 aerial survey (NNSA/NFO, 2015a). The modeled survey results are shown in relation to the sample plot locations in Figures D.2-3 and D.2-4.

Before each sample plot was established in the field, a FIDLER survey was performed to identify a 100-$m^2$ area at the location with the highest FIDLER radiological readings. Within each sample plot, four composite samples were collected. Each composite sample was composed of nine randomly located aliquots, resulting in a total of 36 aliquots collected from each plot. Each aliquot was collected using a "vertical-slice cylinder and bottom-trowel" method. This required the insertion of the 3.5-inch (in.) inside diameter cylinder to a depth of 5 cm, excavation of the outside soil along one side of the cylinder (to permit trowel placement), and horizontal insertion of a trowel along the bottom of the cylinder. This method captured a cylindrical-shaped section of the soil from 0 to 5 cm bgs.

### *D.2.3.2 TLDs*

A total of 19 TLDs were staged at CAU 412 with the objective of collecting *in situ* measurements to determine external radiological dose. Two TLDs were placed at the center of each of the five sample plots established during the CAI; one was staged at 1 m and one at 30 cm above ground surface (ags). The TLDs placed at 1 m measure external radiation received by an upright individual; the TLDs placed at 30 cm measure external radiation to a prone individual under the ground troops land use scenario. TLDs were not placed at the two sample plots established during the 2012 PI. The rationale for placement of TLDs at different heights is provided in the CAU 412 SAFER Plan (NNSA/NFO, 2015a).

A total of six background TLDs were placed at three locations not impacted by the CAU 412 release. The background TLDs were staged at 1 m and 30 cm ags at each location. One TLD was placed on the top of each soil mound at a height of 1 m ags. Table D.2-3 lists the number and location of TLDs placed at CAU 412 during the CAI; Figure D.2-2 shows the TLD locations.

TLDs were also placed at three background locations to measure background radiation. The background TLDs measure dose from natural sources in areas unaffected by the CAU-related releases. The locations of the three background TLDs were selected using the 2006 aerial radiation survey.

Once retrieved from the field locations, the TLDs were analyzed by automated TLD readers that are calibrated and maintained by the NNSS M&O contractor. This approach allowed for the use of existing QC procedures for TLD processing. Details of the environmental monitoring TLD program and TLD QC are presented in Section D.3.0. All readings conformed to the approved QC program and are considered representative of the external radiological dose at each location.

#### *D.2.3.3 Soil Mounds*

A total of six grab soil samples were collected from three soil mounds identified at CAU 412. In accordance with the SAFER Plan (NNSA/NFO, 2015a), one sample from the mound surface and one sample from the interior of the mound (i.e., subsurface) were collected. The locations of the soil mounds are shown in Figure D.2-2. Table D.2-4 lists the soil samples collected.

### *D.2.4 Dose Calculations*

Soil sample and TLD data are used to calculate a TED that could potentially be received by a human receptor at the site. The TED is defined in 10 CFR Part 835 (CFR, 2016) as the sum of the effective dose (for external exposures) and the committed effective dose (for internal exposures). The internal dose calculated from soil sample results and the external dose calculated from TLD measurements were combined to determine TED at each sample location. Methods used for calculating internal, external, and total dose are presented in the Soils RBCA document (NNSA/NFO, 2014).

The calculated TED is an estimate of the true (unknown) TED. It is uncertain how well the calculated TED represents the true TED. If a calculated TED were directly compared to the FAL, any significant difference between the true TED and the calculated TED could lead to decision errors. To reduce the probability of a false-negative decision error for probabilistic sampling results, a conservative estimate of dose (i.e., the 95 percent UCL) is calculated. By definition, there will be a 95 percent probability that the true dose is less than the 95 percent UCL of the calculated dose. The probabilistic

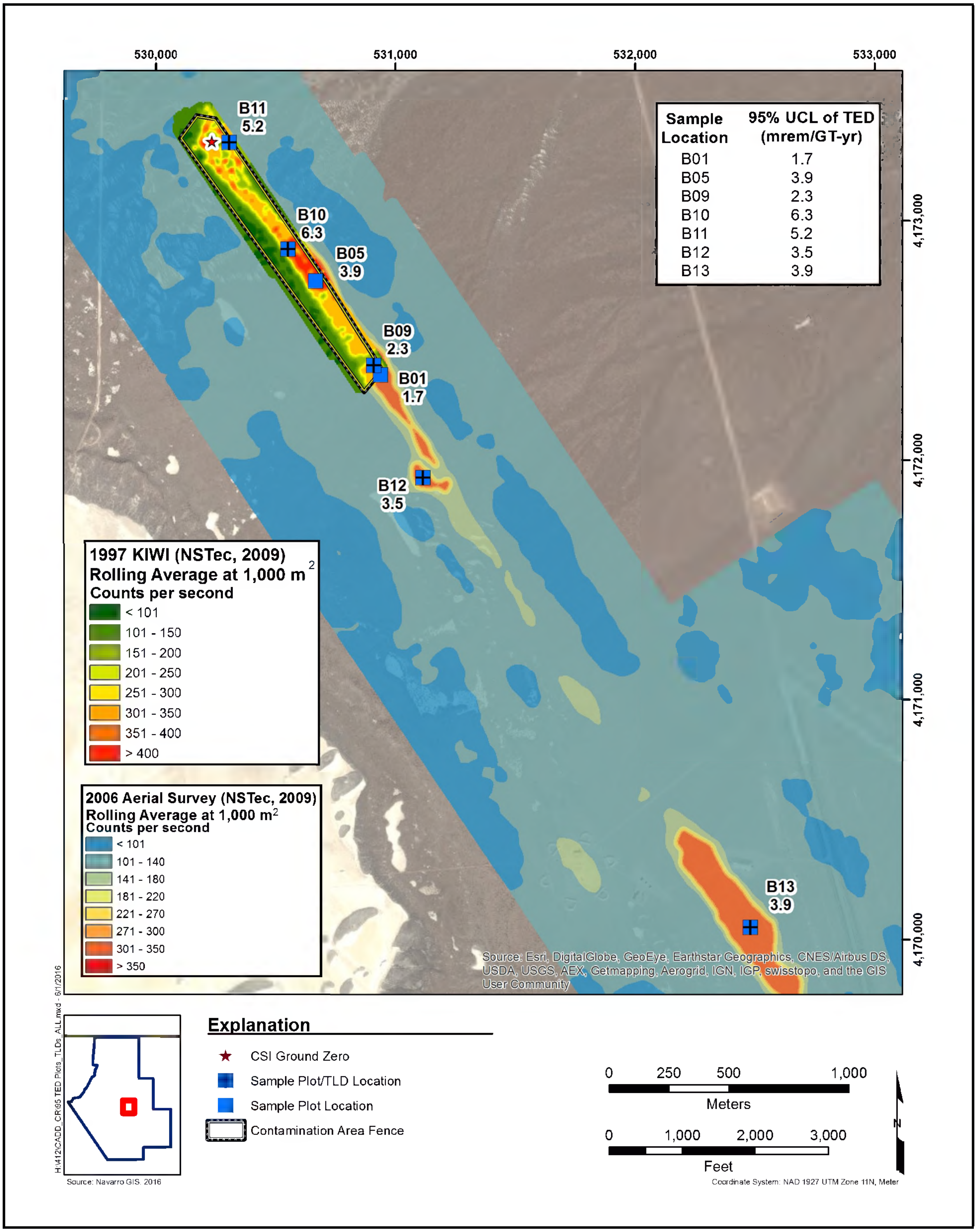


**Figure D.2-3**
**95% UCL of the TED at Sample Plot Locations**
**(mrem/GT-yr)**

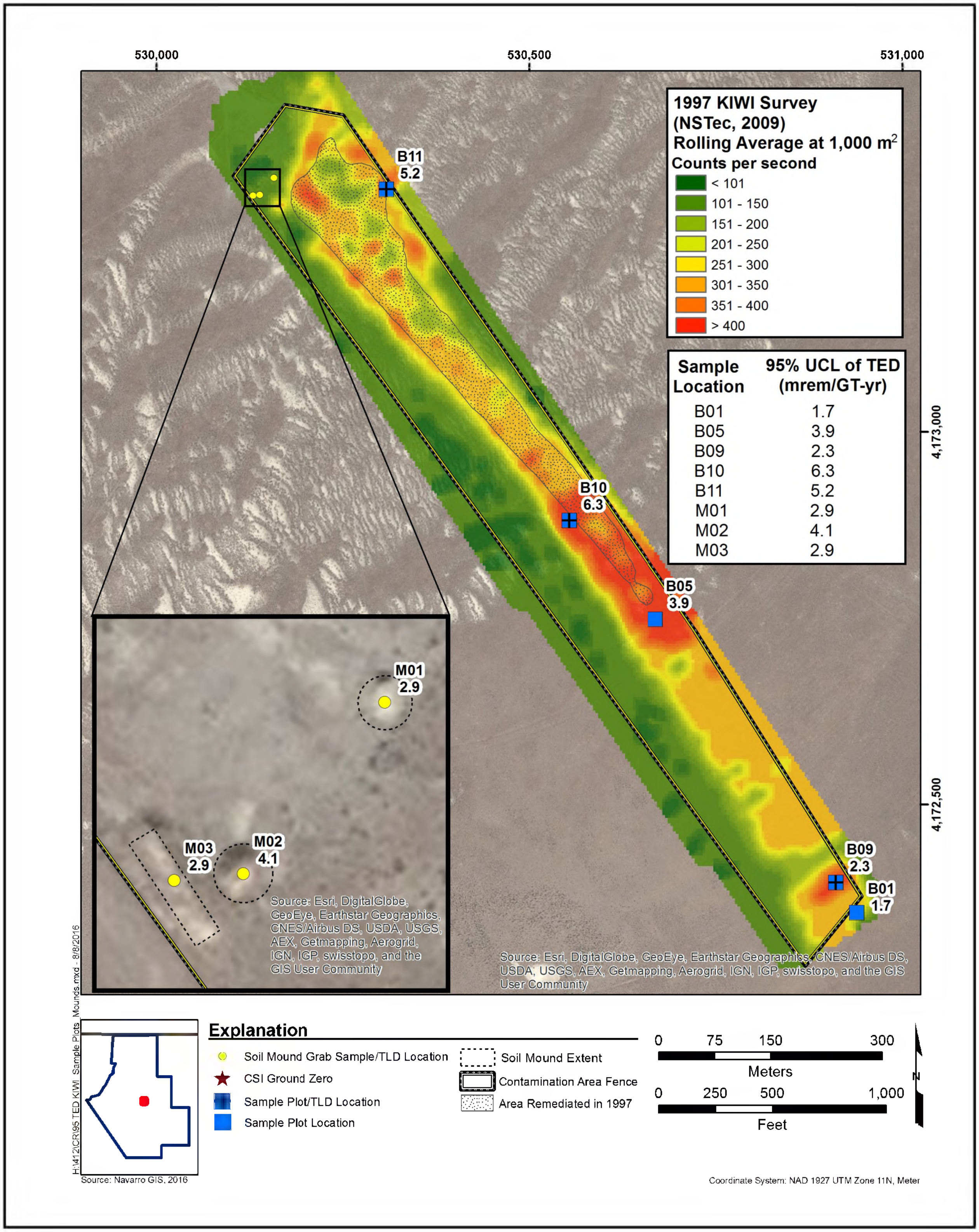


**Figure D.2-4**
**95% UCL of the TED at Sample Locations within CA Fence (mrem/GT-yr)**

## Table D.2-3
## CAU 412 TLDs

| Location | TLD Number (height ags) | Date Placed | Date Removed | Purpose |
|---|---|---|---|---|
| B09 | 6375 (30 cm)<br>6216 (1 m) | 04/15/2015 | 09/09/2015 | Sample plot |
| B10 | 6205 (30 cm)<br>6443 (1 m) | 05/05/2015 | 09/09/2015 | Sample plot |
| B11 | 6124 (30 cm)<br>6013 (1 m) | 05/05/2015 | 09/09/2015 | Sample plot |
| B12 | 6051 (30 cm)<br>6064 (1 m) | 04/21/2015 | 09/09/2015 | Sample plot |
| B13 | 6110 (30 cm)<br>6176 (1 m) | 04/21/2015 | 09/09/2015 | Sample plot |
| B14 | 6409 (30 cm)<br>6489 (1 m) | 04/20/2015 | 09/09/2015 | Background |
| B15 | 6438 (30 cm)<br>6241 (1 m) | 04/20/2015 | 09/09/2015 | Background |
| B16 | 6143 (30 cm)<br>6102 (1 m) | 04/20/2015 | 09/09/2015 | Background |
| M01 | 6173 (1 m) | 05/07/2015 | 09/09/2015 | Soil mound |
| M02 | 6249 (1 m) | 05/07/2015 | 09/09/2015 | Soil mound |
| M03 | 6293 (1 m) | 05/07/2015 | 09/09/2015 | Soil mound |

## Table D.2-4
## CAU 412 Soil Mound Samples

| Sample Location | Sample Number | Sample Date | Sample Location Biasing Factor | Depth (cm bgs) |
|---|---|---|---|---|
| M01 | AB2B630 | 05/07/2015 | Visible Extent of Soil Mound | 0 - 15 |
| | AB2B631 | | | 15 - 30 |
| M02 | AB2B632 | | Visible Extent of Soil Mound | 0 - 15 |
| | AB2B633 | | | 15 - 30 |
| M03 | AB2B634 | | Visible Extent of Soil Mound | 0 - 15 |
| | AB2B635 | | | 15 - 30 |

sampling design as described in the SAFER Plan (NNSA/NFO, 2015a) conservatively prescribes using the 95 percent UCL of the TED for DQO decisions. For sample locations where a TLD and multiple soil samples are collected (i.e., sample plots), the 95 percent UCL of the TED is calculated as the sum of the 95 percent UCLs of the internal and external doses. For grab sample locations where a TLD was also placed, the 95 percent UCL of the TED is calculated as the sum of the 95 percent UCL of the external dose and the calculated internal dose estimate. For sample locations where a TLD was not placed, external dose is estimated as described in Section D.2.4.2.

To reduce the probability of a false-negative decision error for judgmental sampling results, samples were biased to the locations of highest radioactivity and/or visible sedimentation areas. Samples from these locations will produce TED results that are higher than from adjacent locations of lower radioactivity (within the exposure area that is being characterized for dose). This will conservatively overestimate the true TED of the exposure area and protect against false-negative decision errors.

A minimum number of samples is required to assure sufficient confidence in dose statistics for probabilistic sampling such as the average and 95 percent UCL (EPA, 2006). As stated in the SAFER Plan (NNSA/NFO, 2015a), if the minimum sample size criterion cannot be met, it must be assumed that contamination exceeds the FAL. The calculation of the minimum sample size is described in Section 4.1.2.1.

The following sections describe the calculation of internal, external, and TED at each sample location at CAU 412. The TED is compared to the radiological dose FAL, which is based on the GT exposure scenario. The GT exposure scenario assumes the maximum amount of time an individual ground troop could be deployed during any single mission or operation is 14 days, 24 hr/day, and will participate in three such deployments a year. This results in a total of 1,008 hr/yr of potential exposure. The FAL is used in making DQO decisions related to FFACO site closure.

Dose calculations using the IA exposure scenario are also presented in the tables in this section for informational purposes. The IA scenario is a standard exposure scenario established in the Soils RBCA document (NNSA/NSO, 2014) that uses an exposure duration of 2,000 hr/yr and assumes a worker is assigned to the site for his or her entire career (25 years). If the calculated dose at a site exceeds 25 millirem per Industrial Area year (mrem/IA-yr), NNSA/NFO will determine whether an administrative UR or other institutional control is appropriate to guard against a more intensive future use of the site (i.e., a longer exposure duration).

### *D.2.4.1 Internal Dose Calculations*

Internal dose was calculated using the radionuclide analytical results from soil samples and the corresponding RRMGs presented in the SAFER Plan (NNSA/NFO, 2015a). The internal dose RRMG for a particular radionuclide is that concentration in surface soil that would cause an internal dose to a receptor of 25 mrem/yr (under the appropriate exposure scenario) independent of any other radionuclide (assuming that no other radionuclides contribute dose). For each sample, the radionuclide-specific analytical result was divided by its corresponding internal RRMG to yield a fraction of the 25-mrem/yr dose, and then multiplied by 25 to yield an internal dose estimate (in mrem/yr) at that sample location. The total internal dose corresponding to each soil sample was calculated by adding the dose contribution from each radionuclide. Soil concentrations of Pu isotopes are inferred from gamma spectroscopy results as described in the representativeness discussion of Section 4.1.2.1. The internal doses for all radionuclides detected in a soil sample (excluding lead-212 and -214, niobium-94, potassium-40, and thallium-208) were then summed to yield an internal dose for that sample in accordance with the Soils RBCA document (NNSA/NFO, 2014). At sample plot locations, a 95 percent UCL was calculated for the internal dose in each sample plot using the results of all soil samples collected in that plot (NNSA/NFO, 2014). The standard deviation, number of samples, minimum sample size, average, and 95 percent UCL of the internal dose at soil sample plots are presented in Table D.2-5.

For the soil mound sample locations where only one sample was collected, statistical inferences could not be calculated, and the single analytical result was used to calculate the internal dose. The average internal doses at the soil mound locations are presented in Table D.2-6.

### *D.2.4.2 External Dose Calculations*

External dose may be estimated using the total dose RRMGs or may be calculated using TLD data. At CAU 412, TLD data were used to calculate external dose at the soil sample plot locations sampled during the CAI. The TLDs contain four individual elements. External dose at each TLD location is determined using the readings from TLD elements 2, 3, and 4. Each of these elements is considered to

**Table D.2-5**
**Average and 95% UCL Internal Dose at Sample Plot Locations**

| Sample Location | Standard Deviation (GT Scenario) | Number of Samples | Minimum Sample Size (GT Scenario) | Ground Troops (mrem/GT-yr) | | Industrial Area (mrem/IA-yr) | |
|---|---|---|---|---|---|---|---|
| | | | | Average | 95% UCL | Average | 95% UCL |
| B01 | 0.2 | 4 | 3 | 1.1 | 1.4 | 1.3 | 1.6 |
| B05 | 0.4 | 5 | 3 | 3.0 | 3.5 | 3.5 | 4.0 |
| B09 | 0.3 | 4 | 3 | 1.5 | 1.8 | 1.7 | 2.1 |
| B10 | 0.4 | 4 | 3 | 1.3 | 1.8 | 1.5 | 2.0 |
| B11 | 0.1 | 4 | 3 | 0.4 | 0.6 | 0.5 | 0.6 |
| B12 | 0.3 | 4 | 3 | 1.1 | 1.4 | 1.2 | 1.7 |
| B13 | 0.1 | 4 | 3 | 0.2 | 0.3 | 0.2 | 0.3 |

**Table D.2-6**
**Average Internal Dose at Soil Mound Locations**

| Sample Location | Sample Depth (cm bgs) | Number of Samples | Ground Troops (mrem/GT-yr) | Industrial Area (mrem/IA-yr) |
|---|---|---|---|---|
| M01 | 0 - 15 | 1 | 0.0 | 0.0 |
| | 15 - 30 | 1 | 0.0 | 0.0 |
| M02 | 0 - 15 | 1 | 1.4 | 1.6 |
| | 15 - 30 | 1 | 1.1 | 1.3 |
| M03 | 0 - 15 | 1 | 0.1 | 0.1 |
| | 15 - 30 | 1 | 0.1 | 0.1 |

be a separate independent measurement of external dose. A 95 percent UCL of the average of these measurements was calculated for each TLD location. Element 1 is designed to measure dose to the skin and is not relevant to the determination of the external dose for the purpose of the CAI.

External dose estimates for CAU 412 are presented as net values (i.e., background radiation dose has been subtracted). The background dose at CAU 412 was calculated as the average of the background TLD results from locations B14, B15, and B16, which are shown in Figure D.2-2.

At sample locations where no TLD was placed (2012 sample plots and soil mound subsurface), a TLD equivalent external dose was calculated by multiplying the RESRAD-derived external dose by a correction factor. This correction factor was developed to account for an observed difference between

RESRAD-derived external dose and TLD readings as described in the Soils RBCA document (NNSA/NFO, 2014). The correction factor was derived by evaluating previous data from Soils Activity sites where both TLD and RESRAD-derived external dose data were available. Evaluation of this data showed good correlation between these paired data with a weighted average correction factor of 1.58 for average TLD values and 1.69 for 95 percent UCL TLD values. The correlation of TLD dose to RESRAD external dose is presented in Figure D.2-5. This evaluation also demonstrated that this correction factor was not influenced by the type of release (e.g., weapons test or safety experiment) (Figure D.2-6) or the amount of activity present (Figure D.2-7). However, it demonstrated that at very low external dose levels (as external doses approached zero), the relationship between RESRAD-derived external dose and TLD external dose had no correlation. Therefore, attempting to use site-specific data to correct RESRAD-derived external dose at sites where external dose is low (such as CAU 412) can result in erratic and erroneous results.

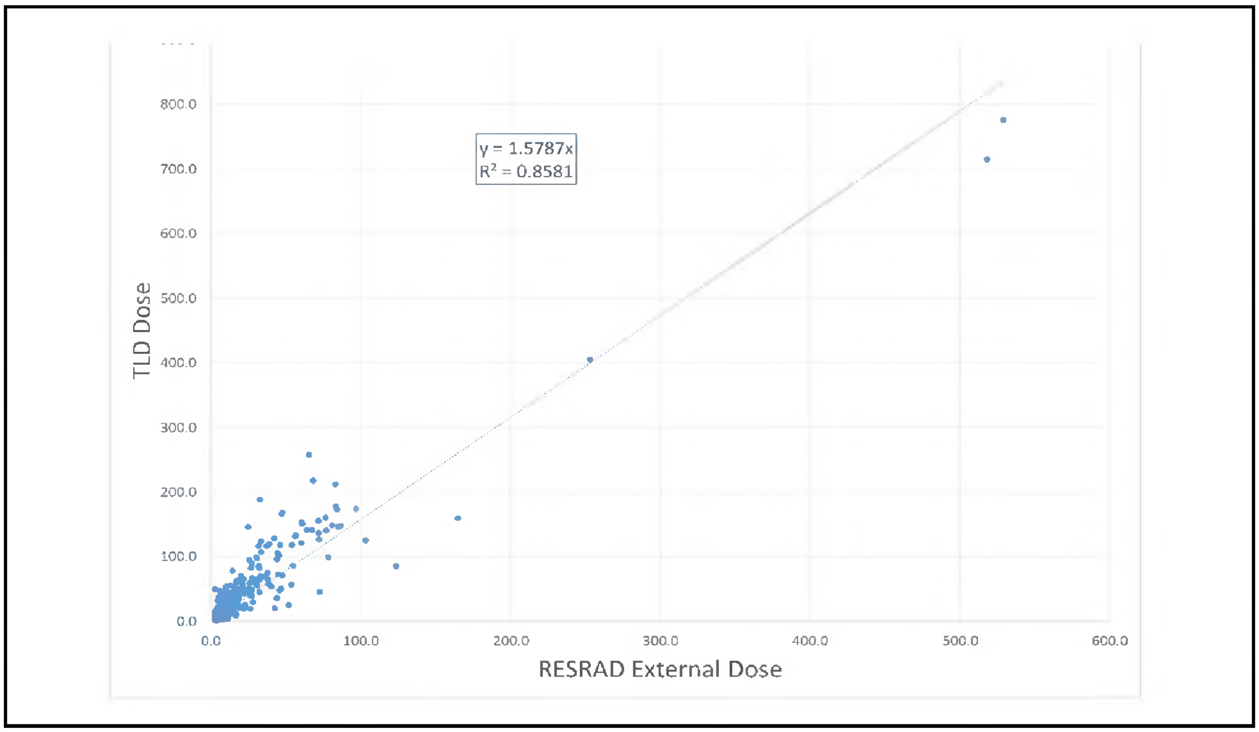


**Figure D.2-5**
**Correlation of TLD Dose to RESRAD External Dose**

External dose was calculated for the IA exposure scenario (2,000-hour exposure duration) and then scaled to the GT exposure scenario (1,008-hour exposure duration) for each TLD location. This was accomplished by calculating the hourly rate (mrem/hr) for the IA scenario and multiplying this rate

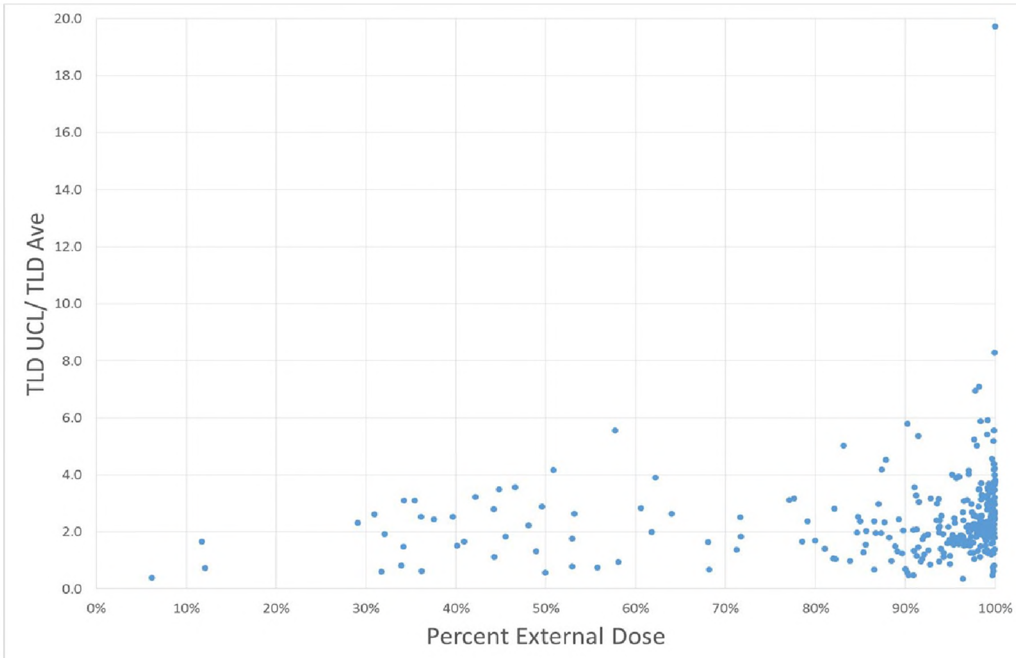


**Figure D.2-6**
**Correlation of Correction Factor to Release Type**

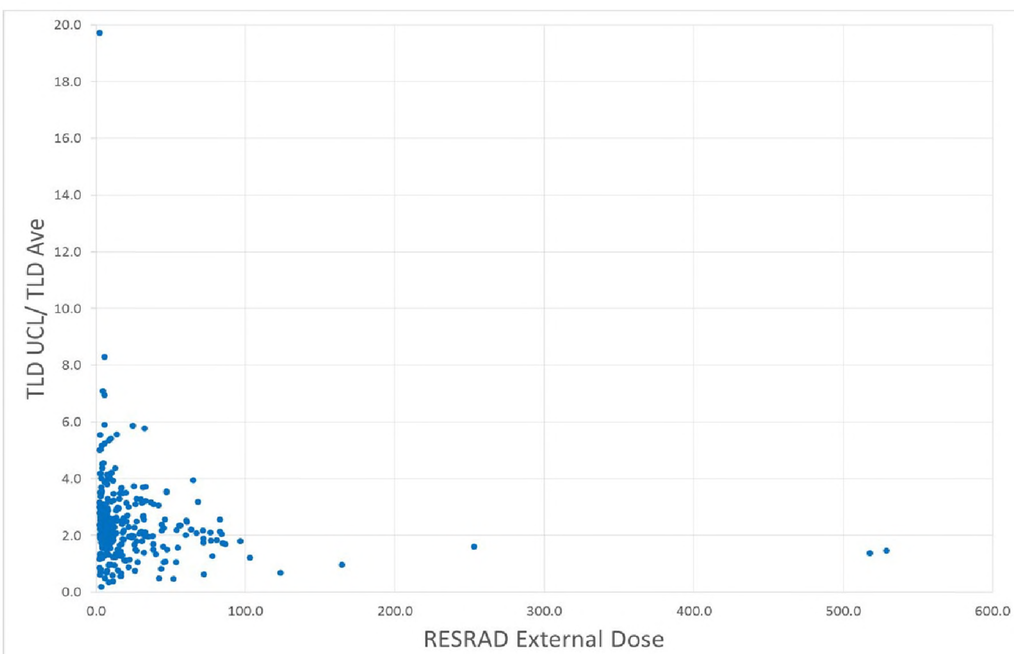


**Figure D.2-7**
**Correlation of Correction Factor to External Dose**

by the number of hours in the GT scenario (1,008 hours). The statistical data and the average and 95 percent UCL external doses for the sample plot and soil mound locations are presented in Tables D.2-7 and D.2-8, respectively.

### Table D.2-7
### Average and 95% UCL External Dose at Sample Plot Locations

| Sample Location | Standard Deviation (GT Scenario) | Number of Elements | Minimum Sample Size (GT Scenario) | Ground Troops (mrem/GT-yr) | | Industrial Area (mrem/IA-yr) | |
|---|---|---|---|---|---|---|---|
| | | | | Average | 95% UCL | Average | 95% UCL |
| B01 | N/A[a] | N/A[a] | N/A[a] | 0.2 | 0.2 | 0.3 | 0.4 |
| B05 | N/A[a] | N/A[a] | N/A[a] | 0.4 | 0.4 | 0.6 | 0.7 |
| B09 | 0.2 | 3 | 3 | 0.2 | 0.5 | 0.2 | 0.9 |
| B10 | 1.4 | 3 | 3 | 2.2 | 4.5 | 3.5 | 7.1 |
| B11 | 0.9 | 3 | 3 | 3.8 | 4.6 | 6.0 | 7.3 |
| B12 | 0.6 | 3 | 3 | 1.1 | 2.1 | 1.7 | 3.3 |
| B13 | 0.9 | 3 | 3 | 2.1 | 3.6 | 3.4 | 5.7 |

[a] No TLD was placed at this location. External dose was calculated in accordance with Section D.2.4.2.

N/A = Not applicable

### Table D.2-8
### Average and 95% UCL External Dose at Soil Mound Locations

| Sample Location | Sample Depth (cm bgs) | Standard Deviation (GT Scenario) | Number of Elements | Minimum Sample Size (GT Scenario) | Ground Troops (mrem/GT-yr) | | Industrial Area (mrem/IA-yr) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Average | 95% UCL | Average | 95% UCL |
| M01 | 0 - 15 | 0.2 | 3 | 3 | 2.6 | 2.9 | 4.2 | 4.6 |
| | 15 - 30 | N/A[a] | N/A[a] | N/A[a] | 0.1 | 0.1 | 0.2 | 0.2 |
| M02 | 0 - 15 | 0.4 | 3 | 3 | 2.1 | 2.7 | 3.3 | 4.3 |
| | 15 - 30 | N/A[a] | N/A[a] | N/A[a] | 0.3 | 0.3 | 0.4 | 0.4 |
| M03 | 0 - 15 | 0.5 | 3 | 3 | 1.9 | 2.8 | 3.0 | 4.4 |
| | 15 - 30 | N/A[a] | N/A[a] | N/A[a] | 0.1 | 0.1 | 0.1 | 0.1 |

[a] No TLD was placed at this location. External dose was calculated in accordance with Section D.2.4.2.

#### *D.2.4.3 Total Effective Dose*

The TED for each sample plot, grab sample location, and TLD location was calculated by adding the external dose values and the internal dose values. The radionuclides that are the primary contributors to the TED at CAU 412 are Pu-239/240 and, to a lesser extent, Am-241. Values for both the average TED and the 95 percent UCL of the TED for the GT and IA exposure scenarios are presented in Table D.2-9. None of the CAU 412 sample locations exceed the dose-based FAL of 25 mrem/GT-yr. The TED data for the sample plot locations are presented in Figures D.2-3 and D.2-4 in relation to the aerial and KIWI radiological survey data that were used to select the plot locations. The TED data for the soil mound sample locations are presented in Figure D.2-4.

### *D.2.5 Comparison to Action Levels*

Two PALs for radioactivity were presented in the SAFER Plan: (1) an annual dose limit of 25 mrem/GT-yr and (2) a removable alpha contamination level. The PALs are used for screening purposes. Additional detail with regard to the PALs and the GT scenario may be found in the SAFER Plan (NNSA/NFO, 2015a).

The comparison of investigation data to the FAL is used to determine whether corrective action under the FFACO is required at a site. As discussed in Appendix H, the radiological dose-based FAL of 25 mrem/GT-yr was the only FAL established for CAU 412. The total dose and internal dose residual radioactive material guidelines (RRMGs) associated with this FAL are presented in Tables D.2-10 and D.2-11, respectively. For removable contamination, if the HCA criterion of 2,000 dpm/100 cm$^2$ is exceeded, it is assumed that the dose-based radiological FAL of 25 mrem/yr is also exceeded and corrective action is required. It should be noted that the HCA criterion is not dose-based. As such, it does not correlate with a dose value that could be compared to the 25 mrem/GT-yr FAL established for CAU 412. In the absence of a dose-based FAL specific to removable contamination, the assumption equating the HCA criterion to the total dose FAL was necessary to account for potential removable contamination risks at the site.

This CR also presents a calculated radiological dose based on a 25-mrem/yr dose limit using the IA exposure scenario. The IA scenario is based on a 2,000 hr/yr exposure duration and is fully described in the Soils RBCA document (NNSA/NSO, 2014). The IA exposure scenario dose is evaluated to

**Table D.2-9**
**TED at Sample Locations (mrem/yr)**

| Location | Sample Location | Sample Depth (cm bgs) | Ground Troops | | Industrial Area | |
|---|---|---|---|---|---|---|
| | | | Average TED | 95% UCL of TED | Average TED | 95% UCL of TED |
| Plot | B01 | 0 - 5 | 1.4 | 1.7 | 1.7 | 2.0 |
| | B05 | 0 - 5 | 3.4 | 3.9 | 4.1 | 4.7 |
| | B09 | 0 - 5 | 1.6 | 2.3 | 1.9 | 2.9 |
| | B10 | 0 - 5 | 3.5 | 6.3 | 4.9 | 9.2 |
| | B11 | 0 - 5 | 4.2 | 5.2 | 6.4 | 7.9 |
| | B12 | 0 - 5 | 2.1 | 3.5 | 2.9 | 4.9 |
| | B13 | 0 - 5 | 2.3 | 3.9 | 3.6 | 6.0 |
| Soil Mounds | M01 | 0 - 15 | 2.7 | 2.9 | 4.2 | 4.7 |
| | | 15 - 30 | 0.1 | 0.1 | 0.2 | 0.2 |
| | M02 | 0 - 15 | 3.5 | 4.1 | 4.9 | 5.9 |
| | | 15 - 30 | 1.4 | 1.4 | 1.7 | 1.7 |
| | M03 | 0 - 15 | 2.0 | 2.9 | 3.1 | 4.5 |
| | | 15 - 30 | 0.1 | 0.1 | 0.2 | 0.2 |

determine whether implementation of best management practices (BMPs) at CAU 412 is necessary (see Section D.2.5.3).

### *D.2.5.1 Radiological Dose*

The FAL for CAU 412 was established based on a dose limit of 25 mrem/yr over an annual exposure time of 1,008 hours (GT exposure scenario). This scenario assumes an individual ground troop would be deployed to the CSI site three times a year, with each deployment lasting 14 days, 24 hr/day.

No location at CAU 412 exceeded the FAL of 25 mrem/GT-yr; thus, no corrective action is required.

**Table D.2-10**
**Total Dose RRMGs**
**for the Ground Troops Exposure Scenario**

| Radionuclide | RRMG (pCi/g) |
|---|---|
| Ag-108m | 4.72E+01 |
| Al-26 | 3.05E+01 |
| Am-241 | 2.90E+03 |
| Am-243 | 3.48E+02 |
| Cm-243 | 5.67E+02 |
| Cm-244 | 1.01E+04 |
| Co-60 | 3.25E+01 |
| Cs-137 | 1.29E+02 |
| Eu-152 | 6.78E+01 |
| Eu-154 | 6.33E+01 |
| Eu-155 | 1.70E+03 |
| Nb-94 | 4.90E+01 |
| Np-237 | 3.29E+02 |
| Pu-238 | 5.19E+03 |
| Pu-239/240 | 4.76E+03 |
| Pu-241 | 2.35E+05 |
| Sr-90 | 1.20E+04 |
| Tc-99 | 1.23E+06 |
| Th-232 | 9.18E+02 |
| U-233 | 2.47E+04 |
| U-234 | 2.77E+04 |
| U-235 | 4.49E+02 |
| U-238 | 2.47E+03 |

A soil sample at this RRMG value would present an internal dose potential of 25 mrem per calendar year.

Ag = Silver
Al = Aluminum
Cm = Curium
Co = Cobalt
Eu = Europium
mrem = Millirem
Nb = Niobium
Np = Neptunium
Sr = Strontium
Th = Thorium

**Table D.2-11**
**Internal Dose RRMGs**
**for the Ground Troops Exposure Scenario**

| Radionuclide | RRMG (pCi/g) |
|---|---|
| Ag-108m | 7.34E+05 |
| Al-26 | 4.83E+05 |
| Am-241 | 5.97E+03 |
| Am-243 | 5.95E+03 |
| Cm-243 | 8.14E+03 |
| Cm-244 | 1.02E+04 |
| Co-60 | 5.01E+05 |
| Cs-137 | 1.25E+05 |
| Eu-152 | 1.16E+06 |
| Eu-154 | 8.21E+05 |
| Eu-155 | 5.32E+06 |
| Nb-94 | 9.82E+05 |
| Np-237 | 1.09E+04 |
| Pu-238 | 5.21E+03 |
| Pu-239/240 | 4.77E+03 |
| Pu-241 | 2.46E+05 |
| Sr-90 | 5.27E+04 |
| Tc-99 | 2.62E+06 |
| Th-232 | 4.57E+03 |
| U-233 | 2.77E+04 |
| U-234 | 2.89E+04 |
| U-235 | 3.00E+04 |
| U-238 | 2.96E+04 |

A soil sample at this RRMG value would present an internal dose potential of 25 mrem per calendar year.

#### *D.2.5.2 Removable Contamination*

As discussed in the Soils RBCA document (NNSA/NSO, 2014), it is assumed that corrective action is required at areas that exceed the HCA criterion of 2,000 dpm/100 $cm^2$ for removable alpha contamination. If an area exceeds this criterion, it is assumed that the dose-based radiological FAL is also exceeded and corrective action is necessary.

Removable contamination surveys were completed at three soil sample plots (locations B05, B10, B11) within the CA fence and at each of the three soil mounds. In addition, personnel were monitored for removable contamination during the CAI as they exited the CA fence. These data, combined with existing removable contamination survey data collected outside the CA fence in 2010 (NSTec, 2011), were used to determine whether the HCA criterion was exceeded at CAU 412. The removable alpha contamination survey data at the soil sample plot locations and the soil mounds were all below the HCA criterion; the highest survey result (34.1 dpm/100 $cm^2$) was at sample plot location B05. Survey results for personal protective equipment worn during CAI sampling ranged from 0 to 8 dpm/100 $cm^2$ Figure D.2-8 shows the locations where removable contamination survey data were collected at CAU 412.

No surveyed area at CAU 412 exceeded the removable contamination HCA criterion; thus, it is assumed that the FAL of 25 mrem/GT-yr is also not exceeded and corrective action is not required.

#### *D.2.5.3 Best Management Practices*

In order to determine whether BMPs (e.g., administrative URs) are appropriate at CAU 412, a comparison is made to determine whether radiological dose exceeds the 25 mrem/IA-yr action level. The IA scenario is a standard exposure scenario established in the Soils RBCA document (NNSA/NSO, 2014) that uses an exposure duration of 2,000 hr/yr and assumes a worker is assigned to the site for his or her entire career (25 years). If the comparison indicates that the radiological dose to a industrial worker exceeds 25 mrem/IA-yr, NNSA/NFO will determine whether an administrative UR or other institutional control is appropriate to guard against a more intensive future use of the site (i.e., a longer exposure duration).

No location at CAU 412 exceeded the dose limit of 25 mrem/IA-yr; thus, no BMPs based on radiological dose are recommended.

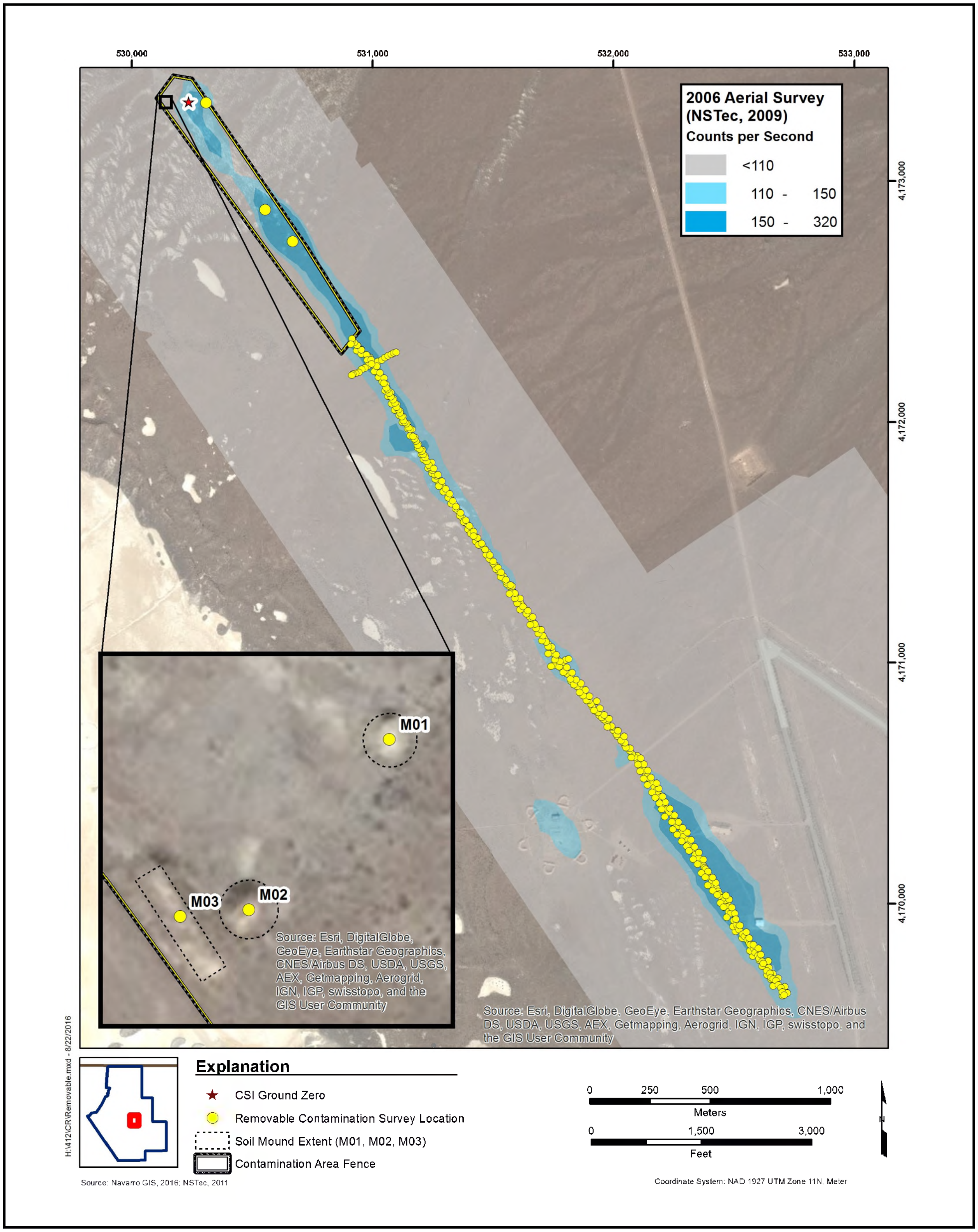


**Figure D.2-8**
**Removable Contamination Survey Locations**

### D.2.6 Nature and Extent of COCs

The 25-mrem/GT-yr FAL was not exceeded at any location, and no PSM or other releases were identified at the site. As a result, no COCs were identified at CAU 412.

### D.2.7 Deviations from the SAFER Plan/Revised Conceptual Site Model

All CAI activities were conducted in accordance with the SAFER Plan (NNSA/NFO, 2015a), with one exception. For sample locations where no TLD data exist (e.g., 2012 sample plots), the SAFER Plan states that external dose will be estimated using the methodology found in the Soils RBCA document (NNSA/NSO, 2014). However, an alternate method for deriving external dose at these locations was applied, as explained in Section D.2.4.2.

All other SAFER Plan requirements were met at CAU 412. The information gathered during the CAI supports the CSM as presented in the SAFER Plan (NNSA/NFO, 2015a). Therefore, no revisions were necessary to the CSM.

# D.3.0 Quality Assurance

This section contains a summary of QA/QC measures implemented during the sampling and analysis activities conducted in support of the CAU 412 CAI. The following subsections discuss the data validation process, QC samples, and nonconformances. A detailed evaluation of the DQIs is presented in Section 4.1.

Laboratory analyses were conducted for samples used in the decision-making process to provide a quantitative measurement of any contaminants of potential concern (COPCs) present. Rigorous QA/QC was implemented for all laboratory sample data, including documentation, verification and validation of analytical results, and affirmation of DQI requirements related to laboratory analysis. Detailed information regarding the QA program is contained in the Soils Activity QAP (NNSA/NSO, 2012).

## D.3.1 Data Validation

Data validation was performed in accordance with the Soils Activity QAP (NNSA/NSO, 2012) and approved protocols and procedures. All laboratory data from samples collected and analyzed for CAU 412 were evaluated for data quality in a tiered process. Data were reviewed to ensure that samples were appropriately processed and analyzed, and the results were evaluated using validation criteria. Documentation of the data qualifications resulting from these reviews is retained in CAU 412 files as a hard copy and electronic media.

All laboratory data were subjected to a Tier I and Tier II data evaluation. A Tier III evaluation was performed on the analytical results for samples that represent 5 percent of the samples collected for site characterization.

### D.3.1.1 Tier I Evaluation

Tier I evaluation for radiochemical analysis examines, but is not limited to, the following items:

- Sample count/type consistent with chain of custody.
- Analysis count/type consistent with chain of custody.
- Correct sample matrix.

- Significant problems and/or nonconformances stated in cover letter or case narrative.
- Completeness of certificates of analysis.
- Completeness of Contract Laboratory Program (CLP) or CLP-like packages.
- Completeness of signatures, dates, and times on chain of custody.
- Condition-upon-receipt variance form included.
- Requested analyses performed on all samples.
- Date received/analyzed given for each sample.
- Correct concentration units indicated.
- Electronic data transfer supplied.
- Results reported for field and laboratory QC samples.
- Whether or not the deliverable met the overall objectives.

#### *D.3.1.2 Tier II Evaluation*

Tier II evaluation for radiochemical analysis examines, but is not limited to, the following items:

- Correct detection limits achieved.

- Blank contamination evaluated and, if significant, qualifiers are applied to sample results.

- Certificate of Analysis consistent with data package documentation.

- QC sample results (duplicates, laboratory control samples [LCSs], laboratory blanks) evaluated and used to determine laboratory result qualifiers.

- Sample results, uncertainty, and minimum detectable concentration (MDC) evaluated.

- Detector system calibrated with National Institute of Standards and Technology (NIST)-traceable sources.

- Calibration sources preparation was documented, demonstrating proper preparation and appropriateness for sample matrix, emission energies, and concentrations.

- Detector system response to daily or weekly background and calibration checks for peak energy, peak centroid, peak full-width half-maximum, and peak efficiency, depending on the detection system.

- Tracers NIST-traceable, appropriate for the analysis performed, and recoveries that met QC requirements.

- Documentation of all QC sample preparation complete and properly performed.

- Spectra lines, photon emissions, particle energies, peak areas, and background peak areas support the identified radionuclide and its concentration.

#### *D.3.1.3 Tier III Evaluation*

The Tier III review is an independent examination of the Tier II evaluation and the laboratory reported data. A Tier III review of 5 percent of the samples collected was performed by Analytical Quality Associates, Inc. of Albuquerque, New Mexico. The Tier II and Tier III evaluations were in agreement, and evaluated data were used. This review included the following additional evaluations:

- Review
  - case narrative, chain of custody, and sample receipt forms;
  - lab qualifiers (applied appropriately);
  - method of analyses performed as dictated by the chain of custody;
  - raw data, including chromatograms, instrument printouts, preparation logs, and analytical logs;
  - manual integrations to determine whether the response is appropriate;
  - data package for completeness.
- Determine sample results qualifiers through the evaluation of (but not limited to)
  - tracers and QC sample results (e.g., duplicates, LCSs, blanks, matrix spikes) evaluated and used to determine sample results qualifiers;
  - sample preservation, sample preparation/extraction and run logs, sample storage, and holding time;
  - instrument and detector tuning;
  - initial and continuing calibrations;
  - calibration verification (initial, continuing, second source);
  - retention times;
  - second column and/or second detector confirmation;
  - mass spectra interpretation;
  - interference check samples and serial dilutions;

- post-digestion spikes and method of standard additions;
- breakdown evaluations.

- Perform calculation checks of
  - at least one analyte per QC sample and its recovery;
  - at least one analyte per initial calibration curve, continuing calibration verification, and second source recovery;
  - at least one analyte per sample that contains positive results (hits); radiochemical results only require calculation checks on activity concentrations (not error).
- Verify that target compound detects identified in the raw data are reported on the results form.
- Document any anomalies for the laboratory to clarify or rectify. The contractor should be notified of any anomalies.

### *D.3.2 Field QC Samples*

The CAU 412 dataset contains one FD, which was collected during the PI from a sample plot (AB2B606). This sample was sent blind to the laboratory to be analyzed for the investigation parameters listed in the SAFER Plan (NNSA/NFO, 2015a). For this sample, the duplicate results precision (i.e., relative percent differences [RPDs] between the environmental sample results and their corresponding FD sample results) was evaluated.

### *D.3.3 Field Nonconformances*

There were no field nonconformances identified for the CAI.

### *D.3.4 Laboratory Nonconformances*

Laboratory nonconformances are generally due to fluctuation in analytical instrumentation operations, sample preparations, missed holding times, spectral interferences, high or low chemical yields/spike recoveries, or percent differences in duplicate precision. All laboratory nonconformances were reviewed for relevance and, where appropriate, data were qualified accordingly.

### D.3.5 TLD Data Validation

The data from the TLD measurements met rigorous data quality requirements. TLDs were obtained from, and measured by, the Environmental Technical Services group at the NNSS. This group is responsible for a routine environmental monitoring program at the NNSS. TLDs were submitted to the Environmental Technical Services group for analysis using automated TLD readers that are calibrated and maintained by the National Security Technologies, LLC (NSTec), Radiological Control Department in accordance with existing QC procedures for TLD processing. A summary of the routine environmental monitoring TLD QC program can be found in the *Nevada Test Site Routine Radiological Environmental Monitoring Plan* (BN, 2003). Certification is maintained through the DOE Laboratory Accreditation Program for dosimetry.

The determination of the external dose component of the TED by TLDs was determined to be the most accurate method because of the following factors:

1. *TLDs are exposed at the sample plots for an extended time period that approximates the 2,000 hours of exposure time used for the IA exposure scenario.* This long-term exposure allows for a more accurate estimate of external dose, taking into account temporal variations.

2. *The use of a TLD to determine an individual's external dose is the standard in radiation safety and serves as the "legal dose of record" when other measurements are available.* Specifically, 10 CFR Part 835.402 (CFR, 2016) indicates that personal dosimeters must be provided to monitor individual exposures and that the monitoring program that uses the dosimeters must be accredited in accordance with a DOE Laboratory Accreditation Program.

## D.4.0 Summary

The SAFER Plan (NNSA/NFO, 2015a) identified the presumed corrective action for CAU 412 as clean closure. This presumption was based on implementation of the interim corrective action in 1997 and data collected during subsequent investigations. In order to supplement existing data and determine whether site closure objectives have been achieved, closure verification data were collected at CAU 412 as part of a CAI. The CAI confirmed that radionuclides at the site are not present in excess of the FAL, and further corrective action at the site is not required.

Each of the closure objectives defined in the SAFER Plan was achieved as indicated:

- *Radiological contamination at the site is less than the FAL using the GT exposure scenario (i.e., the radiological dose is less than the FAL).* No sample location exceeded the radiological dose FAL.
- *Removable alpha contamination is less than the HCA criterion.* Removable alpha contamination at the site was less than the HCA criterion, so it is assumed that the dose associated with removable contamination is less than the radiological dose FAL.
- *No PSM is present at the site, and any impacted soil associated with PSM has been removed so that remaining soil contains contaminants at concentrations less than the FALs.* No PSM was identified at CAU 412.
- *There is sufficient information to characterize investigation and remediation waste for disposal.* Soil sample results and radiological survey data are sufficient to characterize the investigation waste generated during the CAI; no remediation waste was generated during the CAI.

Based on the interim corrective action implemented in 1997 and the CAI, clean closure of the site is complete, the closure objectives established in the SAFER Plan have been achieved, and no further corrective action at the site is required.

## D.5.0 References

BN, see Bechtel Nevada.

Bechtel Nevada. 2003. *Nevada Test Site Routine Radiological Environmental Monitoring Plan*, DOE/NV/11718--804. Prepared for the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. Las Vegas, NV.

CFR, see *Code of Federal Regulations*.

*Code of Federal Regulations*. 2016. Title 10 CFR, Part 835, "Occupational Radiation Protection." Washington, DC: U.S. Government Printing Office.

EPA, see U.S. Environmental Protection Agency.

Navarro GIS, see Navarro Geographic Information Systems.

N-I, see Navarro-Intera, LLC.

NNSA/NFO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office.

NNSA/NSO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office.

NSTec, see National Security Technologies, LLC.

National Security Technologies, LLC. 2009. GIS Data Transmittal to U.S. Air Force, Product ID 20091029-01-P012-R04, 15 December. Las Vegas, NV.

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U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014. *Soils Risk-Based Corrective Action Evaluation Process*, Rev. 1, DOE/NV--1475-Rev. 1. Las Vegas, NV.

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U.S. Environmental Protection Agency. 2006. *Data Quality Assessment: Statistical Methods for Practitioners,* EPA QA/G-9S, EPA/240/B-06/003. Washington, DC: Office of Environmental Information.

# Appendix E

# Waste Disposition Documentation

# *E.1.0 Waste Disposition Documentation*

The wastes listed in Table E.1-1 were generated during CAI activities at CAU 412.

**Table E.1-1**
**CAU 412 Waste Summary Table**

| Waste Container Number | Waste Description | Waste Type | Waste Disposition | | | |
|---|---|---|---|---|---|---|
| | | | Disposal Facility | Waste Volume ($yd^3$) | Disposal Date | Disposal Doc |
| 412B01 | Debris/soil/metal fragments from TTR CAUs 411, 412, 413, and 414 | LLW | Area 5 RWMC | 25.4 | 08/15/2016 | CD |

CD = Certificate of Disposal
RWMC = Radioactive Waste Management Complex

Waste disposal documentation is presented in Attachment E-1.

# Attachment E-1

# Waste Disposal Documentation

(1 Page)

COPY

# Certificate of Disposal

This is to certify that the Waste Stream No. LITN-000000006, Revision 16, shipment number **ITL16022** with container numbers 412B01 was shipped and received at the Nevada National Security Site Radioactive Waste Management Complex in Area 5 for disposal as stated below.

| Mark Heser | Navarro | LL Waste Coordinator |
| --- | --- | --- |
| **Shipped by** | **Organization** | **Title** |
| /s/ Mark Heser | | 8/15/16 |
| **Signature** | | **Date** |

| Stephen E Wolf | NSTec | Waste Specialist |
| --- | --- | --- |
| **Received by** | **Organization** | **Title** |
| /s/ Stephen E. Wolf | | 08/16/16 |
| **Signature** | | **Date** |

# Appendix F

# Modifications to the Post-closure Plan

# F.1.0 Modifications to the Post-closure Plan

This appendix is not applicable to CAU 412, because the site is being clean closed and a post-closure plan is not required.

# Appendix G

# Use Restrictions

# *G.1.0 Use Restrictions*

This appendix is not applicable to CAU 412, because the site is being clean closed and URs are not required.

# Appendix H

# Risk Evaluation

# H.1.0 Risk Assessment

The RBCA process used to establish FALs is described in the Soils RBCA document (NNSA/NFO, 2014). This process conforms with *Nevada Administrative Code* (NAC) Section 445A.227, which lists the requirements for sites with soil contamination (NAC, 2014a). For the evaluation of corrective actions, NAC Section 445A.22705 (NAC, 2014b) requires the use of ASTM International (ASTM) Method E1739 (ASTM, 1995) to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary." For the evaluation of corrective actions, the FALs are established as the necessary remedial standard.

The ASTM Method E1739 defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses:

- **Tier 1 evaluation.** Sample results from source areas (highest concentrations) are compared to Tier 1 action levels based on generic (non-site-specific) conditions (i.e., the PALs established in the CAU 412 SAFER Plan [NNSA/NFO, 2015]). The FALs may then be established as the Tier 1 action levels, or the FALs may be calculated using a Tier 2 evaluation.

- **Tier 2 evaluation.** Conducted by calculating Tier 2 action levels using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 action levels are then compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis.

- **Tier 3 evaluation.** Conducted by calculating Tier 3 action levels on the basis of more sophisticated risk analyses using methodologies described in Method E1739 that consider site-, pathway-, and receptor-specific parameters.

The RBCA decision process stipulated in the Soils RBCA document (NNSA/NFO, 2014) is summarized in Figure H.1-1.

## H.1.1 Scenario

CAU 412, Clean Slate I Plutonium Dispersion (TTR), comprises one CAS: TA-23-01CS, Pu Contaminated Soil. This CAU consists of a release of radionuclides to the surrounding soil from a storage–transportation test conducted on May 25, 1963.

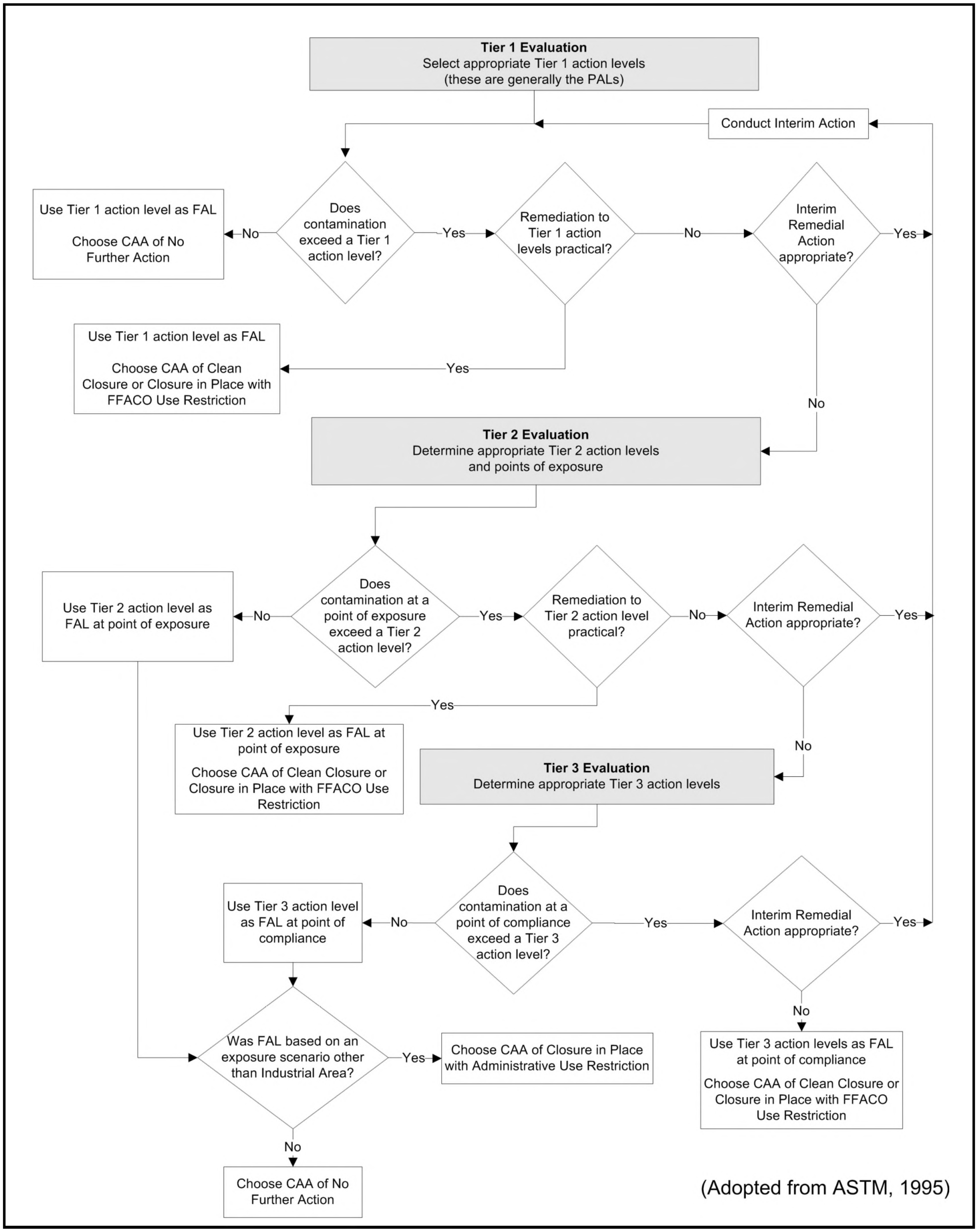


**Figure H.1-1**
**RBCA Decision Process**

### H.1.2 Site Assessment

Investigation activities at CAU 412 included visual surveys, ground-based radiation surveys, collection of surface and subsurface soil samples, and placement of TLDs. The CAI results are presented in Appendix D. No soil sample location at CAU 412 exceeded a dose of 25 mrem/GT-yr. None of the CAI data or the existing removable contamination survey data exceeded the removable alpha contamination HCA criterion of 2,000 dpm/100 $cm^2$.

### H.1.3 Site Classification and Initial Response Action

The four major site classifications listed in Table 3 of the ASTM Standard are (1) immediate threat to human health, safety, and the environment; (2) short-term (0 to 2 years) threat to human health, safety, and the environment; (3) long-term (greater than 2 years) threat to human health, safety, or the environment; and (4) no demonstrated long-term threats.

Based on the completion of the interim corrective action in 1997 and the CAI, CAU 412 does not contain contaminants that present an immediate threat to human health, safety, and the environment; therefore, no additional corrective interim response action is necessary at the site. CAU 412 has been determined to be a Classification 4 site as defined by ASTM Method E1739 (ASTM, 1995).

### H.1.4 Development of Tier 1 Action Level Lookup Table

Tier 1 action levels are defined as the PALs listed in the SAFER Plan (NNSA/NFO, 2015) as established during the DQO process. The PALs represent a very conservative estimate of risk, are preliminary in nature, and are generally used for site screening purposes. Although the PALs are not intended to be used as FALs, FALs may be defined as the Tier 1 action level (i.e., PAL) value if implementing a corrective action based on the Tier 1 action level is appropriate.

Two PALs for radioactivity were presented in the SAFER Plan: (1) a radiological dose-based action level (25 mrem/GT-yr) and (2) a removable contamination action level (2,000 dpm/100 $cm^2$).
The PAL for removable contamination was determined inappropriate for use as a FAL as it is not based on dose or risk. For removable contamination, if the HCA criterion of 2,000 dpm/100 $cm^2$ is exceeded, it is assumed that the radiological FAL of 25 mrem/GT-yr is also exceeded and corrective action is required.

The radiological dose-based PAL was based on the GT exposure scenario, which assumes the maximum amount of time an individual ground troop could be deployed during any single mission or operation is 14 days, 24 hr/day, and will participate in three such deployments a year. This results in a total of 1,008 hr/yr of potential exposure. The 25-mrem/yr dose-based Tier 1 action level for radiological contaminants is determined by calculating the dose a site worker would receive if exposed to the site contaminants over an annual exposure period of 1,008 hours.

The 25-mrem/yr radiological FAL is consistent with the DOE dose constraint for the release or clearance of land found in DOE Order 458.1 (DOE, 2013). A 25-mrem/yr dose constraint for unrestricted use is also found in U.S. Nuclear Regulatory Commission (CFR, 2016) and Nevada state regulations (NAC, 2014c).

Chemical PALs were defined in the SAFER Plan; however, no chemical COPCs were defined or discovered during the CAI.

### *H.1.5 Exposure Pathway Evaluation*

For all releases, the DQOs stated that site workers could be exposed to COCs through oral ingestion, inhalation, or dermal contact (absorption) of soil or debris due to inadvertent disturbance of these materials or irradiation by radioactive materials. The potential exposure pathways would be through worker contact with the contaminated soil or debris currently present at the site. The limited migration demonstrated by the analytical results, elapsed time since the releases, and depth to groundwater support the selection and evaluation of only surface and shallow subsurface contact as the complete exposure pathways. Ingestion of groundwater is not considered to be a significant exposure pathway.

### *H.1.6 Comparison of Site Conditions with Tier 1 Action Levels*

An exposure duration based on the GT scenario (1,008 hr/yr) was used to calculate the Tier 1 action levels (i.e., PALs). There are no sample locations at CAU 412 that exceed the Tier 1 action levels. Based on the unrealistic but conservative assumption that a ground troop would be exposed to the maximum dose calculated at any sampled location, this individual would receive a 25-mrem dose at CAU 412 in the exposure time listed in Table H.1-1.

**Table H.1-1**
**Minimum Exposure Time to Receive a 25-mrem/yr Dose in the GT Exposure Scenario**

| Sample Location | Location of Maximum Dose | Average TED (mrem/GT-yr) | Minimum Exposure Time (hours) |
|---|---|---|---|
| Sample Plot | B11 | 4.2 | 6,048 |

### *H.1.7 Evaluation of Tier 1 Results*

The GT exposure scenario was established by the USAF as the appropriate land use scenario for the CAU 412 site (USAF, 2014). The types of work activities that are currently conducted at the site are consistent with the GT scenario used in the development of the Tier 1 PAL. No sample location at CAU 412 exceeded the Tier 1 action level. However, in order to facilitate comparison of CAU 412 data to reasonable points of exposure (as opposed to source areas in the Tier 1 evaluation), a Tier 2 evaluation was conducted.

### *H.1.8 Tier 1 Remedial Action Evaluation*

No corrective actions are proposed based on Tier 1 action levels.

### *H.1.9 Tier 2 Evaluation*

No additional data were needed to complete a Tier 2 evaluation.

### *H.1.10 Development of Tier 2 Action Levels*

The Tier 2 action levels are typically compared to contaminant values that are representative of areas at which an individual or population may come in contact with a COC originating from a CAS. This concept is illustrated in the EPA's Human Health Evaluation Manual (EPA, 1989). This document states that "the area over which the activity is expected to occur should be considered when averaging the monitoring data for a hot spot. For example, averaging soil data over an area the size of a residential backyard (e.g., an eighth of an acre) may be most appropriate for evaluating residential soil pathways." When evaluating industrial receptors, the area over which an industrial worker is exposed may be much larger than for residential receptors. For a site that is limited to industrial uses, the receptor would be a site worker, and patterns of employee activity would be used to estimate the area over which the receptor is exposed. This can be very complicated to calculate, as industrial workers may perform routine activities at many locations where only a portion of these locations may be contaminated.

The GT exposure scenario was established by the USAF as the appropriate land use scenario for the CAU 412 site (USAF, 2014). The types of work activities that are currently conducted at the site are consistent with the GT scenario used in the development of the Tier 1 PAL. Therefore, the Tier 2 action level is defined as 25 mrem/yr under the GT exposure scenario.

### *H.1.11 Comparison of Site Conditions with Tier 2 Action Levels*

There are no locations at CAU 412 that exceed the radiological Tier 2 action level.

### *H.1.12 Tier 2 Remedial Action Evaluation*

Based on the Tier 2 evaluation, soil contamination at CAU 412 is not present at levels that exceed Tier 2 action levels and no remedial actions are required. Therefore, the Tier 2 action level of 25 mrem/GT-yr is established as the FAL, and a Tier 3 evaluation is not necessary.

# H.2.0 Recommendations

The CAI for CAU 412 verified that contamination is not present at the site in excess of the FAL, and further corrective action is not required. Based on the interim corrective action implemented in 1997 and the CAI, clean closure of the site is complete, and the closure objectives established in the SAFER Plan (NNSA/NFO, 2015) have been achieved.

The corrective action of clean closure at CAU 412 is based on an evaluation of both the GT and the IA exposure scenarios. The conservative estimates of dose at the locations of highest radioactivity were all below the FAL for both of these scenarios. If land use were to change that could result in potential exposures exceeding that of the IA exposure scenario (such as release of this property to the public), the closure of CAU 412 would need to be reevaluated.

## H.3.0 References

ASTM, see ASTM International.

ASTM International. 1995 (reapproved 2015). *Standard Guide for Risk-Based Corrective Action Applied at Petroleum Release Sites*, ASTM E1739 - 95(2015). West Conshohocken, PA.

CFR, see *Code of Federal Regulations*.

*Code of Federal Regulations*. 2016. Title 10 CFR, Part 20, "Standards for Protection Against Radiation." Washington DC: U.S. Government Printing Office.

DOE, see U.S. Department of Energy.

EPA, see U.S. Environmental Protection Agency.

NAC, see *Nevada Administrative Code.*

NNSA/NFO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office.

*Nevada Administrative Code*. 2014a. NAC 445A.227, "Contamination of Soil: Order by Director for Corrective Action; Factors To Be Considered in Determining Whether Corrective Action Required." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 29 February 2016.

*Nevada Administrative Code*. 2014b. NAC 445A.22705, "Contamination of Soil: Evaluation of Site by Owner or Operator; Review of Evaluation by Division." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 29 February 2016.

*Nevada Administrative Code*. 2014c. NAC 459.316 to 459.3184 "Radiological Criteria for Termination of License." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 29 February 2016.

USAF, see U.S. Air Force, 99 ABW/CC.

U.S. Air Force, 99 ABW/CC. 2014. Letter to R.Boehlecke (NNSA/NFO) titled "Air Force Response to DOE Request to Close Five Radiological Sites on the NTTR," 2 May. Nellis AFB, NV.

U.S. Department of Energy. 2013. *Radiation Protection of the Public and the Environment,* DOE Order 458.1, Change 3. Washington, DC: Office of Health, Safety, and Security.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014. *Soils Risk-Based Corrective Action Evaluation Process*, Rev. 1, DOE/NV--1475-Rev. 1. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2015. *Streamlined Approach for Environmental Restoration (SAFER) Plan for Corrective Action Unit 412: Clean Slate I Plutonium Dispersion (TTR), Tonopah Test Range, Nevada*, Rev. 0, DOE/NV--1534. Las Vegas, NV.

U.S. Environmental Protection Agency. 1989. *Risk Assessment Guidance for Superfund, Volume I, Human Health Evaluation Manual (Part A),* EPA/540/1-89/002. Washington, DC: Office of Emergency and Remedial Response.

# Appendix I

# Evaluation of Corrective Action Alternatives

# I.1.0 Evaluation of Corrective Action Alternatives

This appendix is not applicable to CAU 412, because the presumed corrective action of clean closure was proposed in the SAFER Plan and confirmed by the CAI.

# Appendix J

# Sample Location Coordinates

# J.1.0 Sample Location Coordinates

The center of each sample plot and each soil mound at CAU 412 were surveyed using a GPS instrument. Survey coordinates for these locations are listed in Table J.1-1.

**Table J.1-1**
**Sample Plot and Soil Mound Location Coordinates for CAU 412**

| Sample Plot/Location | Easting[a] | Northing[a] |
|---|---|---|
| B01 | 530939 | 4172355 |
| B05 | 530669 | 4172749 |
| B09 | 530911 | 4172396 |
| B10 | 530554 | 4172881 |
| B11 | 530309 | 4173325 |
| B12 | 531117 | 4171927 |
| B13 | 532482 | 4170052 |
| M01 | 530151 | 4173349 |
| M02 | 530132 | 4173326 |
| M03 | 530123 | 4173326 |

[a]UTM Zone 11, NAD 1927 (U.S. Western) in meters.

NAD = North American Datum
UTM = Universal Transverse Mercator

Nine aliquot sample locations were established at each plot for each composite sample in accordance with the procedure described in the Soils RBCA document (NNSA/NFO, 2014). In some cases, aliquot locations were moved due to surface/subsurface obstructions or conditions (e.g., rocks, vegetation, and animal burrows). These offsets (distance and direction) of each aliquot location were recorded in the project files. It is important to note that if an offset was less than the nominal 4-in. width of core sampler the original coordinate was not modified.

## J.2.0 References

NNSA/NFO, see U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014. *Soils Risk-Based Corrective Action Evaluation Process*, Rev. 1, DOE/NV--1475-Rev. 1. Las Vegas, NV.

# Appendix K

# Nevada Division of Environmental Protection Comments

(4 Pages)

# NEVADA ENVIRONMENTAL MANAGEMENT OPERATIONS ACTIVITY
## DOCUMENT REVIEW SHEET

| | |
|---|---|
| 1. Document Title/Number: Closure Report for Corrective Action Unit 412: Clean Slate I Plutonium Dispersion (TTR), Tonopah Test Range, Nevada, June 2016 | 2. Document Date: June 2016 |
| 3. Revision Number: | 4. Originator/Organization: Navarro |
| 5. Responsible DOE NNSA/NFO Activity Lead: Tiffany Lantow | 6. Date Comments Due: |
| 7. Review Criteria: Chris Andres and Scott Page, Nevada Division of Environmental Protection | |
| 8. Reviewer/Organization Phone No.: (702) 486-2850, extensions 232 and 237 | 9. Reviewer's Signature: |

| 10. Comment Number/Location | | 11. Type[a] | 12. Comment | 13. Comment Response |
|---|---|---|---|---|
| 1. | Executive Summary, Page ES-2, Bullets 2 and 3 | | See Comment 4. | See response to Comment #4. |
| 2. | Section 2.1, Page 7, Paragraph 1 | | First sentence: Were corrective action investigation activities actually conducted during the same time frame as those for CAU 411? Verify. | Yes, corrective action investigations at CAU 411 and CAU 412 took place during the timeframe specified. |
| 3. | Section 2.4, Page 9, Paragraph 1 | | 1st and 2nd sentences: Add references for these statements. | The following references were added after the first and second sentences of Section 2.4, respectively: "(Sanchez et al., 1998)" and "(BN, 1998)".<br><br>In addition, the following references were added to Section 6.0, *References*:<br><br>Sanchez, M., M. Shotton, and C. Lyons. 1998. "Remedial Actions of Nuclear Safety Shot Sites: Double Tracks and Clean Slates," DOE/NV/11718-196. Presented at Waste Management '98. Tuscon, AZ. 1–5 March.<br><br>Bechtel Nevada. 1998. *An In Situ Radiological Survey Conducted During the Remediation Activities at the Clean Slate 1 Site*, DOE/NV/11718-218. Prepared by S.R. Riedhauser. Las Vegas, NV: Remote Sensing Laboratory. |
| 4. | Section 3.0, Page 12, Paragraph 2 | | Last sentence: Waste disposal documentation for investigation-derived waste at CAU 412, presumably combined with documentation from CAU 411, was not available when the final CR CAU 411CR was approved by NDEP on 15 July 2016. As such, a Notice of Completion for CAU 411 has not yet been issued by NDEP and is pending receipt of documentation. A similar requirement exists for CAU 412. | The waste disposal documentation for waste generated at CAU 412 was added as Attachment E-1 to Appendix E, Waste Disposition Documentation. |

[a]Comment Types: M = Mandatory, S = Suggested.
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|---|---|---|---|---|
| 5. | Section 4.1.10.3, Page 27, Paragraph 1 | | 1st sentence: Previous documents (e.g.CR for CAU 411) have stated FIDLER detectors are calibrated annually; there is no similar calibration statement in this section. Clarify. | The paragraph in Section 4.1.10.3 was deleted and replaced with the following:<br>"The FIDLER data meet the data quality requirements listed in Section 2.6.1 of the Soils QAP (NNSA/NSO, 2012) through the verification of acceptable instrument performance. This was accomplished through the use of control charts and daily operational tests (performing daily background and response checks). This assures that the instrument responds appropriately to higher levels of radiation with correspondingly higher readings. The FIDLER readings are used qualitatively to represent generally observed radiation levels relative to the nearby background radiation level. These are expressed in terms of multiples of the background radiation level (multiples of background [MOB]). The qualitative MOB values are used to distinguish a spatial pattern of where radioactivity is relatively higher and lower. These values become semi-quantitative if a relationship is established between MOB values and quantitative dose levels that meets the quality criterion defined in the Soils RBCA document (NNSA/NFO, 2014).<br>FIDLER data are also used qualitatively to guide the biasing of sampling locations. As used for these purposes, the quality of FIDLER survey data is sufficient to meet the requirements of decision-supporting data." |
| 6. | Section 5.0, Page 29, Paragraph 2 | | See Comment 4. | See response to Comment #4. |
| 7. | Section D.2.2, Page D-4, Figure D.2-1 | | Add the "Area Remediated in 1997" border to appropriate area inside the CA boundary, in agreement with Fig. 2-1. | Revised as requested. |

[a]Comment Types: M = Mandatory, S = Suggested.
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|---|---|---|---|---|
| 8. | Section D.2.2, Page D-5, Paragraph 1 | | Last sentence: Change "Section D.2-1" to "Figure D.2-1". | Revised as requested. |
| 9. | Section D.2.3.2, Page D-9, Paragraph 1 | | 3rd sentence: Provide background information about the paired TLDs placed at 1m and 30cm above ground surface (ags) for sample plots and background, an apparent variance from 1m placement for routine NNSS environmental monitoring; and why soil mound TLDs were placed only at 1m ags. | An explanation of the use of two TLDs at CAU 412 is provided in the SAFER Plan (Section B.8.2.3). In summary, placement of a TLD at a height of 30 cm was proposed in the DQOs to measure external radiation to a prone individual under the ground troops land use scenario. The soil mound TLDs were placed at 1 m in accordance with the DQOs and the CAU 412 SAFER Plan.<br><br>The following was added after the second sentence of paragraph 1, Section D.2.3.2: "The TLDs placed at 1 m measure external radiation received by an upright individual; the TLDs placed at 30 cm measure external radiation to a prone individual under the ground troops land use scenario." |
| 10. | Section D.2.3.1, Page D-12, Figure D.2-4 | | Because grab samples were taken from, and TLDs were emplaced on,soil mound sites for independent characterization and results shown in Appendix D, suggest modifying figure and legend to reflect these sample locations/types. | The figure legend was modified to reflect the soil mound sample and TLD locations/type. |
| 11. | Section D.2.4.2, Page D-16, Paragraph 1 | | See Comment 9. | See response to Comment #9. |
| 12. | Section D.2.4.2, Pages D-17, D-18, Figures D.2-4 thru D.2-7 | | Major and minor X and Y axis lines and axis labels are very difficult to view and analyze; suggest substantial graphic improvement. | The figures were revised to improve visibility of the x and y axes labels. |

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|---|---|---|---|---|
| 13. | Section D.2.5.2, Page D-24, Paragraph 2 | | First sentence: Fig D.2-8 does not appear to show the removable contamination surveys for the three soil mounds. | The removable contamination surveys were conducted on each soil mound surface at random locations. The soil mound locations were added to Figure D.2-8. |
| 14. | Section D.2.5.2, Pages D-25, Figure D.2-8 | | Add removable contamination survey locations for soil mounds. | See response to Comment #13. |
| 15. | Appendix E, Page E-1 | | See Comment 4. | See response to Comment #4. |

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