# *FEDERAL FACILITY AGREEMENT AND CONSENT ORDER* (FFACO)
# RECORD OF TECHNICAL CHANGE (ROTC)

**Corrective Action Unit (CAU) Number:** 541
**CAU Description:** Small Boy
**CAU Owner:** Soils - Environmental Restoration (ER)

**ROTC No.** DOE/NV--1539-ROTC 2 **Page** 1 of 15

**Document Type** Corrective Action Decision Document/Closure Report (CADD/CR) **Date** 11/19/2019

The following technical changes (including justification) are requested by:

| Tiffany Gamero | Long-Term Monitoring Activity Lead |
|---|---|
| Requestor Name | Requestor Title |

**Description of Change:**

1. This ROTC replaces the Use Restriction (UR) information listed in the documentation for CAU 541.

   UR forms have been updated to list all UR requirements, including but not limited to: post-closure site controls (signs, fencing, etc.), inspection and maintenance requirements, and Geographic Information Systems (GIS) coordinate information. The UR requirements and form(s) included in this ROTC represent the current corrective action requirements for each Corrective Action Site (CAS) in this CAU and supersede information concerning corrective action and post-closure requirements in existing documentation.

**Justification:**

1. Some changes in the UR requirements from those found in closure documents have been subsequently modified in letters, memos, and inspection reports. This has resulted in difficulty in determining current post-closure requirements. A review of the post-closure requirements for this CAU has been conducted to ensure that all requirements have been identified and documented on the new UR form. The new UR form was developed to be inclusive of all requirements for long-term monitoring and standardize information contained in the URs consistent with current protocols.

# *FEDERAL FACILITY AGREEMENT AND CONSENT ORDER* (FFACO)
# RECORD OF TECHNICAL CHANGE (ROTC)

**Corrective Action Unit (CAU) Number:** 541
**CAU Description:** Small Boy
**CAU Owner:** Soils - Environmental Restoration (ER)

**ROTC No.** DOE/NV--1539-ROTC 2 **Page** 2 of 15

**Document Type** Corrective Action Decision Document/Closure Report (CADD/CR) **Date** 11/19/2019

**Schedule Impacts:**

No impacts to schedule.

**ROTC applies to the following document(s):**

- U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2016. Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada, Rev. 0, DOE/NV--1539. Las Vegas, NV.
- ROTC-1 for CAU 541 CADD/CR (DOE/NV--1539), dated 12/08/2016.

UNCONTROLLED

# *FEDERAL FACILITY AGREEMENT AND CONSENT ORDER* (FFACO)
# RECORD OF TECHNICAL CHANGE (ROTC)

**Corrective Action Unit (CAU) Number:** 541
**CAU Description:** Small Boy
**CAU Owner:** Soils - Environmental Restoration (ER)

**ROTC No.** DOE/NV--1539-ROTC 2 **Page** 3 of 15

**Document Type** Corrective Action Decision Document/Closure Report (CADD/CR) **Date** 11/19/2019

**Approvals:**

/s/ Wilhelm R. Wilborn
Date 12/9/19

Kevin Cabble
Activity Lead
Environmental Management (EM) Nevada Program

/s/ Wilhelm R. Wilborn
Date 12/9/19

Bill Wilborn
Deputy Program Manager, Operations
Environmental Management (EM) Nevada Program

/s/ Mark McLane
Date 12/18/19

FOR Christine Andres
Chief, Bureau of Federal Facilities
Nevada Division of Environmental Protection (NDEP)

# U.S. Department of Energy, Environmental Management Nevada Program
# Use Restriction Information

## General Information

| | |
|---|---|
| **Use Restriction (UR) Type(s):** | Administrative Only |
| **Corrective Action Unit (CAU) Number & Description:** | 541 - Small Boy |
| **Corrective Action Site (CAS) Number & Description:** | 05-23-04 - Atmospheric Tests (6) - BFa Site |
| **CAU/CAS Owner:** | Soils - ER |
| **Note:** | N/A |

## Section I. *Federal Facility Agreement and Consent Order* (FFACO) UR

*An FFACO UR is not identified for this site.*

## Section II. Administrative UR

### Basis for Administrative UR

**Summary Statement:** This Administrative UR is established to protect workers should future land use result in increased exposure to site contaminants. Radiological contaminants are present that exceed action levels under the Industrial Area (2,000 hours per year) exposure scenario.

# U.S. Department of Energy, Environmental Management Nevada Program
# Use Restriction Information

## Administrative UR Physical Description

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Boundary | UR Point[1] | Easting[2] | Northing[2] |
|---|---|---|---|
| Admin Boundary | 1 | 595,523 | 4,072,676 |
| | 2 | 595,215 | 4,072,788 |
| | 3 | 595,291 | 4,073,213 |
| | 4 | 595,472 | 4,073,333 |
| | 5 | 595,643 | 4,073,263 |
| | 6 | 595,787 | 4,072,832 |
| | 7 | 595,523 | 4,072,676 |

[1]UR Points are listed clockwise beginning at the southernmost point. If multiple points share the southernmost Northing coordinate, the easternmost point is listed as Point 1.

[2]UR Coordinate values presented herein were captured in North American Datum of 1983, and rounded to the nearest meter when necessary; due to that rounding, coordinates may not reflect the original precision of values contained within the source GIS data set.

**Boundary Applies to:** Surface

**Starting Depth:** 0 **Ending Depth:** 15

**Depth Unit:** Centimeters

**Survey Source:** GIS

## Administrative UR Requirements

**Administrative URs do not require onsite postings or other physical barriers, and they do not require periodic inspections or maintenance.**

### Site Controls:

This Administrative UR is recorded as described in **Section IV. Recordation Requirements** to restrict activities within the area defined by the coordinates listed above and depicted in the attached figure without prior notification of NDEP unless the activities are conducted under the provisions of 10 CFR, Part 835, Occupational Radiation Protection and 10 CFR, Part 851, Worker Safety and Health Program.

# U.S. Department of Energy, Environmental Management Nevada Program
# Use Restriction Information

## Section III. Supporting Documentation

### UR Source Document(s)

ROTC 2 for CAU 541 CADD/CR (DOE/NV--1539), dated 11/19/2019.

ROTC-1 for CAU 541 CADD/CR (DOE/NV--1539), dated 12/08/2016.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2016. Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada, Rev. 0, DOE/NV--1539. Las Vegas, NV.

### Attachments

- Administrative UR Boundary Map (UTM, Zone 11, NAD 83 meters)
- Supplemental Information Figure (UTM, Zone 11, NAD 83 meters)

## Section IV. Recordation Requirements

### Recordation:

The above UR(s) are recorded in the:

- FFACO Database
- NNSA M&O Contractor GIS
- USAF (Nellis Air Force Base Range Operations) GIS
- EM Nevada Program CAU/CAS Files

## Section V. EM Nevada Program Approval

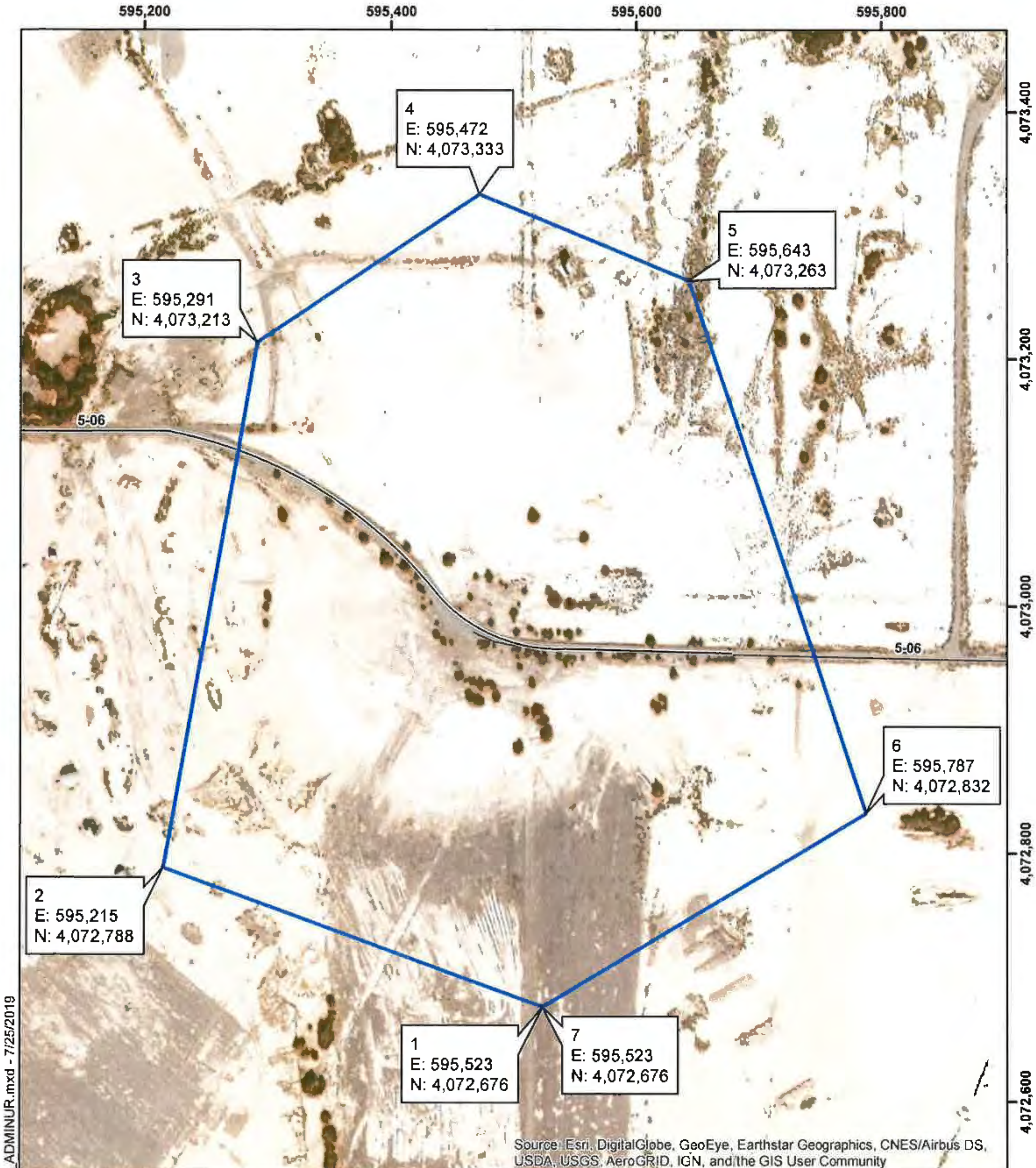
/s/ Tiffany Gamero

Date: 12/5/2019

Tiffany Gamero

Activity Lead

EM Nevada Program




H:\541\GPS\CAS05-23-04_ADMINUR.mxd - 7/25/2019

**CAU 541, CAS 05-23-04**
**Atmospheric Tests (6) - BFa Site**
**Administrative UR Boundary**

**Explanation**

- Administrative UR
- Light Duty Road
- Unimproved Road

0 40 80 160 Meters

0 125 250 500 Feet

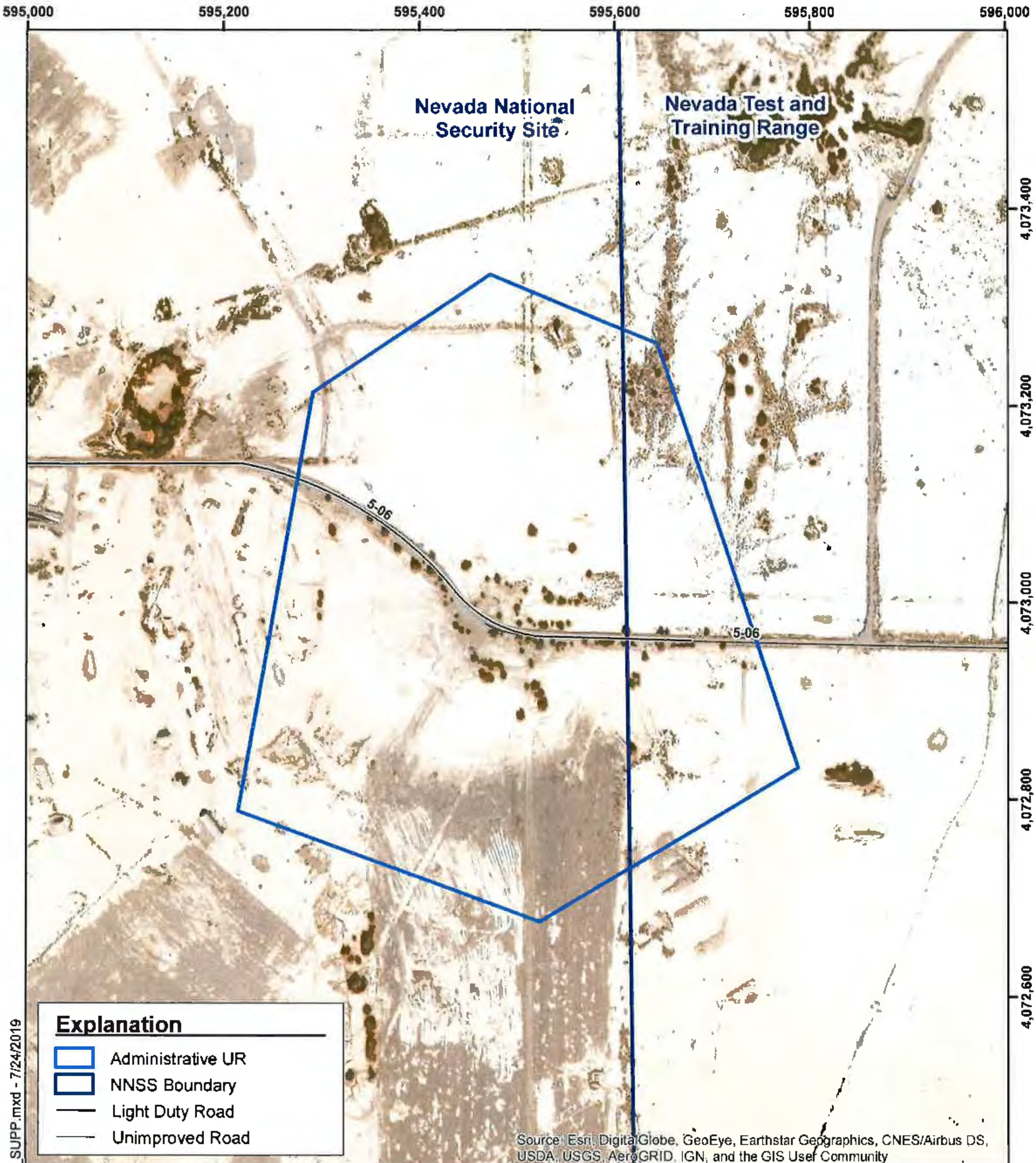
N

Source: Navarro GIS, 2019

Coordinate System: NAD 1983 UTM Zone 11N, Meter

## Supplemental Information Figure

The attached supplemental information figure(s) are included to capture site feature information that was available in previous iterations of this Use Restriction (UR) to prevent loss of that information.




H:\541\GPS\CAS05-23-04_SUPP.mxd - 7/24/2019

**CAU 541, CAS 05-23-04**
**Atmospheric Tests (6) - BFa Site**
**Administrative UR Boundary**

0 40 80 160 Meters

0 100 200 400 Feet

N

Source: Navarro GIS, 2019

NOTE: Size and location of features are approximated
Coordinate System: NAD 1983 UTM Zone 11N, Meter

# U.S. Department of Energy, Environmental Management Nevada Program
# Use Restriction Information

## General Information

| | |
|---|---|
| **Use Restriction (UR) Type(s):** | Administrative Only |
| **Corrective Action Unit (CAU) Number & Description:** | 541 - Small Boy |
| **Corrective Action Site (CAS) Number & Description:** | 05-45-03 - Atmospheric Test Site - Small Boy |
| **CAU/CAS Owner:** | Soils - ER |
| **Note:** | N/A |

## Section I. *Federal Facility Agreement and Consent Order* (FFACO) UR

*An FFACO UR is not identified for this site.*

## Section II. Administrative UR

### Basis for Administrative UR

**Summary Statement:** This Administrative UR is established to protect workers should future land use result in increased exposure to site contaminants. Radiological contaminants are present that exceed action levels under the Industrial Area (2,000 hours per year) exposure scenario.

# U.S. Department of Energy, Environmental Management Nevada Program
# Use Restriction Information

## Administrative UR Physical Description

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Boundary | UR Point[1] | Easting[2] | Northing[2] |
|---|---|---|---|
| Admin Boundary | 1 | 596,449 | 4,073,012 |
| | 2 | 596,006 | 4,073,339 |
| | 3 | 595,869 | 4,073,580 |
| | 4 | 596,426 | 4,074,121 |
| | 5 | 596,905 | 4,074,332 |
| | 6 | 597,200 | 4,074,257 |
| | 7 | 597,362 | 4,074,017 |
| | 8 | 596,856 | 4,073,261 |
| | 9 | 596,449 | 4,073,012 |

[1]UR Points are listed clockwise beginning at the southernmost point. If multiple points share the southernmost Northing coordinate, the easternmost point is listed as Point 1.

[2]UR Coordinate values presented herein were captured in North American Datum of 1983, and rounded to the nearest meter when necessary; due to that rounding, coordinates may not reflect the original precision of values contained within the source GIS data set.

**Boundary Applies to:** Surface

**Starting Depth:** 0 **Ending Depth:** 15

**Depth Unit:** Centimeters

**Survey Source:** GIS

## Administrative UR Requirements

**Administrative URs do not require onsite postings or other physical barriers, and they do not require periodic inspections or maintenance.**

### Site Controls:

This Administrative UR is recorded as described in **Section IV. Recordation Requirements** to restrict activities within the area defined by the coordinates listed above and depicted in the attached figure without prior notification of NDEP unless the activities are conducted under the provisions of 10 CFR, Part 835, Occupational Radiation Protection and 10 CFR, Part 851, Worker Safety and Health Program.

# U.S. Department of Energy, Environmental Management Nevada Program
# Use Restriction Information

## Section III. Supporting Documentation

### UR Source Document(s)

ROTC 2 for CAU 541 CADD/CR (DOE/NV--1539), dated 11/19/2019.

ROTC-1 for CAU 541 CADD/CR (DOE/NV--1539), dated 12/08/2016.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2016. Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada, Rev. 0, DOE/NV--1539. Las Vegas, NV.

### Attachments

- Administrative UR Boundary Map (UTM, Zone 11, NAD 83 meters)
- Supplemental Information Figure (UTM, Zone 11, NAD B3 meters)

## Section IV. Recordation Requirements

### Recordation:

The above UR(s) are recorded in the:

- FFACO Database
- NNSA M&O Contractor GIS
- USAF (Nellis Air Force Base Range Operations) GIS
- EM Nevada Program CAU/CAS Files

## Section V. EM Nevada Program Approval

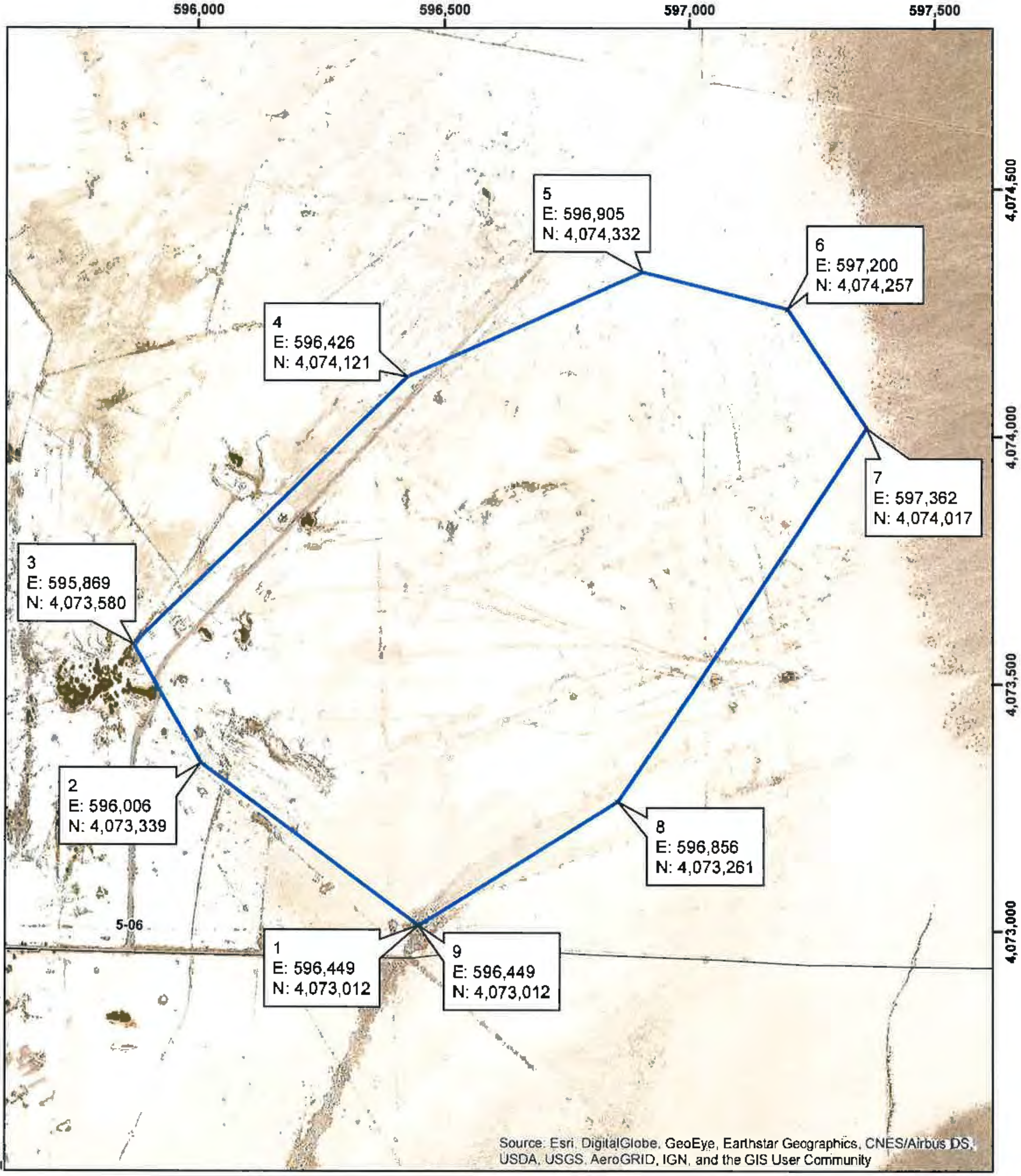
/s/ Tiffany Gamero

Date: 12/5/2019

Tiffany Gamero

Activity Lead

EM Nevada Program




**CAU 541, CAS 05-45-03**
**Atmospheric Test Site - Small Boy**
**Administrative UR Boundary**

**Explanation**

- Administrative UR
- Light Duty Road
- Unimproved Road

0 75 150 300 Meters

0 250 500 1,000 Feet

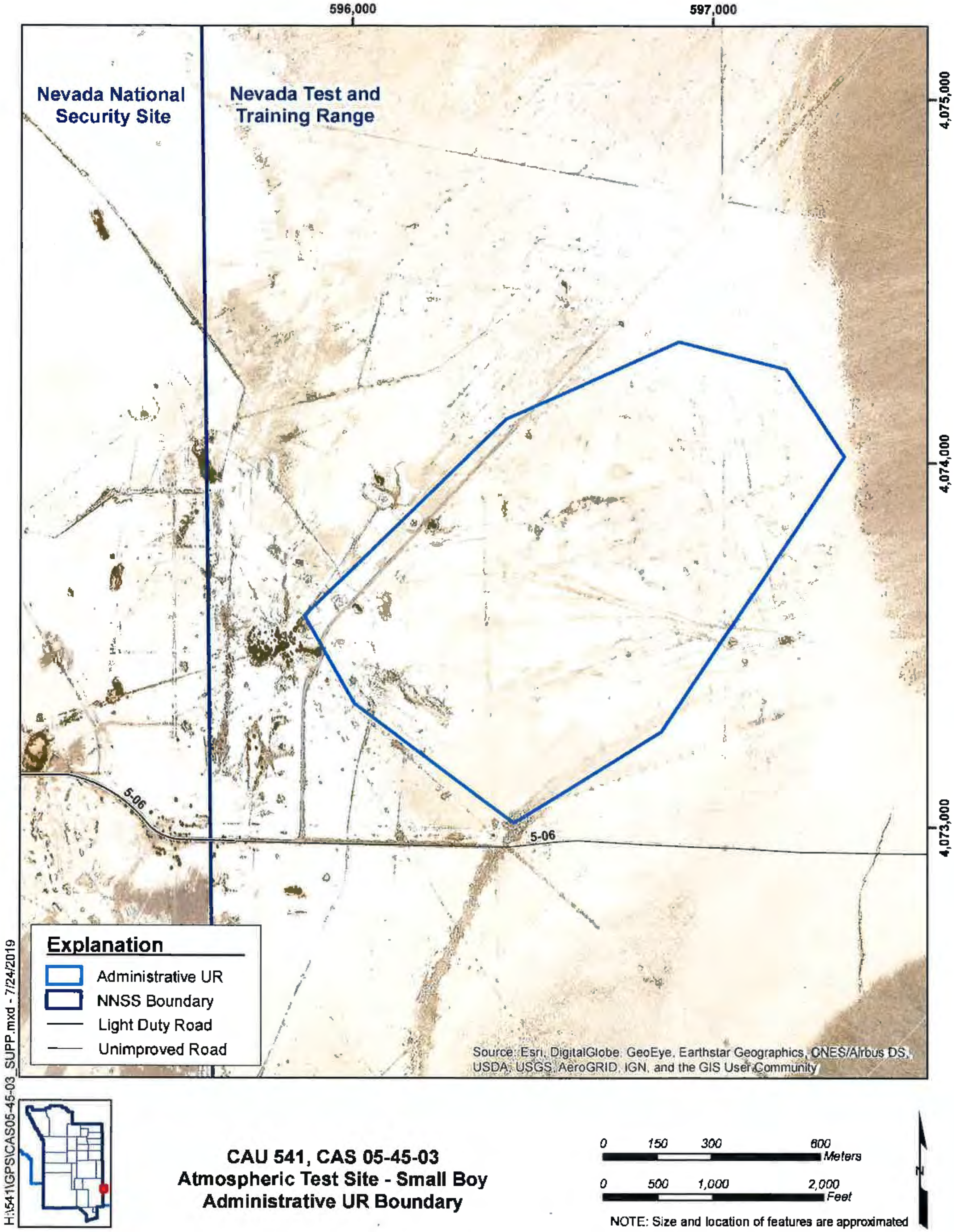
N

Source: Navarro GIS, 2019

Coordinate System: NAD 1983 UTM Zone 11N, Meter

## Supplemental Information Figure

The attached supplemental information figure(s) are included to capture site feature information that was available in previous iterations of this Use Restriction (UR) to prevent loss of that information.




Source: Navarro GIS, 2019

**CAU 541, CAS 05-45-03**
**Atmospheric Test Site - Small Boy**
**Administrative UR Boundary**

NOTE: Size and location of features are approximated
Coordinate System: NAD 1983 UTM Zone 11N, Meter

# RECORD OF TECHNICAL CHANGE

Technical Change No. DOE/NV--1539-ROTC-1 Page 1 of 7

Activity Name Soils - CAU 541, Small Boy Date 12/08/16

The following technical changes (including justification) are requested by:

| Lynn Kidman | Sr. Technical Advisor |
|---|---|
| (Name) | (Title) |

Description of Change:

Replaced Attachment D-1 Use Restrictions. The numerical values for the use restriction coordinates were changed in the UR tables and on the maps. The maps were replaced with color versions, a scale was added to the CAS 05-23-04 BFa UR map, and the CAS 05-45-03 Small Boy UR map was changed from landscape to portrait.

Justification:

The coordinates for the use restrictions were based on an incorrect projected coordinate system. The UR maps distributed with the CADD/CR, Rev 0 were in black and white. The scale was missing from the CAS 05-23-04 BFa UR map and the CAS 05-45-03 Small Boy UR map was landscape which was not consistent with other CAU UR maps that are portrait.

The task time will be **Unchanged** by approximately 0 days.

Applicable Activity-Specific Document(s):

Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada. Rev. 0, August 2016. DOE/NV--1539

| Approved By: | /s/ Tiffany A. Lantow<br>Activity Lead | Date 12/8/2016 |
|---|---|---|
| | /s/ Robert F. Boehlecke<br>EM Operations Manager | Date 12/12/16 |
| | /s/ Chris Andres<br>NDEP | Date 12/13/16 |

# Use Restriction Information

**CAU Number/Description:** CAU 541, Small Boy
**Applicable CAS Number/Description:** CAS 05-23-04, Atmospheric Tests (6) – BFa Site

**Contact (DOE AL/Activity):** NNSA Nevada Field Office Soils Activity Lead

**FFACO Use Restriction Physical Description:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| N/A | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**Depth:** N/A

**Survey Source (GPS, GIS, etc):** N/A

**Basis for FFACO UR(s):**

**Summary Statement:** N/A

**Contaminants Table:**

| Maximum Concentration of Contaminants for CAU 541<br>CAS 05-23-04, Atmospheric Tests (6) – BFa Site | | | |
|---|---|---|---|
| **Constituent** | **Maximum Concentration** | **Action Level** | **Units** |
| N/A | | | |
| | | | |
| | | | |
| | | | |

**Site Controls:** NA

**Administrative Use Restriction Physical Description*:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| Southeast | 4,072,832 | 595,787 |
| South | 4,072,676 | 595,523 |
| Southwest | 4,072,788 | 595,215 |
| Northwest | 4,073,213 | 595,291 |
| North | 4,073,333 | 595,472 |
| Northeast | 4,073,263 | 595,643 |

**Depth:** 6 inches bgs

**Survey Source (GPS, GIS, etc):** GIS

*Coordinates for the Administrative Use Restriction exclude the area defined by the FFACO Use Restriction coordinates.

Note: Effective upon acceptance of closure documents by NDEP

# Use Restriction Information

**Basis for Administrative UR(s)**:

**Summary Statement**: This administrative use restriction (UR) is to protect workers from receiving a dose exceeding 25 mrem/yr from contamination that is present at this site if current site usage were to increase in the future. Using the maximum calculated dose rate at this site, a worker could receive a 25-mrem dose in 437 hours of site exposure. The maximum concentration of any radionuclide detected in soil samples that could contribute more than 10 percent of the action level is presented in the contaminants table below. The analytical results and locations of all samples are presented in the CADD/CR for CAU 541.

**Contaminants Table:**

| **Maximum Concentration of Contaminants for CAU 541<br>CAS 05-23-04, Atmospheric Tests (6) – BFa Site** | | | |
|---|---|---|---|
| **Constituent** | **Maximum Concentration*** | **Action Level**** | **Units** |
| Cesium-137 | 13.3 | 81 | pCi/g |
| Europium-152 | 33.8 | 43 | pCi/g |
| | | | |
| | | | |

*Highest measured value
**Action level based on 25 mrem/yr under the Industrial Area scenario

**Site Controls:** New activities that would cause a site worker to be exposed to site radiological contamination for a period of more than that of current land use (defined above) are restricted within the area defined by the coordinates listed above and depicted in the attached figure without prior notification and approval of NDEP unless the activities are conducted under the provisions of 10 CFR Part 835. This administrative UR is recorded in the FFACO database, M&O Contractor GIS, USAF (Nellis Air Force Base Range Operations), and the NNSA/NFO CAU/CAS files. No physical site controls are required for this administrative UR.

**UR Maintenance Requirements (applies to both FFACO and Administrative UR(s) if Administrative UR exists):**

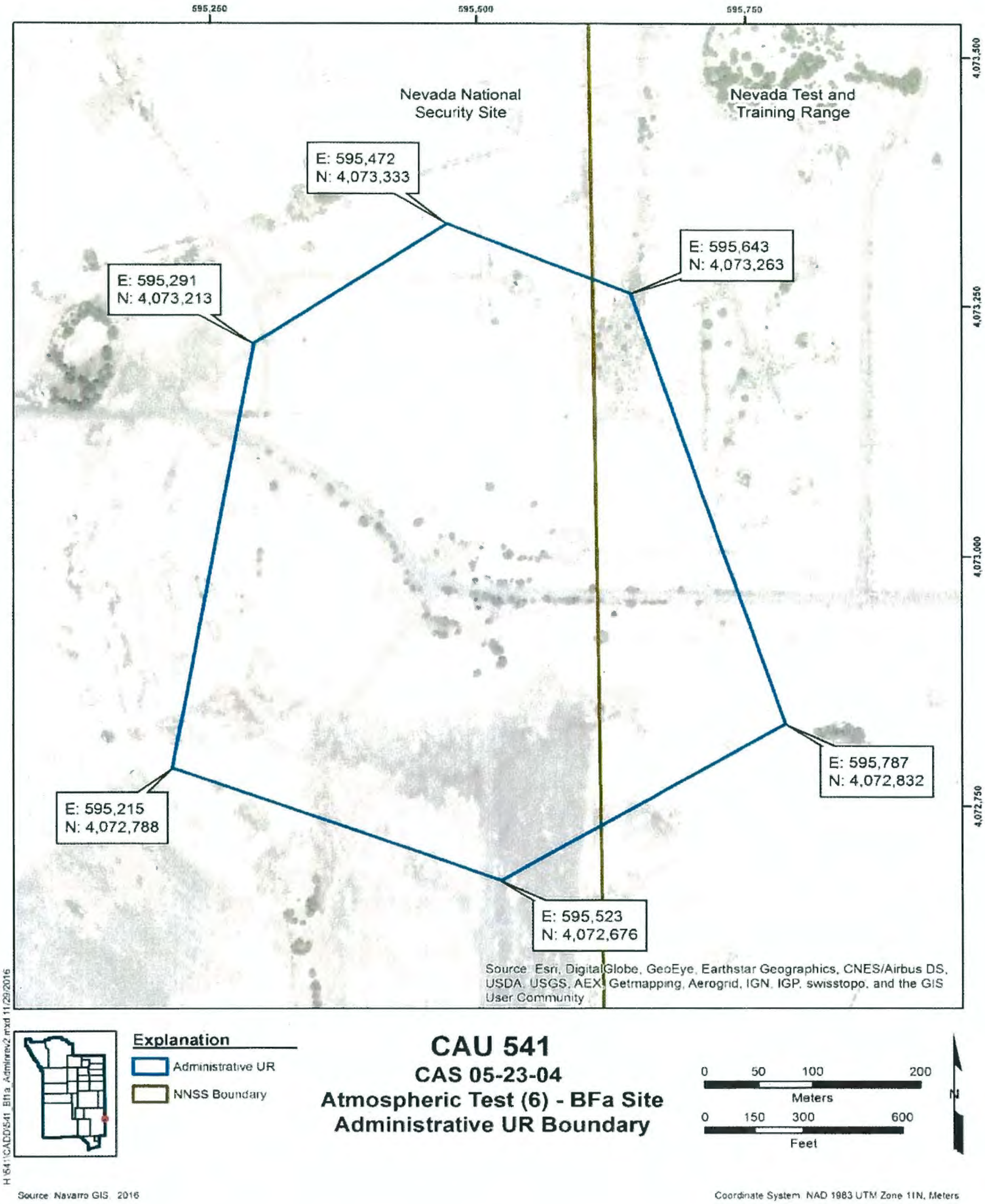
**Description:** No maintenance is required for this administrative use restriction.

**Inspection/Maintenance Frequency:** N/A

| |
|---|
| The future use of any land related to this Corrective Action Unit (CAU), as described by the above surveyed location, is restricted from any DOE or Air Force activity that may alter or modify the containment control as approved by the state and identified in the CAU CR or other CAU documentation unless appropriate concurrence is obtained in advance. |

**Comments:** None

**Submitted By:** /s/ Tiffany A. Lantow **Date:** 12/8/2014



595,250
595,500
595,750
4,073,500
4,073,250
4,073,000
4,072,750
Nevada National Security Site
Nevada Test and Training Range
E: 595,472
N: 4,073,333
E: 595,643
N: 4,073,263
E: 595,291
N: 4,073,213
E: 595,787
N: 4,072,832
E: 595,215
N: 4,072,788
E: 595,523
N: 4,072,676
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community
H:\541\CADD\541_Bf1a_Adminrev2.mxd 11/29/2016
Explanation
Administrative UR
NNSS Boundary
CAU 541
CAS 05-23-04
Atmospheric Test (6) - BFa Site
Administrative UR Boundary
0 50 100 200
Meters
0 150 300 600
Feet
N
Source: Navarro GIS, 2016
Coordinate System: NAD 1983 UTM Zone 11N, Meters

# Use Restriction Information

**CAU Number/Description:** CAU 541, Small Boy
**Applicable CAS Number/Description:** CAS 05-45-03, Atmospheric Test Site – Small Boy

**Contact (DOE AL/Activity):** NNSA Nevada Field Office Soils Activity Lead

**FFACO Use Restriction Physical Description:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| N/A | | |
| | | |

**Depth:** N/A

**Survey Source (GPS, GIS, etc):** N/A

**Basis for FFACO UR(s):**

**Summary Statement:** N/A

**Contaminants Table:**

| Maximum Concentration of Contaminants for CAU 541<br>CAS 05-45-03, Atmospheric Test Site – Small Boy | | | |
|---|---|---|---|
| **Constituent** | **Maximum Concentration** | **Action Level** | **Units** |
| N/A | | | |
| | | | |

**Site Controls:** N/A

**Administrative Use Restriction Physical Description*:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| Southeast | 4,073,261 | 596,856 |
| South | 4,073,012 | 596,449 |
| Southwest | 4,073,339 | 596,006 |
| West | 4,073,580 | 595,869 |
| Northwest | 4,074,121 | 596,426 |
| North | 4,074,332 | 596,905 |
| Northeast | 4,074,257 | 597,200 |
| East | 4,074,017 | 597,362 |

**Depth:** 6 inches bgs

**Survey Source (GPS, GIS, etc):** GIS

*Coordinates for the Administrative Use Restriction exclude the area defined by the FFACO Use Restriction coordinates.

Note: Effective upon acceptance of closure documents by NDEP

# Use Restriction Information

**Basis for Administrative UR(s)**:

**Summary Statement**: This administrative use restriction (UR) is to protect site workers from receiving a dose exceeding 25 mrem/yr from contamination that is present at this site if current site usage were to increase in the future. Using the maximum calculated dose rate at this site, a worker could receive a 25-mrem dose in 174 hours of site exposure. The maximum concentration of any radionuclide detected in soil samples that could contribute more than 10 percent of the action level is presented in the contaminants table below. The analytical results and locations of all samples are presented in the CADD/CR for CAU 541.

**Contaminants Table:**

| Maximum Concentration of Contaminants for CAU 541<br>CAS 05-45-03, Atmospheric Test Site – Small Boy | | | |
|---|---|---|---|
| **Constituent** | **Maximum Concentration*** | **Action Level**** | **Units** |
| Cesium-137 | 359 | 81 | pCi/g |
| Plutonium-239/240 | 8,265 | 4,120 | pCi/g |
| Americium-241 | 3,110 | 2,110 | pCi/g |
| | | | |

*Highest measured value

**Action level based on 25 mrem/yr under the Industrial Area scenario

**Site Controls:** New activities that would cause a site worker to be exposed to site radiological contamination for a period of more than that of current land use (defined above) are restricted within the area defined by the coordinates listed above and depicted in the attached figure without prior notification and approval of NDEP unless the activities are conducted under the provisions of 10 CFR Part 835. This administrative UR is recorded in the FFACO database, M&O Contractor GIS, USAF (Nellis Air Force Base Range Operations), and the NNSA/NFO CAU/CAS files. No physical site controls are required for this administrative UR.

**UR Maintenance Requirements (applies to both FFACO and Administrative UR(s) if Administrative UR exists):**

**Description:** No maintenance is required for this administrative use restriction.

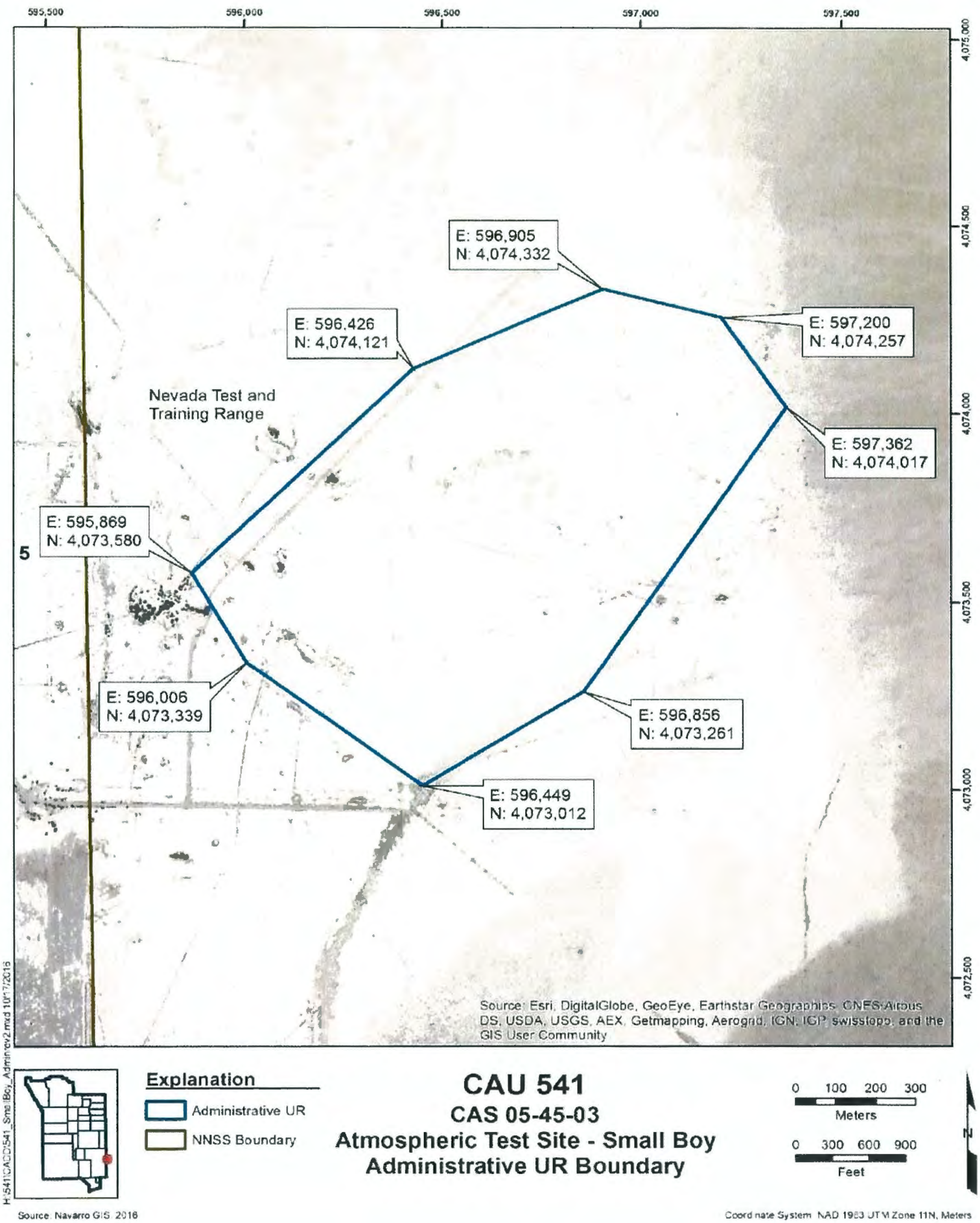
**Inspection/Maintenance Frequency:** N/A

The future use of any land related to this Corrective Action Unit (CAU), as described by the above surveyed location, is restricted from any DOE or Air Force activity that may alter or modify the containment control as approved by the state and identified in the CAU CR or other CAU documentation unless appropriate concurrence is obtained in advance.

**Comments:** None

**Submitted By:** /s/ Tiffany A. Lantow **Date:** 12/8/2016

# Use Restriction Information




Note: Effective upon acceptance of closure documents by NDEP

Nevada
Environmental
Management
Operations Activity

DOE/NV--1539

National Nuclear Security Administration

# Corrective Action Decision Document/ Closure Report for Corrective Action Unit 541: Small Boy Nevada National Security Site and Nevada Test and Training Range, Nevada

Controlled Copy No.: UNCONTROLLED
Revision No.: 0

August 2016

UNCLASSIFIED

/s/ Joseph P. Johnston 08/04/2016
Joseph P. Johnston, Navarro CO Date

Approved for public release; further dissemination unlimited.

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

Available for sale to the public from:

U.S. Department of Commerce
National Technical Information Service
5301 Shawnee Road
Alexandria, VA 22312
Telephone: 800.553.6847
Fax: 703.605.6900
E-mail: *orders@ntis.gov*
Online Ordering: *http://www.ntis.gov/help/ordermethods.aspx*

Available electronically at *http://www.osti.gov/bridge*

Available for a processing fee to U.S. Department of Energy and its contractors, in paper, from:

U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
Phone: 865.576.8401
Fax: 865.576.5728
Email: *reports@adonis.osti.gov*

DOE/NV--1539

# CORRECTIVE ACTION DECISION DOCUMENT/ CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 541: SMALL BOY NEVADA NATIONAL SECURITY SITE AND NEVADA TEST AND TRAINING RANGE, NEVADA

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

Controlled Copy No.: UNCONTROLLED

Revision No.: 0

August 2016

**CORRECTIVE ACTION DECISION DOCUMENT/CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 541: SMALL BOY NEVADA NATIONAL SECURITY SITE AND NEVADA TEST AND TRAINING RANGE, NEVADA**

Approved by: /s/ Tiffany A. Lantow Date: 08/02/2016

Tiffany A. Lantow
Soils Activity Lead

Approved by: /s/ Robert F. Boehlecke Date: 08/02/2016

Robert F. Boehlecke
Environmental Management Operations Manager

# *Table of Contents*

## ***Table of Contents*** *(Continued)*

## ***Table of Contents*** *(Continued)*

## *Table of Contents (Continued)*

## ***Table of Contents*** *(Continued)*

## List of Figures

## List of Tables

## List of Tables *(Continued)*

**Number** **Title** **Page**

## *List of Tables (Continued)*

## List of Acronyms and Abbreviations

| | |
|---|---|
| agl | Above ground level |
| ALM | Adult Lead Methodology |
| Am | Americium |
| ANPR | Advance Notice of Proposed Rulemaking |
| ASTM | ASTM International |
| bgs | Below ground surface |
| BMP | Best management practice |
| CAA | Corrective action alternative |
| CADD | Corrective action decision document |
| CAI | Corrective action investigation |
| CAIP | Corrective action investigation plan |
| CAS | Corrective action site |
| CAU | Corrective action unit |
| CFR | *Code of Federal Regulations* |
| cm | Centimeter |
| COC | Contaminant of concern |
| COPC | Contaminant of potential concern |
| cpm | Counts per minute |
| cps | Counts per second |
| CR | Closure report |
| Cs | Cesium |
| CSM | Conceptual site model |
| day/yr | Days per year |
| DNWR | Desert National Wildlife Refuge |
| DOE | U.S. Department of Energy |
| DQA | Data quality assessment |

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

| | |
|---|---|
| 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 |
| FSL | Field-screening level |
| FSR | Field-screening result |
| ft | Foot |
| gal | Gallon |
| g/day | Grams per day |
| GIS | Geographic Information Systems |
| GPS | Global Positioning System |
| GZ | Ground zero |
| HASL | Health and Safety Laboratory |
| HAZMAT | Hazardous materials |
| hr/day | Hours per day |
| hr/yr | Hours per year |
| in. | Inch |
| in./yr | Inches per year |
| kt | Kiloton |
| LCL | Lower confidence limit |
| LLW | Low-level waste |
| m | Meter |

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

| | |
|---|---|
| $m^2$ | Square meter |
| MDC | Minimum detectable concentration |
| MET | Military Effects Test |
| mg/kg | Milligrams per kilogram |
| MLLW | Mixed low-level waste |
| mm | Millimeter |
| M&O | Management and operating |
| MOB | Multiples of background |
| mrem | Millirem |
| mrem/GT-yr | Millirem per Ground Troops year |
| mrem/IA-yr | Millirem per Industrial Area year |
| mrem/OU-yr | Millirem per Occasional Use Area year |
| mrem/yr | Millirem per year |
| N/A | Not applicable |
| NAC | *Nevada Administrative Code* |
| NAD | North American Datum |
| NDEP | Nevada Division of Environmental Protection |
| NNSA/NFO | U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office |
| NNSS | Nevada National Security Site |
| NSTec | National Security Technologies, LLC |
| NTTR | Nevada Test and Training Range |
| OU | Occasional Use |
| PAL | Preliminary action level |
| PCB | Polychlorinated biphenyl |
| pCi/g | Picocuries per gram |
| PIC | Pressurized ion chamber |

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

| | |
|---|---|
| PPE | Personal protective equipment |
| PRG | Preliminary Remediation Goal |
| PSM | Potential source material |
| Pu | Plutonium |
| QA | Quality assurance |
| QAP | Quality Assurance Plan |
| QC | Quality control |
| $r^2$ | Coefficient of determination |
| RadCon | Radiological Control |
| RBCA | Risk-based corrective action |
| RCRA | *Resource Conservation and Recovery Act* |
| RfD | Reference dose |
| RMA | Radioactive material area |
| RRMG | Residual radioactive material guideline |
| RSL | Regional Screening Level |
| RWMC | Radioactive waste management complex |
| SCL | Sample collection log |
| Sr | Strontium |
| SVOC | Semivolatile organic compound |
| Tc | Technetium |
| TED | Total effective dose |
| TLD | Thermoluminescent dosimeter |
| TRS | Terrestrial radiological survey |
| U | Uranium |
| UCL | Upper confidence limit |
| UR | Use restriction |

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

| | |
|---|---|
| USAF | U.S. Air Force |
| UTM | Universal Transverse Mercator |
| VOC | Volatile organic compound |
| $yd^3$ | Cubic yard |

# Executive Summary

This Corrective Action Decision Document/Closure Report presents information supporting the closure of Corrective Action Unit (CAU) 541: Small Boy, Nevada National Security Site, Nevada. This 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 541 comprises the two corrective action sites (CASs) listed in Table ES-1.

**Table ES-1**
**CAU 541 CASs and Corrective Actions**

| CAS Number | CAS Description | Corrective Action |
|---|---|---|
| 05-23-04 | Atmospheric Tests (6) - BFa Site | No Further Action |
| 05-45-03 | Atmospheric Test Site - Small Boy | No Further Action |

The purpose of this Corrective Action Decision Document/Closure Report is to provide justification and documentation supporting the recommendation that no further corrective action is needed for CAU 541 based on the no further action alternative listed in Table ES-1.

Corrective action investigation (CAI) activities were performed from October 23, 2014, through September 28, 2015, as set forth in the *Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada*; and in accordance with the *Soils Activity Quality Assurance Plan*, which establishes requirements, technical planning, and general quality practices.

The approach for the CAI was to investigate and make data quality objective (DQO) decisions based on the types of releases present. To facilitate site investigation and DQO decisions, all identified releases (i.e., CAS components) were organized into study groups. The reporting of investigation results and the evaluation of DQO decisions are at the release level. The corrective action alternatives (CAAs) were evaluated and corrective actions applied at the FFACO CAS level.

The purpose of the CAI was to fulfill data needs as defined during the DQO process. The CAU 541 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 DQO data needs.

Investigation results were evaluated against final action levels (FALs) established in this document. A radiological dose FAL of 25 millirem per year was established based on the Occasional Use Area exposure scenario (80 hours of annual exposure). The DOE, National Nuclear Security Administration Nevada Field Office (NNSA/NFO), U.S. Air Force, and management and operating contractor responsible for the sites were consulted to determine that the maximum potentially exposed individual for any CAU 541 site is a military trainee. Although the PALs were based on a military ground troops exposure scenario, the FALs were developed in the CAU 541 risk assessment based on an exposure scenario consistent with a military trainee. Radiological doses do not exceed the FAL at any location at CAU 541; thus, corrective actions are not required for radioactivity. However, potential source material in the form of lead bricks was identified at CASs 05-23-04 and 05-45-03, a lead-acid battery at CAS 05-23-04, and several lead pieces at CAS 05-45-03 that are assumed to exceed the FAL and require corrective action. This potential source material was removed during the CAI under a corrective action.

The corrective actions implemented at CAU 541 were developed based on an evaluation of analytical data from the CAI and the detailed and comparative analysis of the CAAs. The CAAs were selected on technical merit focusing on performance, reliability, feasibility, safety, and cost. The implemented corrective actions meet all requirements for the technical components evaluated. The CAAs meet all applicable federal and state regulations for closure of the site. Based on the implementation of these corrective actions, NNSA/NFO provides the following recommendations:

- No further corrective actions are necessary for CAU 541.
- The Nevada Division of Environmental Protection issue a Notice of Completion to NNSA/NFO for closure of CAU 541.
- CAU 541 be moved from Appendix III to Appendix IV of the FFACO.

# 1.0 Introduction

This Corrective Action Decision Document (CADD)/Closure Report (CR) presents information supporting the closure of Corrective Action Unit (CAU) 541, Small Boy, located in the eastern portion of Area 5 of the Nevada National Security Site (NNSS), and the western edge of the Nevada Test and Training Range (NTTR) on Range 65C (formerly the Nellis Air Force Range), Nevada. CAU 541 comprises the two corrective action sites (CASs) shown on Figure 1-1 and listed below:

- 05-23-04, Atmospheric Tests (6) - BFa Site
- 05-45-03, Atmospheric Test Site - Small Boy

A detailed discussion of the history of this CAU is presented in the *Corrective Action Investigation Plan* (CAIP) *for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada* (NNSA/NFO, 2014a).

The release sources specific to CAU 541 are listed in Table 1-1. To facilitate site investigation and the evaluation of data quality objective (DQO) decisions for different releases, the reporting of investigation results and the evaluation of DQO decisions for different releases were organized into study groups. The study groups and the CASs associated with each release are described in Table 1-1. The needs for corrective action and corrective action alternatives (CAAs) are evaluated separately for each release that required corrective action. The meeting to decide DQOs was held in Las Vegas, Nevada, on April 1, 2014. Meetings to discuss and decide CAAs were held in Las Vegas, Nevada, on June 8, 2015, and in Washington, DC, on June 17, 2015. Subsequent CAA meetings were held on August 18 and 25, 2015, in Las Vegas, Nevada. Present at these meetings were representatives from the Nevada Division of Environmental Protection (NDEP); the U.S. Air Force (USAF); and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO).

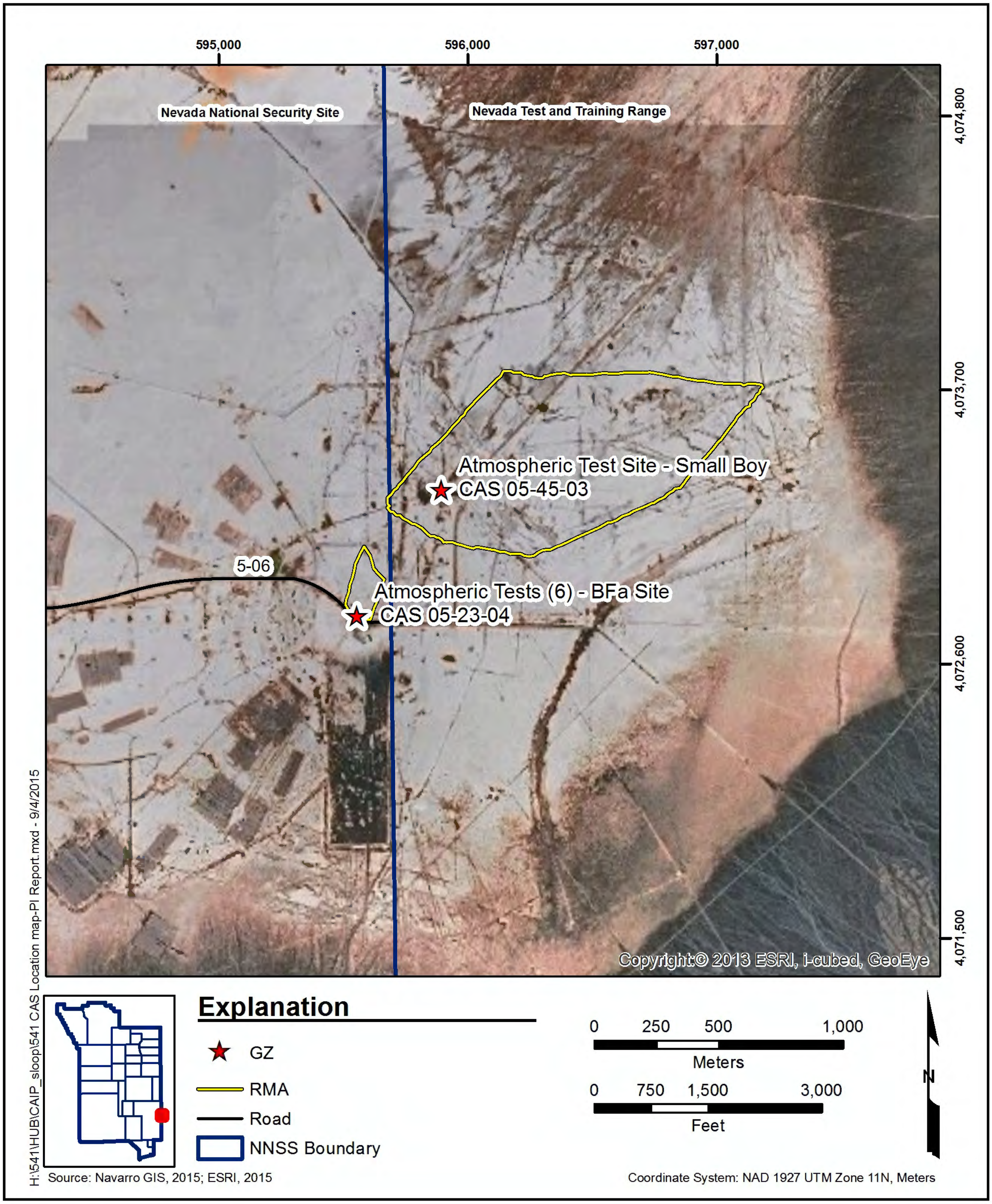



**Figure 1-1**
**CAU 541 CAS Location Map**

**Table 1-1**
**CAU 541 Releases with Associated CASs and Study Groups**

| Release | CAS Number | Study Group | Release Type |
|---|---|---|---|
| Weapons-effects and weapons-related atmospheric tests (BFa Site) | 05-23-04 | 1 | Surface release of radionuclides from atmospheric tests |
| Weapons-effects atmospheric test (Small Boy Site) | 05-45-03 | 2 | Surface release of radionuclides from an atmospheric tower test |
| Spills and Debris | 05-23-04 and 05-45-03 | 3 | Surface release of lead from battery and bricks |

The release sources specific to CAU 541 study groups are identified in the following text (DOE/NV, 2000):

***For Study Group 1 (BFa Site)***

- Encore was a weapons-effects test at the BFa Site as part of Operation Upshot-Knothole with a yield of 27 kilotons (kt). The test was an airdrop test performed on May 8, 1953. Encore was the first of six tests performed at this site.

- Grable was a weapons-related test at the BFa Site as part of Operation Upshot-Knothole with a yield of 15 kt. The airburst test fired from a 280-millimeter (mm) artillery gun was performed on May 25, 1953.

- The Military Effects Test (MET) was a weapons-effects test at the BFa Site as part of Operation Teapot. The test was performed on April 15, 1955, from a 400-foot (ft) tower with a yield of 22 kt.

- Priscilla was a weapons-related balloon test at the BFa Site as part of Operation Plumbbob. The test was performed on June 24, 1957, and conducted at 700 ft with a yield of 37 kt. The yield for Priscilla was the largest observed for CAU 541.

- Wrangell was a weapons-related test at the BFa Site as part of Operation Hardtack II with a yield of 115 tons. The balloon test was performed on October 22, 1958, from a height of 1,500 ft.

- Sanford was a weapons-related test at the BFa Site performed as part of Operation Hardtack II. The 4.9-kt balloon test was conducted on October 26, 1958, also from a height of 1,500 ft. Sanford was the last of six tests performed at this site.

- Radionuclide contaminants that were initially deposited onto the soil surface may have been subsequently displaced through erosion or mechanical disturbance of the soil. This potential release is located on the Frenchman Flat playa (dry) lake bed on the NNSS and NTTR. Slight depressions are observed at the immediate ground zero (GZ) area at the BFa Site that have been observed to collect water during wetter periods.

***For Study Group 2 (Small Boy Site)***

- Small Boy consisted of one test at the Small Boy site conducted on July 14, 1962. This weapons-effects test, as part of Operation Sunbeam, was a low-yield test conducted from a 10-ft tower on the NTTR. A potential release that is included and evaluated in the closure of CAU 541 includes the radiological anomaly located to the south of the Small Boy site as described in the CAU 541 CAIP, Section 2.4.2 (NNSA/NFO, 2014a).

- Radionuclide contaminants that were initially deposited onto the soil surface may have been subsequently displaced through erosion or mechanical disturbance of the soil. This potential release is located on the Frenchman Flat playa (dry) lake bed on the NNSS and NTTR. Slight depressions are observed at the immediate GZ area at the Small Boy site that have been observed to collect water during wetter periods.

***For Study Group 3 (Spills and Debris)***

- Other releases are present at CAU 541. Lead batteries and bricks were identified. There is the potential to find additional spills or debris that could provide a source for the release of contamination to the surface soils. Extensive testing facilities and debris remain from activities performed at the sites. Numerous concrete and steel structures, military fortifications (foxholes and bunkers), bridge/railroad infrastructure, domes, shelters, and diagnostic instrumentation locations remain at this site that could provide the source for a release of contamination. These items remained intact at the site as cultural resources identified as part of the Frenchman Flat Historic District.

The corrective actions described in this document were implemented in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; DOE, Environmental Management; U.S. Department of Defense; and DOE, Legacy Management.

## *1.1 Purpose*

The purpose of this CADD/CR is to provide documentation and justification that no further corrective action is needed for the closure of CAU 541 based on the implementation of corrective actions. This includes a description of investigation activities, an evaluation of the data, and a description of corrective actions that were performed. The CAIP (NNSA/NFO, 2014a) provides information relating to the scope and planning of the investigation. Therefore, that information will not be repeated in this document.

### *1.2 Scope*

The corrective action investigation (CAI) for CAU 541 was completed by demonstrating through environmental soil and thermoluminescent dosimeter (TLD) sample analytical results the nature and extent of contaminants of concern (COCs) at any study group. For radiological releases, a COC is defined as the presence of radionuclides that jointly present a dose to a receptor exceeding a final action level (FAL) of 25 millirem per year (mrem/yr). For chemical releases, a COC is defined as the presence of a contaminant above its corresponding FAL. The presence of a COC requires a corrective action. A corrective action is also required if a waste present within a release site contains a contaminant that, if released to soil, would cause the soil to contain a COC. Such a waste is considered to be potential source material (PSM) as defined in the *Soils Risk-Based Corrective Action* (RBCA) *Evaluation Process* document (NNSA/NFO, 2014b).

The activities used to identify, evaluate, and select preferred CAAs for CAU 541 included the following:

- Performed visual surveys to identify biasing factors for selecting soil and PSM sample locations.
- Performed radiological surveys to identify biasing factors for selecting soil and PSM sample locations.
- Established sample plot and biased sample locations.
- Collected soil samples at sample plot and biased sampling locations.
- Submitted soil samples for analysis.
- Staged TLDs at selected locations to include soil sample and background locations.
- Collected and submitted TLDs for analysis.
- Collected Global Positioning System (GPS) coordinates of sample locations, TLD locations, and points of interest.

- Performed corrective actions for the removal of PSM wastes.
- Conducted waste management activities (e.g., sampling, disposal).
- Evaluated corrective action objectives based on the results of the CAI and the CAA screening criteria.
- Justified and implemented CAAs.

The CAI activities were completed in accordance with the CAIP (NNSA/NFO, 2014a) except as noted in Appendix A and in accordance with 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 RBCA document (NNSA/NFO, 2014b).

The CAU 541 dose estimates were made using conservative estimates of site physical properties, contaminant properties, dose conversion properties, exposure paradigms, and exposure durations. While these multiple layers of conservatism result in projected doses that are higher than actual expected doses, they also provide protection against uncertainties that could result in making a false-negative decision error. Therefore, the dose estimates presented herein are intended to provide an upper boundary of the potential dose that a receptor could reasonably receive under the exposure scenarios defined in this document. They are not intended to predict the actual dose a receptor would receive from site contamination.

### 1.3 CADD/CR Contents

This document is divided into the following sections and appendices:

- Section 1.0, “Introduction,” summarizes the purpose, scope, and contents of this document.
- Section 2.0, “Corrective Action Investigation Summary,” summarizes the investigation field activities and the results of the investigation, and justifies that no further corrective action is needed.
- Section 3.0, “Recommendation,” provides the basis for requesting that the CAU be moved from Appendix III to Appendix IV of the FFACO.

- Section 4.0, “References,” provides a list of all referenced documents used in the preparation of this CADD/CR.
- Appendix A, *Corrective Action Investigation Results*, provides a description of the CAU 541 objectives, field investigation and sampling activities, investigation results, waste management, and quality assurance (QA).
- Appendix B, *Data Assessment*, provides a data quality assessment (DQA) that reconciles DQO assumptions and requirements to the investigation results.
- Appendix C, *Risk Assessment*, provides documentation of the chemical and radiological RBCA processes as applied to CAU 541.
- Appendix D, *Closure Activity Summary*, provides details on the completed closure activities, and includes the required verification activities and supporting documentation.
- Appendix E, *Evaluation of Corrective Action Alternatives*, provides a discussion of the results of the CAI, the alternatives considered, and the rationale for the selected alternative.
- Appendix F, *Sample Location Coordinates*, presents the CAI sample location coordinates.
- Appendix G, *Pressurized Ion Chamber External Dose Measurement,* presents specific informational data requested by USAF.
- Appendix H, *Nevada Division of Environmental Protection Comments*, contains NDEP comments on the draft version of this document.
- Appendix I, *USAF Letter,* presents the letter from USAF regarding land use changes at CAU 541.

### 1.3.1 Applicable Programmatic Plans and Documents

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

- CAIP for CAU 541, Small Boy (NNSA/NFO, 2014a)
- Soils QAP (NNSA/NSO, 2012)
- Soils RBCA document (NNSA/NFO, 2014b)
- FFACO (1996, as amended)

### *1.3.2 Data Quality Assessment Summary*

The CAIP (NNSA/NFO, 2014a) contains the DQOs as agreed to by decision makers before the field investigation. The DQO process ensures that the right type, quality, and quantity of data will be available to support the resolution of those decisions with an appropriate level of confidence. A 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 Appendix B and summarized in Section 2.2.2. Using both the DQO and DQA processes helps to ensure that DQO decisions are sound and defensible.

Based on this evaluation, the nature and extent of COCs at CAU 541 have been adequately identified to implement the corrective actions. 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 Corrective Action Investigation Summary

The following subsections summarize the investigation activities and investigation results, and justify why no further corrective action is required at CAU 541. Detailed investigation activities and results for individual CAU 541 study groups are presented in Appendix A of this document.

## 2.1 Investigation Activities

CAI activities were conducted from October 23, 2014, through September 28, 2015. The purpose of the CAI was to provide the additional information needed to resolve the following CAU 541-specific DQOs:

- Determine whether COCs are present in the soils associated with CAU 541.
- Determine the extent of identified COCs.
- Ensure that adequate data have been collected to evaluate closure alternatives under the FFACO.

The field investigation was completed as specified in the CAIP as described in Section A.2.0, which provides the general investigation and evaluation methodologies.

Data to calculate radiological dose were provided by the analytical results of TLD samples for external radiological dose and soil samples for the calculation of internal radiological dose. Data to evaluate chemical risk were provided by analytical results of soil samples.

The DQO Decision I (the presence of a COC) and Decision II (the extent of COC contamination) were resolved for radiological release sites by the collection of soil and TLD samples. DQO Decision I and II for PSM were resolved by the visual identification of PSM in the form of metallic lead debris. DQO Decision II was resolved as the physical extent of the debris that was verified by soil samples following the removal of the PSM.

For DQO Decision I, sample locations were established judgmentally based on the presence of biasing factors (e.g., lead bricks and 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 would receive from working at the release site. Where 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.

Sample locations for DQO Decision II (the extent of COC contamination) for radiological COCs were selected judgmentally at locations estimated to provide a range of dose values from the highest dose to a level below the FAL. The extent of radiological COC contamination was defined as a boundary that encompasses radiation survey isopleths with a value that corresponds to a total effective dose (TED) of 25 mrem/yr. To accomplish this, the relationship between TED (the sum of internal and external dose) and radiation survey values is estimated from a simple linear regression of paired calculated TED and radiation survey values for each sample location. Then the radiation survey value that corresponds to 25 mrem/yr is calculated from the regression equation. Confidence in estimating the extent of Decision II was provided by a more conservative estimate of the radiation survey value corresponding to 25 mrem/yr. This is accomplished using the uncertainty of how well the calculated relationship between TED and radiation survey values (i.e., the regression) represents the assumed true relationship. This uncertainty includes the uncertainty of how well the calculated TED represents true TED and the uncertainty of how well the radiation survey instrument readings represent the calculated TED. This combined uncertainty was estimated using an uncertainty interval as defined in the *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance* (EPA, 2009a). This process for using regression uncertainty in establishing a conservative estimate of the extent of COC contamination is presented in the Soils RBCA document (NNSA/NFO, 2014b).

The calculated 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, 2015) as the sum of the effective dose (for external exposures) and the committed effective dose (for internal exposures).

As described in Appendix C, the TED 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. Therefore, TED is reported in this document based on the following three exposure scenarios that address the potential exposure of industrial workers to contaminants in soil:

- **Industrial Area.** Assumes continuous industrial use of a site. This scenario assumes that this is the regular assigned work area for the worker who will be on the site for an entire career (8 hours per day [hr/day], 250 days per year [day/yr] for 25 years). The TED values calculated using this exposure scenario are the TED an industrial area worker receives during 2,000 hours of annual exposure to site radioactivity and are expressed in terms of millirem per Industrial Area year (mrem/IA-yr).

- **Ground Troops.** Assumes noncontinuous work activities at a site. This site-specific exposure scenario addresses exposure of military ground troops who are not assigned to the area as a regular worksite but would regularly visit for 24 hr/day, 14 days per deployment, for 3 deployments per year (1,008 hours per year [hr/yr]). The TED calculated using this scenario is the TED a military ground troop receives during 1,008 hours of annual exposure to site radioactivity and is expressed in terms of millirem per Ground Troops year (mrem/GT-yr).

- **Occasional Use Area.** Assumes occasional work activities at a site. This scenario addresses industrial workers who are not assigned to the area as a regular worksite but may occasionally use the site. This scenario assumes that this is an area where the worker does not regularly visit but may occasionally use for short-term activities. A site worker under this scenario is assumed to be on the site for an equivalent of 80 hr/yr (or 8 hr/day for 10 day/yr) for 5 years. The TED values calculated using this exposure scenario are the TED an occasional use worker receives during 80 hours of annual exposure to site radioactivity and are expressed in terms of millirem per Occasional Use Area year (mrem/OU-yr).

In accordance with the graded approach described in the Soils 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 are classified as decisional and will be used to make corrective action decisions. Survey data are classified as decision supporting and are not used, by themselves, to make corrective action decisions. As presented in Appendix C, the radiological FALs are based on the Occasional Use Area exposure scenario for both the BFa Site and Small Boy.

The following subsections describe specific investigation activities conducted at each study group. Additional information regarding the investigation is presented in Appendix A.

### *2.1.1 Study Group 1, BFa Site*

Investigation activities at Study Group 1, BFa Site included performing visual inspections, conducting GPS-assisted terrestrial radiological surveys (TRSs), staging TLDs, and collecting surface soil samples (see Figure A.3-2). During the visual inspections, no biasing factors were identified. The TRSs were conducted over the area surrounding GZ to identify locations of elevated radiological readings that would indicate the locations of the fallout plume. The results of the TRS (see Figure A.3-1) showed that the highest gamma radiation readings corresponded to locations near GZ and confirmed that the relatively concentric fallout plume was positioned as expected. One 100-square-meter ($m^2$) sample plot (location A01a) was then established at the area containing the highest anomalous readings as detected during the TRSs (see Figure A.3-2). Soil sampling to determine internal dose at this sample plot consisted of the collection of composite surface soil samples from nine unbiased locations. TLDs were installed at 38 locations along three vectors within Study Group 1 to measure external radiological doses.

Radionuclide contaminants that were initially deposited onto the soil surface, and that may have subsequently been displaced through erosion or mechanical disturbance, were investigated for buried contamination. Field screening at depth and soil sampling were performed at two locations (A01a and A02a) at the BFa Site. Location A01a was selected as this is the location of the highest elevated radiological readings in the area, and A02a was selected at a slight depression at the immediate GZ area that has been observed to collect water in wetter periods. Screening of the soil to a depth of 30 centimeters (cm) did not show the presence of buried contamination, as discussed in Section A.2.2.2. A surface grab sample was collected at both locations as part of the investigation. See Section A.3.1 for additional information on investigation activities at the Study Group 1, BFa Site. Results of the sampling effort are reported in Section 2.2.

The CSM and associated discussion for this study group are provided in the CAIP (NNSA/NFO, 2014a). The contamination pattern of the radionuclides at the Study Group 1, BFa Site is consistent with the CSM in that the radiological contamination is greatest at the release point (GZ) and generally decreases with distance in a general concentric pattern from the release point. No modification to the CSM was warranted as information gathered during the CAI supported and validated the CSM as presented in the CAIP.

### *2.1.2 Study Group 2, Small Boy Site*

Investigation activities at Study Group 2, Small Boy Site included performing visual inspections, conducting GPS-assisted TRSs, staging TLDs, and collecting soil samples within the detected radiological plume and the radiological anomaly to the south (see Figure A.4-2). The TRSs were conducted over the entire area surrounding GZ to include the area to the northeast and the southern anomalous area. The TRSs were performed to identify locations of elevated radiological readings that would indicate the locations of the fallout plume. The results of the TRS (see Figure A.4-1) showed that the highest gamma radiation readings correspond to locations to the northeast of GZ. The TRS confirmed that the radionuclides released from the Small Boy test were distributed in a defined, but irregular, pattern of surface contamination. This pattern extends from GZ toward the northeast generally decreasing in concentration with increased distance from the release location. Although generally decreasing in concentration, the pattern is irregular and not concentric.

Soil sampling activities to determine internal dose were collected at sample plots and at grab sample locations (see Figure A.4-2). Two 100-$m^2$ sample plots (B01 and B02) were then established at the area containing the highest anomalous readings as detected during the TRSs, one each for the Small Boy site (location B02) and the radiological anomaly to the south (location B01). Six other sample plots at various locations and 12 grab samples were also collected. Sampling at plot locations consisted of the collection of composite surface soil samples from nine unbiased locations within each sample plot. Grab samples were collected at 12 locations within the plume to measure internal dose, and TLDs were placed in conjunction to measure external radiological dose.

Radionuclide contaminants that were initially deposited onto the soil surface, and that may have subsequently been displaced through erosion or migration, were investigated for buried contamination. Field screening at depth and soil sampling were performed at two locations (B01 and B03) at the Small Boy site and the anomalous area to the south. One location at the Small Boy site (B03) was selected at a slight depression at the immediate GZ area that has been observed to collect water in wetter periods. The other location was selected at the anomalous radiologically elevated area to the south (B01). Screening of the soil to a depth of 30 cm at each site was performed as discussed in Section A.2.2.2. Surface soil samples were collected at each of the two locations and at the 5 to

10 cm depth at the B03 location. Additional information on investigation activities at Study Group 2 is provided in Section A.4.1. Results of the sampling effort are reported in Section 2.2.

The CSM and associated discussion for this study group are provided in the CAIP (NNSA/NFO, 2014a). The contamination pattern of the radionuclides measured at Study Group 2 is consistent with the CSM. No modification to the CSM was warranted, as information gathered during the CAI supported and validated the CSM as presented in the CAIP.

### 2.1.3 Study Group 3, Spills and Debris

Investigation activities at Study Group 3, Spills and Debris included performing visual inspections, collecting surface soil samples, and removing selected debris. Lead bricks, lead pieces, and the remains of a breached lead-acid battery were identified as PSM and removed at the time of the CAI, as the nature and extent of the release was apparent and removal could be readily performed.

Visual inspections identified four locations (C01 through C04) where PSM was present (see Figure A.5-1). The PSM identified as metallic lead was completely removed under a corrective action. Any contamination potentially remaining was evaluated by collecting verification samples from the immediate area of each located item. A 4-$m^2$ sample area (2 by 2 meters [m]) was established for each of the PSM locations. Sampling at each location consisted of the collection of a composite surface soil sample from nine unbiased locations within each sample area that was submitted for laboratory analysis. Results of these samples demonstrated that no COCs remain. See Section A.5.1 for additional information on investigation activities at Study Group 2. Results of the sampling effort are reported in Section 2.2.

The CSM and associated discussion for this study group are provided in the CAIP (NNSA/NFO, 2014a). The contamination pattern of the radionuclides measured at Study Group 3 is consistent with the CSM. No modification to the CSM was warranted, as information gathered during the CAI supported and validated the CSM as presented in the CAIP.

## 2.2 Results

The data summary provided in Section 2.2.1 defines the COCs identified at CAU 541. Section 2.2.2 summarizes the assessment made in Appendix B, which demonstrates that the investigation results satisfy the DQO data requirements.

The preliminary action levels (PALs) and FALs 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 541 release. As such, it is dependent upon the cumulative annual hours of exposure to site contamination. The PALs for radioactivity were established in the CAIP (NNSA/NFO, 2014a) based on a dose limit of 25 mrem/yr over an annual exposure time of 1,008 hours (i.e., the Ground Troops scenario that a military ground troop or site worker would be exposed to site contamination 24 hr/day with 14 days per deployment for 3 deployments per year with 100 percent of time spent outdoors). In terms of exposure duration, the Ground Troops scenario at 1,008 hr/yr falls between the Industrial Area (2,000 hr/yr) and Remote Worker (336 hr/yr) land use scenarios used on the NNSS Soils Activity sites. However, the TED for the Remote Worker scenario is not addressed in this report.

As a result of discussions with the stakeholders during the CAA meeting (Section 1.0), the most exposed individuals at both sites were more appropriately determined to be site workers at approximately 10 to 20 hr/yr as opposed to ground troops at 1,008 hr/yr. As a result, the FALs for radioactivity were established in Appendix C based on the Occasional Use Area exposure scenario dose limit of 25 mrem/yr over an annual exposure time of 80 hours.

To be comparable to these action levels, the CAU 541 investigation results are presented in terms of the dose a receptor would receive from site contamination under the Industrial Area (mrem/IA-yr), Ground Troops (mrem/GT-yr), and Occasional Use Area (mrem/OU-yr) exposure scenarios.

The chemical PALs are based on the U.S. Environmental Protection Agency (EPA) Region 9 Regional Screening Levels (RSLs) for chemical contaminants in industrial soils (EPA, 2015) except where natural background concentrations of *Resource Conservation and Recovery Act* (RCRA) metal exceed the screening level (e.g., arsenic on the NNSS). With the exception of lead, the chemical FALs were established in Appendix C at the PAL concentrations.

### 2.2.1 Summary of Analytical Data

The following subsections present a summary of the analytical and computational results for soil and TLD samples at Study Groups 1 through 3. All sampling and analyses were conducted as specified in the CAIP (NNSA/NFO, 2014a). Results that are equal to or greater than the FAL are identified by bold text in the data tables.

Chemical results are reported as individual analytical results compared to their individual FALs. PSM samples are evaluated against the PSM criteria and assumptions defined in Section 2.3 to determine whether a release of the waste to the surrounding environmental media could cause the presence of a COC in the environmental media. Radiological results are reported as doses that are comparable to the dose-based FAL of 25 mrem/OU-yr as established in Appendix C. Calculation of the TED for each sample was accomplished through summation of internal and external dose as described in Sections A.3.3.3 and A.4.3.3.

Judgmental sample results are reported as individual analytical results and as multiple contaminant analyses where the combined effect of contaminants are compared to FALs. Probabilistic sample results are reported as the average and the 95 percent UCL of the average results.

#### 2.2.1.1 Study Group 1

Based on the results of TLD and surface soil samples (0 to 5 cm below ground surface [bgs]) collected at Study Group 1, BFa Site (see Figure A.3-3), radiological contamination does not exceed the FAL at any location. The average and the 95 percent UCL TED values for the Industrial Use, Ground Troops, and Occasional Use exposure scenarios for all sample locations are presented in Table A.3-8.

#### 2.2.1.2 Study Group 2

Based on the results of TLD and surface soil samples (0 to 5 cm bgs) collected at Study Group 2, Small Boy Site (see Figure A.4-3), radiological contamination exceeds the FAL at no location. The average and the 95 percent UCL TED values for the Industrial Use, Ground Troops, and Occasional Use exposure scenarios for all sample locations are presented in Table A.4-8.

#### 2.2.1.3 Study Group 3

It is assumed that lead contamination at the location of the lead bricks, pieces, and battery exceed the FALs. Therefore, a corrective action is required. A corrective action of removal of the lead material was completed during the CAI, and verification samples were collected. The sample locations are shown in Figure A.5-1. The analytical results of soil samples collected after corrective action are presented in Table A.5-3. Contamination in the remaining soil was below FALs and required no further corrective action.

### 2.2.2 Data Assessment Summary

The DQA is presented in Appendix B and includes an evaluation of the data quality indicators (DQIs) to determine the degree of acceptability and usability of the reported data in the decision-making process. The DQO process defines the type, quality, and quantity of data needed to support the resolution of DQO decisions at an appropriate level of confidence. Using both the DQO and DQA processes help to ensure that DQO decisions are sound and defensible.

The DQA process is composed of the following steps:

1. Review DQOs and Sampling Design.
2. Conduct a Preliminary Data Review.
3. Select the Test.
4. Verify the Assumptions.
5. Draw Conclusions from the Data.

The results of the DQI evaluation show that data quality issues were identified for the accuracy of two analytes. However, these deficiencies do not affect the decision-making process.

The results of the DQI evaluation in Appendix B show that all DQI criteria were met and that the CAU 541 dataset supports their intended use in the decision-making process. Based on the results of the DQA, the nature and extent of COCs at CAU 541 have been adequately identified to develop and evaluate CAAs. The DQA also determined that information generated during the investigation supports the CSM assumptions, and the data collected met the DQOs.

## 2.3 Justification for No Further Action

No further corrective action is needed for the CASs within CAU 541 based on the absence of contamination exceeding risk-based levels (presented in Section 2.3.1) or the implementation of the corrective actions based on an evaluation of risk, feasibility, and cost-effectiveness (presented in Appendix E). The need for corrective action is evaluated for each release through the resolution of the DQO decisions as presented in Section 2.3.2. The implementation of corrective actions at CAU 541 ensures protection of the public and the environment in accordance with *Nevada Administrative Code* (NAC) 445A (NAC, 2014a).

### 2.3.1 Final Action Levels

The RBCA process used to establish FALs is described in the Soils RBCA document (NNSA/NFO, 2014b). This process conforms with NAC 445A.227, which lists the requirements for sites with soil contamination (NAC, 2014b). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2014c) 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.

This RBCA process defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses. These tiers are defined in Appendix C.

A Tier 1 evaluation was conducted for all detected contaminants to determine whether contaminant levels satisfy the criteria for a quick regulatory closure or warrant a more site-specific assessment. For chemical contaminants, this was accomplished by comparing individual source area contaminant concentration results to the Tier 1 action levels (the PALs established in the CAIP). For radiological contaminants, this was accomplished by comparing the radiological PAL of 25 mrem/GT-yr to the TED at each sample location calculated using the Ground Troops exposure scenario. It was determined in the CAU 541 DQOs and documented in the CAIP (NNSA/NFO, 2014a) that the Ground Troops exposure scenario was appropriate for calculating receptor exposure over time and was the basis for the Tier 1 radiological action level. Contaminants detected at CAU 541 that exceeded Tier I actions levels were radionuclides and chemical contaminants (lead) at both the Study Group 1, BFa Site and the Study Group 2, Small Boy Site.

The Tier 2 evaluation was conducted in accordance with the Soils RBCA document (NNSA/NFO, 2014b). This evaluation (presented in Appendix C) was based on risk to receptors. The risk to receptors from contaminants at CAU 541 is due to chronic exposure to contaminants (e.g., receiving a dose over time). Therefore, the risk to a receptor is directly related to the amount of time a receptor is exposed to the contaminants.

In order to quantify the maximum number of hours a site worker may be present at CAU 541, current and anticipated future site activities were evaluated in the risk evaluation (see Appendix C) as part of the Tier 2 evaluation. This was based on a review of the current and projected use of CAU 541 sites by stakeholders at the CAA meeting where it was determined that workers may be present at these sites for only a limited number of hours per year and not on an extended basis as defined by the Ground Troops exposure scenario (1,008 hrs). The stakeholders concluded that site workers, with the potential to be present at the site for up to 40 hr/yr, would most likely receive the greatest extent of exposure. As a result, it was determined in the risk evaluation that the most exposed individual could not be exposed to site contaminants for more time than is assumed under the Occasional Use (OU) exposure scenario (80 hr/yr). Therefore, TEDs at each location were calculated using the OU exposure scenario and the 95 percent UCL of the TED compared to the FAL. Additional details of the Tier 1 and 2 evaluation for radionuclides are provided in Appendix C.

A Tier 2 evaluation for lead compared the analytical results to the Tier 2 action levels. The Tier 2 action level was calculated using EPA's Adult Lead Methodology (ALM) to estimate the concentration of lead in the blood of pregnant women and their developing fetuses who might be exposed to lead-contaminated soils (EPA, 2009b). This calculation used a site-specific soil ingestion rate (of 0.0667 grams per day [g/day]) and an exposure frequency of 44 day/yr. The FAL for lead established in Appendix C using this methodology is 5,739 milligrams per kilogram (mg/kg).

The FALs for all CAU 541 contaminants of potential concern (COPCs) are shown in Table 2-1.

**Table 2-1**
**Definition of FALs for CAU 541 COPCs**

| COPCs | Tier 1 Based FALs | Tier 2 Based FALs | Tier 3 Based FALs |
|---|---|---|---|
| VOCs | PALs | None | N/A |
| SVOCs | PALs | None | N/A |
| RCRA Metals | PALs | None | N/A |
| Lead | PALs | 5,739 mg/kg | N/A |
| Radionuclides (BFa Site) | PALs | 25 mrem/OU-yr | N/A |
| Radionuclides (Small Boy) | PALs | 25 mrem/OU-yr | N/A |

N/A = Not applicable
SVOC = Semivolatile organic compound
VOC = Volatile organic compound

A corrective action may also be required if a waste present within a CAS contains contaminants that, if released, could cause the surrounding environmental media to contain a COC. Such a waste would be considered PSM. To evaluate wastes for the potential to result in the introduction of a COC to the surrounding environmental media, the conservative assumption is made that any physical waste containment will fail at some point and the contaminants will be released to the surrounding media. The criteria to be used for determining whether a waste is PSM are defined in the Soils RBCA document (NNSA/NFO, 2014b).

### 2.3.2 Resolution of DQO Decisions

The following subsections compare the results presented in Section 2.2 to the FALs presented in Section 2.3.1 for the resolution of DQO decisions and the need for corrective action.

#### 2.3.2.1 Study Group 1, BFa Site Resolution of DQO Decisions

***Decision I***

Decision I was evaluated by measuring TED within a sample plot (location A01a) established within the area of the highest radiological values as determined from the PRM-470 TRS (see Figure A.3-3) and by an investigation of the soil at depth. Based on analytical results for the TLD and soil sample collected at the BFa Site during the investigation of Study Group 1 (see Section A.3.0), no radiological COCs were identified at any sample location. In addition, an investigation for buried contamination (locations A01a and A02a) was performed as radionuclide contaminants that were initially deposited onto the soil surface may have been displaced through erosion or mechanical disturbance. Soil samples and field screening at depth also confirmed that no COC contamination was found. Therefore, Decision I is resolved, and no corrective action is needed.

***Decision II***

As Decision I resulted in the determination that COCs are not present for the radiological release, Decision II does not need resolution.

TLDs were placed in a vector pattern originating from GZ within the areas of highest radiological readings as determined via TRSs. Radiological surveys using a PRM-470 and the field instrument for the detection of low-energy radiation (FIDLER) were conducted over the study area to aid in the selection of vector placement (see Figure A.3-2).

#### 2.3.2.2 Study Group 2, Small Boy Site Resolution of DQO Decisions

***Decision I***

Decision I was resolved by measuring TED within a sample plot established within the areas of the highest radiological values at Study Group 2, Small Boy Site (location B02) and at the radiological anomaly (location B01). Sample plots were placed at the location of the highest readings at both sites based upon the FIDLER TRS (see Figure A.4-3). Based on analytical results for the TLD and soil samples collected at the Small Boy site during the investigation of Study Group 2 (see Section A.4.0), no radiological COCs were identified at any sample location. An investigation for buried contamination (locations B01 and B03) was also performed, as radionuclide contaminants that were initially deposited onto the soil surface may have been displaced through erosion or mechanical disturbance. Soil samples and field screening at depth confirmed that no COC was found. Therefore, Decision I is resolved, and no corrective action is needed.

***Decision II***

As Decision I resulted in the determination that COCs are not present for the radiological release, Decision II does not need resolution.

Sample plots were placed within high, medium, and low elevated areas within the Small Boy plume (locations B04 through B09). Sample plots and associated TLD locations were selected to best represent the distribution of contamination as a result of the observed scattered pattern of contamination.

Soil samples were also collected and TLDs placed in a vector pattern originating from GZ through the areas of highest radiological readings as determined via the FIDLER TRS (locations B10 through B21). Grab soil samples were collected at each of the 12 TLD locations within the vector that were selected based on the aerial and FIDLER surveys. See Figure A.4-2 for TLD and sample locations.

#### 2.3.2.3 Study Group 3, Spills and Debris Resolution of DQO Decisions

***Decision I***

The investigation of potential contamination associated with Study Group 3 was based on the visual identification of debris and stains that would indicate a spill. The DQO decision on the presence of COCs from debris and/or spills was resolved based on the identification of metallic lead as PSM, indicating the presence of a COC. The presence of a PSM was identified at four separate locations as presented in Figure A.5-1 to include one breached lead-acid battery, five lead bricks, and multiple lead pieces. An interim corrective action was completed that involved removing the lead bricks, pieces, and battery parts for disposal.

***Decision II***

The extent was defined by the physical dimensions of the battery, bricks, and pieces; and by the absence of COC from analytical soil sampling completed as part of the interim corrective action. To resolve Decision II, verification samples were collected from the physical location of the breached lead-acid battery (location C04), five lead bricks (locations C01 and C02), and multiple lead pieces (location C03). Analytical results presented in Section A.5.0 indicate that Study Group 3 soil samples for the lead bricks and pieces did not contain COCs. As the results show that the extent of COC contamination is limited to the physical extent of the debris, no further corrective action is required at these locations.

# 3.0 Recommendation

Corrective actions for each potential release were based on an evaluation of analytical data from the CAI, the assumed presence of COCs at select locations, a review of current and future operations at CAU 541, the risk assessment presented in Appendix C, and the comparative analysis of the CAAs presented in Appendix E.

Radiological contamination does not exceed the FAL of 25 mrem/OU-yr for either of the two CASs:

- 05-23-04, Atmospheric Tests (6) - BFa Site
- 05-45-03, Atmospheric Test Site - Small Boy

Therefore, no corrective action is required. However, PSM in the form of metallic lead debris was identified at both CASs and requires corrective action.

An interim corrective action was completed by removing the PSM from the Study Group 1, BFa Site and the Study Group 2, Small Boy Site during the investigation. The extent of COC contamination was defined, and the material was removed under an interim corrective action. Verification samples from the remaining soil showed that all COCs were removed, and no further corrective action is needed at these release sites.

The no further action alternative for CAU 541 CASs are based on the assumption that activities at these sites will be limited to those that are industrial in nature and that the NNSS and NTTR will maintain controlled access (i.e., restrict public access and residential use). Should the future land use of the NNSS or NTTR change such that these assumptions are no longer are valid, additional evaluation may be necessary.

In accordance with the Soils RBCA document (NNSA/NFO, 2014b) and Section 3.3 of the CAIP (NNSA/NFO, 2014a), an administrative use restriction (UR) was implemented as a best management practice (BMP) for any area where an industrial land use of the area could cause a future site worker to receive an annual dose exceeding 25 mrem/yr. This assumes that military or site workers personnel would be exposed to site contamination for a period of 2,000 hr/yr. This administrative UR (implemented as a BMP) is not part of any FFACO corrective action. To determine the extent of the area of the administrative UR, a correlation of radiation survey values to the 95 percent UCL of industrial area TED values was conducted for each radiation survey as described in Section A.2.3.2. An administrative UR boundary was established to encompass the TRS value corresponding to 25 mrem/IA-yr.

At the Study Group 1, BFa Site, radiation surveys were used to help establish the corrective action boundary. A correlation of the TED to the radiation survey values was performed to establish the boundary as discussed in Sections A.2.5 and A.3.5. At this site, the radiation survey that exhibited the best correlation is the PRM-470 TRS. Based on this correlation, the radiation survey value that corresponds to the administrative UR is 3.88 multiples of background (MOB). The corresponding site-specific TRS MOB isopleth and the administrative UR that bounds this isopleth are shown on Figure A.3-4. The administrative UR is presented in Attachment D-1.

At the Study Group 2, Small Boy Site, radiation surveys were used to help establish the corrective action boundary. A correlation of the TED to the radiation survey values was performed to establish the boundary as discussed in Sections A.2.5 and A.4.5. At this site, the radiation survey that exhibited the best correlation is the FIDLER TRS. Based on this correlation, the radiation survey value that corresponds to the administrative UR is 9.48 MOB. The corresponding site-specific TRS MOB isopleth and the administrative UR that bounds this isopleth are shown on Figure A.4-4. The administrative UR is presented in Attachment D-1.

The administrative URs will be recorded and controlled in the same manner as FFACO URs, but do not require posting or inspections. All administrative URs are recorded in the FFACO database, the Management and Operating (M&O) Contractor Geographic Information Systems (GIS), USAF, and the NNSA/NFO CAU/CAS files. The development of URs for CAU 541 are based on current land use. Any proposed activity within a use restricted area that would result in a more intensive use of the site would require NDEP approval.

The CAU 541 dose estimates were made using conservative estimates of site physical properties, contaminant properties, dose conversion properties, exposure paradigms, and exposure durations. While these multiple layers of conservatism result in projected doses that are higher than actual expected doses, they also provide protection against uncertainties that could result in making a false-negative decision error. Therefore, the dose estimates presented herein are intended to provide an upper bound of the potential dose that a receptor could reasonably receive under the exposure scenarios defined in this document. They are not intended to predict the actual dose a receptor would receive from site contamination.

NNSA/NFO requests that NDEP issue a Notice of Completion for this CAU and approve transferring the CAU 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).

# 4.0 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*. 2015. Title 10 CFR, Part 835, "Occupational Radiation Protection." Washington, DC: U.S. Government Printing Office.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

EPA, see U.S. Environmental Protection Agency.

ESRI, see ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, and IGP.

ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, and IGP. 2015. ArcGIS Online website. As accessed at http://www.arcgis.com/home/gallery.html on 2 June.

FFACO, see *Federal Facility Agreement and Consent Order.*

*Federal Facility Agreement and Consent Order.* 1996 (as amended March 2010). Agreed to by the State of Nevada; U.S. Department of Energy, Environmental Management; U.S. Department of Defense; and U.S. Department of Energy, Legacy Management. Appendix VI, which contains the Soils Sites Strategy, was last modified June 2014, Revision No. 5.

NAC, see *Nevada Administrative Code*.

Navarro GIS, see Navarro Geographic Information Systems.

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.

Navarro Geographic Information Systems. 2015. ESRI ArcGIS Software.

*Nevada Administrative Code*. 2014a. NAC 445A, "Water Controls." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 3 June 2015.

*Nevada Administrative Code.* 2014b. 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 4 June 2015.

*Nevada Administrative Code.* 2014c. 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 3 June 2015.

USC, see *United States Code.*

*United States Code*. 2012. Title 42 USC 2011 et seq., "Atomic Energy Act of 1954," as amended. Washington, DC: U.S. Government Printing Office.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014a. *Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada*, Rev. 0, DOE/NV--1524. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014b. *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 Site Office. 2012. *Soils Activity Quality Assurance Plan*, Rev. 0, DOE/NV--1478. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000. *United States Nuclear Tests, July 1945 through September 1992*, DOE/NV--209-REV 15. Las Vegas, NV.

U.S. Environmental Protection Agency. 2009a. *Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities: Unified Guidance*, EPA 530/R-09-007. Washington, DC: Office of Resource Conservation and Recovery.

U.S. Environmental Protection Agency. 2009b. *Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters,* OSWER 9200.2-82. June. Prepared by the Lead Committee of the Technical Review Workgroup for Metals and Asbestos. Washington, DC: Office of Superfund Remediation and Technology Innovation.

U.S. Environmental Protection Agency. 2015. *Pacific Southwest, Region 9: Regional Screening Levels (Formerly PRGs), Screening Levels for Chemical Contaminants*. As accessed at http://www.epa.gov/region9/superfund/prg/ on 17 March. Prepared by EPA Office of Superfund and Oak Ridge National Laboratory.

# Appendix A

# Corrective Action Investigation Results

# A.1.0 Introduction

This appendix presents the CAI activities and analytical results for CAU 541. CAU 541 consists of the releases associated with the CASs listed in Table A.1-1 located in Area 5 of the NNSS and Range 65C of the NTTR (Figure 1-1). To facilitate site investigation and the evaluation of DQO decisions for different potential releases, the reporting of investigation results and the evaluation of DQO decisions for different potential releases were organized into study groups. The study groups and the potential releases associated with each study group are described in Table A.1-1.

**Table A.1-1**
**CAU 541 Releases with Associated CASs and Study Groups**

| Release | CAS Number | Study Group | Release Type |
|---|---|---|---|
| Weapons-effects and weapons-related atmospheric tests (BFa Site) | 05-23-04 | 1 | Surface release of radionuclides from atmospheric tests |
| Weapons-effects atmospheric test (Small Boy Site) | 05-45-03 | 2 | Surface release of radionuclides from an atmospheric tower test |
| Spills and Debris | 05-23-04 and 05-45-03 | 3 | Surface release of lead from battery and bricks |

Although the need for corrective action is evaluated separately for each release, CAAs are applied to each FFACO CAS. The release sources specific to CAU 541 study groups are identified in the following text (DOE/NV, 2000):

***For Study Group 1 (BFa Site)***

- Encore was a weapons-effects test at the BFa Site as part of Operation Upshot-Knothole with a yield of 27 kt. The test was an airdrop test performed on May 8, 1953. Encore was the first of six tests performed at this site.
- Grable was a weapons-related test at the BFa Site as part of Operation Upshot-Knothole with a yield of 15 kt. The airburst test fired from a 280-mm artillery gun was performed on May 25, 1953.

- The MET was a weapons-effects test at the BFa Site as part of Operation Teapot. The test was performed on April 15, 1955, from a 400-ft tower with a yield of 22 kt.

- Priscilla was a weapons-related balloon test at the BFa Site as part of Operation Plumbbob. The test was performed on June 24, 1957, and conducted at 700 ft with a yield of 37 kt. The yield for Priscilla was the largest observed for CAU 541.

- Wrangell was a weapons-related test at the BFa Site as part of Operation Hardtack II with a yield of 115 tons. The balloon test was performed on October 22, 1958, from a height of 1,500 ft.

- Sanford was a weapons-related test at the BFa Site performed as part of Operation Hardtack II. The 4.9-kt balloon test was conducted on October 26, 1958, also from a height of 1,500 ft. Sanford was the last of six tests performed at this site.

- Radionuclide contaminants that were initially deposited onto the soil surface may have been subsequently displaced through erosion or mechanical disturbance of the soil. This potential release is located on the Frenchman Flat playa (dry) lake bed on the NNSS and NTTR. Slight depressions are observed at the immediate GZ area at the BFa Site that have been observed to collect water during wetter periods.

***For Study Group 2 (Small Boy Site)***

- Small Boy consisted of one test at the Small Boy site conducted on July 14, 1962. This weapons-effects test, as part of Operation Sunbeam, was a low-yield test conducted from a 10-ft tower on the NTTR. A potential releases that is included and evaluated in the closure of CAU 541 include a radiological anomaly to the south of the Small Boy site.

- Radionuclide contaminants that were initially deposited onto the soil surface may have been subsequently displaced through erosion or mechanical disturbance of the soil. This potential release is located on the Frenchman Flat playa (dry) lake bed on the NNSS and NTTR. Slight depressions are observed at the immediate GZ area at the Small Boy site that have been observed to collect water during wetter periods.

***For Study Group 3 (Spills and Debris)***

- Other releases are present at CAU 541. Lead batteries and bricks were identified. There is the potential to find additional spills or debris that could provide a source for the release of contamination to the surface soils. Extensive testing facilities and debris remain from activities performed at the sites. Numerous concrete and steel structures, military fortifications (foxholes and bunkers), bridge/railroad infrastructure, domes, shelters, and diagnostic instrumentation locations remain at this site that could provide the source for a release of contamination.

Additional information regarding the history of each site, planning, and the scope of the investigation is presented in the CAU 541 CAIP (NNSA/NFO, 2014a).

### A.1.1 Investigation Objectives

The objective of the investigation was to provide sufficient information to complete corrective actions and support the recommendation for closure of each CAS in CAU 541. This objective was achieved by identifying the nature and extent of COCs; and by evaluating, selecting, and implementing CAAs.

For radiological contamination, a COC is defined as the presence of radionuclides that jointly present a dose to a receptor exceeding the FAL of 25 mrem/yr. For other types of contamination, a COC is defined as the presence of a contaminant at a concentration exceeding its corresponding FAL concentration (see Section A.2.4).

### A.1.2 Contents

This appendix describes the investigation and presents the results. The contents of this appendix are as follows:

- Section A.1.0 describes the investigation background, objectives, and the contents of this document.
- Section A.2.0 provides an investigation overview.
- Sections A.3.0 through A.5.0 provide study-group-specific (see Section A.2.0) information regarding the field activities, sampling methods, and laboratory analytical results from investigation sampling.
- Section A.6.0 summarizes waste management activities.
- Section A.7.0 discusses the QA and quality control (QC) processes followed and the results of QA/QC activities.
- Section A.8.0 provides a summary of the investigation results.
- Section A.9.0 lists the cited references.

The complete field documentation and laboratory data—including field activity daily logs, sample collection logs (SCLs), additional information regarding the history of each site, planning, and the scope of the investigation is presented in the CAU 541 CAIP (NNSA/NFO, 2014a).

# A.2.0 Investigation Overview

Field investigation and sampling activities for the CAU 541 CAI were conducted between October 23, 2014, and September 28, 2015. Investigation activities included visual surveys, radiological surveys, surface and subsurface soil sampling, and TLD sampling.

The investigation and sampling program adhered to the requirements set forth in the CAIP (NNSA/NFO, 2014a) (except any deviations described herein) and in accordance with the Soils QAP (NNSA/NSO, 2012b), 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 RBCA document (NNSA/NFO, 2014b).

In accordance with the graded approach described in the Soils QAP (NNSA/NSO, 2012b), the quality required of a dataset will be determined by its intended use in decision making. Data used to define the presence of COCs are classified as decisional and will be used to make corrective action decisions. Survey data are classified as decision supporting and are not used, by themselves, to make corrective action decisions. The radiological and chemical FALs are presented in Appendix C.

The study groups were investigated by collecting TLD samples for external radiological dose calculations and collecting soil samples for the calculation of internal radiological dose. The field investigation was completed as specified in the CAIP (NNSA/NFO, 2014a) with minor deviations as described in Sections A.2.1 through A.2.5, which provide the general investigation and evaluation methodologies.

## A.2.1 Sample Locations

All sample locations for CAU 541 were selected judgmentally, using biasing factors such as radiological survey results and/or the presence of debris. At study groups where soil sample plots were established, soil samples were collected following a probabilistic approach. One or more composite samples were collected within each sample plot, and TLDs were located at the center of each sample plot. The subsample aliquot locations for each sample were identified using a predetermined random-start, triangular grid pattern.

All sample locations and points of interest were surveyed with a GPS instrument. Appendix F presents these GPS data in a tabular format. Additional information on the selection of sample locations is found in the CAIP and the study-group-specific sections (Sections A.3.0 through A.5.0). Except as noted in the following subsections, CAU 541 sampling locations were accessible, and sampling activities at planned locations were not restricted.

### A.2.2 Investigation Activities

The investigation activities as listed in Section A.2.0 performed at CAU 541 were consistent with the field investigation activities specified in the CAIP (NNSA/NFO, 2014a). The investigation strategy provided the necessary information to establish the nature and extent of contamination associated with each study group. The following subsections describe the specific investigation activities that took place at CAU 541.

#### A.2.2.1 Radiological Surveys

Aerial surveys and TRSs were conducted at the CAU 541 CASs. Aerial radiological surveys were initially conducted within Area 5 of the NNSS in 1994 (BN, 1999) and the NTTR in 1997 (BN, 1997). The 1994 surveys were conducted by flying along a set of parallel flight lines spaced 150 m apart at 60 m above ground level (agl) (BN, 1999). An aerial radiological survey was also conducted in 1997 to measure gamma radiation levels on the NTTR with a 260-m-line spacing at 150 m agl (BN, 1997). A subsequent survey was performed in 2010 that covered both the NNSS and NTTR areas within the immediate CAU area (Stampahar, 2012). The 2010 survey was conducted by flying along a set of parallel flight lines spaced 23 m apart at 15 m agl to provide better resolution of the distribution of site radioactivity. These flyover data provide coverage of the entire CAU and were processed to produce man-made contamination and americium concentration data layers.

TRSs were performed during the site investigation to better understand the distribution of radiological contaminants and to identify specific locations for sample plots and biased sample locations. Extensive TRS were performed for Study Group 1 and 2 areas with the PRM-470 and FIDLER instruments. Survey instrumentation transects were performed at an approximate 20-m spacing with more close spaced transects (approximately 10 m) performed near the GZ areas at both sites and in the center of the Small Boy radiological plume. Count-rate data were collected with a TSA Systems PRM-470 model plastic scintillator. Count-rate and position data were collected and recorded at 1-second intervals, via a Trimble Systems GeoXT GPS unit. The travel speed was approximately 1 to 2 meters per second with the radiation detector held at a height of approximately 18 inches (in.) above the ground surface. Count rates for the PRM-470 and FIDLER are recorded in units of counts per second (cps) and counts per minute (cpm), respectively. As background radiation levels over time, these measurement units were converted to MOB. This provides additional comparability of results that were collected at different times. The radiation surveys generated discrete measurement points (point data). The point data results are presented as continuous spatial distributions (i.e., interpolated surfaces). These were estimated from the point data using an inverse distance weighted interpolation technique using the geostatistical analyst extension of the ArcGIS software.

#### *A.2.2.2 Field Screening*

Field screening at select locations was conducted to aid in the selection of samples submitted for analysis. Field-screening results (FSRs) at the selected location were compared to field-screening levels (FSLs) obtained from an area in the vicinity of the site determined to have minimal impact from the release. Site-specific FSLs were determined each day before investigational soil sampling began. An area was selected in the vicinity of the site that has a minimal probability of being impacted from releases or site operations. Ten or more surface soil aliquots, from the top 5 cm of soil, were collected at random locations within the selected area. The aliquots were then mixed, and 10 one-minute static counts were obtained for both alpha and beta/gamma measurements. The FSLs for both alpha and beta/gamma were calculated by multiplying the sample standard deviation by 2 and adding that value to the sample average.

Field screening was used at both CAU 541 CASs and study groups to evaluate the presence of buried contamination and to aid in the selection of biased samples for laboratory analyses. Buried contamination is defined as the presence of a subsurface layer of radiological contamination that is significantly higher than that of the surface. Field screening was limited to radiological parameters and was conducted using an NE Electra instrument. As part of the Study Group 1 and 2 depth investigations, soil was removed at the sample location and screened for radioactivity in 5-cm-depth increments to a depth of 20 cm bgs, and then at 10-cm increments to a total depth of 30 cm bgs. These

FSRs were used to determine whether a subsurface contamination layer(s) could be distinguished from surface contamination. A depth sample was collected only if the depth interval reading exceeded the FSL, and there was a greater than 20 percent difference between the depth interval reading and the surface soil reading. For locations where a depth sample was collected, the subsurface depth interval with the highest radiological reading was collected as a sample for offsite laboratory analyses.

#### *A.2.2.3 TLD Sampling*

TLDs (Panasonic UD-814) were staged at CAU 541 with the objective of collecting *in situ* measurements to determine the external radiological dose.

The background TLDs are intended to estimate the radiation level at the release site that would be present if contamination from the nuclear test were not present. Therefore, three background TLD locations were selected as close to the release site as possible to be representative of natural radiation at the release site but still unaffected by CAU-related releases. Selection of the locations for the three background TLDs was aided using the 1994 aerial radiation survey (BN, 1999) (Figure A.2-1) to ensure the locations are outside the detected radiation plume while still being representative of the release site geology (playa sediments).

Each TLD was placed at a height of 1 m agl, which is consistent with TLD placement in the NNSS routine environmental monitoring program. 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.

QC processes for TLD processing were followed in accordance with the Soils QAP (NNSA/NSO, 2012b). Details of the environmental monitoring TLD program and TLD QC are presented in Section A.7.0. All readings conformed to the approved QC program and are considered representative of the external radiological dose at each location.

#### *A.2.2.4 Soil Sampling*

Soil sampling at CAU 541 included the collection of surface soil samples (as defined in Section A.2.0) within sample plot and grab sample locations. Within each sample plot, four composite samples were collected. Each composite sample was composed of nine randomly located

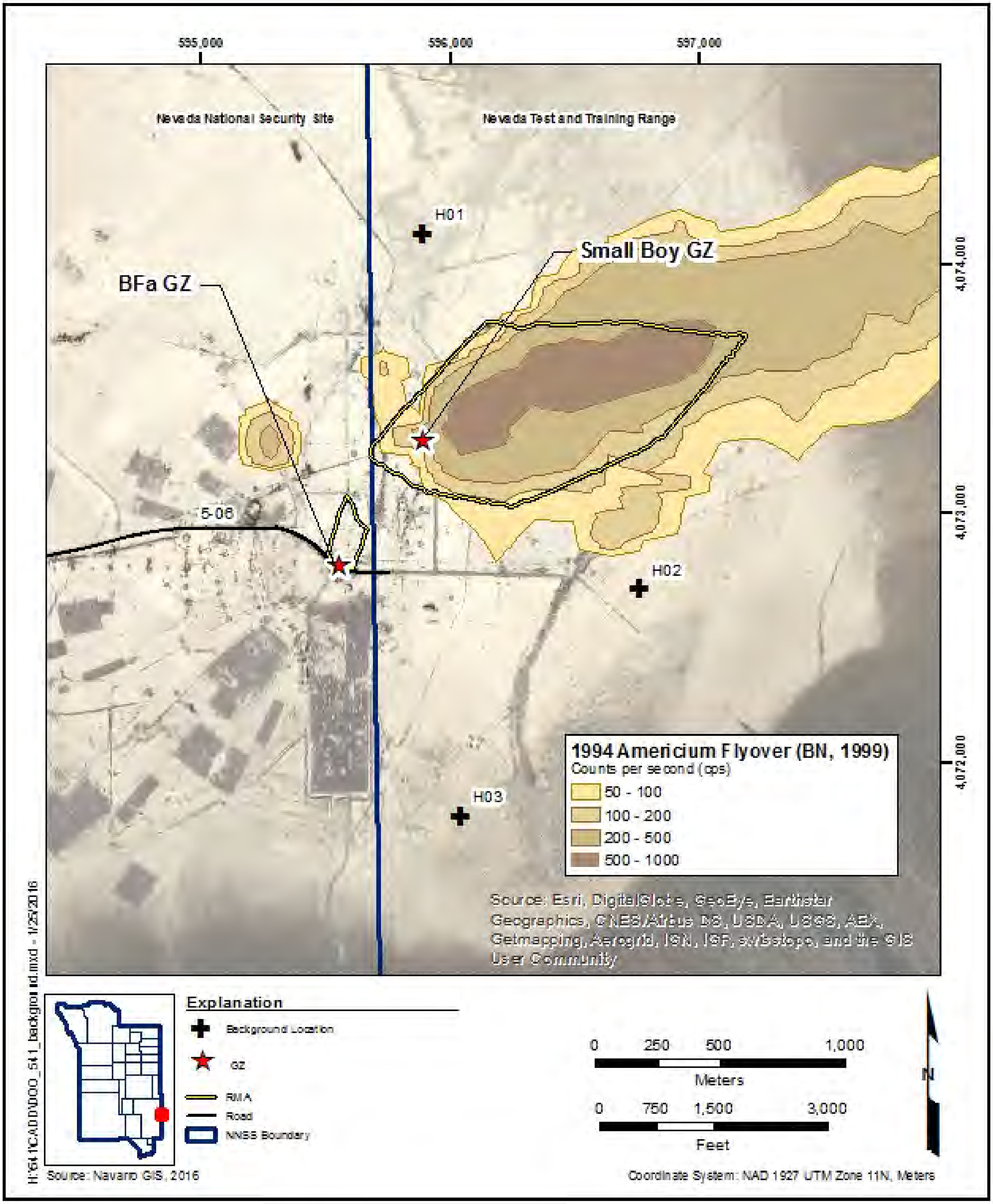



**Figure A.2-1**
**CAU 541 Background TLD Locations**

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-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. Grab samples were also collected at selected locations at the Study Group 2, Small Boy Site by collecting one aliquot to a depth of 5 cm at the selected location.

After collection, samples were carefully placed atop a sieve (#4 mesh) fitted into a bottom pan with a plastic bag liner. Oversized material that did not pass through the sieve was returned to the original sample location.

### *A.2.3 Dose Calculations*

Soil and TLD data are used to calculate a TED that could potentially be received by a human receptor at the site. The following subsections discuss the process for evaluating the soil and TLD data in terms of dose, so the data may be compared directly to the dose-based radiological FAL.

#### *A.2.3.1 Internal Dose Calculations*

Internal dose was calculated using the radionuclide analytical results from soil samples and the corresponding residual radioactive material guideline (RRMG) (NNSA/NFO, 2014b). The internal dose RRMG concentration 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).
The internal dose RRMG for each detected radionuclide (in picocuries per gram [pCi/g] of soil) was derived using RESRAD computer code (Yu et al., 2001) under the appropriate exposure scenario (NNSA/NFO, 2014b). The RRMGs used for the Industrial Area and Occasional Use exposure scenarios are reported in the Soils RBCA document (NNSA/NFO, 2014b) document. The RESRAD input parameters used to determine the RRMGs for the Ground Troops scenario are reported in the CAIP (NNSA/NFO, 2014a).

The total internal dose corresponding to each surface soil sample was calculated by adding the dose contribution from each radionuclide. For each sample, the radionuclide-specific analytical result was divided by its corresponding internal RRMG (NNSA/NFO, 2014b) 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. Soil concentrations of plutonium isotopes are inferred from gamma spectroscopy results as described in the representativeness discussion of Section B.1.1.1.1. The internal doses for all radionuclides detected in a soil sample were then summed to yield an internal dose for that sample. For probabilistic samples, 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, 2014b). For judgmental 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.

For TLD locations where soil samples were not collected, the internal dose was estimated using the external dose measurement from the TLD and the internal-to-external dose ratio from the sample plot with the maximum internal dose within the corresponding release. The internal dose for each of these locations was calculated by multiplying this ratio by the external dose value specific to each location using the following formula:

$$Internal\ dose_{est} = External\ dose_{est} \times [Internal\ dose / External\ dose]_{max}$$

where

*est* = location for the estimate of internal dose
*max* = location of maximum internal dose

Use of this method to estimate internal dose will overestimate the internal dose (and therefore TED) as the internal-to-external dose ratio generally decreases with decreasing TED values.

### A.2.3.2 External Dose Calculations

External dose was calculated using TLDs. The TLDs used at CAU 541 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 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 this investigation.

For subsurface sample locations where external dose measurements were not available, a TLD-equivalent external dose was calculated using the subsurface sample results. This was accomplished by establishing a correlation between RESRAD-calculated external dose from surface samples and the corresponding TLD readings. The RESRAD-calculated external dose from the subsurface samples was then adjusted to TLD-equivalent values using the following formula:

$$Equivalent\ Subsurface_{TLD} = Subsurface_{RR} \times (Surface_{TLD} / Surface_{RR})$$

where

*TLD* = external dose based on TLD readings
*RR* = external dose based on RESRAD calculation from analytical soil concentrations

Estimates of external dose at the CAU 541 sites are presented as net values (i.e., background radiation dose has been subtracted from the raw result [Section A.2.2.3]). The background TLDs were placed in areas beyond the influence of CAS releases (Figure A.2-1). The background dose at CAU 541 was determined to be the average of the background TLD results from locations H01, H02, and H03 (20.5 mrem/IA-yr).

### A.2.3.3 Total Effective Dose

The calculated TED represents the sum of the internal dose and the external dose for each sample location. For locations where a TLD was not placed, TED was calculated directly from the soil sample analytical results. This was accomplished using the method described in Section A.2.3.1 for internal dose, except the RRMGs for TED were used instead of the RRMGs for internal dose.

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 the true TED (i.e., the 95 percent UCL) is used to compare to the FAL. By definition, there will be a 95 percent probability that the true TED is less than the 95 percent UCL of the calculated TED. The probabilistic sampling design as described in the CAIP (NNSA/NFO, 2014a) conservatively prescribes using the 95 percent UCL of the TED for DQO decisions. The 95 percent UCL of the TED is also used for determining the presence or absence of COCs (DQO Decision I). For sample locations where a TLD and multiple soil samples are collected (i.e., sample plots), this is calculated as the sum of the 95 percent UCLs of the internal and external doses. For grab sample locations where a TLD sample was collected, this is calculated as the sum of the 95 percent UCL of the external dose and the single internal dose estimate.

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 CAIP, 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 B.1.1.1.1.

To reduce the probability of a false-negative decision error for judgmental sampling results, samples were biased to locations of higher radioactivity. 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.2.4 Comparison to Action Levels*

The radiological PALs and FALs 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 541 release. As such, it is dependent upon the cumulative annual hours of exposure to site contamination. The PALs were established in the CAIP (NNSA/NFO, 2014a) based on a dose limit of 25 mrem/yr over an annual exposure time of 1,008 hours (i.e., Ground Troops exposure scenario). The FALs were established for the BFa Site and Small Boy as defined in Appendix C based on a dose limit of 25 mrem/yr over an annual exposure time of 80 hours (i.e. the Occasional Use Area scenario in which personnel are exposed to site contamination for 8 hr/day for 10 day/yr).

Results for each of the study groups are presented in Sections A.3.0 through A.5.0. Radiological results are reported as doses that are comparable to the dose-based FAL as established in Appendix C. Chemical results are reported as individual concentrations that are comparable to the individual chemical FALs as established in Appendix C. Results that are equal to or greater than FALs are identified by bold text in the study-group-specific results tables (see Sections A.3.0 through A.5.0).

A COC is defined as any contaminant present in environmental media exceeding a FAL. 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 constituent analysis (NNSA/NFO, 2014b). If COCs are present, corrective action must be considered for the study group.

A corrective action may also be required if a waste present within a study group contains contaminants that, if released, could cause the surrounding environmental media to contain a COC. Such a waste would be considered PSM. To evaluate wastes for the potential to result in the introduction of a COC to the surrounding environmental media, the conservative assumption was made that any physical waste containment would fail at some point and release the contaminants to the surrounding media. The following were used as the criteria for determining whether a waste is PSM:

- A waste, regardless of concentration or configuration, may be assumed to be PSM and handled under a corrective action.
- Based on process knowledge and/or professional judgment, some waste may be assumed to not be PSM if it is clear that it could not result in soil contamination exceeding a FAL.
- If assumptions about the waste cannot be made, then the waste material will be sampled, and the results will be compared to FALs based on the following criteria:
    - For non-liquid wastes, the concentration of any chemical contaminant in soil (following degradation of any physical containment and release of contaminants into soil) would be equal to the mass of the contaminant divided by the mass of the potentially contaminated soil. If the resulting soil concentration exceeds the FAL, then the waste would be considered to be PSM.
    - For non-liquid wastes, the dose resulting from radioactive contaminants in soil (following degradation of any physical containment and release of contaminants into soil) would be calculated using the activity of the contaminant in the waste divided by the mass of the potentially contaminated soil (for each radioactive contaminant) and calculating the combined resulting dose using the RRMGs for TED as described in Section A.2.3.3. If the dose exceeds the FAL, then the waste would be considered to be PSM.

### *A.2.5 Correlation of Dose to Radiation Survey Isopleths*

A boundary for a corrective action or an administrative UR for a particular release site may be established by using radiation survey isopleths if it can be shown that a sufficient correlation exists between TED and radiation survey values. A continuous spatial distribution (i.e., interpolated surface) was estimated from each of the listed radiation surveys using an inverse distance weighted interpolation technique using the geostatistical analyst extension of the ArcGIS software. The average Industrial Area TED value for each study site was then matched with a radiation survey value from the interpolated surface at the corresponding geographic location. A correlation was then calculated between these data pairs for each radiation survey. Correlation statistics are then used to establish the relationship between the paired values as well as an indicator of the strength of the relationship (i.e., the coefficient of determination, or $r^2$). The minimum strength of the relationship for a valid correlation was defined in the DQOs as an $r^2$ of 0.8.

The TED values used in the correlation were the average TED for probabilistic samples or the calculated TED for judgmental samples from biased sample locations. To protect against a Decision II false-negative decision error (the potential for a receptor to receive a dose exceeding the 25-mrem/yr FAL outside the defined boundary), the Soils Activity uses a conservative estimate of the radiation survey value corresponding to 25 mrem/yr. This is accomplished using the uncertainty of how well the calculated relationship between TED and emitted radiation (i.e., the regression) represents the assumed true relationship. This uncertainty includes the uncertainty of how well the calculated TED represents true TED and the uncertainty of how well the radiation survey instrument readings represent emitted radioactivity. These uncertainties were used to conservatively establish corrective action boundaries and administrative UR boundaries by using the 95 percent lower confidence limit (LCL) of the regression correlation as described in the Soils RBCA document (NNSA/NFO, 2014b).

# A.3.0 Study Group 1, BFa Site

The Study Group 1, BFa Site is located in the eastern portion of Area 5 of the NNSS and the western edge of the NTTR. The study group consists of a release of radionuclides to the soil surface as a result of nuclear testing in the 1950s and 1960s. Additional detail on the history of Study Group 1 is provided in the CAIP (NNSA/NFO, 2014a).

## A.3.1 CAI Activities

The specific CAI activities conducted to satisfy the CAIP requirements at this study group are described in the following subsections.

### A.3.1.1 Visual Surveys

A visual survey of the Study Group 1, BFa Site was conducted over the area shown in Figure A.3-1. This survey identified numerous concrete, wood, and steel structures, military fortifications (foxholes and bunkers), bridge/railroad infrastructure, domes, shelters, support structures, and diagnostic instrumentation locations. Although these items could potentially provide the source for a release of contamination, no indications of a release were identified, and no locations were selected for further investigation.

### A.3.1.2 Radiological Surveys

Aerial surveys and TRSs were performed at the Study Group 1, BFa Site. The historical aerial surveys at the BFa Site were conducted in 1994 and 2010 and are described in Section A.2.2.1. The TRSs were conducted at the site during the CAI to identify the spatial distribution of radiological readings and to identify the location of the highest radiological activity. The highest radiological readings were detected southeast of the GZ. Figure A.3-1 presents a graphic representation of the radiological survey data from the PRM-470 TRS. The data presented in the figure represent a continuous spatial distribution (i.e., interpolated surface) estimated from the PRM-470 TRSs using an inverse distance weighted interpolation technique using the geostatistical analyst extension of the ArcGIS software.

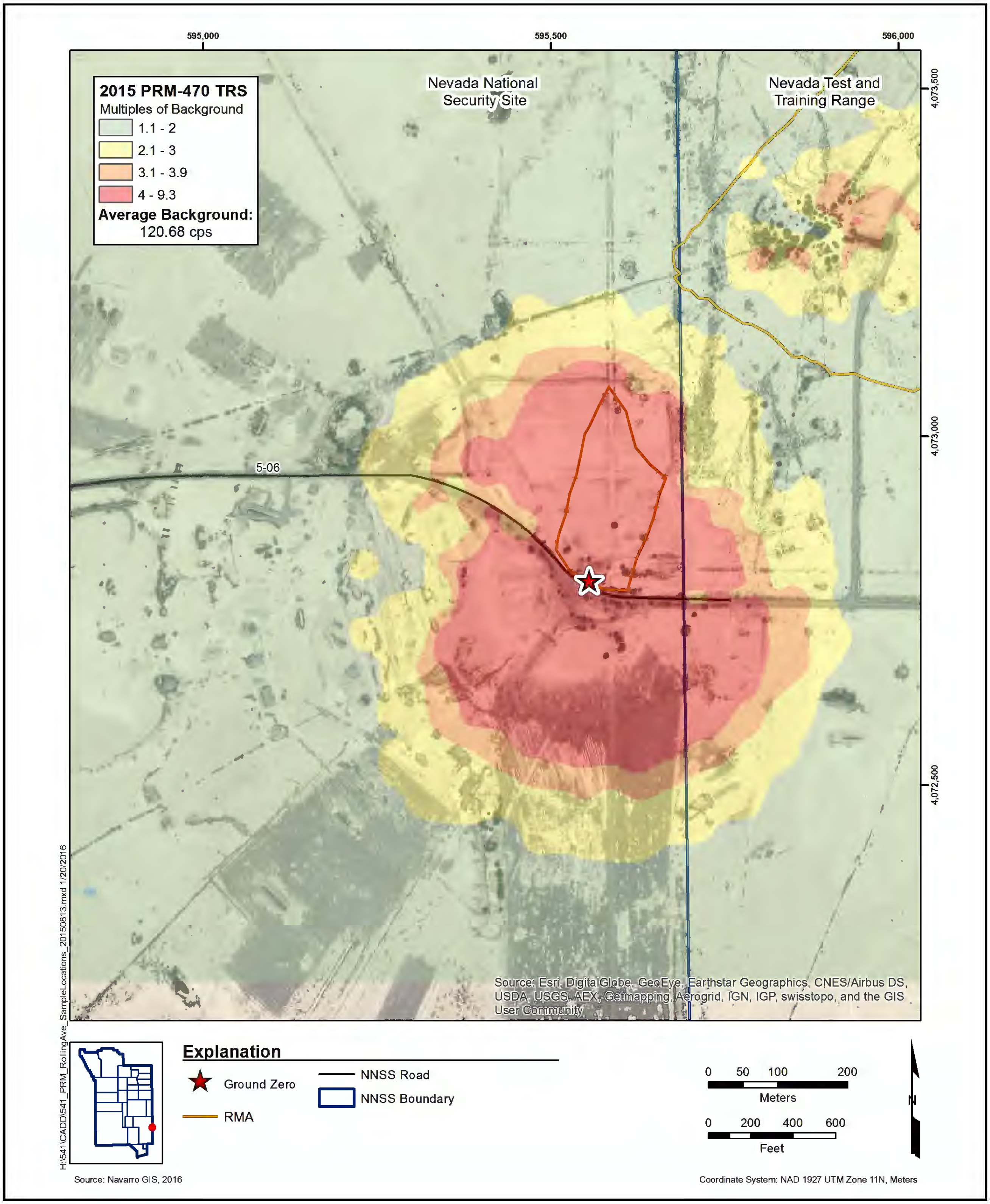



**Figure A.3-1**
**Study Group 1, BFa Site TRSs of Selected Locations**

In addition to the TRSs, the 1994 and 2010 aerial radiological surveys (BN, 1997; Stampahar, 2012) were used to determine the locations of the TLD locations at the Study Group 1 site (Figure A.3-2). The aerial radiological surveys show a concentric pattern of contamination with the most elevated readings closer to GZ. A three-vector TLD pattern was selected as it provided efficient coverage for the observed concentric pattern of elevated radiological measurements.

#### *A.3.1.3 Sample Collection*

Soil samples and TLD samples were collected to satisfy the CAIP requirements (NNSA/NFO, 2014a) at Study Group 1. The specific CAI activities conducted at this study group are described in the following subsections.

##### *A.3.1.3.1 TLD Samples*

A summary of the TLD samples collected for the Study Group 1, BFa Site are provided in Table A.3-1. The TLDs were installed at 43 locations at the BFa Site to calculate external doses (Table A.3-2 and Figure A.3-2).

TLDs were placed at the sampling plot (location A01a), depth screening location (A02a), and in an extensive vector pattern based upon radiological readings from the aerial and TRS. A total of 38 TLDs were placed in three vectors radiating from GZ to measure the external dose within the area impacted by the plume. The three-vector pattern was selected as it provided efficient coverage for the concentric pattern of elevated radiological measurements observed from the aerial survey and TRSs. All TLDs were measured by the NNSS environmental TLD monitoring program.

Three TLDs (H01, H02, and H03) were placed to calculate background (Figure A.2-1). To aid in the determination of the proper background dose to use in TED calculation, Figure A.2-1 shows a background isopleth map generated from the 1994 aerial radiation survey (BN, 1999) was used to verify that background TLDs represent the background dose estimated at CAU 541 TLD locations. It was determined that the background TLD locations are representative of the general area and can be used as a good estimate of true average background dose for all of the environmental TLDs.

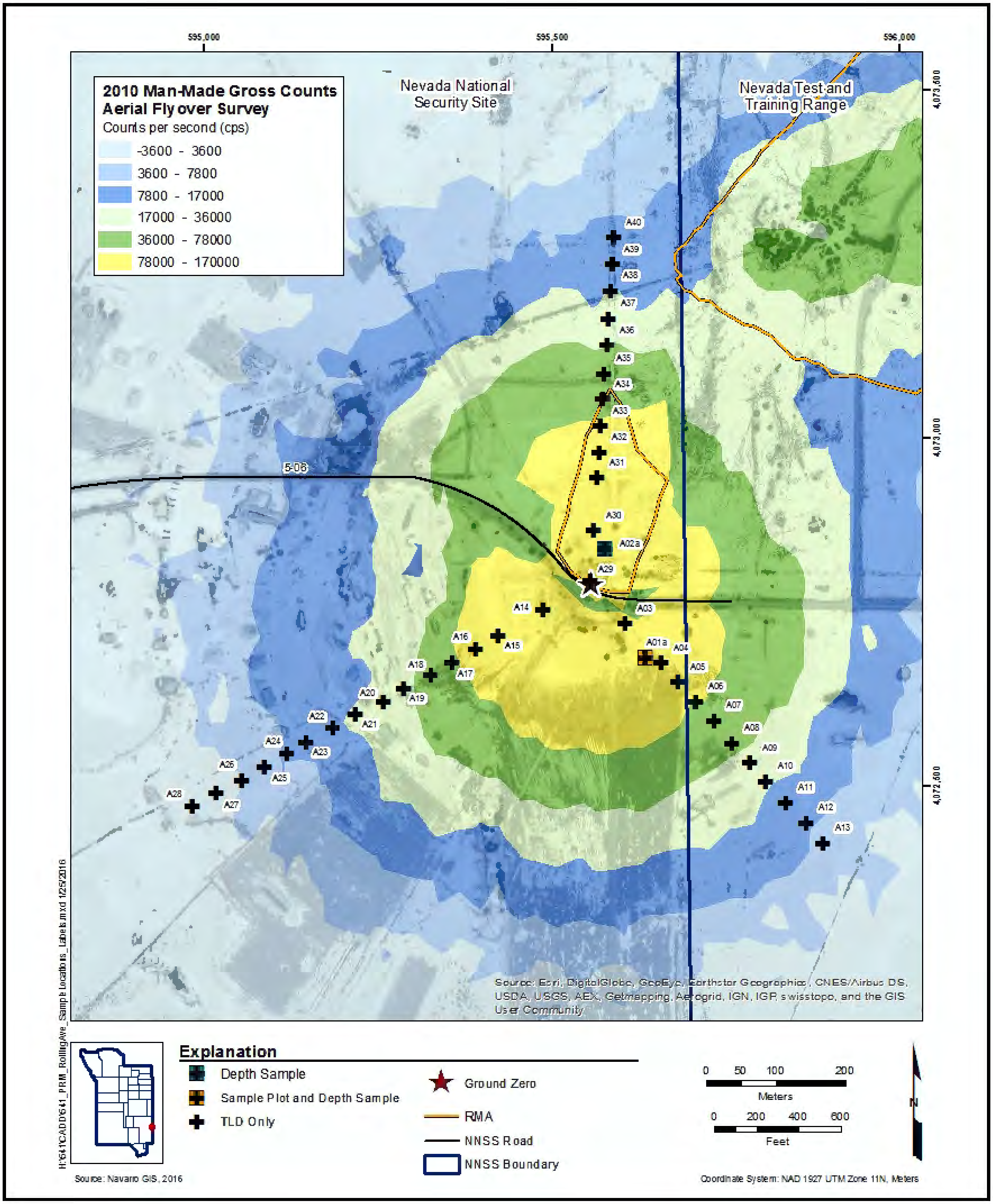



**Figure A.3-2**
**Study Group 1, BFa Site Sample and TLD Locations**

**Table A.3-1**
**Study Group 1, BFa Site TLD Summary**

| Location Type | Number of Locations | Number of TLDs | Analyses (Method) |
|---|---|---|---|
| Plot | 1 | 1 | See Section A.7.5 |
| Subsurface | 1 | 1 | |
| TLD Only | 38 | 38 | |
| Background | 3 | 3 | |
| **Total** | **43** | **43** | |

**Table A.3-2**
**Study Group 1, BFa Site TLDs**
(Page 1 of 2)

| Release | Location | TLD No. | Date Placed | Date Removed | Purpose |
|---|---|---|---|---|---|
| BFa Site | A01a | 6152 | 11/04/2014 | 02/23/2015 | Sample plot |
| | A02a | 6179 | 11/04/2014 | 02/23/2015 | Subsurface screening |
| | A03 | 6059 | 11/04/2014 | 02/23/2015 | TLD only |
| | A04 | 6226 | 11/04/2014 | 02/23/2015 | TLD only |
| | A05 | 6132 | 11/04/2014 | 02/23/2015 | TLD only |
| | A06 | 4751 | 11/04/2014 | 02/23/2015 | TLD only |
| | A07 | 6298 | 11/04/2014 | 02/23/2015 | TLD only |
| | A08 | 6472 | 11/04/2014 | 02/23/2015 | TLD only |
| | A09 | 3166 | 11/04/2014 | 02/23/2015 | TLD only |
| | A10 | 6447 | 11/04/2014 | 02/23/2015 | TLD only |
| | A11 | 6130 | 11/04/2014 | 02/23/2015 | TLD only |
| | A12 | 6228 | 11/04/2014 | 02/23/2015 | TLD only |
| | A13 | 6405 | 11/04/2014 | 02/23/2015 | TLD only |
| | A14 | 6477 | 11/04/2014 | 02/23/2015 | TLD only |
| | A15 | 6411 | 11/04/2014 | 02/23/2015 | TLD only |
| | A16 | 6206 | 11/04/2014 | 02/23/2015 | TLD only |
| | A17 | 4706 | 11/04/2014 | 02/23/2015 | TLD only |
| | A18 | 4859 | 11/04/2014 | 02/23/2015 | TLD only |
| | A19 | 6450 | 11/04/2014 | 02/23/2015 | TLD only |

**Table A.3-2**
**Study Group 1, BFa Site TLDs**
(Page 2 of 2)

| Release | Location | TLD No. | Date Placed | Date Removed | Purpose |
|---|---|---|---|---|---|
| BFa Site (continued) | A20 | 4350 | 11/04/2014 | 02/23/2015 | TLD only |
| | A21 | 6221 | 11/04/2014 | 02/23/2015 | TLD only |
| | A22 | 6268 | 11/04/2014 | 02/23/2015 | TLD only |
| | A23 | 5026 | 11/04/2014 | 02/23/2015 | TLD only |
| | A24 | 5013 | 11/04/2014 | 02/23/2015 | TLD only |
| | A25 | 6416 | 11/04/2014 | 02/23/2015 | TLD only |
| | A26 | 4867 | 11/04/2014 | 02/23/2015 | TLD only |
| | A27 | 6162 | 11/04/2014 | 02/23/2015 | TLD only |
| | A28 | 5008 | 11/04/2014 | 02/23/2015 | TLD only |
| | A29 | 6215 | 11/04/2014 | 02/23/2015 | TLD only |
| | A30 | 1191 | 11/04/2014 | 02/23/2015 | TLD only |
| | A31 | 6011 | 11/04/2014 | 02/23/2015 | TLD only |
| | A32 | 1645 | 11/04/2014 | 02/23/2015 | TLD only |
| | A33 | 6271 | 11/04/2014 | 02/23/2015 | TLD only |
| | A34 | 4501 | 11/04/2014 | 02/23/2015 | TLD only |
| | A35 | 6044 | 11/04/2014 | 02/23/2015 | TLD only |
| | A36 | 4964 | 11/04/2014 | 02/23/2015 | TLD only |
| | A37 | 3431 | 11/04/2014 | 02/23/2015 | TLD only |
| | A38 | 6097 | 11/04/2014 | 02/23/2015 | TLD only |
| | A39 | 4599 | 11/04/2014 | 02/23/2015 | TLD only |
| | A40 | 5268 | 11/04/2014 | 02/23/2015 | TLD only |
| | H01 | 2096 | 11/04/2014 | 02/23/2015 | Background TLD location |
| | H02 | 6490 | 11/04/2014 | 02/23/2015 | Background TLD location |
| | H03 | 6065 | 11/04/2014 | 02/23/2015 | Background TLD location |

### *A.3.1.3.2 Soil Samples*

A summary of soil sampling performed for the Study Group 1, BFa Site is provided in Table A.3-3. All soil samples were submitted for gamma spectroscopy; isotopic uranium (U), isotopic plutonium (Pu), and isotopic americium (Am); and Pu-241. One sample was also selected for strontium (Sr)-90 and technetium (Tc)-99 analysis, as these isotopes were identified as a potential COC. Soil sampling for the Study Group 1, BFa Site at CAU 541 consisted of the collection of composite soil plot samples and subsurface screening sample (Figure A.3-2).

**Table A.3-3**
**Study Group 1, BFa Site Soil Sample Summary**

| Sample Type | Number of Locations | Number of Soil Samples | Analyses (Method) |
|---|---|---|---|
| Plot | 1 | 4 | Pu-241<br>Isotopic U, Pu, and Am;<br>Gamma Spectroscopy (HASL-300)[a] |
| Grab | 1 | 1 | |
| **Total** | **2** | **5** | |

[a]DOE, 1997

HASL = Health and Safety Laboratory

One sample plot and two subsurface sample locations were established at the Study Group 1, BFa Site. Additional information including the sampling purpose along with depth and type information is provided in Table A.3-4. One sample plot (location A01a) was established to measure the TED at the location of the maximum measured radiological readings as determined from the PRM-470 TRS. This location is approximately 150 m to the southeast of GZ.

**Table A.3-4**
**Study Group 1, BFa Site Soil Samples Collected**

| Release | Location | Sample Number | Depth (cm bgs) | Matrix | Purpose |
|---|---|---|---|---|---|
| BFa Site | A01a | A601 | 0.0 - 5.0 | Soil | Environmental |
| | | A602 | 0.0 - 5.0 | Soil | Environmental |
| | | A603 | 0.0 - 5.0 | Soil | Environmental |
| | | A604 | 0.0 - 5.0 | Soil | Environmental |
| | A02a | A003 | 0.0 - 5.0 | Soil | Environmental |

Two sample locations (A01a and A02a) were selected at the BFa Site to evaluate buried contamination by screening samples at depth (Section A.2.2.2). At both locations, screening action levels for the determination of subsurface contamination were not exceeded, so no subsurface samples were submitted for analysis.

### A.3.2 Deviations/Revised Conceptual Site Model

The CAIP requirements (NNSA/NFO, 2014a) were met at this study group. The information gathered during the CAI supports the CSM as presented in the CAIP, and based upon an evaluation of CAI results, no revisions were necessary to the CSM.

The characteristic traits of the CSM as presented in the CAIP were evaluated as part of the CAI. As discussed in the CAIP and presented as the CSM, potential migration pathways include the lateral migration of contaminants due to wind and water across the soil surface and the vertical migration of potential contaminants into subsurface soils. The translocation of contamination at these sites is influenced by wind and water movement on the Frenchman Flat playa. The potential for future migration of COC levels of radioactivity at this site were evaluated based on investigation results, radiological surveys, and the physical properties of the soil and the contaminants. Physical characteristics of the relatively flat topography include the potential for migration from water inundated contaminants, high adsorptive capacities, low moisture content, and depth to groundwater (approximately 708 ft bgs measured at Water Well WW-5a [USGS, 2015]).

Infiltration and percolation of precipitation serve as driving forces for the vertical migration of contaminants. Vertical migration is enhanced by periodic standing water providing a mechanism for transport, high potential evapotranspiration (estimated at 64 in. [BN, 2001]), and limited precipitation for this region (long-term average of 4.88 inches per year [in./yr] measured at Well 5B [ARL/SORD, 2015]). Infiltration is defined as the process where water on the soil surface enters the soil. Percolation is defined as the process of soil water moving downward through the soil in response to gravity. A geochemistry study for isotopic analysis of standing water on the Frenchman Flat playa (Hershey et al., 2013) reviewed during the investigation concluded that residual radionuclides on the dry playa surface may become submerged, providing a mechanism for both horizontal and vertical transport. The study also concluded that a significant portion of standing water infiltrated into the subsurface; however, it did not imply that groundwater recharge to the saturated zone is occurring. Two locations (see Figure A.3-3) where depth sampling was performed in accordance with Section A.2.2.2 during the CAI did not indicate the presence of buried contamination above action levels or of the vertical migration of contaminants above the FAL at these locations. This evaluation supports the CSM as described in the CAIP (NNSA/NFO, 2014a).

### *A.3.3 Investigation Results*

The following subsections present the analytical and computational results for soil and TLD samples. All sampling and analyses were conducted as specified in the CAIP (NNSA/NFO, 2014a). The radiological results are reported as doses that are comparable to the dose-based FAL of 25 mrem/OU-yr. For chemical contaminants, the results are reported as individual concentrations that are comparable to their corresponding FALs. Results that are equal to or greater than FALs are identified by bold text in the results tables.

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. External doses for TLD locations are summarized in Section A.3.3.1. Internal doses for each sample plot are summarized in Section A.3.3.2. The TEDs for each sampled location are summarized in Section A.3.3.3. Chemical contaminant results for Study Group 1, BFa Site are summarized in Section A.5.3.1.

#### *A.3.3.1 External Radiological Dose Calculations*

Estimates for the external dose that a receptor would receive at each Study Group 1, BFa Site TLD sample location were determined as described in Section A.2.3.2. External dose was calculated for the Industrial Area exposure scenario and then scaled (based on exposure duration) to the Ground Troops and Occasional Use Area exposure scenarios for each TLD location. The standard deviation, number of elements, minimum sample size, and 95 percent UCL values of external dose for each exposure scenario are presented in Table A.3-5.

**Table A.3-5**
**Study Group 1, BFa Site 95% UCL External Dose for Each Exposure Scenario**
(Page 1 of 2)

| Release | Location | Standard Deviation | Number of Elements | Minimum Sample Size (OU Scenario) | Industrial Area (mrem/IA-yr) | Ground Troops (mrem/GT-yr) | Occasional Use Area (mrem/OU-yr) |
|---|---|---|---|---|---|---|---|
| BFa Site | A01a | 0.3 | 3 | 3 | **91.4** | **57.6** | 4.6 |
| | A02a | 0.09 | 3 | 3 | **49.2** | **31.0** | 2.5 |
| | A03 | 0.19 | 3 | 3 | **32.9** | 20.8 | 1.6 |
| | A04 | 0.13 | 3 | 3 | **63.4** | **39.9** | 3.2 |
| | A05 | 0.05 | 3 | 3 | **62.5** | **39.4** | 3.1 |
| | A06 | 0.19 | 3 | 3 | **36.0** | 22.7 | 1.8 |
| | A07 | 0.17 | 3 | 3 | **35.1** | 22.1 | 1.8 |
| | A08 | 0.14 | 3 | 3 | **25.1** | 15.8 | 1.3 |
| | A09 | 0.05 | 3 | 3 | 13.0 | 8.2 | 0.7 |
| | A10 | 0.06 | 3 | 3 | 8.4 | 5.3 | 0.4 |
| | A11 | 0.10 | 3 | 3 | 10.2 | 6.4 | 0.5 |
| | A12 | 0.04 | 3 | 3 | 5.7 | 3.6 | 0.3 |
| | A13 | 0.04 | 3 | 3 | 6.8 | 4.3 | 0.3 |
| | A14 | 0.17 | 3 | 3 | **40.2** | **25.3** | 2.0 |
| | A15 | 0.23 | 3 | 3 | **54.4** | **34.3** | 2.7 |
| | A16 | 0.07 | 3 | 3 | **57.9** | **36.5** | 2.9 |
| | A17 | 0.02 | 3 | 3 | **27.9** | 17.6 | 1.4 |
| | A18 | 0.03 | 3 | 3 | **24.6** | 15.5 | 1.2 |
| | A19 | 0.06 | 3 | 3 | 19.9 | 12.5 | 1.0 |
| | A20 | 0.02 | 3 | 3 | 10.3 | 6.5 | 0.5 |
| | A21 | 0.07 | 3 | 3 | 9.6 | 6.0 | 0.5 |
| | A22 | 0.05 | 3 | 3 | 8.1 | 5.1 | 0.4 |
| | A23 | 0.04 | 3 | 3 | 5.0 | 3.2 | 0.3 |
| | A24 | 0.03 | 3 | 3 | 4.8 | 3.1 | 0.2 |
| | A25 | 0.02 | 3 | 3 | 4.6 | 2.9 | 0.2 |
| | A26 | 0.05 | 3 | 3 | 5.4 | 3.4 | 0.3 |
| | A27 | 0.09 | 3 | 3 | 5.7 | 3.6 | 0.3 |
| | A28 | 0.05 | 3 | 3 | 3.8 | 2.4 | 0.2 |

**Table A.3-5**
**Study Group 1, BFa Site 95% UCL External Dose for Each Exposure Scenario**
(Page 2 of 2)

| Release | Location | Standard Deviation | Number of Elements | Minimum Sample Size (OU Scenario) | Industrial Area (mrem/IA-yr) | Ground Troops (mrem/GT-yr) | Occasional Use Area (mrem/OU-yr) |
|---|---|---|---|---|---|---|---|
| BFa Site (continued) | A29 | 0.10 | 3 | 3 | 20.4 | 12.9 | 1.0 |
| | A30 | 0.09 | 3 | 3 | **30.5** | 19.2 | 1.5 |
| | A31 | 0.18 | 3 | 3 | **40.5** | **25.5** | 2.0 |
| | A32 | 0.11 | 3 | 3 | **43.7** | **27.5** | 2.2 |
| | A33 | 0.13 | 3 | 3 | **36.0** | 22.7 | 1.8 |
| | A34 | 0.10 | 3 | 3 | **30.4** | 19.1 | 1.5 |
| | A35 | 0.13 | 3 | 3 | **25.7** | 16.2 | 1.3 |
| | A36 | 0.11 | 3 | 3 | 15.1 | 9.5 | 0.8 |
| | A37 | 0.04 | 3 | 3 | 8.8 | 5.6 | 0.4 |
| | A38 | 0.10 | 3 | 3 | 10.7 | 6.7 | 0.5 |
| | A39 | 0.01 | 3 | 3 | 6.5 | 4.1 | 0.3 |
| | A40 | 0.06 | 3 | 3 | 7.5 | 4.7 | 0.4 |

Bold indicates the values exceeding 25 mrem/yr.

### *A.3.3.2 Internal Radiological Dose Calculations*

Estimates for the internal dose that a receptor would receive at each Study Group 1, BFa Site sample plot were determined as described in Section A.2.3.1. The standard deviation, number of samples, minimum sample size, and 95 percent UCL of the internal dose for each exposure scenario are presented in Table A.3-6. As shown in Table A.3-6, the minimum sample size was met for location A01a.

Table A.3-7 presents the contributions of internal and external doses to TED for each sample. This demonstrates that internal dose at Study Group 1, BFa Site comprises a small percentage of TED and does not exceed external dose at any sample plot.

**Table A.3-6**
**Study Group 1, BFa Site 95% UCL Internal Dose at Soil Sample Locations for Each Exposure Scenario**

| Release | Location | Standard Deviation | Number of Samples | Minimum Sample Size (OU Scenario) | Industrial Area (mrem/IA-yr) | Ground Troops (mrem/GT-yr) | Occasional Use Area (mrem/OU-yr) |
|---|---|---|---|---|---|---|---|
| BFa Site | A01a | 0.002 | 4 | 3 | 0.02 | 0.02 | 0.001 |
| | A02a | N/A[a] | 1 | N/A[a] | 0.03 | 0.03 | 0.002 |

[a]Grab sample collected at this location, rendering statistics inapplicable.

**Table A.3-7**
**Study Group 1, BFa Site Contribution of Internal Dose to TED at Each Soil Sample Location**

| Release | Location | Average Internal Dose (mrem/OU-yr) | Average Total Dose (mrem/OU-yr) | Percent Internal Dose |
|---|---|---|---|---|
| BFa Site | A01a | 0.001 | 4.1 | 0.02 |
| | A02a | 0.002 | 2.3 | 0.09 |

### *A.3.3.3 Total Effective Dose*

The TED for each sample plot, grab sample location, or TLD location was calculated by adding the external dose values and the internal dose values. Values for both the average TED and the 95 percent UCL of the TED for the Industrial Area, Ground Troops, and Occasional Use Area exposure scenarios are presented in Table A.3-8. The 95 percent UCL of the TED for grab sample locations is comprised of the single internal dose result plus the 95 percent UCL of the external dose from the TLDs. Occasional Use TED values are provided on Figure A.3-3.

The TED did not exceed the FAL (the 95 percent UCL of the average TED exceeding 25 mrem/OU-yr) at any sample or TLD location at the Study Group 1, BFa Site (Figure A.3-3).

The TED at this location is currently driven by cesium (Cs)-137 and europium (Eu)-152, which contributed approximately 98 percent of the total dose.

No additional releases were identified at this study group.

**Table A.3-8**
**Study Group 1, BFa Site TED at Sample Locations (mrem/yr)**
(Page 1 of 2)

| Release | Sample Location | Industrial Area | | Ground Troops | | Occasional Use Area | |
|---|---|---|---|---|---|---|---|
| | | Average TED | 95% UCL of TED | Average TED | 95% UCL of TED | Average TED | 95% UCL of TED |
| BFa Site Locations on NNSS | A01a | **81.2** | **91.5** | **51.1** | **57.6** | 4.1 | 4.6 |
| | A02a | **46.2** | **49.3** | **29.1** | **31.0** | 2.3 | 2.5 |
| | A03 | **26.6** | **33.0** | 16.7 | 20.8 | 1.3 | 1.6 |
| | A04 | **59.0** | **63.4** | **37.2** | **39.9** | 2.9 | 3.2 |
| | A05 | **61.0** | **62.5** | **38.4** | **39.4** | 3.0 | 3.1 |
| BFa Site Locations on NTTR | A06 | **29.7** | **36.1** | 18.7 | 22.7 | 1.5 | 1.8 |
| | A07 | **29.3** | **35.2** | 18.5 | 22.1 | 1.5 | 1.8 |
| | A08 | 20.5 | **25.1** | 12.9 | 15.8 | 1.0 | 1.3 |
| | A09 | 11.4 | 13.0 | 7.2 | 8.2 | 0.6 | 0.7 |
| | A10 | 6.4 | 8.4 | 4.0 | 5.3 | 0.3 | 0.4 |
| | A11 | 7.0 | 10.2 | 4.4 | 6.4 | 0.3 | 0.5 |
| | A12 | 4.4 | 5.7 | 2.8 | 3.6 | 0.2 | 0.3 |
| | A13 | 5.5 | 6.8 | 3.5 | 4.3 | 0.3 | 0.3 |
| BFa Site Locations on NNSS | A14 | **34.4** | **40.2** | 21.7 | **25.3** | 1.7 | 2.0 |
| | A15 | **46.5** | **54.4** | **29.3** | **34.3** | 2.3 | 2.7 |
| | A16 | **55.6** | **57.9** | **35.0** | **36.5** | 2.8 | 2.9 |
| | A17 | **27.1** | **27.9** | 17.1 | 17.6 | 1.4 | 1.4 |
| | A18 | 23.6 | 24.6 | 14.8 | 15.5 | 1.2 | 1.2 |
| | A19 | 17.9 | 19.9 | 11.3 | 12.5 | 0.9 | 1.0 |
| | A20 | 9.8 | 10.3 | 6.2 | 6.5 | 0.5 | 0.5 |
| | A21 | 7.2 | 9.6 | 4.5 | 6.0 | 0.4 | 0.5 |
| | A22 | 6.3 | 8.1 | 4.0 | 5.1 | 0.3 | 0.4 |
| | A23 | 3.8 | 5.0 | 2.4 | 3.2 | 0.2 | 0.3 |
| | A24 | 3.8 | 4.8 | 2.4 | 3.1 | 0.2 | 0.2 |
| | A25 | 4.0 | 4.6 | 2.5 | 2.9 | 0.2 | 0.2 |
| | A26 | 3.5 | 5.4 | 2.2 | 3.4 | 0.2 | 0.3 |
| | A27 | 2.7 | 5.7 | 1.7 | 3.6 | 0.1 | 0.3 |

**Table A.3-8**
**Study Group 1, BFa Site TED at Sample Locations (mrem/yr)**
(Page 2 of 2)

| Release | Sample Location | Industrial Area | | Ground Troops | | Occasional Use Area | |
|---|---|---|---|---|---|---|---|
| | | Average TED | 95% UCL of TED | Average TED | 95% UCL of TED | Average TED | 95% UCL of TED |
| BFa Site Locations on NNSS (continued) | A28 | 2.2 | 3.8 | 1.4 | 2.4 | 0.1 | 0.2 |
| | A29 | 17.2 | 20.4 | 10.8 | 12.9 | 0.9 | 1.0 |
| | A30 | **27.4** | **30.5** | 17.3 | 19.2 | 1.4 | 1.5 |
| | A31 | **34.5** | **40.5** | 21.7 | **25.5** | 1.7 | 2.0 |
| | A32 | **39.9** | **43.7** | **25.1** | **27.6** | 2.0 | 2.2 |
| | A33 | **31.5** | **36.0** | 19.9 | 22.7 | 1.6 | 1.8 |
| | A34 | **27.0** | **30.4** | 17.0 | 19.2 | 1.3 | 1.5 |
| | A35 | 21.4 | **25.7** | 13.4 | 16.2 | 1.1 | 1.3 |
| | A36 | 11.3 | 15.1 | 7.1 | 9.5 | 0.6 | 0.8 |
| | A37 | 7.4 | 8.8 | 4.7 | 5.6 | 0.4 | 0.4 |
| | A38 | 7.1 | 10.7 | 4.5 | 6.7 | 0.4 | 0.5 |
| | A39 | 6.3 | 6.5 | 4.0 | 4.1 | 0.3 | 0.3 |
| | A40 | 5.3 | 7.5 | 3.4 | 4.7 | 0.3 | 0.4 |

Bold indicates the values exceeding 25 mrem/yr.

### *A.3.4 Nature and Extent of COCs*

As presented in Section A.3.3, no radiological contamination is present at the Study Group 1, BFa Site that exceeds the FAL of 25 mrem/OU-yr. Therefore, no corrective action is required for radiological contamination associated with Study Group 1.

### *A.3.5 Best Management Practices*

As a BMP, an administrative UR was established to include any area where an industrial land use of the area (2,000 hr/yr under the Industrial Area scenario) could cause a future site worker to receive a dose exceeding 25 mrem/yr. To determine the extent of the area where TED exceeds the Industrial Area scenario, a correlation of radiation survey values to the average Industrial Area TED values was conducted as described in Section A.2.5 for the radiation surveys listed in Table A.3-9. The radiation

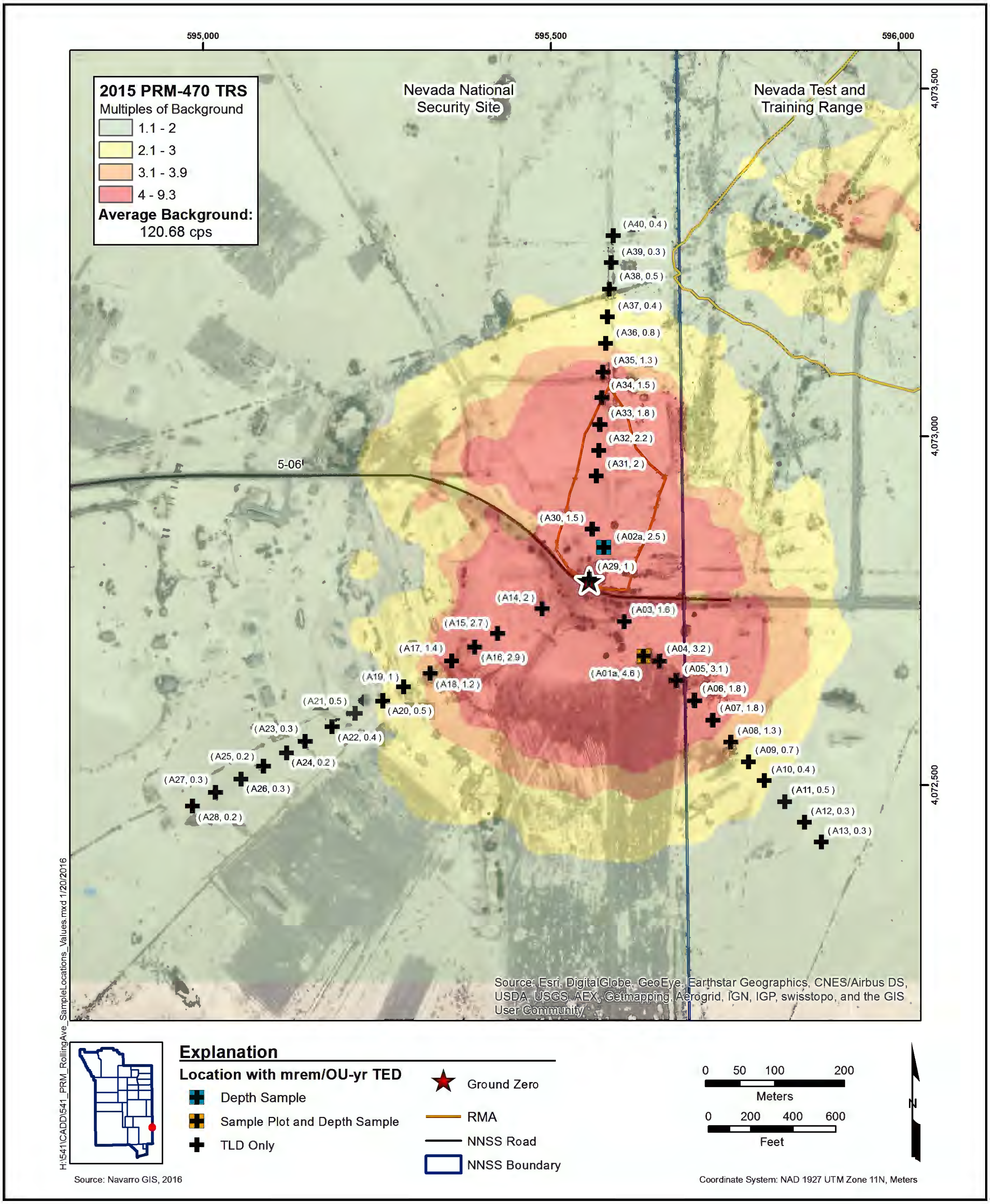



**Figure A.3-3**
**Study Group 1, BFa Site, 95% UCL of the TED**

survey that exhibited the best correlation is the PRM-470 TRS, with a correlation of 0.92. The man-made spectra provided by the PRM-470 was of the greatest use in delineating the spatial distribution of fissioned material at this site. This correlation exceeds the minimum criteria of 0.8 as required by the Soils RBCA document (NNSA/NFO, 2014b). Based on the correlation of TRS with the PRM-470, the radiation survey value that corresponds to the 25-mrem/IA-yr boundary for the BFa Site is 3.88 MOB. The administrative boundary based on this correlation is shown on Figure A.3-4 and presented in Attachment D-1.

**Table A.3-9**
**Study Group 1, BFa Site Correlations of 95% UCL TED with Gamma Surveys**

| Dataset | Coefficient of Determination ($r^2$) |
|---|---|
| 2015 Navarro PRM-470 TRS | 0.92 |
| 2015 Navarro FIDLER TRS | 0.89 |
| 2010 Gamma Flyover - Gross Count | 0.89 |
| 2010 Gamma Flyover - Man Made | 0.87 |
| 1994 Gamma Flyover - Gross Count | 0.74 |
| 1994 Gamma Flyover - Man Made | 0.74 |

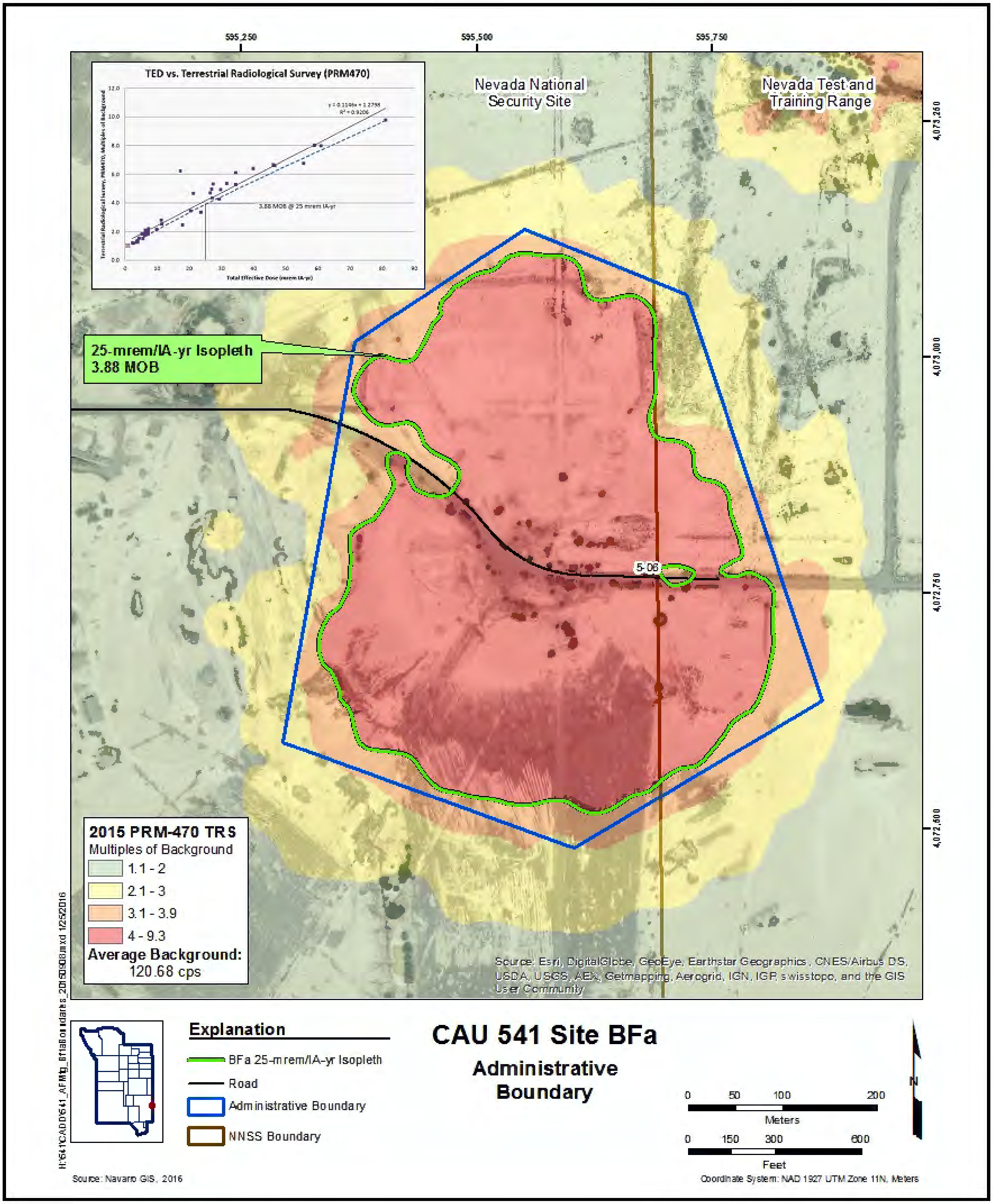



**Figure A.3-4**
**Study Group 1, BFa Site Administrative Boundary**

# A.4.0 Study Group 2, Small Boy Site

The Study Group 2, Small Boy Site is located on the western edge of the NTTR. The study group consists of a release of radioactive material to the soil surface as a result of a weapons-effects test located at the Small Boy site. Additional detail on the history of the Study Group 2, Small Boy Site is provided in the CAIP (NNSA/NFO, 2014a).

## A.4.1 CAI Activities

The specific CAI activities conducted to satisfy the CAIP requirements at this study group are described in the following subsections.

### A.4.1.1 Visual Surveys

A visual survey of the Study Group 2, Small Boy Site site was conducted over the area shown in Figure A.4-1. This survey identified extensive facilities and debris remaining from testing activities. Numerous concrete and steel structures, military fortifications (foxholes and bunkers), wood structures, shelters, and diagnostic instrumentation locations remain at this site. Although these items could potentially provide the source for a release of contamination, no indications of a release were identified, and no locations were selected for further investigation.

### A.4.1.2 Radiological Surveys

Aerial surveys and TRSs were performed at the Study Group 2, Small Boy Site. The aerial surveys are described in Section A.2.2.1. The TRSs were conducted at the site and the radiological anomaly to the south to identify the spatial distribution of radiological readings and to identify the location of the highest radiological readings. Figure A.4-1 presents a graphic representation of the radiological survey data from the FIDLER TRS. The data presented in the figure represent a continuous spatial distribution (i.e., interpolated surface) estimated from the FIDLER TRSs using an inverse distance weighted interpolation technique using the geostatistical analyst extension of the ArcGIS software. The results show a defined, but irregular, pattern of elevated radiological measurements to the northeast of GZ.

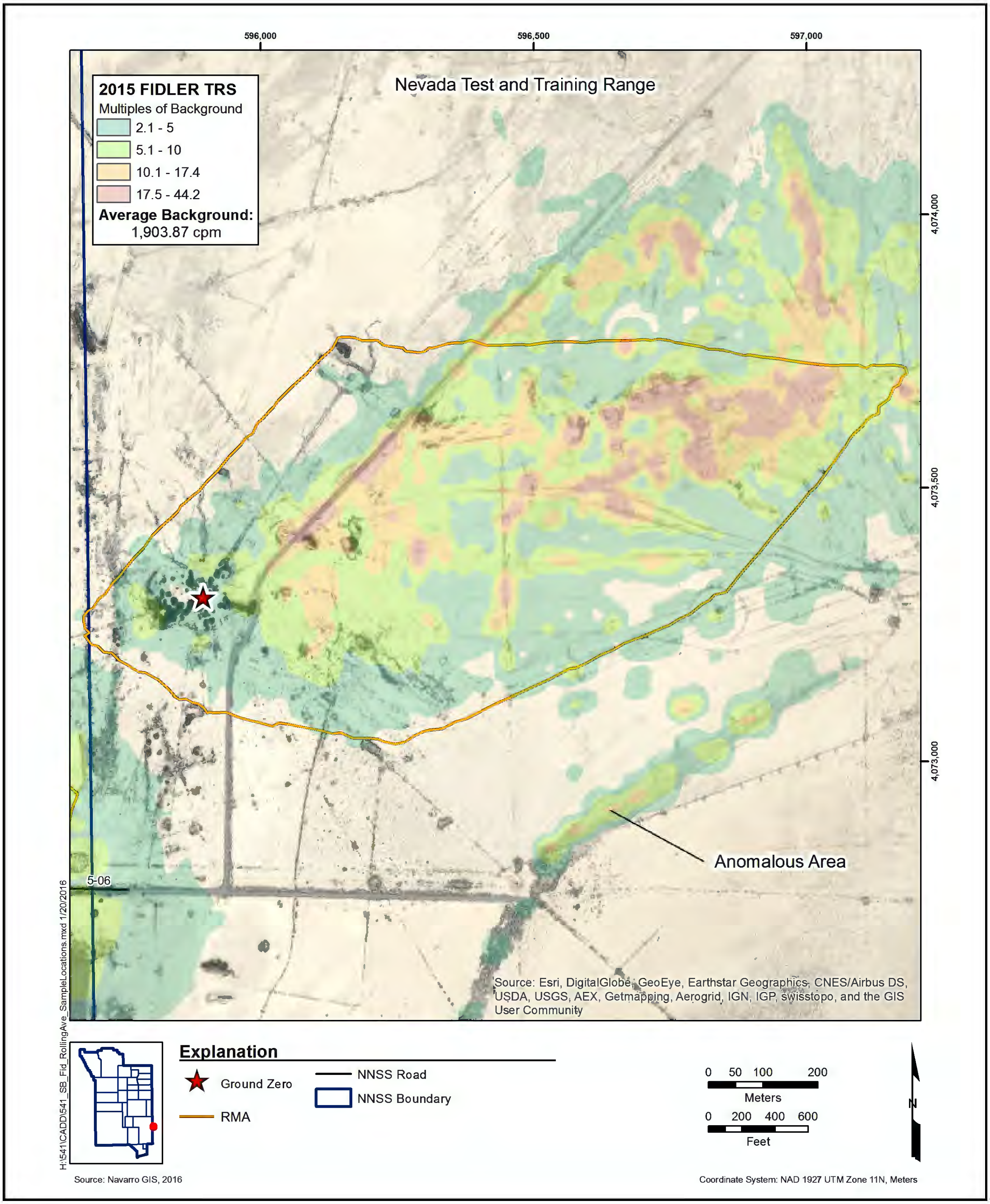



**Figure A.4-1**
**Study Group 2, Small Boy Site TRS**

In addition to the TRSs, the 1994, 1997, and 2010 aerial radiological surveys (BN, 1999 and 1997; Stampahar, 2012) were used to help determine the locations of the soil sample and TLD locations at the Study Group 2, Small Boy Site (Figure A.4-2). The aerial radiological surveys covered the area of the measured radiological plume that extends to the northeast of GZ and were used to select sample locations within the plume.

#### *A.4.1.3 Sample Collection*

Soil samples and TLD samples were collected to satisfy the CAIP requirements (NNSA/NFO, 2014a) at the Study Group 2, Small Boy Site. The specific CAI activities conducted at this study group are described in the following subsections.

##### *A.4.1.3.1 TLD Samples*

A summary of the TLD samples placed at the Study Group 2, Small Boy Site is provided in Table A.4-1. Environmental TLDs were installed at a total of 21 locations (B01 through B21) at Study Group 2 to calculate external doses as presented in Table A.4-2. TLDs were placed at all sample plot and grab sample locations at this site (Figure A.4-2). The 2010 flyover survey data provided in Figure A.4-2 depict the extent of the eastern edge of that survey. The area farther east of the survey was included in the figure due to the selected sample location.

TLDs were placed at each of the eight sampling plot locations (B01, B02, and B04 through B09). Sample plots and TLDs that were placed in the Study Group 2, Small Boy Site detected radiological plume trending to the northeast of GZ and within the radiological anomaly to the south. Seven sample plots (B02 and B04 through B09) to include TLDs were placed within the northeast-trending plume to better characterize the defined, but irregular, pattern of fissioned surface contamination. Location B01 was selected for TLD placement to measure the TED within the anomalous radiologically elevated area to the south of GZ. TLDs were placed at 12 locations within the center axis of the northeast-trending plume to correspond with grab sample locations determined from TRS. Two TLDs (B01 and B03) were selected at the Study Group 2, Small Boy Site and the anomalous area to the south to correspond with locations chosen to evaluate buried contamination. All TLDs were measured by the NNSS environmental TLD monitoring program.

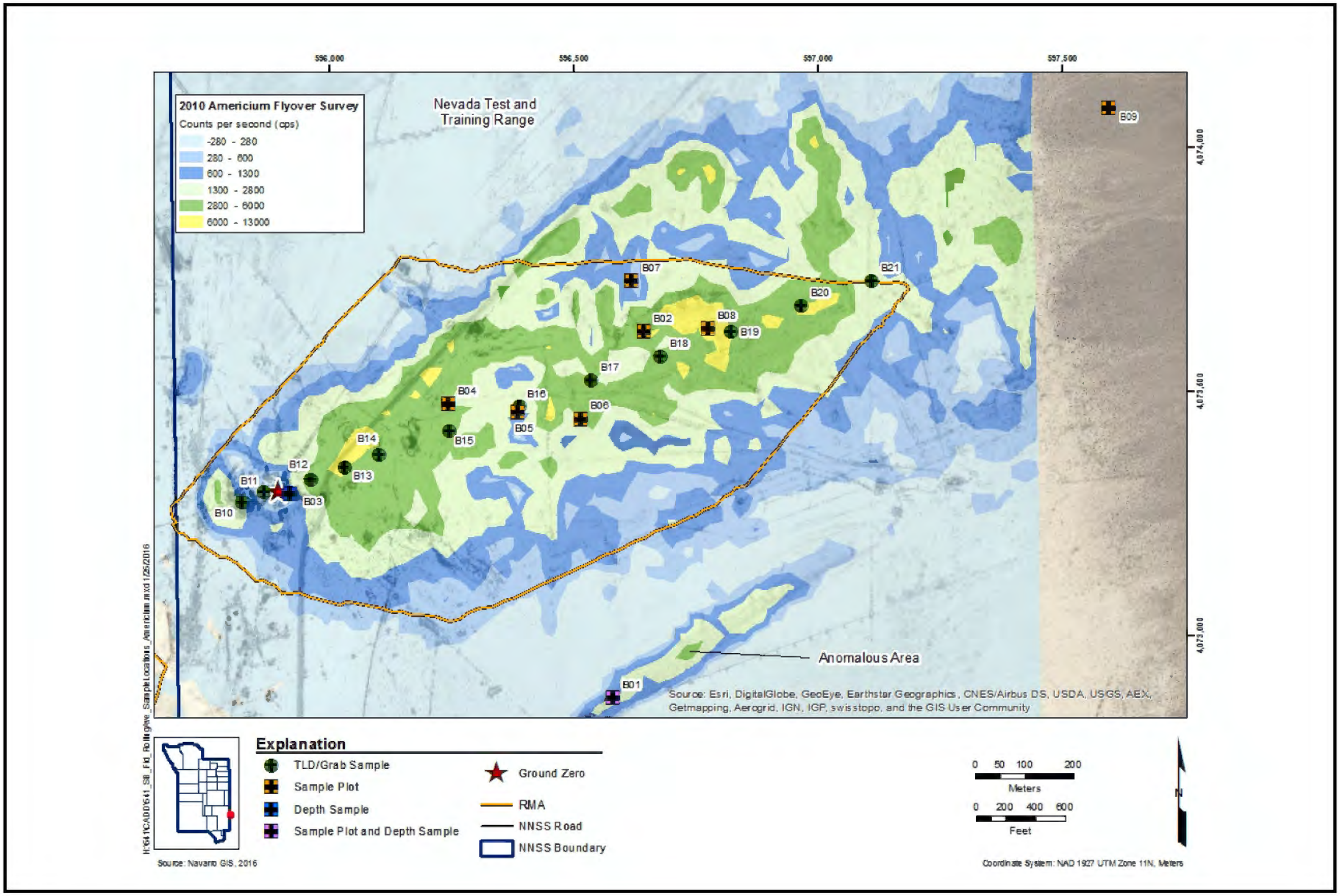



**Figure A.4-2**
**Study Group 2, Small Boy Site Sample and TLD Locations**

**Table A.4-1**
**Study Group 2, Small Boy Site TLD Sample Summary**

| Location Type | Number of Locations | Number of TLDs | Analyses (Method) |
|---|---|---|---|
| Co-located with Grab | 12 | 12 | See Section A.7.5 |
| Plot | 8 | 8 | |
| Subsurface | 1 | 1 | |
| Background | 3 | 3 | |
| **Total** | **24** | **24** | |

**Table A.4-2**
**Study Group 2, Small Boy Site TLDs**
(Page 1 of 2)

| Release | Location | TLD No. | Date Placed | Date Removed | Purpose |
|---|---|---|---|---|---|
| Small Boy | B01 | 5014 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B02 | 4946 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B03 | 4676 | 11/05/2014 | 02/23/2015 | Subsurface sample |
| | B04 | 6086 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B05 | 6192 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B06 | 6265 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B07 | 4179 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B08 | 4329 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B09 | 4532 | 11/18/2014 | 02/23/2015 | Sample plot |
| | B10 | 6182 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B11 | 6412 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B12 | 6328 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B13 | 6492 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B14 | 6171 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B15 | 6439 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B16 | 6251 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B17 | 6222 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B18 | 4414 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B19 | 6165 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |

**Table A.4-2**
**Study Group 2, Small Boy Site TLDs**
(Page 2 of 2)

| Release | Location | TLD No. | Date Placed | Date Removed | Purpose |
|---|---|---|---|---|---|
| Small Boy (continued) | B20 | 6082 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | B21 | 6458 | 11/05/2014 | 02/23/2015 | Concurrent with grab sample |
| | H01 | 2096 | 11/04/2014 | 02/23/2015 | Background TLD location |
| | H02 | 6490 | 11/04/2014 | 02/23/2015 | Background TLD location |
| | H03 | 6065 | 11/04/2014 | 02/23/2015 | Background TLD location |

Three TLDs (H01, H02, and H03) were placed to calculate background (Figure A.2-1). To aid in the determination of the proper background dose to use in TED calculation, Figure A.2-1 shows a background isopleth map generated from the 1994 aerial radiation survey (BN, 1999) was used to verify that background TLDs represent the background dose estimated at CAU 541 TLD locations. It was determined that the background TLD locations are representative of the general area and can be used as a good estimate of true average background dose for all of the environmental TLDs.

### *A.4.1.3.2 Soil Samples*

Soil sampling for the Study Group 2, Small Boy Site included the collection of composite soil plot samples, surface soil grab samples, and subsurface screening and grab samples (Section A.2.2.2). All soil samples were submitted for gamma spectroscopy; Pu-241; and isotopic U, Pu, and Am analyses.

A total of 8 sample plot, 12 grab sample, and 2 subsurface sample locations were established at the Study Group 2, Small Boy Site (Figure A.4-2). Additional information including the sampling purpose along with depth and type information is provided in Table A.4-3.

Sample plot B02 was established at the location with the maximum detected radiological readings from the FIDLER TRS within the radiological plume trending to the northeast of GZ. Sample plot B02 is located approximately 830 m to the northeast of GZ. One sample plot (B01) was placed to measure the TED within the radiological anomaly south of GZ. Sample plot B01 was established at the location of the maximum detected radiological readings from the FIDLER TRS within the anomalous area to the south. Seven additional sample plots (B02 and B04 through B09) were placed in the radiological plume trending to the northeast of GZ within high, medium, and low radiologically

**Table A.4-3**
**Study Group 2, Small Boy Site Soil Samples Collected**
(Page 1 of 2)

| Release | Location | Sample Number | Depth (cm bgs) | Matrix | Purpose |
|---|---|---|---|---|---|
| Small Boy | B01 | B629 | 0.0 - 5.0 | Soil | Anomalous Area Sample Plot. |
| | | B630 | | | |
| | | B631 | | | |
| | | B632 | | | |
| | B02 | B613 | 0.0 - 5.0 | Soil | Sample Plot |
| | | B614 | | | |
| | | B615 | | | |
| | | B616 | | | |
| | B03 | B633 | 0.0 - 5.0 | Soil | Grab Sample |
| | B03a | B634 | 0.0 - 5.0 | Soil | FD of #B633 |
| | B03b | B635 | 5.0 - 10.0 | Soil | Subsurface Grab Sample |
| | B04 | B625 | 0.0 - 5.0 | Soil | Sample Plot |
| | | B626 | | | |
| | | B627 | | | |
| | | B628 | | | |
| | B05 | B621 | 0.0 - 5.0 | Soil | Sample Plot |
| | | B622 | | | |
| | | B623 | | | |
| | | B624 | | | |
| | B06 | B617 | 0.0 - 5.0 | Soil | Sample Plot |
| | | B618 | | | |
| | | B619 | | | |
| | | B620 | | | |
| | B07 | B605 | 0.0 - 5.0 | Soil | Sample Plot |
| | | B606 | | | |
| | | B607 | | | |
| | | B608 | | | |

**Table A.4-3**
**Study Group 2, Small Boy Site Soil Samples Collected**
(Page 2 of 2)

| Release | Location | Sample Number | Depth (cm bgs) | Matrix | Purpose |
|---|---|---|---|---|---|
| Small Boy (continued) | B08 | B609 | 0.0 - 5.0 | Soil | Sample Plot |
| | | B610 | | | |
| | | B611 | | | |
| | | B612 | | | |
| | B09 | B601 | 0.0 - 5.0 | Soil | Sample Plot |
| | | B602 | | | |
| | | B603 | | | |
| | | B604 | | | |
| | B10 | B001 | 0.0 - 5.0 | Soil | Grab Sample |
| | B11 | B002 | 0.0 - 5.0 | Soil | Grab Sample |
| | B12 | B003 | 0.0 - 5.0 | Soil | Grab Sample |
| | B13 | B004 | 0.0 - 5.0 | Soil | Grab Sample |
| | B14 | B005 | 0.0 - 5.0 | Soil | Grab Sample |
| | B15 | B006 | 0.0 - 5.0 | Soil | Grab Sample |
| | B16 | B007 | 0.0 - 5.0 | Soil | Grab Sample |
| | B17 | B008 | 0.0 - 5.0 | Soil | Grab Sample |
| | B18 | B009 | 0.0 - 5.0 | Soil | Grab Sample |
| | B19 | B010 | 0.0 - 5.0 | Soil | Grab Sample |
| | B20 | B011 | 0.0 - 5.0 | Soil | Grab Sample |
| | B21 | B012 | 0.0 - 5.0 | Soil | Grab Sample |

FD = Field duplicate

elevated areas. This was performed to best measure the distribution of contaminants in the defined, but irregular, pattern of surface contamination observed. Grab samples were collected at 12 locations (B10 through B21) along the center axis of the northeast-trending plume as measured from the FIDLER TRS.

Two locations were selected at the Small Boy site (locations B01 and B03) to evaluate buried contamination. Location B03 was selected near the Small Boy GZ and location B01 at the radiological anomaly to the south. Both locations were subjected to field screening at depth and the collection of a surface sample for laboratory analysis. Subsurface samples were collected for laboratory analysis only if a field screening action level at depth was exceeded in accordance with Section A.2.2.2. At location B01, field screening to a depth of 30 cm did not show results exceeding action levels and only a surface soil sample (No. B629 in Table A.4-4) was collected for laboratory analysis. Field screening at the B03 site indicated alpha readings above the action level at a depth of 5 to 10 cm, and subsurface soil sample (No. B635 at location B03b in Table A.4-4) was collected along with the surface sample (No. B633) for laboratory analysis. Laboratory analysis for the depth sample at 5 to 10 cm (No. B635 at location B03b in Table A.4-4) showed no results above the surface sample results.

**Table A.4-4**
**Study Group 2, Small Boy Site 95% UCL External Dose for Each Exposure Scenario**
(Page 1 of 2)

| Release | Location | Standard Deviation | Number of Elements | Minimum Sample Size (OU Scenario) | Industrial Area (mrem/IA-yr) | Ground Troops (mrem/GT-yr) | Occasional Use Area (mrem/OU-yr) |
|---|---|---|---|---|---|---|---|
| Small Boy | B01 | 0.04 | 3 | 3 | 14.6 | 9.2 | 0.7 |
| | B02 | 0.75 | 3 | 3 | **140.7** | **88.6** | 7.0 |
| | B03 | 0.02 | 3 | 3 | 12.9 | 8.1 | 0.6 |
| | B03a | N/A[a] | N/A[a] | N/A[a] | 12.9 | 8.1 | 0.6 |
| | B03b | N/A[a] | N/A[a] | N/A[a] | 2.3 | 1.4 | 0.1 |
| | B04 | 0.08 | 3 | 3 | 13.6 | 8.5 | 0.7 |
| | B05 | 0.05 | 3 | 3 | 6.5 | 4.1 | 0.3 |
| | B06 | 0.04 | 3 | 3 | 6.8 | 4.3 | 0.3 |
| | B07 | 0.05 | 3 | 3 | 2.7 | 1.7 | 0.1 |
| | B08 | 0.26 | 3 | 3 | **61.1** | **38.5** | 3.1 |
| | B09 | 0.03 | 3 | 3 | 0.7 | 0.4 | 0.0 |
| | B10 | 0.13 | 3 | 3 | 22.6 | 14.2 | 1.1 |
| | B11 | 0.05 | 3 | 3 | 6.8 | 4.3 | 0.3 |
| | B12 | 0.15 | 3 | 3 | **32.4** | 20.4 | 1.6 |
| | B13 | 0.24 | 3 | 3 | **27.1** | 17.0 | 1.4 |
| | B14 | 0.10 | 3 | 3 | 18.8 | 11.8 | 0.9 |
| | B15 | 0.10 | 3 | 3 | 6.8 | 4.3 | 0.3 |

**Table A.4-4**
**Study Group 2, Small Boy Site 95% UCL External Dose for Each Exposure Scenario**
(Page 2 of 2)

| Release | Location | Standard Deviation | Number of Elements | Minimum Sample Size (OU Scenario) | Industrial Area (mrem/IA-yr) | Ground Troops (mrem/GT-yr) | Occasional Use Area (mrem/OU-yr) |
|---|---|---|---|---|---|---|---|
| Small Boy (continued) | B16 | 0.03 | 3 | 3 | 4.3 | 2.7 | 0.2 |
| | B17 | 0.06 | 3 | 3 | 5.3 | 3.3 | 0.3 |
| | B18 | 0.11 | 3 | 3 | 15.9 | 10.0 | 0.8 |
| | B19 | 0.14 | 3 | 3 | 20.8 | 13.1 | 1.0 |
| | B20 | 0.08 | 3 | 3 | 14.5 | 9.2 | 0.7 |
| | B21 | 0.08 | 3 | 3 | 7.5 | 4.7 | 0.4 |

[a] No TLD was placed at this location. External dose was calculated using the external RESRAD values.

Bold indicates the values exceeding 25 mrem/yr.

### *A.4.2 Deviations/Revised Conceptual Site Model*

The CAIP requirements (NNSA/NFO, 2014a) were met at this study group. The information gathered during the CAI supports the CSM as presented in the CAIP, and based upon an evaluation of CAI results, no revisions were necessary to the CSM.

The characteristic traits of the CSM as presented in the CAIP were evaluated as part of the CAI. As discussed in the CAIP and presented as the CSM, potential migration pathways include the lateral migration of contaminants across the soil surface and the vertical migration of potential contaminants into subsurface soils. The translocation of contamination at these sites is influenced by wind and water movement on the Frenchman Flat playa. The potential for future migration of COC levels of radioactivity at this site were evaluated based on investigation results, radiological surveys, and the physical properties of the soil and the contaminants. Physical characteristics of the relatively flat topography include the potential for migration from periodic ponding of water, high adsorptive capacities, low moisture content, and depth to groundwater (approximately 708 ft bgs measured at Water Well WW-5a [USGS, 2015]).

Based upon an evaluation of the irregular patterns of elevated radiological contaminants shown in the radiation surveys (either the aerial surveys or TRS) and the locations of vegetation and objects identified in the visual surveys and aerial photographs, the higher levels of radioactivity are generally associated with the presence of vegetation or larger objects (Figure A.4-1). This association supports the CSM that the Small Boy radiation plume was initially a regular concentric pattern similar to that observed at other nuclear test locations. However, the Small Boy test area is unique in that the site is a lake bed subjected to seasonal ponding, and the major contaminants are plutonium and americium in the form of finely divided particles that are tightly adsorbed primarily on the clay fraction of the soil. The finer clay particles are more subject to displacement due to water movement during times of ponding as well as movement by wind during dry periods. This movement occurs in both contaminated and uncontaminated soils resulting in dispersion of contaminated soil particles into the uncontaminated particles, thus reducing the soil concentrations. Where vegetation or objects inhibits this natural process, dispersion is reduced and the original contaminant concentrations are somewhat preserved. This can explain the irregular patterns of radioactivity that is currently observed.

Infiltration and percolation of precipitation serve as driving forces for the vertical migration of contaminants below the FAL. These forces are influenced by standing water providing a mechanism for transport, high potential evapotranspiration (estimated at 64 in. [BN, 2001]), and limited precipitation for this region (long-term average of 4.88 in./yr measured at Well 5B [ARL/SORD, 2015]). A geochemistry study for isotopic analysis of standing water on the Frenchman Flat playa (Hershey et al., 2013) reviewed during the investigation concluded that residual radionuclides on the dry playa surface may become submerged providing a mechanism for both horizontal and vertical transport. The study also concluded that a significant portion of standing water infiltrated into the subsurface; however, it did not imply that groundwater recharge is occurring. Two locations where depth sampling was performed in accordance with Section A.2.2.2 during the CAI did not indicate the presence of buried contamination above the FAL at these locations. Field screening at the location closest to GZ (location B03) did show alpha readings above the action level at 5 to 10 cm and was collected as a sample for laboratory analysis. Subsequent radiochemistry analytical results show that the sample results at depth did not exceed the surface sample results. This evaluation supports the CSM as described in the CAIP (NNSA/NFO, 2014a).

### *A.4.3 Investigation Results*

The following subsections present the analytical and computational results for soil and TLD samples. All sampling and analyses were conducted as specified in the CAIP (NNSA/NFO, 2014a). The radiological results are reported as doses that are comparable to the dose-based FAL of 25 mrem/OU-yr. For chemical contaminants, the results are reported as individual concentrations that are comparable to their corresponding FALs. Results that are equal to or greater than FALs are identified by bold text in the results tables.

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. External doses for TLD locations are summarized in Section A.4.3.1. Internal doses for each sample plot are summarized in Section A.4.3.2. The TEDs for each sampled location are summarized in Section A.4.3.3. Chemical contaminant results for the Small Boy site are summarized in Section A.5.3.1.

#### *A.4.3.1 External Radiological Dose Calculations*

Estimates for the external dose that a receptor would receive at each Study Group 2 TLD sample location were determined as described in Section A.2.3.2. External dose was calculated for the Industrial Area exposure scenario and then scaled (based on exposure duration) to the Ground Troops and Occasional Use Area exposure scenarios for each TLD location. The standard deviation, number of elements, minimum sample size, and 95 percent UCL values of external dose for each exposure scenario are presented in Table A.4-4.

Measurements using a pressurized ion chamber (PIC) were collected at each of the Study Group 2 sample locations to measure external dose. This information and comparison to the external dose determined from TLD measurements is provided in Appendix G.

#### *A.4.3.2 Internal Radiological Dose Calculations*

Estimates for the internal dose that a receptor would receive at each Study Group 2 sample plot were determined as described in Section A.2.3.1. The standard deviation, number of samples, minimum sample size, and 95 percent UCL of the internal dose at the sample plots for each exposure scenario are presented in Table A.4-5. The number of samples and internal dose at the grab sample locations for each exposure scenario are presented in Table A.4-6. As shown in these tables, the minimum sample size was met for all sample locations.

**Table A.4-5**
**Study Group 2, Small Boy Site 95% UCL Internal Dose at Sample Plots for Each Exposure Scenario**

| Release | Location | Standard Deviation | Number of Samples | Minimum Sample Size (OU Scenario) | Industrial Area (mrem/IA-yr) | Ground Troops (mrem/GT-yr) | Occasional Use Area (mrem/OU-yr) |
|---|---|---|---|---|---|---|---|
| Small Boy | B01 | 0.04 | 4 | 3 | 6.8 | 6.1 | 0.4 |
| | B02 | 1.34 | 4 | 3 | **64.7** | **57.6** | 3.9 |
| | B04 | 0.11 | 4 | 3 | 5.0 | 4.5 | 0.3 |
| | B05 | 0.07 | 4 | 3 | 2.7 | 2.4 | 0.2 |
| | B06 | 0.06 | 4 | 3 | 3.1 | 2.8 | 0.2 |
| | B07 | 0.004 | 4 | 3 | 0.2 | 0.2 | 0.0 |
| | B08 | 0.20 | 4 | 3 | 22.5 | 20.1 | 1.4 |
| | B09 | 0.01 | 4 | 3 | 1.2 | 1.1 | 0.1 |

Bold indicates the values exceeding 25 mrem/yr.

Table A.4-7 presents the contributions of internal and external doses to TED for each sample plot. This demonstrates that internal dose at Study Group 2 comprises a significant percentage of TED at most sample plots.

### *A.4.3.3 Total Effective Dose*

The TED for each sample plot and grab sample location (all with TLDs included) was calculated by adding the external dose values and the internal dose values. Values for both the average TED and the 95 percent UCL of the TED for the Industrial Area, Ground Troops, and Occasional Use Area exposure scenarios are presented in Table A.4-8.

As determined by the stakeholders at the CAA meeting, the FAL was determined to be 25 mrem/yr based on the OU Scenario. The TED did not exceed the FAL (the 95 percent UCL of the average TED) for all sample locations on the Small Boy site (Figure A.4-3).

## Table A.4-6
## Study Group 2, Small Boy Site 95% UCL Internal Dose at Grab Sample Locations for Each Exposure Scenario

| Release | Location | Number of Samples | Industrial Area (mrem/IA-yr) | Ground Troops (mrem/GT-yr) | Occasional Use Area (mrem/OU-yr) |
|---|---|---|---|---|---|
| Small Boy | B03 | 1 | 0.0 | 0.0 | 0.0 |
| | B03a | 1 | 0.0 | 0.0 | 0.0 |
| | B03b | 1 | 0.0 | 0.0 | 0.0 |
| | B10 | 1 | 0.0 | 0.0 | 0.0 |
| | B11 | 1 | 0.0 | 0.0 | 0.0 |
| | B12 | 1 | 4.2 | 3.7 | 0.3 |
| | B13 | 1 | 9.4 | 8.4 | 0.6 |
| | B14 | 1 | 16.1 | 14.4 | 1.0 |
| | B15 | 1 | 0.4 | 0.4 | 0.0 |
| | B16 | 1 | 0.3 | 0.2 | 0.0 |
| | B17 | 1 | 0.1 | 0.1 | 0.0 |
| | B18 | 1 | 2.6 | 2.3 | 0.2 |
| | B19 | 1 | 4.3 | 3.9 | 0.3 |
| | B20 | 1 | 0.7 | 0.6 | 0.0 |
| | B21 | 1 | 1.1 | 1.0 | 0.1 |

## Table A.4-7
## Study Group 2, Small Boy Site Contribution of Internal Dose to TED at Each Sample Plot

| Release | Location | Average Internal Dose (mrem/GT-yr) | Average Total Dose (mrem/GT-yr) | Percent Internal Dose |
|---|---|---|---|---|
| Small Boy | Plot B01 | 5.4 | 13.6 | 39.7 |
| | Plot B02 | **34.2** | **106.8** | 32.0 |
| | Plot B04 | 2.6 | 9.5 | 27.7 |
| | Plot B05 | 1.2 | 4.2 | 28.6 |
| | Plot B06 | 1.7 | 5.2 | 32.7 |
| | Pot B07 | 0.1 | 0.8 | 12.5 |
| | Plot B08 | 16.5 | **49.4** | 33.4 |
| | Plot B09 | 0.8 | 0.5 | 100 |

Bold indicates the values exceeding 25 mrem/yr.

**Table A.4-8**
**Study Group 2, Small Boy Site TED at Sample Locations (mrem/yr)**

| Release | Location | Industrial Area | | Ground Troops | | Occasional Use Area | |
|---|---|---|---|---|---|---|---|
| | | Average TED | 95% UCL of TED | Average TED | 95% UCL of TED | Average TED | 95% UCL of TED |
| Small Boy | B01 | 19.1 | 21.4 | 13.6 | 15.3 | 1.0 | 1.1 |
| | B02 | **153.6** | **205.4** | **106.8** | **146.2** | 8.0 | 10.9 |
| | B03 | 12.1 | 12.9 | 7.7 | 8.1 | 0.6 | 0.6 |
| | B03a | 12.1 | 12.9 | 7.7 | 8.1 | 0.6 | 0.6 |
| | B03b | 2.1 | 2.3 | 1.3 | 1.4 | 0.2 | 0.3 |
| | B04 | 13.8 | 18.6 | 9.5 | 13.0 | 0.7 | 1.0 |
| | B05 | 6.1 | 9.2 | 4.2 | 6.5 | 0.3 | 0.5 |
| | B06 | 7.5 | 9.9 | 5.2 | 7.1 | 0.4 | 0.5 |
| | B07 | 1.3 | 2.9 | 0.8 | 1.9 | 0.1 | 0.1 |
| | B08 | **70.7** | **83.6** | **49.4** | **58.5** | 3.7 | 4.4 |
| | B09 | 0.4 | 1.9 | 0.5 | 1.5 | 0.0 | 0.1 |
| | B10 | 18.3 | 22.6 | 11.5 | 14.2 | 0.9 | 1.1 |
| | B11 | 5.2 | 6.8 | 3.3 | 4.3 | 0.3 | 0.3 |
| | B12 | **31.6** | **36.5** | 21.0 | 24.1 | 1.6 | 1.9 |
| | B13 | **28.2** | **36.4** | 20.3 | **25.4** | 1.5 | 1.9 |
| | B14 | **31.5** | **34.9** | 24.0 | **26.2** | 1.7 | 1.9 |
| | B15 | 3.8 | 7.2 | 2.5 | 4.7 | 0.2 | 0.4 |
| | B16 | 3.7 | 4.6 | 2.4 | 3.0 | 0.2 | 0.2 |
| | B17 | 3.3 | 5.3 | 2.1 | 3.4 | 0.2 | 0.3 |
| | B18 | 14.6 | 18.4 | 9.9 | 12.3 | 0.8 | 0.9 |
| | B19 | 20.4 | **25.2** | 14.0 | 17.0 | 1.1 | 1.3 |
| | B20 | 12.5 | 15.2 | 8.0 | 9.7 | 0.6 | 0.8 |
| | B21 | 5.9 | 8.6 | 4.0 | 5.7 | 0.3 | 0.4 |

Bold indicates the values exceeding 25 mrem/yr.

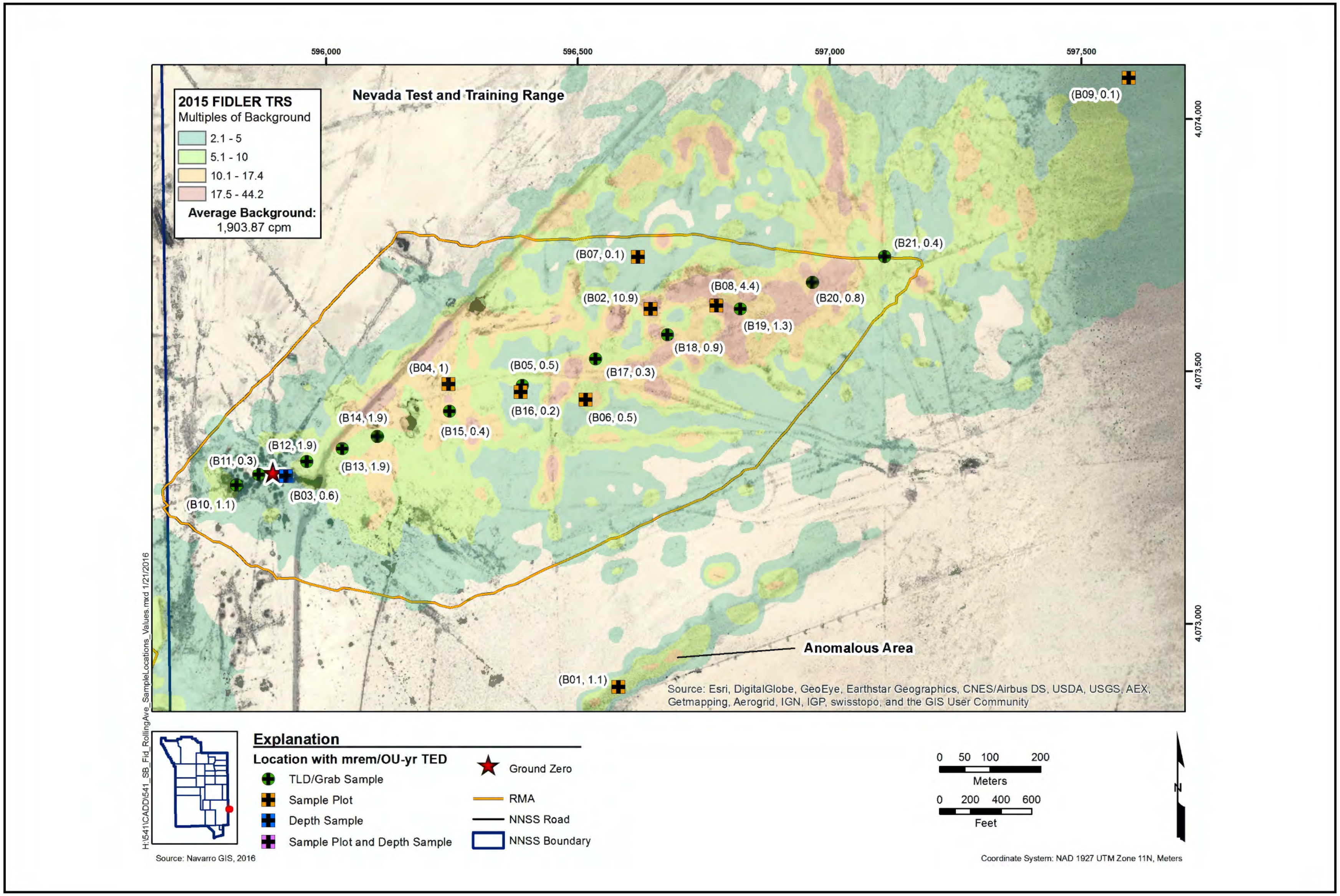



**Figure A.4-3**
**Study Group 2, Small Boy Site 95% UCL of the TED**

The TED at this location is currently driven by Cs-137, Am-241, and Pu-239/240, which contribute approximately 94 percent of the total dose.

### *A.4.4 Nature and Extent of COCs*

As presented in Section A.4.3, no radiological contamination is present at Study Group 2, Small Boy Site that exceeds the FAL of 25 mrem/OU-yr. Therefore, no corrective action is required for radiological contamination associated with Study Group 2.

### *A.4.5 Best Management Practices*

As a BMP, an administrative UR was established to include any area where an industrial land use of the area (2,000 hr/yr under the Industrial Area scenario) could cause a future site worker to receive a dose exceeding 25 mrem/yr. To determine the extent of the area where TED exceeds the Industrial Area scenario, a correlation of radiation survey values to the Industrial Area TED values as described in Section A.2.5 was conducted for the radiation surveys listed in Table A.4-9. The radiation survey that exhibited the best correlation is the FIDLER TRS with a correlation of 0.85. The gamma signature provided by the FIDLER was of the greatest use in delineating the spatial distribution of unfissioned materials at this site. This correlation exceeds the minimum criteria of 0.8 as required by the Soils RBCA document (NNSA/NFO, 2014b). Based on the correlation of TRS with the FIDLER instrument, the radiation survey value that corresponds to the 25-mrem/IA-yr boundary for the Small Boy site is 9.48 MOB. The administrative boundary based on this correlation is shown on Figure A.4-4 and presented in Attachment D-1.

**Table A.4-9**
**Study Group 2, Small Boy Site Correlations of 95% UCL TED with Gamma Surveys**

| Dataset | Coefficient of Determination ($r^2$) |
|---|---|
| 2015 Navarro FIDLER TRS | 0.85 |
| 2015 Navarro PRM-470 TRS | 0.72 |
| 2010 Gamma Flyover - Gross Count | 0.15 |
| 2010 Gamma Flyover - Man Made | 0.19 |
| 1994 Gamma Flyover - Gross Count | 0.00 |
| 1994 Gamma Flyover - Man Made | 0.03 |

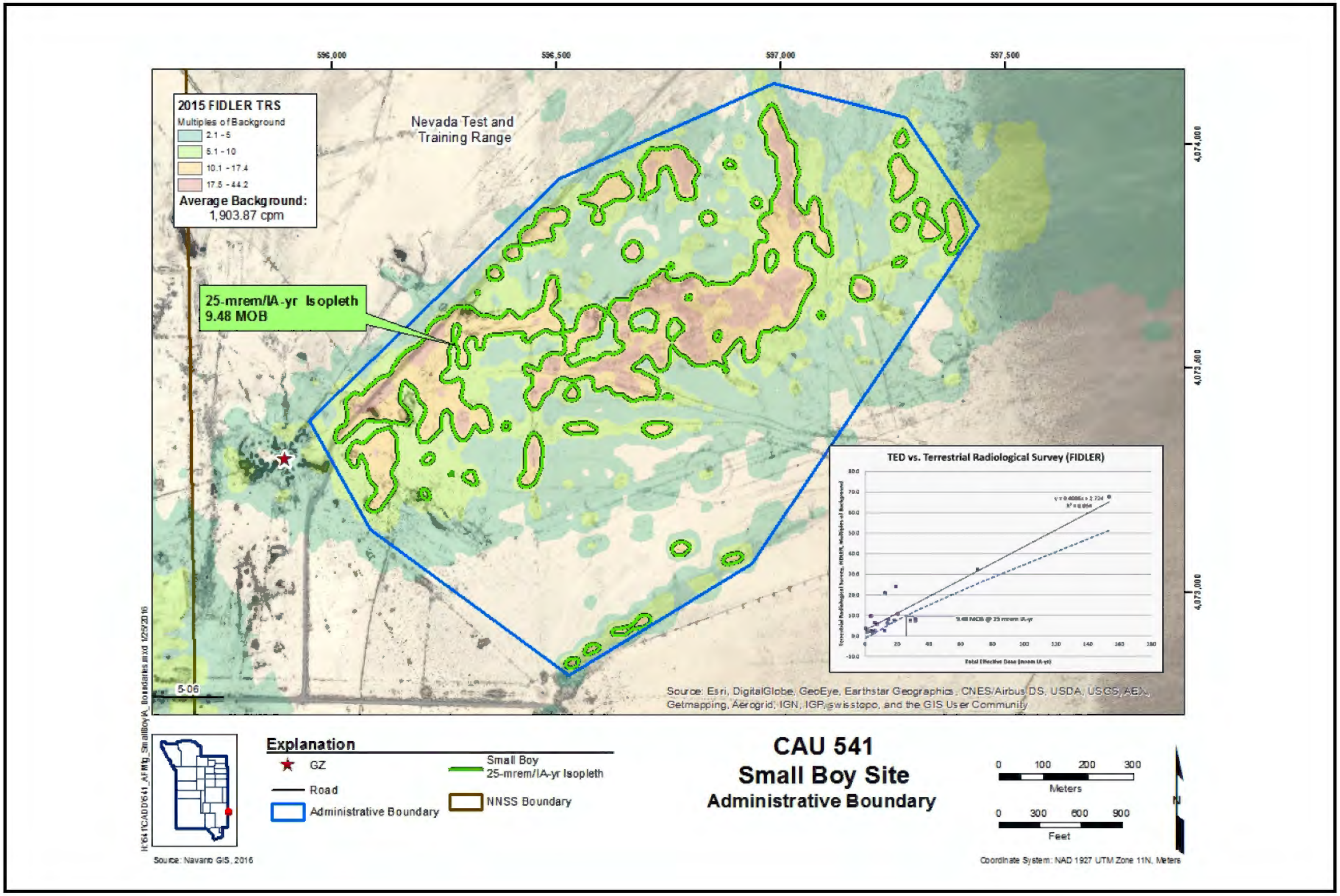



**Figure A.4-4**
**Study Group 2, Small Boy Site Administrative Boundary**

# A.5.0 Study Group 3, Spills and Debris

A component of Study Group 3, Spills and Debris is present at both sites. The study group consists of a release of chemical or radioactive material to the soil from spills or debris. Additional detail on the history of Study Group 3 is provided in the CAIP (NNSA/NFO, 2014a).

## A.5.1 CAI Activities

The specific CAI activities conducted to satisfy the CAIP requirements at this study group are described in the following subsections.

### A.5.1.1 Visual Surveys

Visual surveys of Study Group 3, Spills and Debris were conducted over the areas shown in Figures A.3-1 and A.4-1. This survey identified PSM (lead) during the investigation at both the BFa Site and Small Boy.

### A.5.1.2 Soil Samples

Lead items were identified as PSM at Study Group 3, Spills and Debris. One breached battery (location C04), five lead bricks (locations C01 and C02), and several lead pieces (location C03) were identified as PSM for metallic lead and were removed from the site as an interim corrective action. Samples were collected from soil adjacent to PSM items (Figure A.5-1) to verify completion of the corrective actions. A total of six environmental soil samples to include one FD were collected and the sample locations shown on Figure A.5-1.

Soil samples were collected as summarized in Table A.5-1 to satisfy the CAIP requirements (NNSA/NSO, 2014a) at Study Group 3, Spills and Debris. A summary of the number of samples collected for each site, depth of the sample, and the type of sample for each site of Study Group 3 is provided in Table A.5-2.

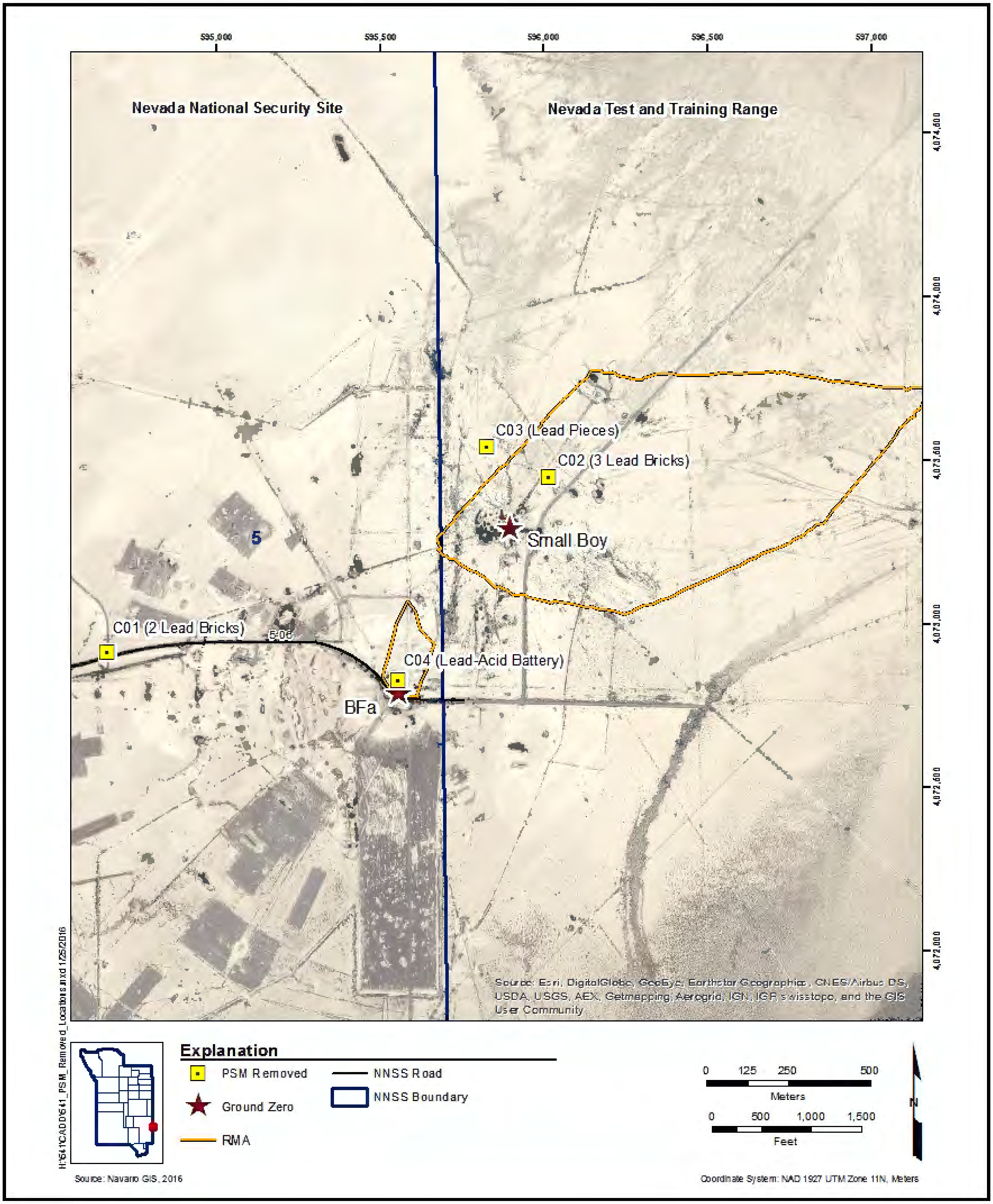



**Figure A.5-1**
**Study Group 3, Spills and Debris Sample Locations**

**Table A.5-1**
**Study Group 3, Spills and Debris Soil Sample Summary**

| Sample Type | Number of Locations | Number of Soil Samples | Analyses (Method) |
|---|---|---|---|
| Grab | 4 | 6 (1 FD) | RCRA Metals |
| **Total** | **4** | **6 (1 FD)** | |

**Table A.5-2**
**Study Group 3, Spills and Debris Samples Collected**

| Site | Location | Sample Number | Depth (cm bgs) | Matrix | Purpose |
|---|---|---|---|---|---|
| BFa Site | C01 | C001 | 0.0 - 5.0 | Soil | Verification |
| | | C002 | 0.0 - 5.0 | Soil | FD of #C001 |
| | C04 | C005 | 0.0 - 5.0 | Soil | Verification |
| | | C006 | 0.0 - 5.0 | Soil | Verification |
| Small Boy | C02 | C003 | 0.0 - 5.0 | Soil | Verification |
| | C03 | C004 | 0.0 - 5.0 | Soil | Verification |

### *A.5.2 Deviations/Revised Conceptual Site Model*

The CAIP requirements (NNSA/NFO, 2014a) were met at this study group. The information gathered during the CAI supports the CSM as presented in the CAIP. Therefore, no revisions were necessary to the CSM.

### *A.5.3 Investigation Results*

The following subsections present the analytical and computational results for soil samples collected for Study Group 3, Spills and Debris areas. All sampling and analyses were conducted as specified in the CAIP (NNSA/NSO, 2014a) to include the analytical parameters and laboratory methods used during this investigation. Sample results above the minimum detectable concentration (MDC) are provided in Table A.5-3. For chemical contaminants, the results are reported as individual concentrations that are comparable to their corresponding FALs. No sample results were equal to or greater than the FAL.

**Table A.5-3**
**Study Group 3, Spills and Debris Sample Results for Metals Detected above MDCs**

| Sample Location | Sample Number | Depth (cm bgs) | COPC (mg/kg) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Arsenic | Barium | Cadmium | Chromium | Lead | Mercury | Selenium | Silver |
| FALs | | | 23 | 190,000 | 9,300 | 33.6 | 5,739 | 43 | 5,100 | 5,100 |
| C01 | C001 | 0 - 5 | 8.47 | 165 | 0.149 (J) | 11.3 | 72.1 (J) | 0.0336 | -- | -- |
| | C002 | 0 - 5 | 8.84 | 152 | 0.223 (J) | 10.6 | 160 (J) | 0.0366 | -- | -- |
| C02 | C003 | 0 - 5 | 8.88 (J) | 112 (J) | 0.22 (J) | 7.46 | 129 | 0.0301 | -- | 0.158 (J) |
| C03 | C004 | 0 - 5 | 7.44 (J) | 168 (J) | 0.376 (J) | 11 | 137 | 0.0416 | -- | -- |
| C04 | C005 | 0 - 5 | 7.89 (J) | 159 | 0.133 (J) | 11.5 | 5,090 (J) | 0.0252 | 0.978 (J) | -- |
| | C006 | 0 - 5 | 7.72 (J) | 152 | -- | 10 | 14.7 (J) | 0.0179 | 1.36 | -- |

J = Estimated value.
-- = Not detected above MDCs.

#### A.5.3.1 Chemical Contaminants

Metallic lead items were identified as PSM at Study Group 3, Spills and Debris. The lead bricks, pieces, and battery were assumed to be PSM and were removed from the site as an interim corrective action. See Section A.6.0 for information on the disposition of these items. A verification sample was collected from the soil surrounding each location for the lead-acid battery (location C04), lead bricks (location C01 and C02), and the lead pieces (location C03). Samples were analyzed for RCRA metals, and the analytical results exceeding MDCs are presented in Table A.5-3. No sample result exceeded FALs. No additional releases were identified at this study group.

### A.5.4 Nature and Extent of COCs

PSM items were identified that contain a COC (metallic lead) and require corrective action. The extent of COCs was determined by the physical extent of the debris. This was confirmed by verification soil sample results. PSM was removed under a corrective action, and no COCs remain at either CAS. No further action is required.

# A.6.0 Waste Management

This section addresses the characterization and management of investigation and remediation wastes. Waste management activities were conducted as specified in the CAIP (NNSA/NFO, 2014a).

## A.6.1 Generated Wastes

The wastes listed in Table A.6-1 were generated during the field investigation activities of CAU 541. 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. Decontamination activities were planned and executed to minimize the volume of material generated.

The amount, type, and source of waste placed into each container were recorded in waste management logbooks that are maintained in the CAU 541 file.

Wastes generated during the CAI were segregated into the following waste streams:

- Disposable personal protective equipment (PPE) and sampling equipment
- Mixed low-level radioactive waste (MLLW) debris

A total of two drums of wastes were generated during the CAI:

- Two drums of waste, for a total of 65 gallons (gal), were characterized as MLLW and recommended for disposal at the NNSS in accordance with the requirements contained in the *Nevada National Security Site Waste Acceptance Criteria* (NNSA/NFO, 2015). Waste included surface contaminated objects to include lead bricks, lead pieces, and battery lead plates.

## A.6.2 Waste Characterization and Disposal

The characterization of the waste and recommended disposition were determined based on a review of the analytical results and compared to federal and state regulations permit requirements, and disposal facility acceptance criteria. Waste characterization documentation is maintained in the CAU 541 project file. Analytical results from the environmental sampling were used to characterize

# Table A.6-1
# Waste Summary Table

| CAS | Waste Items | Waste Characterization | | | | Waste Disposition | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Hazardous | Hydrocarbon | PCBs | Radioactive | Disposal Facility | Waste Volume | Disposal Date | Disposal Doc[a] |
| 05-23-04 and 05-45-03 | Lead bricks, pieces, and debris | Yes | No | No | Yes (MLLW) | Area 5 - RWMC | 65 gal | June 23, 2015 | Onsite HAZMAT transfer paperwork |

[a]Copies of waste disposal documents are located in Attachment D-2 of this document.

HAZMAT = Hazardous materials
PCB = Polychlorinated biphenyl
RWMC = Radioactive Waste Management Complex

the waste and results compared to regulatory criteria. One sample was collected for chromium VI analysis at location C04 where lead material was present. The waste shipping and disposal documentation for CAU 541 are provided in Attachment D-2.

#### A.6.2.1 Industrial Solid Waste

Approximately 2 cubic yards ($yd^3$) of PPE and disposable sampling equipment was generated during CAI activities. The PPE and disposable sampling equipment generated were field screened, as generated, to meet the unrestricted release of materials screening limits of Table 4-2 of the *Nevada National Security Site Radiological Control* (RadCon) *Manual* (NNSA/NSO, 2012a). As a result of screening and process knowledge, the waste was characterized as industrial solid waste that meets the chemical and radiological waste acceptance criteria of the Area 9, U10c solid waste landfill. The solid waste was bagged, marked, and placed in a roll-off container located at Building 23-310 for final disposal at the Area 9, U10c landfill.

#### A.6.2.2 LLW

No low-level waste (LLW) that met the waste acceptance criteria for disposal at the Area 5 RWMC was generated during the CAI.

#### A.6.2.3 MLLW

One 10-gal drum (Container 541pb01) containing lead bricks and lead pieces and one 55-gal drum containing an abandoned and breached lead-acid battery was generated and characterized as MLLW. The waste was transferred to National Security Technologies, LLC (NSTec), Waste Generator Services for treatment and disposal at the Area 5 RWMC on June 23, 2015.

The only source of chemical contamination is lead in the form of bricks, pieces, and plates outside a battery casing; therefore, the waste is characterized as RCRA regulated. The battery was breached and located in a posted radioactive material area (RMA).

Environmental samples used to characterize the waste were collected from a 2-by-2-m grid with nine aliquots composited for one sample. At the BFa Site, three samples were collected. Sample C001 and duplicate sample C002 were collected from around two lead bricks at location C01. Samples C005 (location C04) was collected around the breached lead-acid battery. Several lead plates were located approximately 35 ft south of the battery and the area samples (sample C006). At the Small Boy site, sample C003 (location C02) was collected from around three lead bricks and sample C004 (location C03) collected from around lead pieces. Based on the analytical results, the maximum activity concentrations of Am-241, Pu-239/240, Pu-241, Cs-137, cobalt (Co)-60, Sr-90, Eu-152 in the waste containers exceed the *Nevada Test Site Performance Objective for Certification of Nonradioactive Hazardous Waste* (BN, 1995); therefore, the waste is characterized as MLLW.

#### *A.6.2.4 Recyclable Materials*

No recyclable materials were generated during the CAI.

# A.7.0 Quality Assurance

This section contains a summary of QA/QC measures implemented during the sampling and analysis activities conducted in support of the CAU 541 CAI. The following subsections discuss the data validation process, QC samples, and nonconformances. A detailed evaluation of the DQIs is presented in Appendix B.

Laboratory analyses were conducted for samples used in the decision-making process to provide a quantitative measurement of any 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 QAP (NNSA/NSO, 2012b).

## A.7.1 Data Validation

Data validation was performed in accordance with the Soils QAP (NNSA/NSO, 2012b) and approved protocols and procedures. All laboratory data from samples collected and analyzed for CAU 541 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 541 files as electronic media. All laboratory data were subjected to a Tier I and II evaluations.

Laboratory data packages were reviewed for completeness. The analytical data contained within the packages were evaluated for correctness, compliance, precision, and accuracy. Where issues were encountered within the data, validation-qualifiers were assigned with descriptions.

An independent examination of the data packages was performed on 5 percent of the sample data. This review was performed by TLI Solutions, Inc., in Golden, Colorado. The results of the independent examination of the data packages agreed in general with the original Tier II validation performed for the project, and no corrections resulted from this review.

### A.7.2 QC Samples

During the CAI, two FDs were also sent as blind samples to the laboratory to be analyzed for the investigation parameters listed in the CAIP (NNSA/NFO, 2014a).

No analytical results for CAU 541 were qualified for precision, and the CAIP criterion was met for all contaminants. Sample results that were qualified for accuracy were arsenic and barium; however, there were no analytical data qualified for accuracy that exceeded one-half the FAL. Therefore, the potential for a false positive DQO decision error is negligible, and use of the results that were qualified for accuracy can be confidently used. The representative criterion was met in that the 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). Datasets are considered comparable as they were 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.

Laboratory QC samples used to measure precision and accuracy were analyzed by the laboratory with each batch of samples submitted for analysis. When QC criteria were exceeded, qualifying flags were added to sample results, along with the reason for estimation or rejection. Documentation of data qualifications is retained in the Analytical Services database and in the data packages located in Navarro Central Files.

### A.7.3 Field Nonconformances

There were no field nonconformances identified for the CAI.

### A.7.4 Laboratory Nonconformances

Laboratory nonconformances are generally due to fluctuations in analytical instrumentation operations, sample preparations, missed holding times, spectral interferences, high or low chemical yields/matrix spikes, precision, and the like. All laboratory nonconformances were reviewed for relevance and, where appropriate, data were qualified.

### *A.7.5 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 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 Industrial Area exposure scenario.* This eliminates errors in reading dose-rate meter scale graduations and needle fluctuations that would be magnified when as-read meter values are multiplied from units of “per-hour” to 2,000 hours.

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, 2015) 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.

## *A.8.0 Summary*

Radionuclide and chemical contaminants detected in environmental samples during the CAI were evaluated against FALs to determine the presence and extent of COCs for CAU 541. COCs were assumed to be present where PSM was identified and removed under a corrective action. Verification sample results demonstrated that COCs are not present following the completion of the corrective actions and no further corrective action are required. Based on the determination that no COCs are present, the following alternatives were selected:

- Sample results from the atmospheric release from Study Group 1, BFa Site (CAS 05-23-04, Atmospheric Tests (6) - BFa Site) demonstrated that soil contamination levels do not result in a dose exceeding the radiological FAL for the Occasional Use scenario. The no further action alternative was selected.
- Sample results from the atmospheric release from Study Group 2, Small Boy Site (CAS 05-45-03, Atmospheric Test Site - Small Boy) demonstrated that soil contamination levels do not result in a dose exceeding the radiological FAL for the Occasional Use scenario. The no further action alternative was selected.
- Verification sample results at both the BFa Site and Small Boy demonstrated that soil contamination levels do not result in a dose exceeding the radiological or chemical FALs for the Occasional Use scenario following the completion of interim corrective actions. The no further action alternative was selected.

In addition, BMPs were implemented at locations where an industrial land use of the area (2,000 hr/yr) could cause a future site worker to receive a dose exceeding 25 mrem/yr.

A summary of CAI results and actions implemented are presented in Table A.8-1 for each CAU 541 release.

**Table A.8-1**
**Summary of Investigation Results at CAU 541**

| CAS Number | Name | Study Group | Release | COC | Corrective Action | BMP |
|---|---|---|---|---|---|---|
| 05-23-04 | BFa Site | 1 | Atmospheric Test | None | No further action | Admin UR at 25-mrem/IA-yr isopleth |
| 05-45-03 | Small Boy | 2 | Atmospheric Test | None | No further action | Admin UR at 25-mrem/IA-yr isopleth |
| 05-23-04 and 05-45-03 | BFa Site and Small Boy | 3 | Spills and Debris | Metallic Lead | Removal of lead bricks/pieces and lead-acid battery performed as an interim corrective action | None |

## A.9.0 References

ARL/SORD, see Air Resources Laboratory/Special Operations and Research Division.

Air Resources Laboratory/Special Operations and Research Division. 2015. "Nevada Test Site (NTS) Climatological Rain Gauge Network." As accessed at http://www.sord.nv.doe.gov/home_climate_rain.htm on 5 February.

BN, see Bechtel Nevada.

Bechtel Nevada. 1995. *Nevada Test Site Performance Objective for Certification of Nonradioactive Hazardous Waste*, Rev. 0, G-E11/96.01. Las Vegas, NV.

Bechtel Nevada. 1997. *An Aerial Radiological Survey of the Nevada Test Site and Surrounding Nellis Air Force Range, Southern Nevada*, DOE/NV/11718-022. Prepared for U.S. Department of Energy, Nevada Operations Office. Las Vegas, NV: Remote Sensing Laboratory.

Bechtel Nevada. 1999. *An Aerial Radiological Survey of the Nevada Test Site*, DOE/11718--324. Prepared for U.S. Department of Energy, Nevada Operations Office. Las Vegas, NV: Remote Sensing Laboratory.

Bechtel Nevada. 2001. *Composite Analysis for the Area 5 Radioactive Waste Management Site at the Nevada Test Site, Nye County, Nevada,* DOE/NV--594, Prepared for U.S. Department of Energy, Nevada Operations Office. Las Vegas, NV.

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*. 2015. Title 10 CFR, Part 835, "Occupational Radiation Protection." Washington, DC: U.S. Government Printing Office.

DOE, see U.S. Department of Energy.

DOE/NV, see U.S. Department of Energy, Nevada Operations Office.

EPA, see U.S. Environmental Protection Agency.

ESRI, see ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, and IGP.

ESRI, i-cubed, USDA FSA, USGS, AEX, GeoEye, Getmapping, Aerogrid, and IGP. 2015. ArcGIS Online website. As accessed at http://www.arcgis.com/home/gallery.html on 2 June.

Hershey, R.L., M.E. Cablk, K. LeFebre, L.F. Fenstermaker, and D.L. Decker. 2013. *Water-Chemistry Evolution and Modeling of Radionuclide Sorption and Cation Exchange during Inundation of Frenchman Flat Playa*, DE/NA0000939-10; Publication No. 45252. Prepared for the U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. Las Vegas, NV: Desert Research Institute.

Navarro GIS, see Navarro Geographic Information Systems.

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.

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

Navarro Geographic Information Systems. 2016. ESRI ArcGIS Software.

Stampahar, J., Remote Sensing Laboratory. 2012. Personal communication to M. Knop (N-I) regarding NNSS 2012 Radiological Flyover of Area 3, 5 June. Las Vegas, NV.

USGS, see U.S. Geological Survey.

U.S. Department of Energy. 1997. *The Procedures Manual of the Environmental Measurements Laboratory*, HASL-300. 28th Edition, Vol. I. February. New York, NY.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014a. *Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada*, Rev. 0, DOE/NV--1524. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014b. *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. *Nevada National Security Site Waste Acceptance Criteria,* DOE/NV-325-Rev. 10a. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2012a. *Nevada National Security Site Radiological Control Manual*, DOE/NV/25946--801, Rev. 2. Prepared by Radiological Control Managers' Council. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2012b. *Soils Activity Quality Assurance Plan,* Rev. 0, DOE/NV--1478. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2000. *United States Nuclear Tests, July 1945 through September 1992*, DOE/NV--209-REV 15. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002. *Nevada Test Site Orthophoto Site Atlas*, DOE/NV/11718--604. Prepared by Bechtel Nevada. Las Vegas, NV.

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.

U.S. Geological Survey. 2015. "Groundwater Levels for Nevada." As accessed at http://nwis.waterdata.usgs.gov/nv/nwis/gwlevels on 5 February.

Yu, C., A.J. Zielen, J.J. Cheng, D.J. LePoire, E. Gnanapragasam, S. Kamboj, J. Arnish, A. Wallo III, W.A. Williams, and H. Peterson. 2001. *User's Manual for RESRAD Version 6*, ANL/EAD-4. Argonne, IL: Argonne National Laboratory, Environmental Assessment Division. (Version 7.0 released in April 2014.)

# Appendix B

# Data Assessment

# B.1.0 Data Assessment

The DQA process is the scientific evaluation of the actual investigation results to determine whether the DQO criteria established in the CAU 541 CAIP (NNSA/NFO, 2014a) 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 deviations to the sampling design.

2. *Conduct a Preliminary Data Review.* Review QA reports and inspect 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 are censored, determine the impact on DQO decision error.

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

## B.1.1 Review DQOs and Sampling Design

This section contains a review of the DQO process presented in Appendix A of the CAIP (NNSA/NFO, 2014a). The DQO decisions are presented with the DQO provisions to limit false-negative or false-positive decision errors. Special features, potential problems, or any deviations to the sampling design are also presented.

### B.1.1.1 Decision I

The Decision I statement as presented in the CAIP (NNSA/NFO, 2014a) is as follows: "Is any COC associated with the CAS present in environmental media?" For judgmental sampling decisions, any contaminant associated with a CAS that is present at concentrations exceeding its corresponding FAL will be defined as a COC. For probabilistic sampling decisions, any contaminant for which the 95 percent UCL of the mean exceeds 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 constituent analysis (NNSA/NFO, 2014b). A COC may be assumed to be present based on the presence of wastes that have the potential to release COC concentrations in the future (i.e., PSM). If a COC is detected, then Decision II must be resolved.

#### B.1.1.1.1 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 study group (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 a COC is present at a release), samples were collected and analyzed following these two criteria:

- Samples must be collected in areas most likely to contain a COC.
- The analytical suite selected must be sufficient to identify any COCs present in the samples.

To satisfy the criteria that the samples must be collected in areas most likely to contain a COC, judgmental sample locations were selected at each study group as follows:

- Sample plot locations were selected judgmentally at the highest radiological readings as detected during the PRM-470 and FIDLER TRSs.
- For Study Group 3, judgmental and probabilistic sample locations were selected where lead debris was present as determined during a visual survey of the area of CAU 541.

The analytical methods were chosen during the DQO process as the analyses required to detect any of the COPCs listed in the CAIP that were defined as the contaminants that could reasonably be expected at the site that could contribute to a dose or risk exceeding FALs. The COPCs were identified based on operational histories, waste inventories, release information, investigative background, contaminant sources, release mechanisms, and migration pathways as presented in the CAIP. This provides assurance that the analyses conducted for each sample has the capability of identifying any COPC present in the sample.

All samples were analyzed using the analytical methods listed in Section 3.2 of the CAIP (NNSA/NFO, 2014a).

### *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.
- A sufficient sample size was collected (see Section B.1.1.1.1).
- 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 (inclusive of Study Groups 1 and 2) was accomplished using a random start, systematic triangular grid pattern for sample placement. 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 B.1-1. As shown in this 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 CAIP (NNSA/NFO, 2014a) 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

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

Sample results were assessed against the acceptance criterion for the DQI of sensitivity as defined in the Soils QAP (NNSA/NSO, 2012). The sensitivity acceptance criterion is that analytical detection

**Table B.1-1**
**Input Values and Determined Minimum Number of Samples for Sample Plots**

| Soil Samples | | | | |
|---|---|---|---|---|
| **Source** | **Plot** | **Standard Deviation** | **Minimum Sample Size** | **Samples Collected** |
| Study Group 1 | A01a | 0.002 | 3 | 4 |
| Study Group 2 | B01 | 0.04 | 3 | 4 |
| | B02 | 1.30 | 3 | 4 |
| | B04 | 0.10 | 3 | 4 |
| | B05 | 0.10 | 3 | 4 |
| | B06 | 0.10 | 3 | 4 |
| | B07 | 0.004 | 3 | 4 |
| | B08 | 0.20 | 3 | 4 |
| | B09 | 0.01 | 3 | 4 |

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.

limits will be less than the corresponding FAL (NNSA/NFO, 2014b). All of the chemical analyses met this criterion. For radionuclides, the criterion is that all detection limits are less than their corresponding Occasional Use Area internal dose RRMGs. All of the analytical result detection limits for every radionuclide 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 QAP (NNSA/NSO, 2012). The DQI acceptance criteria are presented in Table 6-1 of the CAIP (NNSA/NFO, 2014a). The individual DQI results are presented in the following subsections.

#### *Precision*

Precision was evaluated as described in Section 6.2.4 of the CAIP (NNSA/NFO, 2014a) and Section 4.2 of the Soils QAP (NNSA/NSO, 2012). No analytical results for CAU 541 were qualified for precision, therefor the quality CAIP criteria of 80 percent was met for the DQI.

*Accuracy*

Accuracy was evaluated as described in Section 6.2.4 of the CAIP (NNSA/NFO, 2014a) and Section 4.2 of the Soils QAP (NNSA/NSO, 2012). The sample results that were qualified for accuracy are presented in Table B.1-2.

**Table B.1-2**
**Accuracy Measurements**

| Constituent | Analyses | Number of Measurements Qualified | Number of Measurements Performed | Percent within Criteria |
|---|---|---|---|---|
| Arsenic | Metals | 2 | 4 | 50 |
| Barium | | 2 | 4 | 50 |

There were no analytical data qualified for accuracy that exceeded one-half the FAL. Therefore, the potential for a false-negative DQO decision error is negligible, and use of the results that were qualified for accuracy can be confidently used. As the accuracy rates for all other constituents meet the acceptance criteria for accuracy, the dataset is determined to be acceptable for the DQI of accuracy.

*Representativeness*

The DQO process as identified in Appendix A of the CAIP (NNSA/NFO, 2014a) was used to address sampling and analytical requirements for CAU 541. 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] and locations that bound COCs) (Section A.2.1). The sampling locations identified in the Criterion 1a discussion meet this criterion.

Special consideration is needed for americium and plutonium 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 americium and plutonium 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 americium to plutonium isotope concentrations) should be equal. Based on process knowledge and demonstrated by analytical results from previously sampled Soils sites, the ratios between americium and plutonium 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 americium 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 americium and plutonium isotopes will be established using the isotopic analytical results and these ratios will be used to infer concentrations of plutonium isotopes using the gamma spectrometry results for Am-241. These inferred plutonium 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 americium and plutonium concentrations that are more representative of the sampled area, the analytical data acquired during the CAU 541 CAI are considered to adequately represent contaminant concentrations of the sampled population.

*Comparability*

Field sampling, as described in the CAIP (NNSA/NFO, 2014a), 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 for the NNSS. Therefore, CAU 541 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 CAIP.

*Completeness*

The CAIP (NNSA/NFO, 2014a) 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 CAIP having valid results. Rejected data (either qualified as rejected or data that failed the criterion of sensitivity) were not used in the resolution of DQO decisions and are not counted toward meeting the completeness acceptance criterion. The dataset for CAU 541 has met the general completeness criteria as sufficient information is available to make the DQO decisions.

#### B.1.1.1.2 DQO Provisions To Limit False-Positive Decision Error

The false-positive decision error was controlled by assessing the potential for false-positive analytical results. 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.

Proper decontamination of sampling equipment also minimized the potential for cross contamination that could lead to a false-positive analytical result.

### B.1.1.2 Decision II

Decision II as presented in the CAIP (NNSA/NFO, 2014a) is as follows: “Is sufficient information available to evaluate potential CAAs?” 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
- Any other information needed to evaluate the feasibility of remediation alternatives

A corrective action will be determined for any site containing a COC. The evaluation of the need for corrective action will include the potential for wastes that are present at the site to cause the future contamination of site environment media if the wastes were to be released.

An interim corrective action of PSM material conducted at both the BFa Site and Small Boy defined the extent of COC contamination based on the physical extent of the debris. Removal of all COCs that were present in the form of metallic lead was demonstrated by verification sample results.

The information needed to predict potential remediation waste types and volumes and information needed to evaluate the feasibility of remediation alternatives was provided by the analytical results from soil samples and the identification of metallic lead.

#### *B.1.1.3 Sampling Design*

The CAIP (NNSA/NFO, 2014a) 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 at the BFa Site and Small Boy were selected judgmentally, and sample aliquots were collected within each plot probabilistically as described in Section A.2.2.4.

- Judgmental grab samples will be conducted at the Small Boy site.

  **Result.** The location of the grab samples were selected judgmentally as described in Section A.2.2.4.

- Judgmental sampling will be conducted at locations of potential contamination identified during the CAI.

  **Result.** Judgmental sampling was conducted at locations where PSM was removed.

### *B.1.2 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. 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 QAP (NNSA/NSO, 2012). The validated dataset quality was found to be satisfactory.

### *B.1.3 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/OU-yr. For other types of contamination, the test for making DQO decisions was the comparison of the maximum analyte result from each release to the corresponding FAL.
All radiological FALs were based on an exposure duration to a site worker using the Occasional Use Area exposure scenario (see Sections C.1.6 through C.1.10). All chemical FALs, except for lead, were based on an exposure duration to a site worker using the Industrial Area exposure scenario. The FAL for lead was based on an exposure duration to a site worker using the Remote Work Area exposure scenario (see Sections C.1.6 through C.1.10).

The key assumptions that could impact a DQO decision are listed in Table B.1-3.

**Table B.1-3**
**Key Assumptions**

| | |
|---|---|
| **Exposure Scenario** | Occasional Use Scenario |
| **Affected Media** | Surface, shallow, and subsurface soil; debris |
| **Location of Contamination/Release Points** | Surface soil surrounding the test areas, surface soil directly below or adjacent to contaminated debris |
| **Transport Mechanisms** | Percolation of precipitation through subsurface media serves as a mechanism for migration of contaminants. Surface water movement provides the transportation of contaminants within or outside the footprints of the study groups. Resuspension by wind and mechanical disturbance are also mechanisms for contaminant transport. However, this transport mechanism is less likely to cause migration of contamination at levels exceeding FALs. |
| **Preferential Pathways** | Lateral transport is expected to dominate over vertical transport due slow percolation rates and the observed ponding of the surface. |
| **Lateral and Vertical Extent of Contamination** | Concentrations are generally expected to decrease with distance and depth from the source, although it is noted that the lateral extent of contamination at Small Boy is a defined, but irregular, pattern of surface contamination. 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** | Research Test and Experiment Zone (NNSS) and Military Use (NTTR)[a] |
| **Other DQO Assumptions** | No indication of subsurface contamination is present as a result of the evaluation of soils at depth. Surface contamination is not present at the BFa Site and Small Boy test areas above action levels. The DQIs were satisfactorily met as discussed in Section B.1.1.1.1. The data collected during the CAI are considered to support the CSM and the DQO decision; therefore, no revisions to the CSM were necessary. |

[a]NNSA/NSO, 2013

### *B.1.4 Verify the Assumptions*

The results of the investigation support the key assumptions identified in the CAU 541 DQOs and Table B.1-3. The pattern of surface contamination observed at BFa Site is more concentric and typical of nuclear test release sites at the NNSS (Figure A.3-1), while the pattern of surface contamination at the Small Boy site is more irregular (Figure A.4-1). While the initial contamination pattern following the tests at both sites was uniform and generally concentric from the GZs, the subsequent erosion and migration of the contamination was different. It is postulated that this difference is due to the nature of the contamination at each site. The BFa Site tests had significant yields where the resulting contamination is largely composed of soil activation products, whereas the Small Boy test had a low yield and the resulting contamination was largely composed of unfissioned nuclear fuel products. The entire surface soil near the BFa Site was activated, and while subsequent erosion and dispersion would have diminished contaminant concentrations, it would not have significantly affected the general contaminant distribution pattern. The major contamination at the Small Boy site is composed of particles within the surface soil matrix that when redistributed by wind and water disperse more in open areas and less where vegetation is present, thus resulting in an irregular distribution pattern similar to the distribution pattern of the nearby vegetation.

All data collected during the CAI supported the CSM, and no revisions to the CSM were necessary.

#### *B.1.4.1 Other DQO Commitments*

The CAIP (NNSA/NFO, 2014a) made the following commitments:

1. Decision I at the BFa Site will be evaluated by measuring TED within a sample plot established within the area of the highest radiological values as determined from the 2010 aerial survey (Stampahar, 2012) and/or a TRS conducted with a handheld instrument.

   **Result:** Decision I was resolved by the placement of a TLD and the collection of environmental samples at one sample plot (A01a) located as a result of the TRS. The TRS was used for final selection of the location as it provided the best resolution and accuracy in the field.

2. As a CAIP commitment, further information at the BFa Site will be obtained by measuring TED at sample locations established in a selected pattern as presented in the CAIP. TLDs will be placed in a vector pattern to measure the external dose.

   **Result:** Further information was collected at the BFa Site by the placement of 38 TLDs in three vectors to measure external dose for use in calculating the TED as required in the CAIP.

3. Subsurface analysis will be performed at two location to investigate for buried contamination at the BFa Site.

   **Result:** The screening of soils to a depth of 30 cm was performed at location A01a and A02 at the BFa Site.

4. Decision I will be evaluated by measuring TED within a sample plot established within the areas of the highest radiological values at Small Boy and at the anomalous radiologically elevated area to the south. One sample plot will be placed at each of the locations based on the results of TRS.

   **Result.** Decision I was resolved by the placement of a TLD and the collection of environmental samples at one sample plot (B01) at the anomalous area and one sample plot (B02) at the Small Boy site. Locations were selected as a result of TRS as required in the CAIP.

5. As a CAIP commitment, further information will be obtained by establishing approximately six sample plot and TLD locations throughout the Small Boy plume. Sample plots will be located within high, medium, and low radiologically elevated areas within the Small Boy plume.

   **Result.** Further information was collected at the Small Boy site by the placement of six sample plots and TLDs at high, medium, and low elevated areas as required in the CAIP.

6. To further evaluate fission products at the Small Boy site, TLDs will be placed in a vector pattern to extend through the axis of the plume. Soil samples will be collected at all TLD locations.

   **Result.** Twelve TLD and corresponding soil sample locations were selected and sampled through the axis of the Small Boy plume.

7. Subsurface analysis will be performed at two locations to investigate for buried contamination at the Small Boy site. One location will be selected at or near the Small Boy GZ and the other at the anomalous area to the south.

   **Result.** The screening of soils to a depth of 30 cm was performed at location B03 at the Small Boy site and at location B01 at the radiological anomaly.

8. Determine whether a potential release is present based on biasing factors such as stains, spills, or debris.

   **Result.** Five lead bricks, numerous lead pieces, and one breached lead-acid battery were located and assumed to be PSM. The PSM was removed and verification samples were collected at each location. No analytical sample results exceeded the FAL. No COCs associated with these debris items remain in the soil.

### *B.1.5 Draw Conclusions from the Data*

The following subsections resolve the two DQO decisions for each of the CAU 541 study groups.

#### *B.1.5.1 Decision Rules for Both Decision I and II*

**Decision rule.** If COCs are inconsistent with the CSM or extends beyond the spatial boundaries identified in the CAIP, then work will be suspended and the investigation strategy will be reconsidered, else the decision will be to continue sampling.

- **Result.** No COCs were identified during the CSI, and hence were found to be consistent with the CSM and to not extend beyond the spatial boundaries.

#### *B.1.5.2 Decision Rules for Decision I*

**Decision rule.** If the population parameter of any COPC in the Decision I population of interest exceeds the corresponding FAL, then that contaminant is identified as a COC and corrective action is required, else no further investigation is needed for that COPC in that population.

- **Result.** COCs were found not to exceed the FAL at any location.

**Decision rule.** If a waste is present that, if released, has the potential to cause the future contamination of site environmental media, then a corrective action will be determined, else no further corrective action will be necessary.

- **Result.** Debris was identified as PSM, and a corrective action of debris removal was completed at both the BFa Site and Small Boy. COCs were found not to exceed the FAL at any location following removal of the PSM.

### B.1.5.3 Decision Rules for Decision II

**Decision rule.** If the population parameter (the observed concentration of any COC) in the Decision II population of interest exceeds the corresponding FAL or potential remediation waste types have not been adequately defined, then additional samples will be collected to complete the Decision II evaluation, else the extent of the COC contamination has been defined.

- **Result**. The only COCs identified were debris items containing metallic lead. The extent of contamination was defined by the physical extent of the debris. This was demonstrated through the results of verification samples.

## *B.2.0 References*

EPA, see U.S. Environmental Protection Agency.

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.

PNNL, see Pacific Northwest National Laboratory.

Pacific Northwest National Laboratory. 2007. *Visual Sample Plan, Version 5.0 User's Guide*, PNNL-16939. Richland, WA.

Stampahar, J., Remote Sensing Laboratory. 2012. Personal communication to M. Knop (N-I) regarding NNSS 2012 Radiological Flyover of Area 3, 5 June. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014a. *Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada*, Rev. 0, DOE/NV--1524. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014b. *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 Site Office. 2012. *Soils Activity Quality Assurance Plan*, Rev. 0, DOE/NV--1478. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2013. *Final Site-Wide Environmental Impact Statement for the Continued Operation of the Department of Energy/National Nuclear Security Administration Nevada National Security Site and Off-Site Locations in the State of Nevada*, DOE/EIS-0426. Las Vegas, NV.

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 C

# Risk Assessment

# C.1.0 Risk Assessment

The RBCA process used to establish FALs is described in the Soils RBCA document (NNSA/NFO, 2014b). This process conforms with 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 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 541 CAIP [NNSA/NFO, 2014a]). 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, 2014b) is summarized in Figure C.1-1.

The following PSM are assumed to contain sufficient quantities of hazardous chemicals to cause the underlying soil to exceed a FAL when the PSM is eventually released to the soil:

- Lead bricks
- Lead pieces
- Lead-acid battery

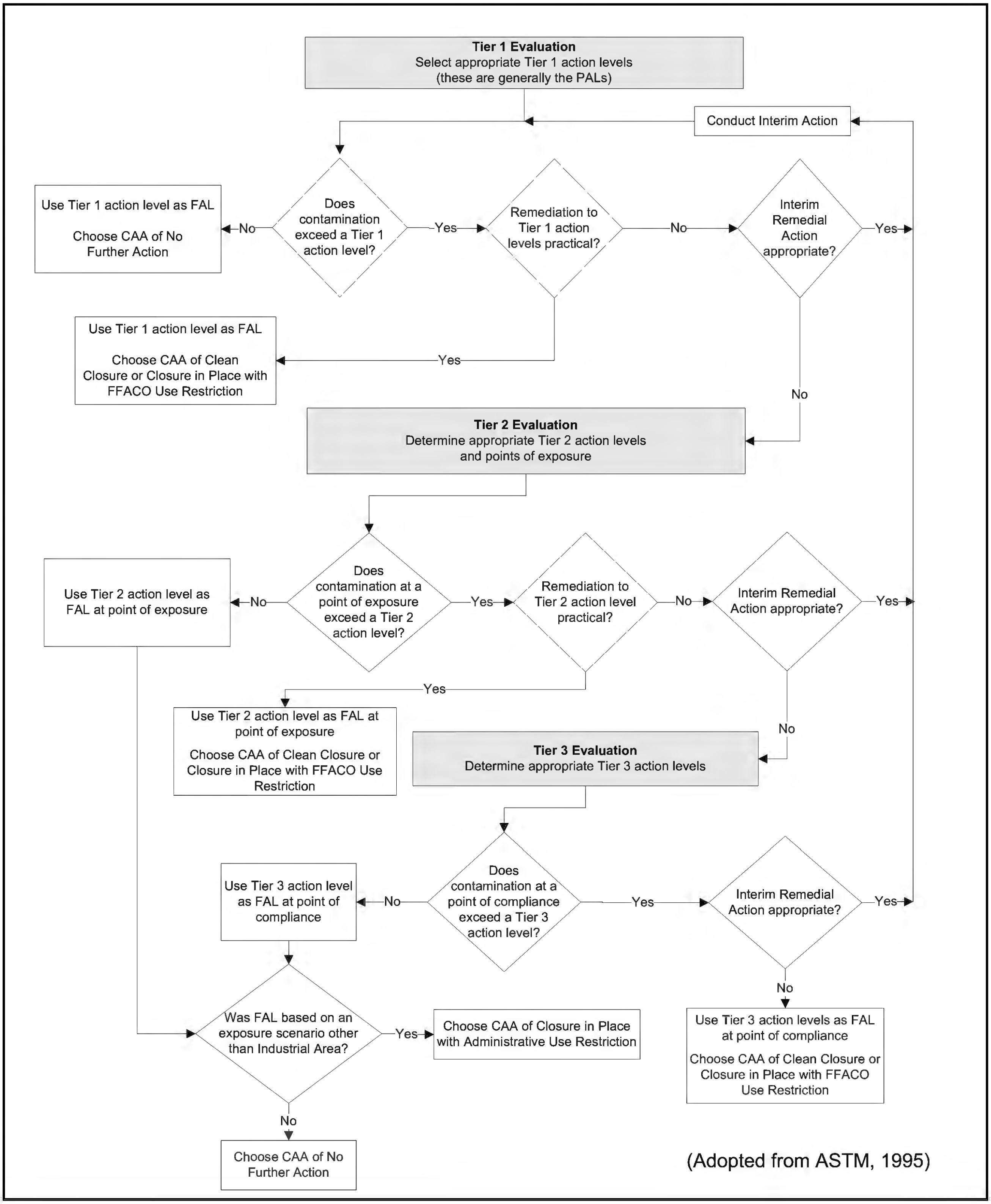



**Figure C.1-1**
**RBCA Decision Process**

The contamination associated with these releases is assumed to exceed FALs and require corrective action. Therefore, the need for corrective action will not be included in this risk evaluation. The corrective actions for the PSM debris were completed during the CAI.

However, this risk evaluation is intended for use in making corrective action decisions for CAU 541 conditions at the conclusion of the CAI (after the completion of any interim corrective actions).

### *C.1.1 Scenario*

CAU 541, Small Boy, comprises the following two CASs:

- 05-23-04, Atmospheric Tests (6) - BFa Site
- 05-45-03, Atmospheric Test Site - Small Boy

CASs 05-23-04 (referred to as Study Group 1, BFa Site in this document) and 05-45-03 (referred to as Study Group 2, Small Boy Site in this document) consist of a release of radioactive contaminants, primarily fission and unfissioned products, to the environment from testing activities.

CASs 05-23-04 (Study Group 1, BFa Site) consists of a release of radioactive contaminants to the environment from six atmospheric tests at this site. The BFa Site is an inactive site located in the eastern portion of Area 5 of the NNSS. CAS 05-45-03 (Study Group 2, Small Boy Site) consists of a release of radioactive contaminants to the environment from one atmospheric test at this site. Small Boy is an inactive site with a GZ located inside the current NTTR boundary, and plume extending northeast several thousand meters across NTTR land and onto a small portion of the Desert National Wildlife Refuge (DNWR). A radiological anomaly is also noted to the south of GZ.

A potential release is also associated with radionuclide contaminants that were initially deposited onto the soil surface that may have been subsequently displaced through erosion or mechanical disturbance of the soil. Included in the CAU 541 scope were potential releases to the soil from spills and debris.

### *C.1.2 Site Assessment*

Investigation activities at all study groups included an evaluation of radiological and chemical contamination resulting from atmospheric testing and associated support activities. The BFa Site and

Small Boy include the area affected by the surface release of radioactivity associated with atmospheric testing. Staged TLDs and soil samples collected at various locations within these releases were used to calculate TED (Section A.2.3) to military ground troops and site workers. Soil samples were also collected to determine the presence of chemical COCs. The maximum calculated TED (based on the Occasional Use scenario) does not exceed the FAL at any locations within the investigation area of CAU 541.

The TED from multiple sample locations at CAU 541 did not exceed the Occasional Use Area scenario based FAL established in this appendix (25 mrem/OU-yr). The Occasional Use Are scenario is used as it conservatively represents the activities performed at this site. The maximum calculated TED (based on the Occasional Use Area scenario) was 4.6 mrem/yr at the Study Group 1, BFa Site; and 10.9 mrem/yr at the Study Group 2, Small Boy Site. If it was shown that site usage were to change to a continuous industrial work site in the future, an industrial worker could potentially receive a TED in excess of 25 mrem/yr. The maximum calculated TED (based on the Industrial Area scenario) was 91.5 mrem/yr at the BFa Site and 205.4 mrem/yr at Small Boy.

Extensive testing facilities and debris remain from activities performed at the sites. Numerous concrete and steel structures, military fortifications (foxholes and bunkers), bridge/railroad infrastructure, domes, shelters, and diagnostic instrumentation locations remain at this site; however, these have not proven to be a source of contamination. It was assumed that lead contamination at the location of the identified lead bricks, pieces, and battery exceed the FALs. An interim corrective action of removal of the lead was completed during the CAI and verification samples were collected to confirm the extent of COC contamination. The analytical results of soil samples collected after corrective action determined that contamination in the remaining soil was below FALs and required no further corrective action.

### *C.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 CAI and the completion of interim corrective actions, the study sites at CAU 541 no longer contains contaminants that present an immediate threat to human health, safety, or the environment; therefore, no interim response actions are necessary at these sites. Therefore, CAU 541 has been determined to be a Classification 2 site as defined by ASTM Method E1739 (ASTM, 1995).

### *C.1.4 Development of Tier 1 Action Level Lookup Table*

Tier 1 action levels are defined as the PALs listed in the CAIP (NNSA/NFO, 2014a) as established during the DQO process. The PALs represent a very conservative estimate of risk that are preliminary in nature, and 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.

The PALs are based on the Ground Troops exposure scenario, which assumes that a military ground troop is present at a particular location for 3 deployments per year (24 hr/day, 14 days per deployment). The 25-mrem/yr dose-based Tier 1 action level for radiological contaminants is determined by calculating the dose a military ground troop would receive if exposed to the site contaminants over an annual exposure period of 1,008 hours.

The Tier 1 action levels for chemical contaminants are the following PALs as defined in the CAIP:

- EPA Region 9 RSLs (EPA, 2015).
- Background concentrations for RCRA metals were evaluated when natural background exceeds the PAL, as is often the case with arsenic. Background is considered the mean plus two times the standard deviation of the mean based on data published in Mineral and Energy Resource Assessment of the Nellis Air Force Range (NBMG, 1998; Moore, 1999).
- For COPCs without established RSLs, a protocol similar to EPA Region 9 was used to establish an action level; otherwise, an established value from another source may be chosen.

Although the PALs are based on a military Ground Troops scenario, no regularly assigned work is currently conducted at this site, and there are no currently assigned work stations in the surrounding area. Therefore, at this time, the use of a military Ground Troops scenario is not representative of current or projected future land use.

### C.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 military personnel or worker contact with the contaminated soil or various debris currently present at the site. The absence of COCs 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.

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

An exposure time based on the Ground Troops scenario (1,008 hr/yr) was used to calculate the Tier 1 action levels (i.e., PALs). For radiological contaminants, dose values were calculated for comparison to the Tier 1 action level based on an exposure time of 1,008 hr/yr. Individual chemical analytical results were directly compared to chemical PALs.

Sampled locations at each CAU 541 release that exceed a Tier 1 action level (i.e., PAL) for radiological constituents are listed in Table C.1-1. Chemical contamination (lead) was detected at one sample location (C04 at 5,090 mg/kg) that exceeded the Tier 1 action level of 800 mg/kg for lead. Based on the unrealistic but conservative assumption that a site worker would be exposed to the maximum dose calculated at any sampled location, this Industrial Site worker would receive a 25-millirem (mrem) dose at each of these release locations in the exposure times listed in Table C.1-2.

**Table C.1-1**
**Locations Where TED Exceeds the Tier 1 Action Level at CAU 541 (mrem/GT-yr)**

| Release | Sample Location | Tier 1 Average TED | Tier 1 95% UCL TED |
|---|---|---|---|
| Study Group 1, BFa Site | A01a | **51.1** | **57.6** |
| | A02a | **29.1** | **31.0** |
| | A04 | **37.2** | **39.9** |
| | A05 | **38.4** | **39.4** |
| | A14 | 21.7 | **25.3** |
| | A15 | **29.3** | **34.3** |
| | A16 | **35.0** | **36.5** |
| | A31 | 21.7 | **25.5** |
| | A32 | **25.1** | **27.6** |
| Study Group 2, Small Boy Site | B02 | **106.8** | **146.2** |
| | B08 | **49.4** | **58.5** |
| | B13 | 20.3 | **25.4** |
| | B14 | 24.0 | **26.2** |

Bold indicates the values exceeding 25 mrem/yr.

**Table C.1-2**
**Minimum Exposure Time to Receive a 25-mrem/yr Dose**

| Release | Location of Maximum Dose | Maximum 95% UCL TED (mrem/GT-yr) | Minimum Exposure Time (hours) |
|---|---|---|---|
| Study Group 1, BFa Site | A01a | 57.6 | 438 |
| Study Group 2, Small Boy Site | B02 | 146.2 | 172 |

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

For the release sites where contamination exceeded the PALs as listed in Table C.1-1 and the lead contamination at location C04, NNSA/NFO determined, from subsequent evaluation, that remediation to the Tier 1 action level is not appropriate. The risk to receptors from contaminants at CAU 541 is due to chronic exposure to contaminants (e.g., receiving a dose over time). Therefore, the risk to a receptor is directly related to the amount of time a receptor is exposed to the contaminants.

A review of the current and projected use at all sites in CAU 541 determined that workers and military personnel may be present at these sites for only a few hours per year (see Section C.1.10), and it is not reasonable to assume that any worker would be present at this site for 1,008 hr/yr. Therefore, it was determined to conduct a Tier 2 evaluation.

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

No remedial actions are proposed for contamination that exceeds Tier 1 action levels.

### *C.1.9 Tier 2 Evaluation*

A Tier 2 evaluation was performed for lead and radiological contamination. No additional data were needed to complete the Tier 2 evaluation.

### *C.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 or military receptors, the area over which personnel are exposed may be much larger than for residential receptors. For a site that is limited to industrial or military uses, the receptor would be a site worker or military troop, and patterns of activity would be used to estimate the area over which the receptor is exposed. This can be very complicated to calculate, as industrial workers or military personnel may perform routine activities at many locations where only a portion of these locations may be contaminated. A more practical measure of integrated risk to radiological dose is to calculate the portion of total work time that personnel are in proximity to elevated contaminant levels.

For the development of radiological Tier 2 action levels, the annual dose limit for site workers or military personnel is 25 mrem/yr (the same as was used for the Tier 1 evaluation). The Tier 2 evaluation is based on a receptor exposure time that is more specific to actual site conditions.

The maximum potential exposure time for the most exposed individual at any CAU 541 release was determined based on an evaluation of current and reasonable future activities that may be conducted at the site.

Activities on the NNSS and NTTR are strictly controlled through a formal work control process or orders. This process requires facility managers or military officers to authorize all work activities that take place on the land or at the facilities within their purview. As such, authorizing personnel are aware of all activities conducted at the site. The personnel responsible for the area of CAU 541 identified the general types of work activities that are currently conducted at the site, to include military trainees and inspection and maintenance workers. Site activities that may occur in the future were identified by assessing tasks related to maintenance of existing infrastructure and long-term stewardship of the site (e.g., inspection and maintenance of UR signs, trespasser). In order to estimate the amount of time spent conducting current or future activities, NNSA/NFO, USAF, and/or the M&O contractor responsible for these activities were consulted. Under the current and projected land use at each of the CAU 541 releases, individuals within the following work-related classifications were identified as being potentially exposed to site contamination:

- **Military Trainee.** Periodic military training activities conducted within CAU 541. These workers typically spend one to two weeks per year training in the general area that includes these CASs. Although they are routinely advised to avoid areas containing radiological contamination and the sites will be posted with warning signs, these workers could potentially inadvertently enter these CAS areas. This work may include personnel travelling through a CAS to reach other destinations. It was conservatively assumed that this type of worker would spend up to one week per year (40 hours) in one or more of these CASs.

- **Sheep Hunter.** Sheep hunter activities are restricted to well-defined boundaries within the DNWR. The nearest point of the detectable plume from the Small Boy test is approximately 1.5 miles from the sheep hunting boundary. Therefore, the sheep hunter would not be directly exposed to the contaminant plume and would be expected to hunt well away from the contaminant plume in the more elevated areas where vegetation is more abundant and sheep would preferentially graze. Therefore, there is a very low potential for the sheep hunter to be directly exposed to site contamination. However, the sheep hunter might have the potential to be indirectly exposed to site radiation through the consumption of contaminated meat from a harvested sheep. The potential dose from eating a contaminated sheep is based on the potential for the sheep to become contaminated and the potential transfer of contamination from the ingested meat. According to the NNSS biologist, sheep might walk across the Small Boy contamination area but would not be expected to feed or spend much time in the area because good fodder is either non-existent or poor. Therefore, it is expected that very little of the feed from the sheep would come from potentially contaminated plants. As most of the internal dose at the Small Boy site comes from Pu-239/240, to receive a dose from these potentially contaminated plants, Pu-239/240 would have to be incorporated into the plant tissue, transferred to the edible portions of the sheep, and then transferred from the ingested sheep meat to the sheep hunter.

The potential transfer of Pu-239/240 from soil to plant, plant to sheep, and sheep to sheep hunter greatly diminishes the Pu-239/240 concentrations because under most environmental conditions, plutonium occurs in forms that are comparatively insoluble and are poorly transferred across biological membranes (Whicker and Schultz, 1982). In the first transfer of soil to plant, well less than 10 percent—and usually less than 1 percent—of the plutonium in the soil is distributed among the litter, biota, and plants. Of the amount contained in plants, only about 0.05 percent of the Pu-239/240 is absorbed from the gastrointestinal tract into the bloodstream after ingestion (ANL, 2007). Most of the Pu-239/240 in the bloodstream deposits about equally in the liver and bones. Therefore, the dose from Pu-239/240 associated with the ingestion of sheep meat is expected to be inconsequential.

In summary, the movement of Pu from soil and sediments to plants and animals is greatly inhibited by its insolubility and strong discrimination at biological membranes. For each of these transfers, it has been estimated that $10^{-4}$ is a reasonable discrimination factor for Pu to be applied at each step in the soil-plant-animal mineral chain (Whicker and Schultz, 1982).

Therefore, as the sheep hunter has much less potential to receive a dose from the Small Boy release than the military trainee, it was determined that the Military Trainee scenario provides a more exposed individual than does the Sheep Hunter scenario.

- **Inspection and Maintenance Worker.** Workers or military personnel sent to conduct the annual inspection of the UR areas. The URs require a periodic inspection to ensure that any required access controls are intact and legible. This may require two people to spend up to 10 hr/yr each at each UR.

- **Security Personnel.** This would include workers who do not have a specific work assignment at one of the CASs, but may be in the area for security purposes possibly resulting from close proximity to the Spill Test Facility. The Spill Test Facility does not place security or other personnel near the CASs during operations; however, it was noted that security personnel pass through the area and perform quick surveillances. It was conservatively assumed that workers would spend 5 hr/yr in one of these CASs.

- **Site Visitor.** This would include visitors who do not have a specific work assignment at one of the CASs but may be included in periodic tours to Area 5. Visitors would tour the area to visit historic sites near the BFa Site on the NNSS and would not be allowed outside the vehicle or within posted radiological areas. It was conservatively assumed that visitors would spend one-half hour per year in one of these CASs.

- **Trespasser.** This would include workers or individuals who do not have a specific work assignment at one of the CASs. Although the sites will be posted with warning signs, workers could potentially inadvertently enter these CAS areas and come in contact with site contamination. This is assumed to be an infrequent occurrence (i.e., once per year) that would result in a potential exposure of less than a day (8 hours).

Under the current land use at the BFa Site and Small Boy release, the most exposed individual would be the military trainee, who would be exposed to site contamination for less than 40 hr/yr.

An unrealistic but worst-case assumption that this most exposed individual were to remain at the location of the maximum dose for the entire maximum estimated time spent at the site, this worker would receive a maximum potential dose at each release as listed in Table C.1-3.

**Table C.1-3**
**Maximum Potential Dose to Most Exposed Individual at CAU 541 Releases**

| Study Group/Site | Most Exposed Worker | Exposure Time | Maximum Potential Dose |
|---|---|---|---|
| Study Group 1, BFa Site | Military Trainee | 40 hr/yr | 2.3 mrem/yr |
| Study Group 2, Small Boy Site | Military Trainee | 40 hr/yr | 5.8 mrem/yr |

In the CAU 541 CAA meetings (Section 1.0), it was conservatively determined that the Occasional Use Area exposure scenario (as listed in Section 3.1.1 of the CAIP [NNSA/NFO, 2014a]) would be appropriate in calculating receptor exposure time based on current land use at all CAU 541 releases. This exposure scenario assumes exposure to site workers who are not assigned to the area as a regular work site but may occasionally use the site for intermittent or short-term activities. Individuals under this scenario are assumed to be on the site for an equivalent of 80 hr/yr. As the use of this scenario provides a more conservative (longer) exposure to site contaminants than the most exposed individual (based on current and projected future land use), the development and evaluation of Tier 2 action levels were based on the Occasional Use Area exposure scenario.

The EPA's risk assessment tool for lead (the Adult Lead Methodology [ALM]) was used to calculate a Tier 2 action level for lead. This methodology is recommended by EPA because a reference dose (RfD) value for lead is not available. In the commercial/industrial setting, the most sensitive receptor is the fetus of a worker who has a non-residential exposure to lead. Based on the available scientific data, a fetus is more sensitive to the adverse effects of lead than an adult (National Academy of Sciences, 1993). The EPA assumes that cleanup levels that are protective of a fetus will also afford protection for male or female adult workers. An outdoor industrial soil Tier 2 action level was calculated for lead at CAU 541 using EPA's ALM to estimate the concentration of lead in the blood of pregnant women and developing fetuses who might be exposed to lead-contaminated soils (EPA, 2009). The ALM is a series of equations for calculation of fetal risks from adult exposures to specified levels of soil lead contamination. These equations conservatively estimate lead concentrations in blood based on the ingestion of lead in soil. The equations are a relationship between soil lead concentration, soil ingestion rate, and a correlation of lead ingested and blood lead concentrations from numerous studies. While the soil ingestion rate includes direct ingestion and ingestion of inhaled dust, dermal absorption is not included, as dermal absorption is generally not a significant route of exposure for inorganic lead and quantifying uptake from dermal exposure to soil-borne lead is not currently recommended by EPA (EPA, 2009). This approach supports EPA's goal of limiting the risk of elevated fetal blood concentrations due to lead exposures to women of child-bearing age. The ALM model is used to estimate blood lead concentrations, which can then be correlated to estimate possible adverse health effects in persons who have been exposed.

Although the Tier 2 action levels for other contaminants were developed using the Occasional Use Area exposure scenario, the Tier 2 action level for lead was developed using the Remote Work Area exposure scenario. The Remote Work Area exposure scenario was used to calculate the Tier 2 action level for lead because EPA states that the minimum frequency of exposure of 1 day per week is recommended for short-term exposures. The recommended full-time exposure frequency of 219 day/yr equates to approximately 44 weeks per year. At 1 day per week, this minimum exposure frequency of 44 day/yr is equivalent to the Remote Work Area exposure scenario.

Therefore, the Remote Work Area exposure scenario soil ingestion rate (0.067 g/day) and the exposure frequency of 44 day/yr were used to calculate a Tier 2 action level for lead of 5,739 mg/kg.

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

For the locations with contamination that exceeded Tier 1 action levels provided in Table C.1-1, the TEDs calculated using the Occasional Use Area exposure scenario were then compared to the 25-mrem/OU-yr Tier 2 action level. As shown in Table C.1-4, none of the 95 percent UCL TED values exceeded the 25-mrem/OU-yr Tier 2 action level.

**Table C.1-4**
**Occasional Use Area Scenario TED at CAU 541 (mrem/OU-yr)**

| Release | Sample Location | Average TED | 95% UCL TED |
|---|---|---|---|
| Study Group 1, BFa Site | A01a | 4.1 | 4.6 |
| | A02a | 2.3 | 2.5 |
| | A04 | 2.9 | 3.2 |
| | A05 | 3.0 | 3.1 |
| | A14 | 1.7 | 2.0 |
| | A15 | 2.3 | 2.7 |
| | A16 | 2.8 | 2.9 |
| | A31 | 1.7 | 2.0 |
| | A32 | 2.0 | 2.2 |
| Study Group 2, Small Boy Site | B02 | 8.1 | 10.9 |
| | B08 | 3.7 | 4.4 |
| | B13 | 1.5 | 1.9 |
| | B14 | 1.7 | 1.9 |

The Tier 2 action level for lead of 5,739 mg/kg is greater than the concentration of lead at location C04 of 5,090 mg/kg.

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

Based on the Tier 2 evaluation, soil contamination is not present at levels that exceed Tier 2 action levels. As corrective actions are not required for these locations, the Tier 2 action levels are established as the FALs.

As the FALs for all contaminants that were passed on to a Tier 2 evaluation were established as the Tier 2 action levels, a Tier 3 evaluation is not necessary (see Figure C.1-1 for a flow-chart explanation of how this conclusion was reached).

## *C.2.0 Summary*

The Tier 2 action levels are typically compared to results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis. Points of exposure are defined as those locations or areas at which an individual or population may come in contact with a COC originating from a release. However, for CAU 541, the Tier 2 action levels were conservatively compared to the maximum contaminant concentration from single point locations.

The FAL for radiological contamination was based on an exposure time of 80 hr/yr of site worker exposure to CAS surface soils. The FAL for lead was based on an exposure time of 44 day/yr of site worker exposure to CAS surface soils. The FALs for other chemical contaminants was based on an exposure time of 2,000 hr/yr of site worker exposure to CAS surface soils.

The CAU 541 dose estimates were made using conservative estimates of site physical properties, contaminant properties, dose conversion properties, exposure paradigms, and exposure durations. While these multiple layers of conservatism result in projected doses that are higher than actual expected doses, they also provide protection against uncertainties that could result in making a false-negative decision error. Therefore, the dose estimates presented herein are intended to provide an upper bound of the potential dose that a receptor could reasonably receive under the exposure scenarios defined in this document. They are not intended to predict the actual dose a receptor would receive from site contamination.

The decisions for CAU 541 are based on the assumption that activities on the NNSS and NTTR will be limited to those that are industrial or military in nature and that the NNSS and NTTR will maintain controlled access (i.e., restrict public access and residential use). Should the future land use of these areas change such that these assumptions no longer are valid, additional evaluation may be necessary.

## *C.3.0 References*

ANL, see Argonne National Laboratory.

ASTM, see ASTM International.

Argonne National Laboratory. 2007. *Radiological and Chemical Fact Sheets to Support Health Risk Analyses for Contaminated Areas*. Argonne, IL: Environmental Science Division.

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

EPA, see U.S. Environmental Protection Agency.

Moore, J., Science Applications International Corporation. 1999. Memorandum to M. Todd (SAIC), "Background Concentrations for NTS and TTR Soil Samples," 3 February. Las Vegas, NV.

NAC, see *Nevada Administrative Code.*

NBMG, see Nevada Bureau of Mines and Geology.

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

National Academy of Sciences. 1993. *Measuring Lead Exposure in Infants, Children, and Other Sensitive Populations.* Washington, DC: National Academy Press.

*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 3 June 2015.

*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 4 June 2015.

Nevada Bureau of Mines and Geology. 1998. *Mineral and Energy Resource Assessment of the Nellis Air Force Range*, Open-File Report 98-1. Reno, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2014a. *Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada*, Rev. 0, DOE/NV--1524. Las Vegas, NV.

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

U.S. Environmental Protection Agency. 2009. *Update of the Adult Lead Methodology's Default Baseline Blood Lead Concentration and Geometric Standard Deviation Parameters,* OSWER 9200.2-82. June. Prepared by the Lead Committee of the Technical Review Workgroup for Metals and Asbestos. Washington, DC: Office of Superfund Remediation and Technology Innovation.

U.S. Environmental Protection Agency. 2015. *Pacific Southwest, Region 9: Regional Screening Levels (Formerly PRGs), Screening Levels for Chemical Contaminants*. As accessed at http://www.epa.gov/region9/superfund/prg/ on 17 March. Prepared by EPA Office of Superfund and Oak Ridge National Laboratory.

Whicker, F.W., and V. Schultz. 1982. *Radioecology: Nuclear Energy and the Environment*, Volume I. Boca Raton, FL: CRC Press.

# Appendix D

# Closure Activity Summary

# *D.1.0 Closure Activity Summary*

The following subsections document closure activities completed for CAU 541 at CASs 05-23-04 (Study Group 1, BFa Site) and 05-45-03 (Study Group 2, Small Boy Site). Surface soil samples, TLD measurements, and TRS measurements were collected to characterize the presence and lateral extent of radiological contamination at these sites.

## *D.1.1 CAS 05-23-04 (Study Group 1, BFa Site) Closure Activities*

Based on the results of this investigation, the no further action alternative is implemented for CAS 05-23-04, Atmospheric Tests (6) - BFa Site, and an administrative UR is established to encompasses the surface soil area exceeding a dose of 25 mrem/IA-yr (Figure A.4-4). No radiological or chemical COCs were identified at the Study Group 1, BFa Site based upon a 25-mrem/OU-yr FAL. Therefore, the no further action alternative is implemented for the site. In accordance with the Soils RBCA document (NNSA/NFO, 2014b) and Section 3.3 of the CAIP (NNSA/NFO, 2014a), an administrative UR was established defined by the coordinates presented in Attachment D-1. This administrative UR was established to prevent a future site worker from receiving a dose exceeding 25 mrem/IA-yr if there were a more intensive use of the site in the future and is recorded in the FFACO database, NNSS M&O Contractor GIS, USAF (Nellis Air Force Base Operations), and the NNSA/NFO CAU/CAS files.

## *D.1.2 CAS 05-45-03 (Study Group 2, Small Boy Site) Closure Activities*

Based on the results of this investigation, the no further action alternative is implemented for CAS 05-45-03, Atmospheric Test Site - Small Boy, and an administrative UR is established to encompasses the surface soil area exceeding a dose of 25 mrem/IA-yr (Figure A.4-4). No radiological or chemical COCs were identified at the Study Group 2, Small Boy Site based upon a 25-mrem/OU-yr FAL. Therefore, the no further action alternative is implemented for the site. In accordance with the Soils RBCA document (NNSA/NFO, 2014b) and Section 3.3 of the CAIP (NNSA/NFO, 2014a), an administrative UR was established defined by the coordinates presented in Attachment D-1. This administrative UR was established to prevent a future site worker from receiving a dose exceeding 25 mrem/IA-yr if there were a more intensive use of the site in the future and is recorded in the FFACO database, NNSS M&O Contractor GIS, USAF (Nellis Air Force Base Operations), and the NNSA/NFO CAU/CAS files.

### *D.1.3 CASs 05-23-04 and 05-45-03 (Study Group 3, Spills and Debris) Closure Activities*

Based on the results of this investigation, the no further action alternative is implemented for the lead items identified as PSM at Study Group 3**,** Spills and Debris. The lead bricks, pieces, and battery were assumed to be PSM and were removed from the site as an interim corrective action. Samples were collected from soil adjacent to the PSM to verify completion of corrective actions and to show there are no COCs identified at the site. Samples were analyzed for RCRA metals, and no sample result exceeded the FAL.

## D.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. 2014a. *Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada*, Rev. 0, DOE/NV--1524. Las Vegas, NV.

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

# Attachment D-1

# Use Restrictions

(6 Pages)

# Use Restriction Information

**CAU Number/Description:** CAU 541, Small Boy
**Applicable CAS Number/Description:** CAS 05-23-04, Atmospheric Tests (6) – BFa Site

**Contact (DOE AL/Activity):** NNSA Nevada Field Office Soils Activity Lead

**FFACO Use Restriction Physical Description:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| N/A | | |
| | | |
| | | |
| | | |
| | | |
| | | |

**Depth:** N/A

**Survey Source (GPS, GIS, etc):** N/A

**Basis for FFACO UR(s):**

**Summary Statement:** N/A

**Contaminants Table:**

| Maximum Concentration of Contaminants for CAU 541<br>CAS 05-23-04, Atmospheric Tests (6) – BFa Site | | | |
|---|---|---|---|
| **Constituent** | **Maximum Concentration** | **Action Level** | **Units** |
| N/A | | | |
| | | | |
| | | | |
| | | | |

**Site Controls:** NA

**Administrative Use Restriction Physical Description*:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| Southeast | 4,072,635 | 595,866 |
| South | 4,072,479 | 595,603 |
| Southwest | 4,072,591 | 595,294 |
| Northwest | 4,073,016 | 595,371 |
| North | 4,073,136 | 595,551 |
| Northeast | 4,073,066 | 595,723 |

**Depth:** 6 inches bgs

**Survey Source (GPS, GIS, etc):** GIS

*Coordinates for the Administrative Use Restriction exclude the area defined by the FFACO Use Restriction coordinates.

Note: Effective upon acceptance of closure documents by NDEP

# Use Restriction Information

**Basis for Administrative UR(s)**:

**Summary Statement**: This administrative use restriction (UR) is to protect workers from receiving a dose exceeding 25 mrem/yr from contamination that is present at this site if current site usage were to increase in the future. Using the maximum calculated dose rate at this site, a worker could receive a 25-mrem dose in 437 hours of site exposure. The maximum concentration of any radionuclide detected in soil samples that could contribute more than 10 percent of the action level is presented in the contaminants table below. The analytical results and locations of all samples are presented in the CADD/CR for CAU 541.

**Contaminants Table:**

| **Maximum Concentration of Contaminants for CAU 541<br>CAS 05-23-04, Atmospheric Tests (6) – BFa Site** | | | |
|---|---|---|---|
| **Constituent** | **Maximum Concentration*** | **Action Level **** | **Units** |
| Cesium-137 | 13.3 | 81 | pCi/g |
| Europium-152 | 33.8 | 43 | pCi/g |
| | | | |
| | | | |

*Highest measured value
**Action level based on 25 mrem/yr under the Industrial Area scenario

**Site Controls:** New activities that would cause a site worker to be exposed to site radiological contamination for a period of more than that of current land use (defined above) are restricted within the area defined by the coordinates listed above and depicted in the attached figure without prior notification and approval of NDEP unless the activities are conducted under the provisions of 10 CFR Part 835. This administrative UR is recorded in the FFACO database, M&O Contractor GIS, USAF (Nellis Air Force Base Range Operations), and the NNSA/NFO CAU/CAS files. No physical site controls are required for this administrative UR.

**UR Maintenance Requirements (applies to both FFACO and Administrative UR(s) if Administrative UR exists):**

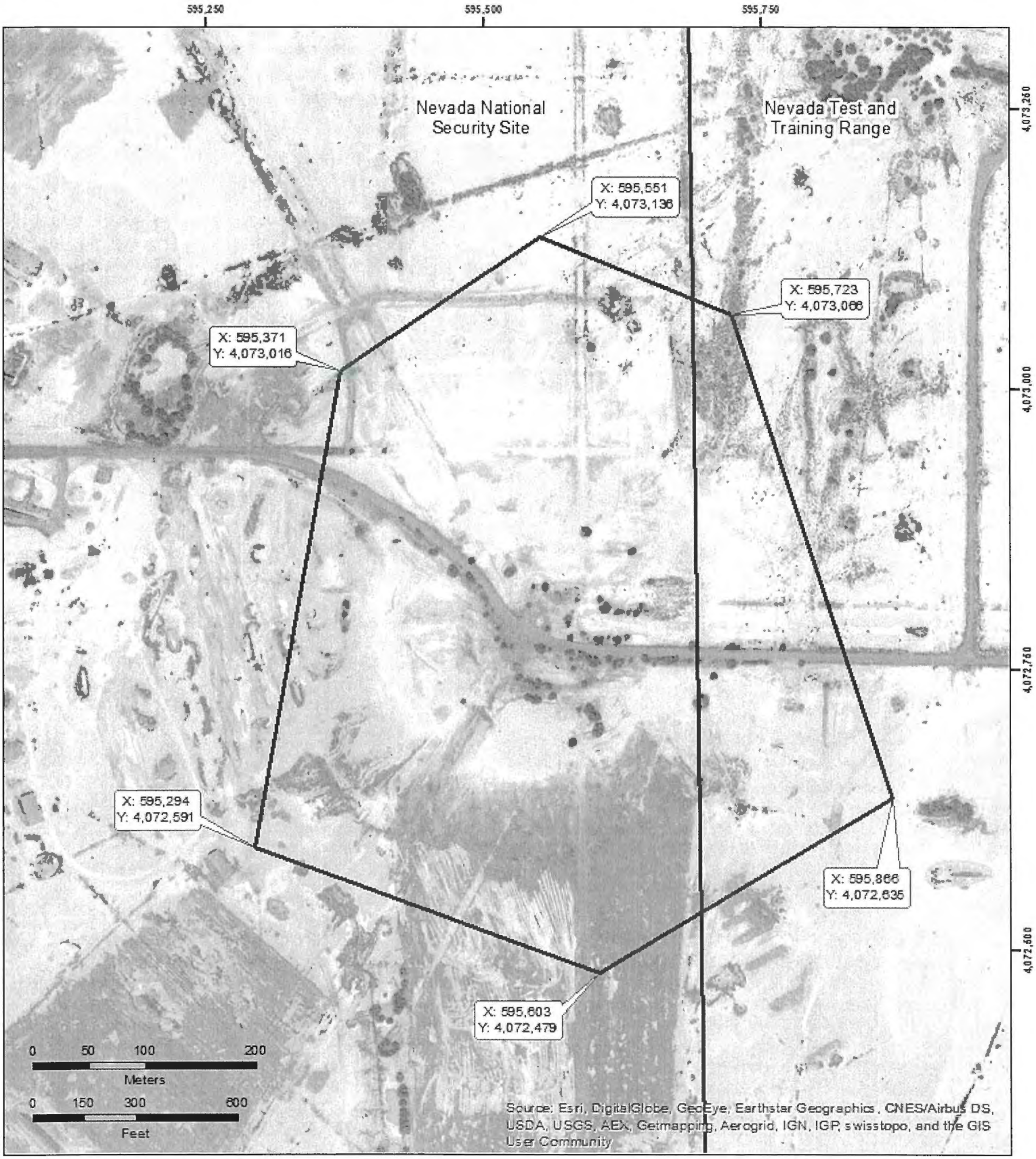
**Description:** No maintenance is required for this administrative use restriction.

**Inspection/Maintenance Frequency:** N/A

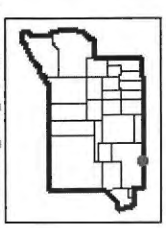
| |
|---|
| The future use of any land related to this Corrective Action Unit (CAU), as described by the above surveyed location, is restricted from any DOE or Air Force activity that may alter or modify the containment control as approved by the state and identified in the CAU CR or other CAU documentation unless appropriate concurrence is obtained in advance. |

**Comments:** None

**Submitted By:** /s/ Tiffany A. Lantow **Date:** 01/27/2016




I:\541\CADD\541_Bf1a_FRACO.mxd 1/25/2016



**Explanation**

- Administrative Boundary
- NNSS Boundary

# CAU 541

## CAS 05-23-04, Atmospheric Test (6) - BFa Site
## Administrative UR Boundary

N

Source: Navarro GIS, 2016

Coordinate System: NAD 1927 UTM Zone 11N, Meters

# Use Restriction Information

**CAU Number/Description:** CAU 541, Small Boy
**Applicable CAS Number/Description:** CAS 05-45-03, Atmospheric Test Site – Small Boy

**Contact (DOE AL/Activity):** NNSA Nevada Field Office Soils Activity Lead

**FFACO Use Restriction Physical Description:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| N/A | | |
| | | |

**Depth:** N/A

**Survey Source (GPS, GIS, etc):** N/A

**Basis for FFACO UR(s):**

**Summary Statement:** N/A

**Contaminants Table:**

| Maximum Concentration of Contaminants for CAU 541 CAS 05-45-03, Atmospheric Test Site – Small Boy | | | |
|---|---|---|---|
| Constituent | Maximum Concentration | Action Level | Units |
| N/A | | | |
| | | | |

**Site Controls:** N/A

**Administrative Use Restriction Physical Description*:**

**Surveyed Area (UTM, Zone 11, NAD 83, meters):**

| UR Points | Northing | Easting |
|---|---|---|
| Southeast | 4,073,065 | 596,935 |
| South | 4,072,815 | 596,528 |
| Southwest | 4,073,142 | 596,085 |
| West | 4,073,384 | 595,948 |
| Northwest | 4,073,924 | 596,506 |
| North | 4,074,135 | 596,984 |
| Northeast | 4,074,060 | 597,279 |
| East | 4,073,820 | 597,441 |

**Depth:** 6 inches bgs

**Survey Source (GPS, GIS, etc):** GIS

*Coordinates for the Administrative Use Restriction exclude the area defined by the FFACO Use Restriction coordinates.

Note: Effective upon acceptance of closure documents by NDEP

# Use Restriction Information

**Basis for Administrative UR(s)**:

**Summary Statement**: This administrative use restriction (UR) is to protect site workers from receiving a dose exceeding 25 mrem/yr from contamination that is present at this site if current site usage were to increase in the future. Using the maximum calculated dose rate at this site, a worker could receive a 25-mrem dose in 174 hours of site exposure. The maximum concentration of any radionuclide detected in soil samples that could contribute more than 10 percent of the action level is presented in the contaminants table below. The analytical results and locations of all samples are presented in the CADD/CR for CAU 541.

**Contaminants Table:**

| Maximum Concentration of Contaminants for CAU 541<br>CAS 05-45-03, Atmospheric Test Site – Small Boy | | | |
|---|---|---|---|
| **Constituent** | **Maximum Concentration*** | **Action Level ** ** | **Units** |
| Cesium-137 | 359 | 81 | pCi/g |
| Plutonium-239/240 | 8,265 | 4,120 | pCi/g |
| Americium-241 | 3,110 | 2,110 | pCi/g |
| | | | |

*Highest measured value
**Action level based on 25 mrem/yr under the Industrial Area scenario

**Site Controls:** New activities that would cause a site worker to be exposed to site radiological contamination for a period of more than that of current land use (defined above) are restricted within the area defined by the coordinates listed above and depicted in the attached figure without prior notification and approval of NDEP unless the activities are conducted under the provisions of 10 CFR Part 835. This administrative UR is recorded in the FFACO database, M&O Contractor GIS, USAF (Nellis Air Force Base Range Operations), and the NNSA/NFO CAU/CAS files. No physical site controls are required for this administrative UR.

**UR Maintenance Requirements (applies to both FFACO and Administrative UR(s) if Administrative UR exists):**

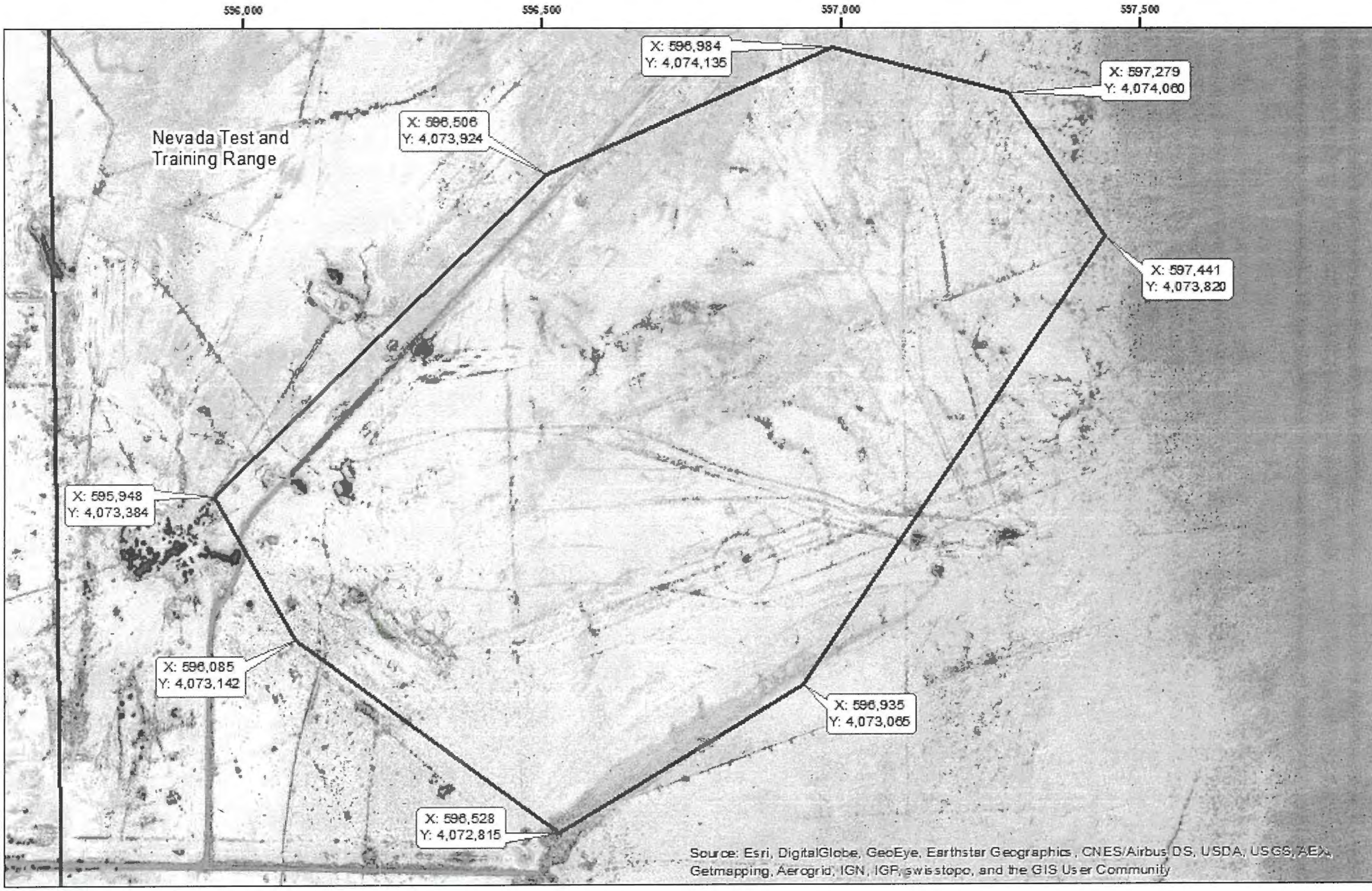
**Description:** No maintenance is required for this administrative use restriction.

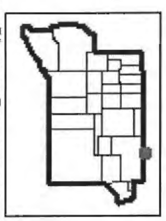
**Inspection/Maintenance Frequency:** N/A

The future use of any land related to this Corrective Action Unit (CAU), as described by the above surveyed location, is restricted from any DOE or Air Force activity that may alter or modify the containment control as approved by the state and identified in the CAU CR or other CAU documentation unless appropriate concurrence is obtained in advance.

**Comments:** None

**Submitted By:** /s/ Tiffany A. Lantow **Date:** 01/27/2016



H:\541\CADD\541_SmallBoy_FFACO.mxd 1/25/2016

Source: Navarro GIS, 2016

**Explanation**

- Administrative UR
- NNSS Boundary

# CAU 541

## CAS 05-45-03, Atmospheric Test Site - Small Boy
## Administrative UR Boundary

0 100 200 300
Meters

0 300 600 900
Feet

N

Coordinate System: NAD 1927 UTM Zone 11N, Meters

# Attachment D-2

# Waste Disposal Documentation

(2 Pages)

NSTec Form FRM-0266 | 04/04/13 Rev. 05

# ONSITE WASTE TRANSPORT MANIFEST

Manifest Document No.: 1 5 N 4 2

Page 1 of 1

Generation/Out-of-Service Date: 04-28-2015

1. Generator's Name, Organization, and Location: (Please Print)
Mark Heser, Navarro
Generator's Phone : ( 702 ) 295-2124

2. Receiving Facility, Organization, Location: (Please Print)
RWMC
Area 5, Bldg.24
Contact Phone: ( 702 ) 295-6811

3a. Transporter Name: (Please Print) Rick Hendricks

Transport Date: 6/23/2015

3b. Vehicle I.D. Number: G82-04280

| | HM | 4. U.S. D.O.T. Description. Include: EPA Waste Code and Package Tracking Numbers. | 5. Containers No. | 5. Containers Type | 6. Total Quantity | 7. Unit Wt./Vol. (P or K) |
|---|---|---|---|---|---|---|
| a | X | UN2913, Waste, Radioactive Material, Surface Contaminated Objects (SCO-II), 7, Pu-239, Pu-240, Pu-241, Am-241, Cs-137, Co-60, Sr-90, Eu-152, solid, oxide,1.08E+07 Bq, Fissile Excepted, Exclusive Use Shipment. D008, D011 | 1 | CM | 5150 | P |
| b | | | | | | |
| c | | | | | | |
| d | | | | | | |
| e | | | | | | |
| f | | | | | | |
| g | | | | | | |

*Use continuation pages for additional items, as necessary.*

8. Special Handling Instructions/Additional Information: 24-Hour emergency contact: 702-295-0311 / Secondary: Mike McKinnon 5-1406 (Name & phone no.)

D004, D005, D006, D007, D009, D010.HAZTRAK tracking # DPM15T02, Package # 15M002. ERG # 162

8a. This is to certify that the above named materials are properly classified, described, packaged, marked, labeled, and are in proper condition for transportation according to the applicable regulations of the Department of Transportation.

Robert Zion /s/ Signature on file — Printed Name / Signature — Date: 6/23/2015

9. Released by: Robert H Zion (Printed Name) — /s/ Signature on file (Signature) — Date: 6/23/2015

10. Received for Transport by: Rick Hendricks (Printed Name) — /s/ Signature on file (Signature) — Date: 6-23-2015

11. Discrepancy Indication:

12. Disposal/Accumulation Site Signature: *(Acknowledges acceptance of waste)*
Stephen E Wolf (Printed Name) — /s/ Signature on file (Signature) — Date: 06/23/15

# NTS On-Site HazMat Transfer - Published

**Tracking No:** DPM15T02
Carrier: NSTEC ON BEHALF OF NNSA
Vehicle: G620428D GV
**Driver:** RICHARD HENDRICKS

**Depart:** 23-JUN-2015 Arrival: 23-JUN-2015

| From: | | To: | |
|---|---|---|---|
| | ROBERT ZION | | CHRISTOPHER CHALUPKA |
| | NSTEC | | NSTEC |
| | BASE CAMP | | BASE CAMP |
| | 3-02 & 3-03 INTERSECTION | | TRU PAD |
| | MERCURY, NV 89023 | | MERCURY, NV 89023 |
| | Area: 03 | | Area: 05 |
| | Bldg: CAU-568 | | Bldg: 024 |
| | Phone: 702/295-4594 | | Phone: 702-295-6348 |
| | Mobile: 702/533-0304 | | Mobile: |

Entered By: THERESA HALE Date Entered: 11-JUN-2015
**Modified By:** THERESA HALE Date Modified: 22-JUN-2015

| Shipped Material(s) | Package(s) | Unit(s) | Guide No. |
|---|---|---|---|
| UN2913, RADIOACTIVE MATERIAL, SURFACE CONTAMINATED OBJECTS (SCO-II) NON FISSILE OR FISSILE-EXCEPTED, 7 WASTE RADIONUCLIDES:PU-239, PU-240, PU-241, AM-241, CS-137, CO-60, SR-90, EU-152 PHYSICAL FORM:SOLID CHEMICAL FORM:OXIDE PACKAGE ACTIVITY:1.08E+07 BQ CATEGORY:FISSILE EXCEPTED, EXCLUSIVE USE SHIPMENT, PACKAGE # 15M002 | 1 BOX, METAL | 5,150 POUND(S) (GROSS) | 162 |

## Emergency Response Number
## 702-295-0311 Contact / Contract / ID: NNSS DUTY MANAGER

**Secondary Emergency Response Contact And/Or Comments**
MICHAEL MCKINNON 295-1406, CELL 702/417-0537

**In the event of an emergency on the Nevada National Security Site, immediately contact the Operations Command Center (OCC) Duty Manager at 702/295-0311 for assistance.**

## EMERGENCY RESPONSE

By Phone
702-295-0311

By Radio
'MAYDAY - MAYDAY - MAYDAY'

**In the event of an incident involving Hazardous Material:**

1. Gather HazMat shipping papers and NAER Guidebook
2. Isolate the immediate area
3. Assess the situation:
   a. Fire, Spill, or Leak?
   b. People, Property, or the Environment at risk?
4. Contact On-site Emergency Response Personnel
5. Reference On-Site HazMat Transfer Tracking Number

This is to certify that the above-named materials are properly classified, described, packaged, marked, placarded, and labeled and are in proper condition for transportation according to the applicable regulations of the U.S Department of Transportation. As a signatory I cerify that I have been trained and tested to the reauirements of 49 CFR. Part 172-700 and is compliant with the NTS OTSD.

Authorized Signature: /s/ Signature on file Date: 6/23/2015 Time: ____________

Received by: /s/ Signature on file Date: 6/23/15 Time: ____________

# Appendix E

# Evaluation of Corrective Action Alternatives

# *E.1.0 Introduction*

This appendix presents the corrective action objectives for CAU 541, describes the general standards and decision factors used to screen the various CAAs, and develops and evaluates a set of selected CAAs that will meet the corrective action objectives. This CAA evaluation is intended for use in making corrective action decisions for CAU 541 conditions at the conclusion of the CAI (after the completion of any interim corrective actions).

On May 1, 1996, EPA issued an Advance Notice of Proposed Rulemaking (ANPR) for corrective action for releases from solid waste management units at hazardous waste management facilities (EPA, 1996). The EPA states that the ANPR should be considered the primary corrective action implementation guidance (Laws and Herman, 1997). The ANPR states that a basic operating principle for remedy selection is that corrective action decisions should be based on risk. It emphasizes that current and reasonably expected future land use should be considered when selecting corrective action remedies and encourages use of innovative site characterization techniques to expedite site investigations.

The ANPR provides the following EPA expectations for corrective action remedies (EPA, 1996):

- Treatment should be used to address principal threats wherever practicable and cost-effective.
- Engineering controls, such as containment, should be used where wastes and contaminated media can be reliably contained, pose relatively low long-term threats, or for which treatment is impracticable.
- A combination of methods (e.g., treatment, engineering, and institutional controls) should be used, as appropriate, to protect human health and the environment.
- Institutional controls should be used primarily to supplement engineering controls as appropriate for short- or long-term management to prevent or limit exposure.
- Innovative technologies should be considered where such technologies offer potential for comparable or superior performance or implementability, less adverse impacts, or lower costs.
- Usable groundwater should be returned to maximum beneficial use wherever practicable.

- Contaminated soils should be remediated as necessary to prevent or limit direct exposure and to prevent the transfer of unacceptable concentrations of contaminants from soils to other media.

### *E.1.1 Corrective Action Objectives*

The corrective action objectives are the FALs as defined in the Soils RBCA document (NNSA/NFO, 2014b). This process conforms with NAC 445A.227, which lists the requirements for sites with soil contamination (NAC, 2014a). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2014b) requires the use of 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.

### *E.1.2 Screening Criteria*

The screening criteria used to evaluate and select the preferred CAAs are identified in the *Guidance on RCRA Corrective Action Decision Documents* (EPA, 1991) and the *Final RCRA Corrective Action Plan* (EPA, 1994).

CAAs are evaluated based on four general corrective action standards and five remedy selection decision factors. All CAAs must meet the four general standards to be selected for evaluation using the remedy selection decision factors.

The general corrective action standards are as follows:

- Protection of human health and the environment
- Compliance with media cleanup standards
- Control the source(s) of the release
- Comply with applicable federal, state, and local standards for waste management

The remedy selection decision factors are as follows:

- Short-term reliability and effectiveness
- Reduction of toxicity, mobility, and/or volume
- Long-term reliability and effectiveness
- Feasibility
- Cost

### *E.1.2.1 Corrective Action Standards*

The following subsections describe the corrective action standards used to evaluate the CAAs.

***Protection of Human Health and the Environment***

Protection of human health and the environment is a general mandate of the RCRA statute (EPA, 1994). This mandate requires that the corrective action include any necessary protective measures. These measures may or may not be directly related to media cleanup, source control, or management of wastes.

***Compliance with Media Cleanup Standards***

The CAAs are evaluated for the ability to meet the proposed media cleanup standards. The media cleanup standards are the FALs defined in Section 2.3.1.

***Control the Source(s) of the Release***

The CAAs are evaluated for the ability to stop further environmental degradation by controlling or eliminating additional releases that may pose a threat to human health and the environment. Unless source control measures are taken, efforts to clean up releases may be ineffective or, at best, will involve a perpetual cleanup. Therefore, each CAA must provide effective source control to ensure the long-term effectiveness and protectiveness of the corrective action.

***Comply with Applicable Federal, State, and Local Standards for Waste Management***

The CAAs are evaluated for the ability to be conducted in accordance with applicable federal and state regulations (e.g., 40 CFR 260 to 282, "Hazardous Waste Management" [CFR, 2015a]; 40 CFR 761 "Polychlorinated Biphenyls," [CFR, 2015b]; and NAC 444.842 to 444.980, "Facilities for Management of Hazardous Waste" [NAC, 2012]).

### *E.1.2.2 Remedy Selection Decision Factors*

The following text describes the remedy selection decision factors used to evaluate the CAAs.

***Short-Term Reliability and Effectiveness***

Each CAA must be evaluated with respect to its effects on human health and the environment during implementation of the selected corrective action. The following factors will be addressed for each alternative:

- Protection of the community from potential risks associated with implementation, such as fugitive dusts, transportation of hazardous materials, and explosion
- Protection of workers during implementation
- Environmental impacts that may result from implementation
- The amount of time until the corrective action objectives are achieved

***Reduction of Toxicity, Mobility, and/or Volume***

Each CAA must be evaluated for its ability to reduce the toxicity, mobility, and/or volume of the contaminated media. Reduction in toxicity, mobility, and/or volume refers to changes in one or more characteristics of the contaminated media by using corrective measures that decrease the inherent threats associated with that media.

***Long-Term Reliability and Effectiveness***

Each CAA must be evaluated in terms of risk remaining at the CAU after the CAA has been implemented. The primary focus of this evaluation is on the extent and effectiveness of the control that may be required to manage the risk posed by treatment of residuals and/or untreated wastes.

***Feasibility***

The feasibility criterion addresses the technical and administrative feasibility of implementing a CAA and the availability of services and materials needed during implementation. Each CAA must be evaluated for the following criteria:

- **Construction and Operation.** The feasibility of implementing a CAA given the existing set of waste and site-specific conditions.
- **Administrative Feasibility.** The administrative activities needed to implement the CAA (e.g., permits, URs, public acceptance, rights of way, offsite approval).

- **Availability of Services and Materials.** The availability of adequate offsite and onsite treatment, storage capacity, disposal services, necessary technical services and materials, and prospective technologies for each CAA.

***Cost***

Costs for each alternative are estimated for comparison purposes only. The cost estimate for each CAA includes both capital, and operation and maintenance costs, as applicable. The following is a brief description of each component:

- **Capital Costs.** Costs that include direct costs that may consist of materials, labor, construction materials, equipment purchase and rental, excavation and backfilling, sampling and analysis, waste disposal, demobilization, and health and safety measures. Indirect costs are separate and not included in the estimates.

- **Operation and Maintenance Costs.** Separate costs that include labor, training, sampling and analysis, maintenance materials, utilities, and health and safety measures. These costs are not included in the estimates.

### *E.1.3 Development of CAAs*

This section identifies and briefly describes the viable corrective action technologies and the CAAs considered for each CAU 541 CAS. The CAAs are based on the current nature of contamination at CAU 541, which does not include contamination removed as part of the corrective actions completed during the CAI (Section 2.2.1). Based on the review of existing data, future use, and current operations at the NNSS, the following alternatives have been developed for consideration at CAU 541:

- **Alternative 1.** No Further Action
- **Alternative 2.** Clean Closure
- **Alternative 3.** Closure in Place

#### *E.1.3.1 Alternative 1 – No Further Action*

Under Alternative 1, no corrective action activities will be implemented. This alternative is a baseline case with which to compare and assess the other CAAs and their ability to meet the corrective action standards.

#### *E.1.3.2 Alternative 2 – Clean Closure*

Alternative 2, clean closure, is not applicable, as there are no COCs at CAU 541 above the FAL at either CAS.

#### *E.1.3.3 Alternative 3 – Closure in Place*

Alternative 3, closure in place, is not applicable, as there are no COCs at CAU 541 above the FAL at either CAS.

### *E.1.4 Evaluation of CAAs*

The evaluation of CAAs did not include corrective actions that were completed during the CAI. The interim corrective actions that were completed during the CAU 541 field investigation were as follows:

- Removal of lead pieces and bricks at Study Group 3. This corrective action involved the removal of five lead bricks and several lead pieces from surface or partially buried locations. Confirmation samples were collected and analyzed.
- Removal of a lead-acid battery and soil at Study Group 3. This corrective action involved the removal of one breached lead-acid battery. Because the case was not intact, a confirmation sample was collected and analyzed.

Verification of the completion of these corrective actions are documented in this report. Remaining surface contamination at the Study Group 1, BFa Site and Study Group 2, Small Boy Site does not exceed FALs and does not require corrective action. Therefore, the no further action alternative was selected for these sites.

Each CAA presented in Section E.1.3 was evaluated by stakeholders in the CAA meetings (Section 1.0) based on the general corrective action standards listed in Section E.1.2. The CAAs of clean closure and closure in place with UR are not applicable, as there are no COCs that require corrective action and the CAA of no further action meets the general corrective action standards.

# E.2.0 Recommended Alternative

The no further action alternative was selected as there are no COCs detected at CAU 541 above the FAL at either CAS. Although the no further action alternative has been recommended, BMPs will be performed as follows. In accordance with the Soils RBCA document (NNSA/NFO, 2014b) and Section 3.3 of the CAIP (NNSA/NFO, 2014a), an administrative UR was identified as a BMP for areas where a future site worker could receive an annual radiological dose exceeding 25 mrem/IA-yr if the land use were to change and a more intensive use of the area (up to a full time industrial or military use) was implemented. This conservative assumption is that a worker would be exposed to site contamination for a period of 2,000 hr/yr. This administrative UR (implemented as a BMP) is not part of any FFACO corrective action. To determine the extent of this area, a correlation of radiation survey values to the 95 percent UCL of Industrial Area TED values was conducted as discussed in Section A.2.5 for each area where dose is present at a level exceeding 25 mrem/IA-yr. The radiation survey with the best correlation was the PRM-470 TRS at the Study Group 1, BFa Site (Section A.3.5) and the FIDLER TRS at the Study Group 2, Small Boy Site (Section A.4.5). The administrative UR boundaries for the BFa Site (Figure A.3-4) and Small Boy (Figure A.4-4) were identified to encompass the TRS isopleth corresponding to a dose of 25 mrem/IA-yr. The administrative URs will be recorded and controlled in the same manner as the FFACO URs, but will not require posting or inspections. The administrative URs are presented in Attachment D-1.

All URs are recorded in the FFACO database, NNSS M&O Contractor GIS, USAF, and the NNSA/NFO CAU/CAS files. The development of URs for CAU 541 are based on current land use. Any proposed activity within a use restricted area that would result in higher risk to the most exposed site worker than that presented in the risk evaluation (Appendix C) would require NDEP approval.

## E.3.0 Cost Estimates

There is no cost for the no further action alternative.

# E.4.0 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*. 2015a. Title 40 CFR, Parts 260 to 282, "Hazardous Waste Management." Washington, DC: U.S. Government Printing Office.

*Code of Federal Regulations*. 2015b. Title 40 CFR 761, "Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions." Washington, DC: U.S. Government Printing Office.

EPA, see U.S. Environmental Protection Agency.

Laws, E.P., and S.A. Herman, U.S. Environmental Protection Agency. 1997. Memorandum to RCRA/CERCLA Senior Policy Managers Region I–X titled "Use of the Corrective Action Advance Notice of Proposed Rulemaking as Guidance," 17 January. Washington, DC: Offices of Solid Waste and Emergency Response, and Enforcement and Compliance Assurance.

NAC, see *Nevada Administrative Code*.

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

*Nevada Administrative Code*. 2012. NAC 444.842 to 444.980, "Facilities for Management of Hazardous Waste." Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 3 June 2015.

*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 4 June 2015.

*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 3 June 2015.

U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office. 2014a. *Corrective Action Investigation Plan for Corrective Action Unit 541: Small Boy, Nevada National Security Site and Nevada Test and Training Range, Nevada*, Rev. 0, DOE/NV--1524. Las Vegas, NV.

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

U.S. Environmental Protection Agency. 1991. *Guidance on RCRA Corrective Action Decision Documents: The Statement of Bases, Final Decision and Response to Comments*, EPA/540/G-91/011. Washington, DC: Office of Waste Programs Enforcement.

U.S. Environmental Protection Agency. 1994. *Final RCRA Corrective Action Plan*, EPA/520-R-94-004. Washington, DC: Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency. 1996. "Corrective Action for Releases from Solid Waste Management Units at Hazardous Waste Management Facilities," 1 May. In *Federal Register*, Vol. 61, No. 85.

# Appendix F

# Sample Location Coordinates

# F.1.0 Sample Location Coordinates

The southwest corner of each sample plot, TLD, background, and the locations of individual (judgmental) sample locations for the CAU 541 CASs were surveyed using a GPS instrument. Survey coordinates for these locations are listed in Tables F.1-1 and F.1-2.

**Table F.1-1**
**Sample Plot/Location Coordinates for Atmospheric Test Site - Small Boy[a], BFa Site**
(Page 1 of 2)

| Easting[b] | Northing[b] | Sample Plot/Location |
|---|---|---|
| **Sample Plot Location** | | |
| 595634.4 | 4072684.3 | A01a |
| **Depth Sample Location** | | |
| 595576.4 | 4072840.6 | A02a |
| **TLD Locations** | | |
| 595606.5 | 4072733.8 | A03 |
| 595656.9 | 4072676.8 | A04 |
| 595681.5 | 4072649.3 | A05 |
| 595707.3 | 4072621.3 | A06 |
| 595733.4 | 4072593.6 | A07 |
| 595759.1 | 4072561.8 | A08 |
| 595784.4 | 4072533.7 | A09 |
| 595807.5 | 4072506.9 | A10 |
| 595836.7 | 4072476.5 | A11 |
| 595864.9 | 4072447.1 | A12 |
| 595889.3 | 4072418.4 | A13 |
| 595488.3 | 4072752.7 | A14 |
| 595424.1 | 4072716.9 | A15 |
| 595391.4 | 4072697.3 | A16 |
| 595357.8 | 4072677.6 | A17 |
| 595327.3 | 4072659.3 | A18 |
| 595288.4 | 4072640.5 | A19 |

## Table F.1-1
## Sample Plot/Location Coordinates for Atmospheric Test Site - Small Boy[a], BFa Site
(Page 2 of 2)

| Easting[b] | Northing[b] | Sample Plot/Location |
|---|---|---|
| 595258.4 | 4072621.0 | A20 |
| 595218.8 | 4072603.4 | A21 |
| 595185.9 | 4072584.2 | A22 |
| 595147.1 | 4072562.9 | A23 |
| 595120.2 | 4072546.6 | A24 |
| 595087.4 | 4072527.6 | A25 |
| 595054.7 | 4072508.8 | A26 |
| 595018.1 | 4072489.6 | A27 |
| 594985.1 | 4072470.3 | A28 |
| 595556.1 | 4072795.5 | A29 |
| 595560.1 | 4072867.2 | A30 |
| 595565.8 | 4072943.4 | A31 |
| 595569.3 | 4072979.9 | A32 |
| 595570.9 | 4073017.4 | A33 |
| 595573.8 | 4073056.1 | A34 |
| 595575.7 | 4073092.7 | A35 |
| 595579.3 | 4073133.6 | A36 |
| 595581.7 | 4073171.9 | A37 |
| 595584.8 | 4073211.7 | A38 |
| 595587.2 | 4073249.9 | A39 |
| 595589.8 | 4073288.8 | A40 |
| **Background Locations** | | |
| 595887.9 | 4074123.2 | H01 |
| 596758.1 | 4072698.3 | H02 |
| 596038.2 | 4071787.7 | H03 |

[a]All sample plot coordinates are from the southwest corner
[b]UTM Zone 11, NAD 1927 (U.S. Western) in meters.

NAD = North American Datum
UTM = Universal Transverse Mercator

**Table F.1-2**
**Sample Plot/Location Coordinates for Atmospheric Test Site - Small Boy[a], Small Boy Site**
(Page 1 of 2)

| Easting[b] | Northing[b] | Sample Plot/Location |
|---|---|---|
| **Sample Plots** | | |
| 596580.9 | 4072873.9 | B01 |
| 596644.6 | 4073623.5 | B02 |
| 596243.8 | 40733474.7 | B04 |
| 596386.7 | 4073458.4 | B05 |
| 596515.5 | 4073443.8 | B06 |
| 596619.7 | 4073726.6 | B07 |
| 596775.7 | 4073629.9 | B08 |
| 5975294.3 | 4074081.7 | B09 |
| **Depth Sample Location** | | |
| 595920.7 | 4073291.6 | B03 |
| **TLD/Grab Sample Location** | | |
| 595823.0 | 4073273.9 | B10 |
| 595866.9 | 4073295.2 | B11 |
| 595962.2 | 4073320.8 | B12 |
| 596032.6 | 4073346.1 | B13 |
| 596102.4 | 4073370.7 | B14 |
| 596245.3 | 4073420.5 | B15 |
| 596390.1 | 4073471.5 | B16 |
| 596535.3 | 4073524.1 | B17 |
| 596677.9 | 4073572.6 | B18 |
| 596822.5 | 4073623.7 | B19 |
| 596966.1 | 4073676.1 | B20 |
| 597109.7 | 4073727.3 | B21 |

**Table F.1-2**
**Sample Plot/Location Coordinates for Atmospheric Test Site - Small Boy[a], Small Boy Site**
(Page 2 of 2)

| Easting[b] | Northing[b] | Sample Plot/Location |
|---|---|---|
| **Background Locations** | | |
| 595887.9 | 4074123.2 | H01 |
| 596758.1 | 4072698.3 | H02 |
| 596038.2 | 4071787.7 | H03 |

[a]All sample plot coordinates are from the southwest corner
[b]UTM Zone 11, NAD 1927 (U.S. Western) in meters.

Nine aliquot sample locations were established at each plot for each composite sample (4 composite samples, 36 aloquoit sample locations). Visual Sample Plan software (PNNL, 2007) was used to derive coordinates for a systematic triangular grid pattern based on a randomly generated origin or starting point. 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.

## *F.2.0 References*

PNNL, see Pacific Northwest National Laboratory.

Pacific Northwest National Laboratory. 2007. *Visual Sample Plan, Version 5.0 User's Guide*, PNNL-16939. Richland, WA.

# Appendix G

# Pressurized Ion Chamber External Dose Measurement

# G.1.0 Pressurized Ion Chamber External Dose Measurement

Based upon a request from USAF, PIC data were collected for informational purposes only and were not intended for use in the decision-making process. The data are included in this appendix to capture the information.

External dose measurements using a PIC were collected at each sample location (except location B09) at the Study Group 2, Small Boy Site at 1 m agl (Figure A.4-2). This information, along with the average external dose determined from TLD measurements discussed in Appendix A, is provided in Table G.1-1. PIC readings were collected in the field over an approximate 2-minute period with an estimated 20 percent variance observed from the average value recorded. The PIC is a hand-held, battery-operated radiation detection instrument used for the measurement of exposure and exposure rates by the measurement of gamma radiation.

**Table G.1-1**
**Study Group 2, Small Boy Site External Dose from TLD and PIC (mrem/OU-yr)**
(Page 1 of 2)

| Location | PIC Readings | TLD Readings (Average) |
|---|---|---|
| B01 | 0.64 | 0.65 |
| B02 | 5.44 | 5.76 |
| B03 | 0.48 | 0.61 |
| B04 | 0.4 | 0.55 |
| B05 | 0.32 | 0.23 |
| B06 | 0.16 | 0.28 |
| B07 | 0.32 | 0.06 |
| B08 | 2 | 2.61 |
| B10 | 1.28 | 0.91 |
| B11 | 0.32 | 0.26 |
| B12 | 1.12 | 1.37 |
| B13 | 0.64 | 0.95 |
| B14 | 0.24 | 0.77 |
| B15 | 0 | 0.17 |

**Table G.1-1**
**Study Group 2, Small Boy Site External Dose from TLD and PIC (mrem/OU-yr)**
(Page 2 of 2)

| Location | PIC Readings | TLD Readings (Average) |
|---|---|---|
| B16 | 0 | 0.17 |
| B17 | 0 | 0.16 |
| B18 | 0.32 | 0.6 |
| B19 | 0.8 | 0.8 |
| B20 | 0.48 | 0.59 |
| B21 | 0.24 | 0.24 |

A comparison of the mrem/OU-yr measurements for each location from the TLD and PIC source is provided in Figure G.1-1. The correlation of the two measurements is determined with an $r^2$ value of 0.97, as presented in Figure G.1-2.

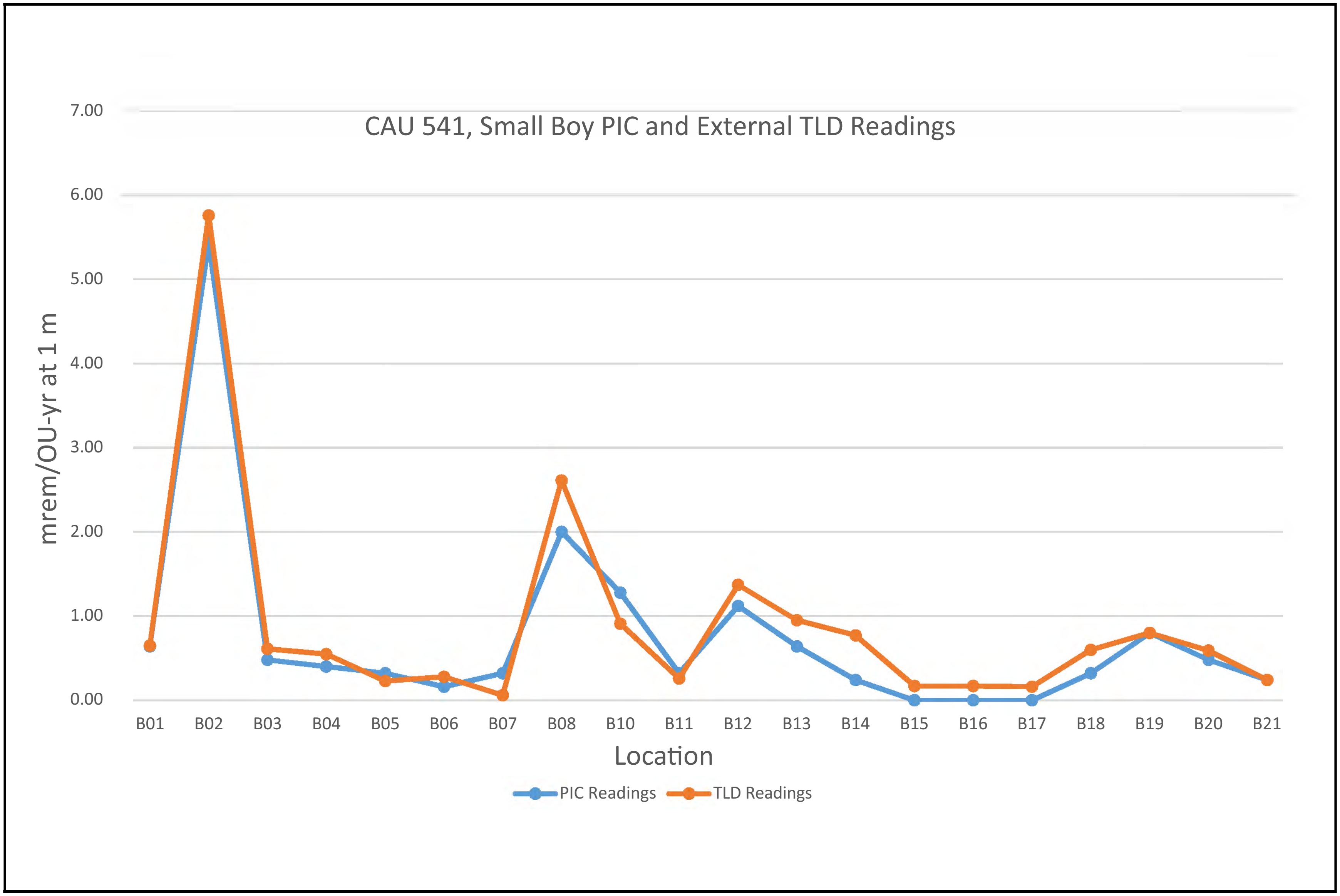



**Figure G.1-1**
**CAU 541 PIC and External TLD Results**

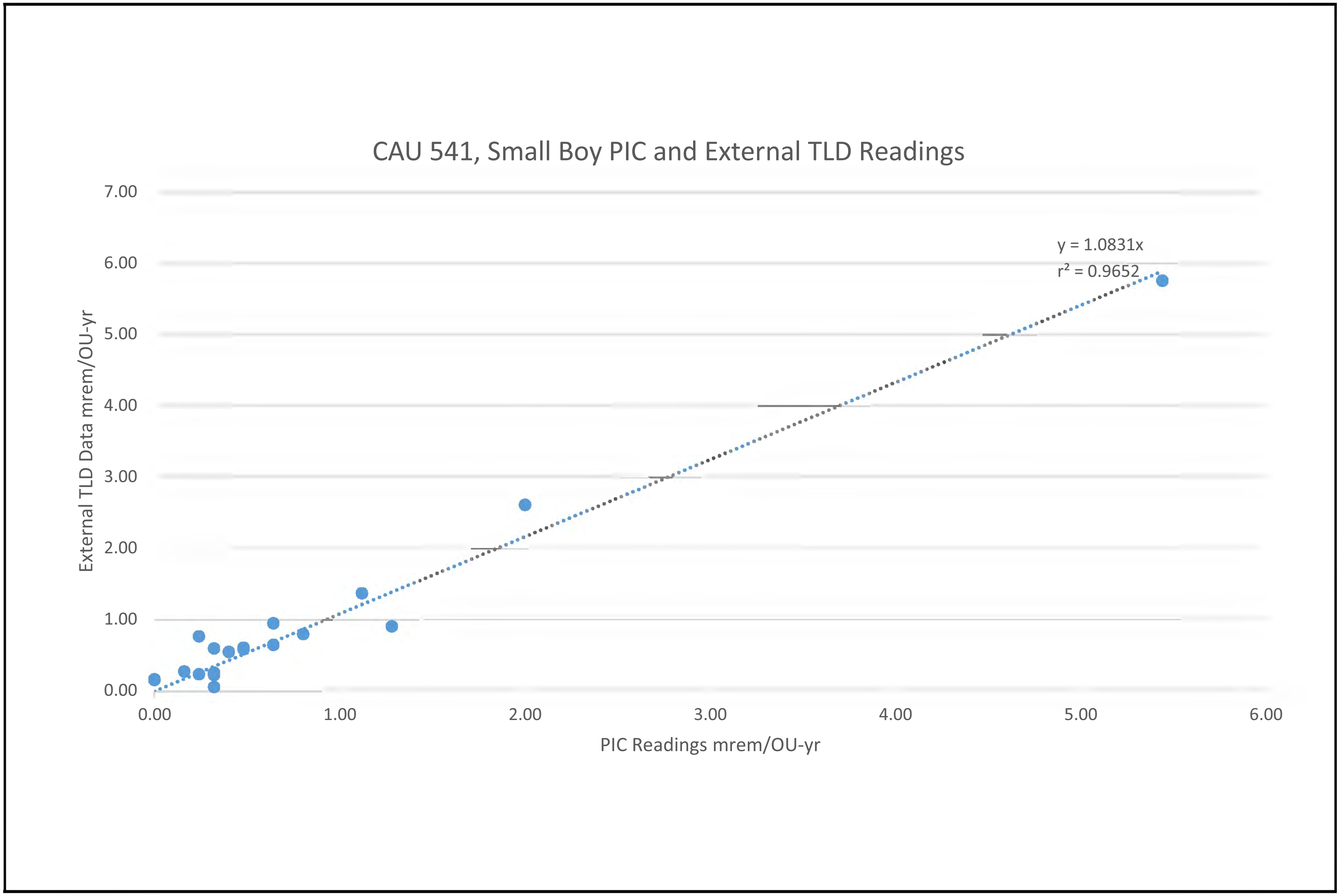



**Figure G.1-2**
**CAU 541 PIC and External TLD Results Correlation**

# Appendix H

# Nevada Division of Environmental Protection Comments

(15 Pages)

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 1.) Section 2.2, Page 14, 2nd Paragraph | | Sentence beginning with "As a result...": identify the organizational elements (stakeholders) and the date and place of the meeting. The purpose is to emphasize and document participation of NNSA, NDEP, and DHHQ input. If input was considered from an additional DoD elements (i.e., meetings with NTTR range operations, etc.), this should also be mentioned. | The following statement was added to the end of the third paragraph in Section 1.0: "The meeting to decide DQOs was held in Las Vegas, Nevada, on April 1, 2014. Meetings to discuss and decide CAAs were held in Las Vegas, Nevada, on June 8, 2015, and in Washington, DC, on June 17, 2015. Subsequent CAA meetings were held on August 18 and 25, 2015, in Las Vegas, Nevada. Present at these meetings were representatives from the Nevada Division of Environmental Protection (NDEP); the U.S. Air Force (USAF); and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field Office (NNSA/NFO)."<br><br>A reference to Section 1.0 was provided in this section. | |
| 2.) Section 2.2, Page 14, 2nd Paragraph | | • At the end of the sentence ending "...3 deployments per year", add the following: "with 100% of time spent outdoors".<br>• At the end of the sentence ending "...3 deployments per year", add a new comment (or equivalent): "In terms of exposure duration, the Ground Troops scenario at 1,008 hours/year) falls between the Industrial Area (2,000 hours/year) and Remote Worker (336 hours/year) land use scenarios used on the NNSS Soils Activity sites. However, the TED for Remote Worker exposure scenario is not addressed in this report." | The addition and the added sentence were included as edited:<br>• "...3 deployments per year with 100 percent of time spent outdoors."<br>• "In terms of exposure duration, the Ground Troops scenario at 1,008 hr/yr falls between the Industrial Area (2,000 hr/yr) and Remote Worker (336 hr/yr) land use scenarios used on the NNSS Soils Activity sites. However, the TED for the Remote Worker scenario is not addressed in this report." | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 3.) Section 3.0, Page 23, 2nd and 3rd Paragraphs | | Assess the site-specific reason(s) why survey data from TRSs (PRM-470) and FIDLER accounted for the best correlations at BFa and Small Boy, respectively. | It is agreed that further information regarding radiological surveys and the correlation of data was needed.<br><br>Replace the first sentence of the seventh paragraph of Section 3.0 with the following: “At the Study Group 1, BFa Site, radiation surveys were used to help establish the corrective action boundary. A correlation of the TED to the radiation survey values was performed to establish the boundary as discussed in Sections A.2.5 and A.3.5. At this site, the radiation survey that exhibited the best correlation is the PRM-470 TRS.”<br><br>Replace the first sentence of the eighth paragraph of Section 3.0 with the following: “At the Study Group 2, Small Boy Site, radiation surveys were used to help establish the corrective action boundary. A correlation of the TED to the radiation survey values was performed to establish the boundary as discussed in Sections A.2.5 and A.4.5. At this site, the radiation survey that exhibited the best correlation is the FIDLER TRS.” | |
| 4.) Section A.2.2.2, Page A-6, 2nd Paragraph | | 1st sentence: "...buried contamination": does this imply deliberate burial or incidental presence due to test release of alpha and beta/gamma? | The following statement was added as the second sentence to clarify buried contamination as discussed in the CAIP: “Buried contamination is defined as the presence of a subsurface layer of radiological contamination that is significantly higher than that of the surface.” | |

# Nevada Environmental Management Operations Activity

## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 5.) Section A.2.2.3, Page A-7, 2nd Paragraph | | • DOE/EC-0173T “”Environmental Regulatory Guide for Radiological Effluent Monitoring and Environmental Surveillance”) states: “Background…stations should be a minimum distance of 15-20 km from the larger sites and 10-15 km from….smaller sites…”. These control points appear to be approx. 1000 m from GZs.<br>• The first two thirds of the paragraph elaborate on why the post-processed AMS image is problematic for determining appropriate background. Then the second from the last sentence says it was "determined" that the background locations "are representative". Clarify. | The second paragraph of Section A.2.2.3 was replaced with the following:<br><br>“The background TLDs are intended to estimate the radiation level at the release site that would be present if contamination from the nuclear test were not present. Therefore, three background TLD locations were selected as close to the release site as possible to be representative of natural radiation at the release site but still unaffected by CAU-related releases. Selection of the locations for the three background TLDs was aided using the 1994 aerial radiation survey (BN, 1999) (Figure A.2-1) to ensure the locations are outside the detected radiation plume while still being representative of the release site geology (playa sediments).” | |
| 6.) Section A.2.2.3, Page A-7, 4th Paragraph | | 1st sentence: Is there an approach that would not have allowed appropriate QC procedure.to apply? Statement is ambiguous | The sentence was replaced with the following: “QC processes for TLD processing were followed in accordance with the Soils QAP (NNSA/NSO, 2012b)." | |
| 7.) Section A.2.3.2, Page A-11, 4th Paragraph | | 1st sentence: document contains no apparent justification for this assertion; see comment #5. | Please refer to the response for comment #5.<br><br>A reference to Section A.2.2.3 was provided in the first sentence. | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 8.) Section A.2.4, Page A-14, 4th Paragraph | | Is there a reference for this method/equation? Is it standardized beyond use here? | The third subset (discussing liquid waste) of the third bullet in the 4th paragraph was removed as no liquid wastes were associated with this investigation. The equation cited in this comment was included with this subset and removed. | |
| 9.) Section A.2.5, Page A-14, 1st Paragraph | | Reference and describe the software/modeling package (i.e., trade name, etc.) used to estimate spatial distribution (interpolated surface); reference as necessary throughout related document sections. | The following was added to the end of the second sentence: "…using the geostatistical analyst extension of the ArcGIS software."<br><br>A reference to ArcGIS was also provided in other applicable sections (Sections A.2.2.1, A.3.1.2, and A.4.1.2). | |
| 10.) Section A.3.1.3.1, Page A-18, 3rd Paragraph | | 1st sentence: What is meant by the term "field" background? Was final TLD background site selection determined with a PIC or other suitable instrument? Last sentence: "It was determined ...." ; there is no apparent justification for this statement. | The term "field" background was inadvertently used in the CADD. The word "field" was removed.<br><br>Background locations were determined using the method described in Section A.2.2.3. | |
| 11.) Section A.3.1.3.1, Page A-19 | | Legend: Change'TLD' to 'TLD Only' to match Table A.3-2 | Comment incorporated. | |
| 12.) Section A.3.1.3.2, Page A-23, 1st Paragraph | | See comment #4. | Please see the response to comment #4.<br><br>A reference to Section A.2.2.2 was provided in this section of the document. | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 13.) Section A.3.2, Page A-23, 2nd Paragraph | | • 2nd sentence: before, "...across the soil..." add the phrase, "due to wind and water"<br>• Last sentence: "long distance" should be re-phrased to, "depth"; also; refer to a specific well for which the DTW was cited: http://nevada.usgs.gov/doe_nv/ntsarea5.php | Comments incorporated.<br><br>The groundwater depth reference was revised as follows: "(approximately 708 ft bgs measured at Water Well WW-5a [USGS, 2015])." | |
| 14.) Section A.3.2, Page A-23, 3rd Paragraph | | •1st sentence: Infiltration and percolation are different processes which should be briefly explained.<br>• 2nd sentence: replace the "mechanism" with the phrase, "driving force".<br>• 2nd to last sentence: after phrase, "groundwater recharge" add the phrase "to the saturated zone".<br>• Last sentence: cite the figure or table where these are shown | 1st bullet: A definition of each process was provided after the second and third sentence in the third paragraph as follows: "Infiltration is defined as the process where water on the soil surface enters the soil. Percolation is defined as the process of soil water moving downward through the soil in response to gravity."<br><br>2nd bullet: The beginning of the second sentence of the third paragraph was replaced with the following for clarification: "Vertical migration is enhanced by periodic standing water ….."<br><br>3rd bullet: comment incorporated<br><br>4th bullet: A reference to Figure A.3-3 was provided where depth samples were noted. | |

# Nevada Environmental Management Operations Activity

## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 15.) Section A.3.2, Page A-24, 1st Paragraph | | 2nd sentence: the results of two depth samples placed on a playa of approx. 6 $mi^2$ in extent do not justify the conclusion that infiltration on the playa is not introducing radionuclides into the subsurface. It only verified that at the two depth sample points radionuclides were "not observed". The Hersey, 2013 study nevertheless suggest an inundated playa does provide the mechanism; strongly suggest reword this sentence to report only the limited sample results while leaving open the scenario postulated by Hersey. | Depth sample locations were selected at both GZ locations in slightly depressed areas (where surface water would collect first and was observed to remain inundated the longest). As discussed in the DQOs, these were considered to be worst-case representations of potential vertical migration.<br><br>To be more precise, the following was added to the second to last sentence: "…at these locations."<br><br>The last sentence of the third paragraph was replaced with the following: "This evaluation supports the CSM as described in the CAIP (NNSA/NFO, 2014a)." | |
| 16.) Section A.3.3.2, Page A-25, 1st Paragraph | | Describe the significance of and add footnoted explanation for bolded values in tables this section. Global comment. | The bold value indicates that the value exceeds 25 mrem/yr. A footnote was included for every table where a value exceeds the 25 mrem/yr threshold. | |
| 17.) Section A.3.3.3, Page A-29, 2nd Paragraph | | The statements and conclusions in this paragraph must be further jusitified, and where appropriate, referenced to other sections of the document. | The third paragraph of Section A.3.3.3 was replaced with the following: "The TED at this location is currently driven by cesium (Cs)-137 and europium (Eu)-152, which contributed approximately 98 percent of the total dose." | |
| 18.) Section A.3.5, Page A-31, Table A.3-9 | | Add dates for PRM-470 and FIDLER datasets. | Comment incorporated. The dates for the surveys were included in the table. | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 19.) Section A.4.1.2, Page A-34, Figure A.4-1 | | Label the 'anomalous area' and on related figures. | The anomalous area was labeled on Figure A.4-1.<br><br>To maintain editorial consistency, the anomalous area was labeled only on other figures where the area was referenced in the text. | |
| 20.) Section A.4.1.3.1, Page A-35, 3rd Paragraph | | See comment #10. | The term "field" background was inadvertently used in the CADD. The word "field" was removed.<br><br>Background locations were determined using the method described in Section A.2.2.3. | |
| 21.) Section A.4.1.3.1, Page A-36, Figure A.4-2 | | AMS data is truncated. Is this intentional? | It was intentional as the eastern edge of the flyover survey data provided in the figure shows the extent of the data. The following was added at the end of the first paragraph: "The 2010 flyover survey data provided in Figure A.4-2 depict the extent of the eastern edge of that survey. The area farther east of the survey was included in the figure due to the selected sample location."<br>To correct an error, Figure A.4-2 was also revised to include the missing date (2010) in the title of the flyover survey. | |
| 22.) Section A.4.1.3.2, Page A-40, 1st Paragraph | | See comment #4. | A reference to Section A.2.2.2, where buried contamination is discussed, was provided. | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 23.) Section A.4.2, Page A-42, 2nd Paragraph | | • Last sentence: change to "water-inundated contaminants"; "long distance" should be re-phrased to, "depth"; refer to specific well for which the DTW was cited: http://nevada.usgs.gov/doe_nv/ntsarea5.php | Changed “water inundated contaminants” to “periodic ponding of water.”<br><br>The groundwater depth reference was revised as follows: “(approximately 708 ft bgs measured at Water Well WW-5a [USGS, 2015]).” | |
| 24.) Section A.4.2, Page A-42, 3rd Paragraph | | 1st sentence: needs a Fig(s) reference illustrating this irregularity; it might be also useful to compare and contrast Small Boy plume irregularity to the adjacent BFa concentric plume which contains similar radionuclides, is also sited on a water-inundated playa subject to similar aeolian processes. | A reference to Figure A.4-1 was included. A compare and contrast of the two sites has been added to Section B.1.4. Refer also to the response for comment #30. | |
| 25.) Section A.4.2, Page A-43, 2nd Paragraph | | Last sentence: See comment #5. | This sentence was replaced with the text in the response to comment #15. | |
| 26.) Section A.4.3.3, Page A-46, 3rd Paragraph | | The statements and conclusions in this paragraph must be further justified, and where appropriate, referenced to other sections of the document. | The third paragraph of Section A.4.3.3 was replaced with the following: “The TED at this location is currently driven by Cs-137, Am-241, and Pu-239/240, which contribute approximately 94 percent of the total dose.” | |
| 27.) Section A.4.5, Page A-49, Table A.4-9 | | Add dates for PRM-470 and FIDLER datasets. | Dates were added to the table. | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 28.) Section A.7.1, Page A-60, 3rd Paragraph | | What were the resutls of the independent data examination by the contracted laboratory? | As supported by the independent data review the following sentence was added at the end of the paragraph:<br><br>“The results of the independent examination of the data packages agreed in general with the original Tier II validation performed for the project, and no corrections resulted from this review.” | |
| 29.) Section B.1.3, Page B-10, 1st Paragraph | | Reiterate why the OU Scenario was selected as the basis for FAL for radionuclide (and not Ground Troops Scenario for Small Boy); and why Remote Worker Scenario was the basis for FAL for lead. | As the discussion for determining the appropriate scenarios is lengthy, a reference to the sections where this is discussed (Sections C.1.6 through C.1.10) was provided at the end of the third and last sentences. | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 30.) Section B.1.3, Page B-10, Table B.1-3 | | Row 6: after "Small Boy", insert the following: "...in contrast to BFa, does not conform with this pattern for reasons postulated in Sec. A.4.2.". Row 8: add footnote references from which these two future land uses were obtained. | A variation to the suggestion is proposed. The following was added after the first sentence of Section B.1.4: "The pattern of surface contamination observed at BFa Site is more concentric and typical of nuclear test release sites at the NNSS (Figure A.3-1), while the pattern of surface contamination at the Small Boy site is more irregular (Figure A.4-1). While the initial contamination pattern following the tests at both sites was uniform and generally concentric from the GZs, the subsequent erosion and migration of the contamination was different. It is postulated that this difference is due to the nature of the contamination at each site. The BFa Site tests had significant yields where the resulting contamination is largely composed of soil activation products, whereas the Small Boy test had a low yield and the resulting contamination was largely composed of unfissioned nuclear fuel products. The entire surface soil near the BFa Site was activated, and while subsequent erosion and dispersion would have diminished contaminant concentrations, it would not have significantly affected the general contaminant distribution pattern. The major contamination at the Small Boy site is composed of particles within the surface soil matrix that when redistributed by wind and water disperse more in open areas and less where vegetation is present, thus resulting in an irregular distribution pattern similar to the distribution pattern of the nearby vegetation."<br><br>For Table B.1-3, row 8, add the following reference to the source: "NNSA/NSO, 2013". | |

# Nevada Environmental Management Operations Activity

## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 31.) Section C.1.1, Page C-3, 3rd Paragraph | | 2nd from last sentence: after "inactive site" insert the following (or equivalent), "with a ground zero located inside the current NTTR boundary and plume extending northwest several thousand meters across NTTR land and onto a small portion of Desert National Wildlife Refugee..." | Comment incorporated as edited: "...with a GZ located inside the current NTTR boundary, and plume extending northwest several thousand meters across NTTR land and onto a small portion of the Desert National Wildlife Refuge (DNWR)."<br><br>Subsequent discussions resulted in the Sheep Hunter being added as a separate work classification. The following was added as the second bullet of the 3rd paragraph in Section C.1.10:<br><br>**"Sheep Hunter.** Sheep hunter activities are restricted to well-defined boundaries within the DNWR. The nearest point of the detectable plume from the Small Boy test is approximately 1.5 miles from the sheep hunting boundary. Therefore, the sheep hunter would not be directly exposed to the contaminant plume and would be expected to hunt well away from the contaminant plume in the more elevated areas where vegetation is more abundant and sheep would preferentially graze. Therefore, there is a very low potential for the sheep hunter to be directly exposed to site contamination. However, the sheep hunter might have the potential to be indirectly exposed to site radiation through the consumption of contaminated meat from a harvested sheep. The potential dose from eating a contaminated sheep is based on the potential for the sheep to become contaminated and the potential transfer of contamination from the ingested meat. According to the NNSS biologist, sheep might walk across the Small Boy contamination area but would not be expected to feed or spend much time in | |

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| | | | the area because good fodder is either non-existent or poor. Therefore, it is expected that very little of the feed from the sheep would come from potentially contaminated plants. As most of the internal dose at the Small Boy site comes from Pu-239/240, to receive a dose from these potentially contaminated plants, Pu-239/240 would have to be incorporated into the plant tissue, transferred to the edible portions of the sheep, and then transferred from the ingested sheep meat to the sheep hunter.<br><br>The potential transfer of Pu-239/240 from soil to plant, plant to sheep, and sheep to sheep hunter greatly diminishes the Pu-239/240 concentrations because under most environmental conditions, plutonium occurs in forms that are comparatively insoluble and are poorly transferred across biological membranes (Whicker and Schultz, 1982). In the first transfer of soil to plant, well less than 10 percent—and usually less than 1 percent—of the plutonium in the soil is distributed among the litter, biota, and plants. Of the amount contained in plants, only about 0.05 percent of the Pu-239/240 is absorbed from the gastrointestinal tract into the bloodstream after ingestion (ANL, 2007). Most of the Pu-239/240 in the bloodstream deposits about equally in the liver and bones. Therefore, the dose from Pu-239/240 associated with the ingestion of sheep meat is expected to be inconsequential.<br><br>In summary, the movement of Pu from soil and sediments to plants and animals is greatly inhibited by its insolubility and strong discrimination at biological membranes. For | |

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| | | | each of these transfers. it has been estimated that 10-4 is a reasonable discrimination factor for Pu to be applied at each step in the soil-plant-animal mineral chain (Whicker and Schultz, 1982).<br><br>Therefore, as the sheep hunter has much less potential to receive a dose from the Small Boy release than the military trainee, it was determined that the Military Trainee scenario provides a more exposed individual than does the Sheep Hunter scenario." | |
| 32.) Section C.1.5, Page C-6, 1st Paragraph | | The "limited migration demostrated" phrase does not seem to agree with the lengthy discussion in Sec. A.4.2, para. 3 about the potential extensive relocation of radionuclides from around the Small Boy GZ into its large plume extending away from GZ. | The paragraph was revised for clarification. The beginning of the third sentence was revised as follows: "The absence of COCs demonstrated by the analytical results…." | |
| 33.) Section C.1.6, Page C-6, 2nd Paragraph | | The phrase "site worker" does not appear in the in Ground Troops exposure scenario described on p. 10. Should this phrase be replaced with "site worker or Ground Troops (military personnel")? Clarify. | The term "site worker" was replaced with "Industrial Site Worker." | |
| 34.) Section C.1.10, Page C-9, 2nd Paragraph | | Last sentence: the phrase "following individuals" is not appropriate because bullet sections that follow actually refer to work-related classifications not individuals. | The term "following individuals" was replaced with "individuals within the following work-related classifications". | |

# Nevada Environmental Management Operations Activity
## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| 10. Comment Number/Location | 11. Type* | 12. Comment | 13. Comment Response | 14. Accept |
|---|---|---|---|---|
| 35.) Section C.1.10, Page C-10, 5th Paragraph | | 1st sentence: reference the date and attendee orgs. of the CAA meeting. | A reference to Section 1.0, where CAA meeting dates and attendees are discussed, was provided. | |
| 36.) Section C.1.12, Page C-13, 2nd Paragraph | | Add the phrase, "see Figure C.1-1 for a flow-chart explanation of how this conclusion was reached" after the sentence. | Comment incorporated. | |
| 37.) Appendix D | | • CASs 05-23-04 & 05-45-03 Admin UR Boundary Maps: for clarity and consistency, recommend NNSS and NTTR callout labels be added to figure IAW other figs presented in document.<br>• "Contact": FFACO Handbook seems to imply that for CAS 45-05-43 a DoD POC should be also be listed. Clarify. | First bullet: The NNSS and NTTR labels were included on the FFACO figures for both CASs.<br><br>Second bullet: USAF contact information was included on each FFACO form. | |
| 38.) Section E.1.4, Page E-6, 4th Paragraph | | 2nd sentence: "...located on the NNSS...": what about the surface contamination that extends onto the NTTR? | The reference to the NNSS was removed as the CAAs are applicable to a site location regardless of political boundaries. | |
| 39.) Section E.1.4, Page E-6, 5th Paragraph | | 1st sentence: identify the stakeholders. | A reference to Section 1.0 was provided where stakeholder attendance is identified as discussed in comment #1. | |

# Nevada Environmental Management Operations Activity

## DOCUMENT REVIEW SHEET

| | | | |
|---|---|---|---|
| **1. Document Title/Number:** | Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 541: Small Boy, Nevada National Security Site, Nevada, Revision 0 | **2. Document Date:** | 11/24/2015 |
| **3. Revision Number:** | 0 | **4. Originator/Organization:** | Navarro |
| **5. Responsible NNSA/NFO Activity Lead:** | Tiffany A. Lantow | **6. Date Comments Due:** | |
| **7. Review Criteria:** | Full | | |
| **8. Reviewer/Organization/Phone No:** | Chris Andres / Scott Page , NDEP, (702) 486-2850 - exts. 232 / 237 | **9. Reviewer's Signature:** | |

| **10. Comment Number/Location** | **11. Type*** | **12. Comment** | **13. Comment Response** | **14. Accept** |
|---|---|---|---|---|
| 40.) Section G.1.0, Page G-1, 1st Paragraph | | Collection of "PIC" data is not explicitly discussed in Sec. A.4.1.3.2 (Soil Samples), collection locations are not shown on Fig. A.4-2 legend along with related soil depth and grab samples and TLD; PIC data purpose and use for determining external, TED, or max. concentration of contaminants in App. D is not clear in the cited section or App G. | Clarification was added to the beginning of Section G.1.0 regarding the collection and use of the PIC data. Collection of PIC data was requested by USAF during the DQO process. It was understood from initial discussions that the data would be used for informational purposes only, that it would not be used in the decision making process, and that the data would be included as an appendix in the CADD to capture the data. As PIC readings were collected at each sample location at the Small Boy site as stated in the CADD, a figure was not required.<br><br>A reference to the Small Boy Site Figure A.4-2 (where sample locations are noted) was included in Section G.1.0.<br><br>The following sentence was added to the beginning of Section G.1.0: “Based upon a request from USAF, PIC data were collected for informational purposes only and were not intended for use in the decision-making process. The data are included in this appendix to capture the information.” | |
| 41.) General | | NDEP reqeusts that comments from USAF submitted to NDEP with Draft CADD/CR (Capt. Krzyaniak and Mr. Rademacher) be separately identified and appended to the final CADD/CR along with those from NDEP. | As discussed, the USAF comments were not included as the USAF comments relate to a previous version of the document. | |

# Appendix I

# USAF Letter

(1 Page)

**DEPARTMENT OF THE AIR FORCE**
**NEVADA TEST AND TRAINING RANGE (ACC)**
**NELLIS AIR FORCE BASE, NEVADA**

30 June 2016

MEMORANDUM FOR DOE, NATIONAL NUCELAR SECURITY ADMINISTRATION – NATIONAL FIELD OFFICE
ATTN: MR. ROBERT F. BOEHLECKE

FROM: 99 NTTR/CC
3770 DUFFER DRIVE, STE 101
NELLIS AFB NV 89191-6520

SUBJECT: USAF Acknowledgement of Final Federal Facility Agreement and Consent Order (FFACO) Closure of Corrective Action Units (CAUs) 98 (Frenchman Flat), CAU 411 (Double Tracks) and 541 (Small Boy)

1. The purpose of this memorandum is to acknowledge the USAF's participation in the FFACO closure of CAUs 98, 411 and 541. This includes a review of the CAUs by the NTTR Radiation Safety Engineer and Environmental Office.

a. The FFACO closure of CAU 98 is consistent with current and foreseeable Air Force missions.

b. The FFACO closure of CAU 411 and the selected Construction Worker exposure scenarios are consistent with current and foreseeable Air Force missions in proximity to CAU 411.

c. The FFACO closure of CAU 541 and the selected Occasional Use exposure scenario is consistent with current and foreseeable Air Force missions in proximity to CAU 541.

2. Should the Air Force determine proposed mission use scenarios would result in potential exposures exceeding those estimated, or there is a proposed transfer/relinquishment of all or part of the NTTR impacting CAUs 98, 411, or 541, it is our understanding the closure of the CAUs would be re-evaluated by DOE to account for the new land use or exposure scenario. The USAF acknowledges the use restrictions to be implemented for each CAU mentioned above.

3. As provided for in Section V.3(f) of the attached Memorandum of Understanding (DE-GM08-98NV13467), DOE maintains responsibility for working with the USAF, Nevada Department of Environmental Protection (NDEP), and other stakeholders as needed to revise or renegotiate any closure agreements and resolve cleanup issues. Additionally, the DOE remains liable for all costs associated with any future negotiations and/or remediation actions for CAUs 98, 411, and 541, consistent with its responsibilities under applicable law.

4. Final USAF approval will be coordinated with the Installation Command Authority once the NDEP has provided acknowledgment of FFACO CAUs 98, 411 and 541.

THOMAS E. DEMPSEY, III
Colonel, USAF
Commander

Attachment:
MOU DE-GM08-98NV13467

"Privacy Act of 1974 as Amended applies—This memo contains information which must be protected IAW DoD 5400.11R, and it is For Official Use Only (FOUO)."

# Library Distribution List

| | Copies |
|---|---|
| U.S. Department of Energy<br>Office of Scientific and Technical Information<br>P.O. Box 62<br>Oak Ridge, TN 37831-0062 | 1 (Uncontrolled, electronic copy) |
| Southern Nevada Public Reading Facility<br>c/o Nuclear Testing Archive<br>P.O. Box 98521, M/S 400<br>Las Vegas, NV 89193-8521 | 2 (Uncontrolled, electronic copies) |
| Manager, Northern Nevada FFACO<br>Public Reading Facility<br>c/o Nevada State Library & Archives<br>100 N. Stewart Street<br>Carson City, NV 89701-4285 | 1 (Uncontrolled, electronic copy) |