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DOE/NV--1490

National Nuclear Security Administration

Closure Report for Corrective Action Unit 465: Hydronuclear Nevada National Security Site, Nevada

Controlled Copy No.: ___
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November 2012

/s/ Joseph P. Johnston, N-I CO, 11/06//2012

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DOE/NV--1490

CLOSURE REPORT
FOR CORRECTIVE ACTION UNIT 465: HYDRONUCLEAR
NEVADA NATIONAL SECURITY SITE, NEVADA

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

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CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 465:
HYDRONUCLEAR
NEVADA NATIONAL SECURITY SITE, NEVADA

Approved by: /s/ Tiffany A. Lantow Date: 11/5/2012

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Robert F. Boehlecke
Environmental Management Operations Manager

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List of Acronyms and Abbreviations

1-D	One dimensional
3-D	Three dimensional
AA	Alluvial aquifer
AA2	Alluvial aquifer 2
AA3	Alluvial aquifer 3
Ac	Actinium
Am	Americium
amsl	Above mean sea level
ASTM	ASTM International
ATCU	Argillic tuff confining unit
bgs	Below ground surface
BMP	Best management practice
BN	Bechtel Nevada
BOL	Bill of lading
BRCU	Belted Range confining unit
CAA	Corrective action alternative
CAI	Corrective action investigation
CAS	Corrective action site
CAU	Corrective action unit
CD	Certificate of Disposal
CFBCU	Crater Flat–Bullfrog confining unit
CHVU	Calico Hills volcanic-rock unit
CLP	Contract Laboratory Program
cm	Centimeter
COC	Contaminant of concern
COPC	Contaminant of potential concern
CR	Closure report

List of Acronyms and Abbreviations *(Continued)*

Cr (VI)	Hexavalent chromium
Cs	Cesium
CSM	Conceptual site model
DOE	U.S. Department of Energy
DQA	Data quality assessment
DQI	Data quality indicator
DQO	Data quality objective
DRI	Desert Research Institute
DVRFS	Death Valley Regional Flow System
EPA	U.S. Environmental Protection Agency
ERMA	Environmental resource management applications
FAL	Final action level
FD	Field duplicate
FFACO	*Federal Facility Agreement and Consent Order*
FIDLER	Field instrument for the detection of low-energy radiation
ft	Foot
g	Gram
g/cm^3	Grams per cubic centimeter
gal	Gallon
GIS	Geographic Information Systems
GPS	Global Positioning System
HE	High explosives
HFM	Hydrostratigraphic framework model
HGU	Hydrogeologic unit
HSU	Hydrostratigraphic unit
in.	Inch
K_d	Partition/distribution coefficient

List of Acronyms and Abbreviations *(Continued)*

kg	Kilogram
km	Kilometer
km^2	Square kilometer
lb	Pound
LCA	Lower carbonate aquifer
LCS	Laboratory control sample
LLW	Low-level waste
LTCU	Lower tuff confining unit
LVF	Landfill Load Verification Form
m	Meter
MDC	Minimum detectable concentration
mg/kg	Milligrams per kilogram
mL/g	Milliliter per gram
mm/yr	Millimeter per year
MS	Matrix spike
MSD	Matrix spike duplicate
N/A	Not applicable
NAC	*Nevada Administrative Code*
NAD	North American Datum
NDEP	Nevada Division of Environmental Protection
NIST	National Institute of Standards and Technology
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NNSS	Nevada National Security Site
OSBCU	Oak Spring Butte confining unit
OVU	Older volcanic-rock unit
PAL	Preliminary action level
PB	Preparation blank

List of Acronyms and Abbreviations *(Continued)*

PCB	Polychlorinated biphenyl
pCi/g	Picocuries per gram
PCU	Playa confining unit
PET	Potential evapotranspiration
POC	Performance Objective for the Certification of Nonradioactive Hazardous Waste
PPE	Personal protective equipment
PSM	Potential source material
Pu	Plutonium
QA	Quality assurance
QAP	Quality Assurance Plan
QC	Quality control
RBCA	Risk-based corrective action
RBSL	Risk-based screening level
RCRA	*Resource Conservation and Recovery Act*
ROTC	Record of Technical Change
RPD	Relative percent difference
RSL	Regional Screening Level
RWMC	Radioactive waste management complex
RWMS	Radioactive waste management site
SAFER	Streamlined Approach for Environmental Restoration
SDG	Sample delivery group
SNJV	Stoller-Navarro Joint Venture
Sr	Strontium
SSTL	Site-specific target level
SVOC	Semivolatile organic compound
TBD	To be determined
TCLP	Toxicity Characteristic Leaching Procedure

List of Acronyms and Abbreviations *(Continued)*

TCU	Tuff confining unit
TM-LVTA	Timber Mountain lower vitric-tuff aquifer
TM-WTA	Timber Mountain welded-tuff aquifer
TSA	Topopah Spring aquifer
TSDF	Treatment, storage, and disposal facility
U	Uranium
UGTA	Underground Test Area
UHM	Uniform Hazardous Waste Manifest
UR	Use restriction
USGS	U.S. Geological Survey
UTCU	Upper tuff confining unit
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
VSU	Volcanic- and sedimentary-rock unit
WVU	Wahmonie volcanic-rock unit
YAA	Younger alluvial aquifer
yd^3	Cubic yard
%R	Percent recovery

Executive Summary

This Closure Report (CR) presents information supporting the closure of Corrective Action Unit (CAU) 465: Hydronuclear, Nevada National Security Site (NNSS), Nevada. This CR complies with the requirements of the *Federal Facility Agreement and Consent Order* 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. The corrective action sites (CASs) within CAU 465 are located within Areas 6 and 27 of the NNSS. CAU 465 comprises the following CASs:

- 00-23-01, Hydronuclear Experiment, located in Area 27 of the NNSS and known as the Charlie site.
- 00-23-02, Hydronuclear Experiment, located in Area 27 of the NNSS and known as the Dog site.
- 00-23-03, Hydronuclear Experiment, located in Area 27 of the NNSS and known as the Charlie Prime and Anja sites.
- 06-99-01, Hydronuclear, located in Area 6 of the NNSS and known as the Trailer 13 site.

The purpose of this CR is to provide documentation supporting the completed corrective actions and provide data confirming that the closure objectives for CASs within CAU 465 were met.

From September 2011 through July 2012, closure activities were performed as set forth in the *Streamlined Approach for Environmental Restoration Plan for CAU 465: Hydronuclear, Nevada National Security Site, Nevada*. As detailed in the Plan, each CAS was divided into two components:

- The surface release component, which addresses potential releases of radiological and nonradiological contaminants (e.g., lead) from historical operations conducted at each CAS in support of the hydronuclear experiments.
- The subsurface release component, which addresses subsurface release of radiological and other contaminants from the hydronuclear experiments at each CAS, the disposal boreholes at CASs 00-23-02 (Dog site) and 06-99-01 (Trailer 13 site), and the landfill/disposal trench at CAS 00-23-02.

Surface Release Component. For the surface release component, corrective action investigation activities were completed to meet the following objectives:

- Determine whether contaminants of concern (COCs) are present.
- If COCs are present, determine their nature and extent, implement appropriate corrective actions, and properly dispose of wastes.

Investigation activities for the surface release component consisted of radiological surveys, visual surveys, geophysical surveys, and the collection of soil and potential source material samples. Analytes detected during the closure activities were evaluated against final action levels to determine COCs for CAU 465. There were no corrective actions required for the surface component at CASs 00-23-01, 00-23-03, and 06-99-01; therefore, the corrective action of no further action was selected. The corrective action of clean closure was completed for the surface release component at CAS 00-23-02 by removing contaminated material sufficiently that COCs no longer exist within the CAS as demonstrated by confirmation sample analytical results.

Subsurface Release Component. Corrective action investigation activities were completed to meet the following objectives:

- Confirm the presence and determine the extent of buried debris in the landfill/disposal trench at CAS 00-23-02 (Dog Site).
- Complete a contaminant water and solute travel time analysis to determine whether engineering controls are necessary.

The closure strategy for the subsurface release component consisted of an analysis of water and solute travel times beneath the CASs and a limited investigation at the landfill/disposal trench at CAS 00-23-02. The presence and extent of buried debris at the landfill/disposal trench was confirmed through geophysical surveys and exploratory excavation. The contaminant travel time analysis concluded that contaminants of potential concern from the CAU 465 sites will not reach groundwater in 1,000 years and will not cause the groundwater to exceed the final action levels. The corrective action of closure in place was completed for the subsurface release component by bounding the extent of COC contamination through conservative analysis, and implementing a use restriction to protect future workers from inadvertent contact with the COCs.

With the completion of closure activities at the four CAU 465 CASs, the DOE, National Nuclear Security Administration Nevada Site Office, requests the following:

- A Notice of Completion to the DOE, National Nuclear Security Administration Nevada Site Office is requested from the Nevada Division of Environmental Protection for closure of CAU 465.

- CAU 465 is transferred from Appendix III to Appendix IV of the *Federal Facility Agreement and Consent Order.*

1.0 Introduction

This Closure Report (CR) presents information supporting closure of Corrective Action Unit (CAU) 465: Hydronuclear, Nevada National Security Site (NNSS), Nevada. This document complies with the requirements of the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management. CAU 465 contains four corrective action sites (CASs) located in Areas 6 and 27 of the NNSS. The NNSS is located approximately 65 miles northwest of Las Vegas, Nevada (Figure 1-1).

CAU 465 comprises the following four CASs that are shown on Figure 1-2:

- 00-23-01, Hydronuclear Experiment, located in Area 27 of the NNSS and known as the Charlie site.
- 00-23-02, Hydronuclear Experiment, located in Area 27 of the NNSS and known as the Dog site.
- 00-23-03, Hydronuclear Experiment, located in Area 27 of the NNSS and known as the Charlie Prime and Anja sites.
- 06-99-01, Hydronuclear, located in Area 6 of the NNSS and known as the Trailer 13 site.

1.1 Purpose

This CR provides documentation and justification for the closure of CAU 465 without further corrective action. This justification is based on process knowledge and the results of the investigative activities conducted in accordance with the *Streamlined Approach for Environmental Restoration Plan* (SAFER) *for CAU 465: Hydronuclear, Nevada National Security Site, Nevada*. (NNSA/NSO, 2011). The SAFER Plan provides information relating to site history as well as the scope and planning of the investigation.

This CR also provides analytical and radiological survey data to confirm that the remediation goals were met as specified in the CAU 465 SAFER Plan, which was approved by the Nevada Division of Environmental Protection (NDEP). The SAFER Plan recommended an evaluation of the corrective

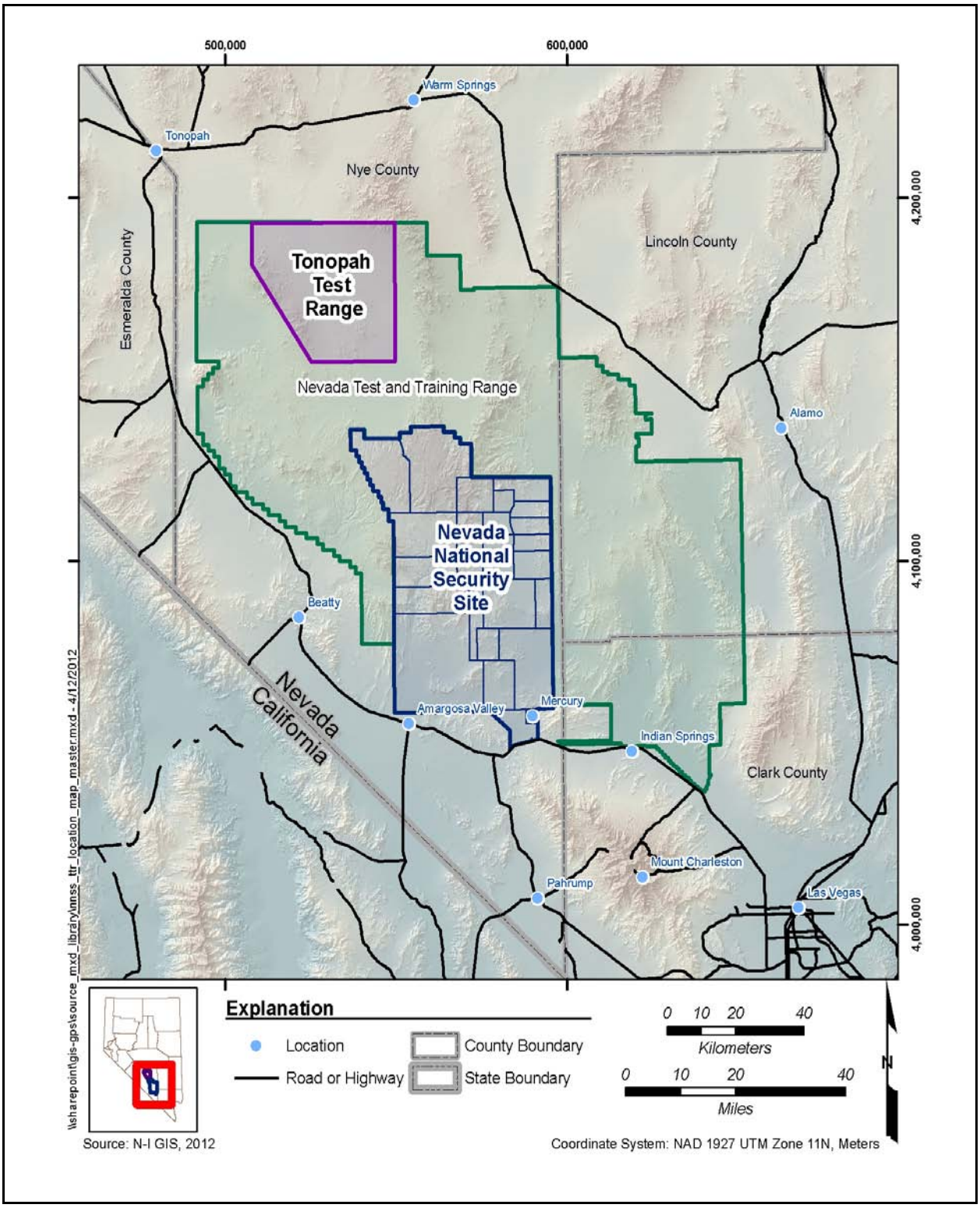


Figure 1-1
Nevada National Security Site

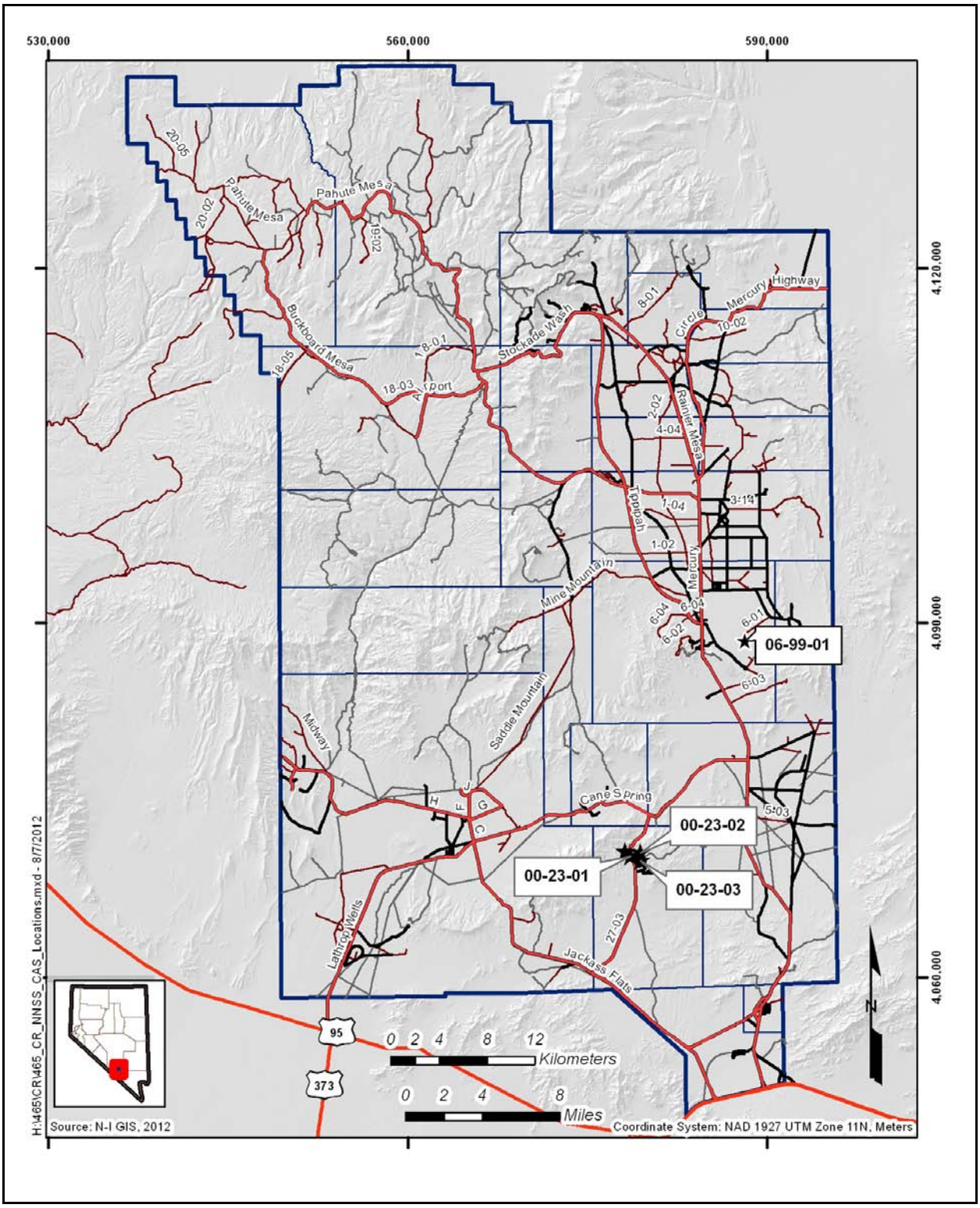


Figure 1-2
CAU 465 CAS Location Map

action alternatives (CAAs); the recommended corrective action for CAU 465 is closure in place with use restrictions (URs). URs are specified in Appendix E.

The hydronuclear sites consist of a series of shallow boreholes ranging from 25 to 80 feet (ft) deep used to conduct hydronuclear experiments (in which conventional explosives were used to assess the safety of nuclear weapons). These experiments are also sometimes referred to as "equation of state" experiments. Radiological materials—including plutonium; depleted, enriched, and natural uranium; and uranium oxide—along with metals (e.g., silver, lead) were used in the experiments and are assumed to be present in the boreholes at concentrations exceeding final action levels (FALs). Several of the boreholes at two CASs (the Dog site and the Trailer 13 site) are known to have been used for the disposal of nonradioactive classified materials associated with the hydronuclear experiments. As such, the contaminants of concern (COCs) associated with these materials are the same as those associated with the experiments. A total of 99 experiments were conducted at CAU 465: 76 experiments in Area 27, and 23 experiments in Area 6. All of the CAU 465 experiments, except one at the Trailer 13 site in Area 6, were conducted subsurface.

1.2 Scope

The scope of the investigation for CAU 465 included a surface component and subsurface component at each CAS. As defined in the CAU 465 SAFER Plan (NNSA/NSO, 2011), the surface component includes potential releases of contaminants to surface soils and the subsurface component includes releases of contaminants from the subsurface hydronuclear experiments, disposal boreholes, and a landfill/disposal trench (Dog site only).

The corrective action of clean closure and implementation of an administrative UR was completed for the surface component by removing contaminated material sufficiently that COCs no longer exist within the CASs as demonstrated by verification sample analytical results. The corrective action of closure in place was completed for the subsurface component by bounding the extent of COC contamination through water and solute travel time analysis and implementing FFACO URs to protect future workers from inadvertent contact with the COCs.

1.3 CR Contents

This CR is divided into the following sections and appendices:

- Section 1.0, "Introduction," summarizes the purpose, scope, and contents of this CR.
- Section 2.0, "Closure Activities," summarizes the closure activities, deviations from the SAFER Plan, the actual schedule, and the site conditions after completion of corrective actions.
- Section 3.0, "Waste Disposition," discusses the wastes generated and entered into an approved waste management system as a result of the corrective action.
- Section 4.0, "Closure Verification Results," describes verification activities and results.
- Section 5.0, "Conclusions and Recommendations," provides the conclusions and recommendations along with the rationale for their determination.
- Section 6.0, "References," provides a list of all referenced documents used in the preparation of this CR.
- Appendix A, *Data Quality Objectives* (DQOs) *as Developed in the* SAFER Plan, provides the DQOs as presented in Appendix B of the CAU 465 SAFER Plan.
- Appendix B, *CAU 465 Hydronuclear Experiment Water and Solute Travel Time Calculations*, documents the time travel analysis for the subsurface release component of the CAU.
- Appendix C, *Confirmation Sampling Test Results*, provides a description of the project objectives, field closure and sampling activities, and closure results.
- Appendix D, *Waste Disposition Documentation*, documents disposal of items removed during closure activities.
- Appendix E, *Use Restrictions*, documents the URs.
- Appendix F, *Geophysical Survey Results, CAS 00-23-02 (Dog Site)*, discusses the geophysical surveys completed at the landfill/disposal trench at the Dog Site.
- Appendix G, *Risk Evaluation*, describes the process followed to determine corrective action levels for the CAU.
- Appendix H, *Nevada Division of Environmental Protection Comments*, contains NDEP comments on the draft version of this document.

1.3.1 Applicable Programmatic Plans and Documents

To ensure all project objectives, health and safety requirements, and quality control (QC) procedures were adhered to, all closure activities were performed in accordance with the following documents:

- *Streamlined Approach for Environmental Restoration Plan for CAU 465: Hydronuclear, Nevada National Security Site, Nevada* (NNSA/NSO, 2011)
- *Soils Risk-Based Corrective Action* (RBCA) *Evaluation Process* (NNSA/NSO, 2012c)
- Record of Technical Change (ROTC) to the CAU 465 SAFER Plan (DOE/NV--1467-ROTC 1) (NNSA/NSO, 2012a)
- *Soils Activity Quality Assurance Plan* (QAP) (NNSA/NSO, 2012b)
- *Federal Facility Agreement and Consent Order* (1996, as amended)

1.3.2 Data Quality Objectives

This section contains a summary of the DQO process that is presented in Appendix A. The DQOs were developed to identify data needs, clearly define the intended use of the environmental data, and design a data collection program that will satisfy these purposes. Because CAU 465 consists of two distinct potential release components (subsurface and surface), two separate problem statements were considered during site closure activities.

The surface release component consists of potential releases of radiological and nonradiological contaminants to surface soils. The problem statement for the surface component of CAU 465 is as follows: “Existing information on the nature and extent of contamination from surface releases at CAU 465 is insufficient to recommend CAAs.” To address this problem, the resolution of two decision statements is required:

- **Decision I.** “Is any COC present in environmental media within the CAS?” Any analytical result for a contaminant of potential concern (COPC) at concentrations exceeding its corresponding FAL will result in that COPC being designated as a COC. A contaminant may also be defined as a COC that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk based upon a multiple constituent analysis (NNSA/NSO, 2012c).

- **Decision II.** "If a COC is present, is sufficient information available to meet the closure objectives?" Sufficient information is defined to include the following:

  - Identifying the lateral and vertical extent of COC contamination in media, if present.
  - The information needed to characterize wastes for disposal.

The presence of a COC would require a corrective action. A corrective action may also be necessary if there is a potential for wastes that are present at a site (i.e., potential source material [PSM]) to release COCs into site environmental media.

To evaluate PSM for the potential to result in the introduction of a COC to the surrounding environmental media, the following conservative assumptions were made:

- Any physical waste containment would fail at some point and release the contents to the surrounding media.
- For non-liquid wastes, the resulting concentration of contaminants in the surrounding soil would be equal to the concentration of contaminants in the wastes.
- For liquid wastes, the resulting concentration of contaminants in the surrounding soil would be calculated based on the concentration of contaminants in the wastes and the liquid-holding capacity of the soil.

The subsurface release component consists of potential releases of radiological and other contaminants from the subsurface hydronuclear experiments, disposal boreholes, and the landfill/disposal trench (Dog site only). The original problem statement from the SAFER Plan (NNSA/NSO, 2011) for the subsurface component of CAU 465 stated: "Additional information on the potential impacts of the hydronuclear experiments, disposal boreholes, and the landfill/disposal trench to groundwater is needed to evaluate and recommend CAAs." To address this problem, resolution of the following Decision I statement is required:

- **Decision I**. "If there is a potential impact on groundwater, then implement engineering controls."

For the subsurface component, if, through modeling, a contaminant is estimated to exceed FALs at the groundwater surface within 1,000 years, then additional engineering or institutional controls and/or corrective actions will be evaluated. If additional controls (e.g., installation of infiltration

controls, soil cover) are determined to mitigate the COC contamination, adequate controls will be put in place.

The original decision rule considered the population parameter of any radionuclide in the Decision I population of interest exceeding the FAL at the groundwater interface within 1,000 years. The water and solute travel time analysis determined that the contaminant travel times in the vadose zone exceeded the 1,000-year regulatory time period. As a result, no further evaluation of groundwater impacts was necessary, but a revision to the decision rule was warranted (see Section 2.2 for a description of the deviation). The revised decision rule is a comparison of the travel time necessary for radionuclide contamination to migrate through the vadose zone to the groundwater interface to the 1,000-year regulatory time period. If the travel time exceeds the 1,000-year regulatory time period, no further analysis of groundwater impacts is required. However if the travel time is less than 1,000 years and the contaminant concentration exceeds the FAL, then additional engineering or institutional controls and/or corrective actions will be evaluated. If engineering (e.g., installation of infiltration controls, soil cover), institutional (e.g., inclusion in existing Underground Test Area [UGTA] monitoring program), and/or other corrective actions are determined to mitigate the COC contamination, adequate controls will be put in place.

1.3.3 Data Quality Assessment Summary

The data quality assessment (DQA) presented in Section 4.3 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 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 help to ensure that DQO decisions are sound and defensible.

The DQA process, as presented in Section 4.3, is composed of the following five 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.

Based on the results of the DQA presented in Section 4.3, the information generated during the investigation supports the conceptual site model (CSM) assumptions (including the revision of the CSM for the landfill/disposal trench at the Dog site), and the data collected meet the DQOs and support their intended use in the decision-making process.

2.0 Closure Activities

As discussed in the CAU 465 SAFER Plan (NNSA/NSO, 2011), each CAS was divided into two components:

- The surface release component, which addresses potential releases of radiological and nonradiological contaminants (e.g., lead) from historical operations conducted at each CAS in support of the hydronuclear experiments; and
- The subsurface release component, which addresses subsurface release of radiological and other contaminants from the hydronuclear experiments at each CAS, disposal boreholes and the landfill/disposal trench at the Dog site.

2.1 Description of Corrective Action Activities

The SAFER Plan (NNSA/NSO, 2011) identified the preferred corrective action for the surface release component as clean closure, to include removal of contaminated media and PSM, as feasible. The closure strategy involved the collection of surface release data as part of a corrective action investigation (CAI). The CAI for CAU 465 consisted of radiological surveys, visual surveys, geophysical surveys, and the collection of soil and PSM samples. The investigation and closure activities associated with the surface release component at each CAS are summarized in Section 2.1.1 and presented in detail in Appendix C.

The SAFER Plan identified the corrective action for the subsurface release component as closure in place with URs. The closure strategy for the subsurface release component consisted of an analysis of water and solute travel times in geologic media beneath the CASs and a limited investigation at the landfill/disposal trench at the Dog site. The objective of the water and solute travel time analysis was to determine the potential for subsurface contaminants to reach the groundwater interface within a period of 1,000 years. The analysis is summarized in Section 2.1.2 and described in detail in Appendix B.

Table 2-1 lists the CAI activities that were conducted at each CAS.

Table 2-1
CAI Activities

Activity	CAS			
	00-23-01	00-23-02	00-23-03	06-99-01
Conducted surface radiological surveys.	X	X	X	X
Performed geophysical surveys.	X	X	X	X
Performed site visual surveys.	X	X	X	X
Conducted exploratory excavation at landfill/disposal trench.	--	X	--	--
Collected soil samples from biased locations.	--	X	--	--
Field screened samples for alpha and beta/gamma radiation.	--	X	--	--
Removed soil and PSM, and collected confirmation samples.	--	X	--	--
Collected samples for waste characterization.	--	X	--	--
Submitted select samples for offsite laboratory analysis.	--	X	--	--

X = Applicable
-- = Not applicable

2.1.1 Surface Release Component

The CAI activities for the surface release component were conducted in accordance with the requirements set forth in the CAU 465 SAFER Plan (NNSA/NSO, 2011). Radiological and visual surveys were performed at each CAS. Radiological surveys were performed to identify the presence, nature, and extent of radiological contaminants at activities statistically distinguishable from background activities. Visual surveys were conducted to identify other potential environmental concerns (e.g., stains, PSM). Geophysical surveys were also conducted at each CAS to locate boreholes associated with the hydronuclear experiments that were not visible on the surface.

Samples of PSM and potentially impacted surface soils were collected as part of the surface release component investigation. A judgmental sampling scheme was implemented to select sample locations and evaluate analytical results, as outlined in the SAFER Plan. Judgmental sampling allows the methodical selection of sample locations that target the populations of interest (defined in the DQOs) rather than non-selective random locations.

For the judgmental sampling scheme, individual sample results (rather than average concentrations) are used to compare to FALs. Therefore, statistical methods to generate site characteristics (averages) are not necessary. If good prior information is available on the target site of interest, then the sampling may be designed to collect samples only from areas known to have the highest concentration levels on the target site. If the observed concentrations from these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006). The judgmental sampling design was used to determine the existence of contamination at specific locations and provide information (such as extent of contamination) about specific areas of the site. Confidence in judgmental sampling scheme decisions was established qualitatively by the validation of the CSM and justification that sampling locations are the most likely locations to contain a COC, if a COC exists.

2.1.1.1 CAS 00-23-01 (Charlie Site)

The Charlie experiment involved a total of 24 test boreholes (DOE/NV, 2001). According to historical records, all of the boreholes were covered with 6 to 8 ft of native soil in 1962 after the experiment. On September 8, 2011, geophysical surveys were completed using an EM-61 instrument to locate the 24 test boreholes associated with the Charlie hydronuclear experiment. The geophysical surveys confirmed the location of all 24 boreholes.

A radiological survey using a field instrument for the detection of low-energy radiation (FIDLER) handheld gamma detector was completed on September 13, 2011. The survey covered the approximately 1-acre site within the fenced area and did not identify any elevated radiological activity distinguishable from background. Results of the survey and the survey area are shown on Figure 2-1.

The site visual survey was conducted on December 12, 2011, within the fenced area and around the outside perimeter of the fence line. The visual survey identified housekeeping debris within the fence, including metal debris, scrap wood, communication line, and cables; however, no PSM or biasing factors were identified requiring additional investigation. As a result, no environmental or PSM samples were collected at the Charlie site.

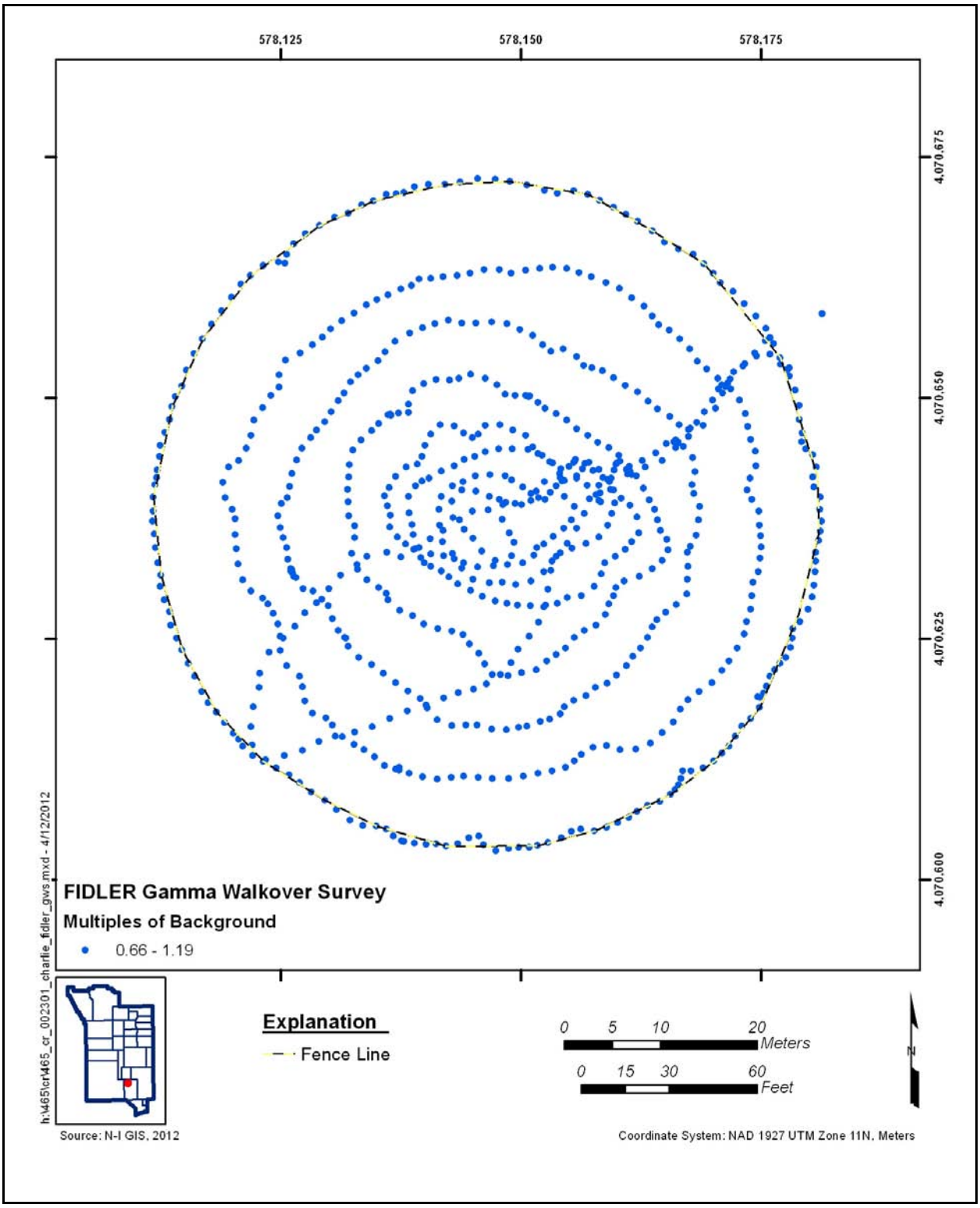


Figure 2-1
CAS 00-23-01 (Charlie Site) FIDLER Survey

Closure activities at the Charlie site included establishment of URs. Waste disposition is summarized in Section 3.0, and details are provided in Appendix C. A discussion of the URs may be found in Section 4.4.

2.1.1.2 CAS 00-23-02 (Dog Site)

The Dog experiment involved a total of 28 test boreholes and 12 disposal boreholes (DOE/NV, 2001). At the time of the initial site visit, two of the test boreholes were not visible on the surface. In order to confirm the location of these test boreholes, on September 8, 2011, geophysical surveys were completed at the site using an EM-61 instrument. The geophysical surveys confirmed the location of the two buried test boreholes.

Radiological surveys using a FIDLER handheld gamma detector were completed at the Dog site on September 14 and December 2, 2011. The surveys covered approximately 9.5 acres within and outside the fenced area. The area outside the fenced compound on the north and west sides of the site were not included in the FIDLER survey as the visual survey did not identify any features of environmental concern (e.g., boreholes, concrete slabs). The radiological surveys did not identify any elevated radiological activity distinguishable from background. Results of the survey and the survey area are shown on Figure 2-2.

The site visual survey was conducted on December 2, 2011. The survey covered the area within the fence and the area outside the perimeter of the fence, including surrounding drainages. The visual survey identified housekeeping debris, including scrap metal, wood, and communication line/cables, a landfill/disposal trench (discussed in Section 2.1.2.1) located southeast of the fenced compound; and PSM, including stained concrete and lead debris. The following PSM was identified at the Dog site:

- A trash pile contaminated with arsenic and lead
- A small, stained concrete pad contaminated with hexavalent chromium (Cr [VI])
- Lead debris (lead bricks and lead plates)

Figure 2-3 shows the locations of each of the items described above. A summary of investigation and closure activities at each PSM location is presented below; additional detail may be found in Appendix C.

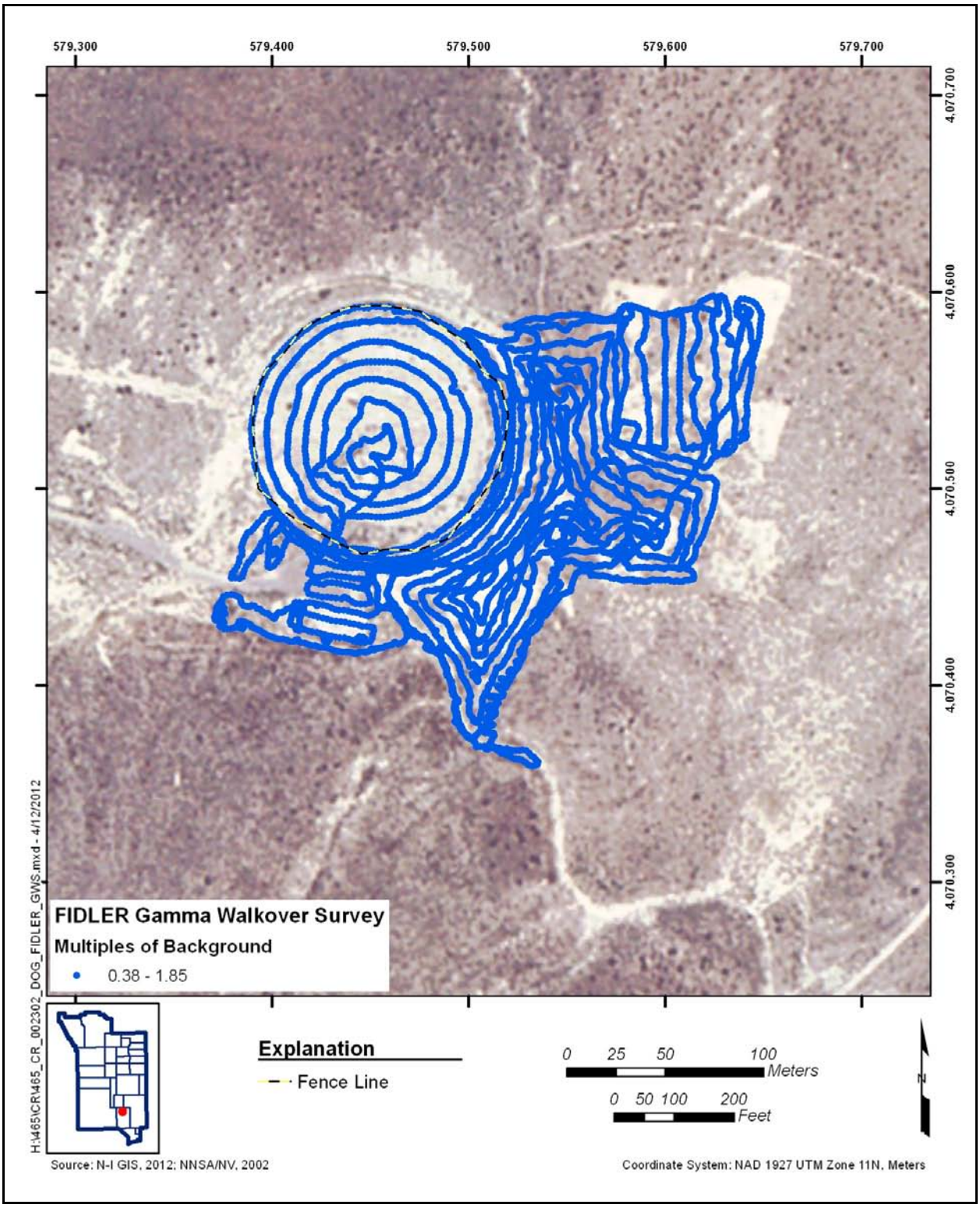


Figure 2-2
CAS 00-23-02 (Dog Site) FIDLER Survey

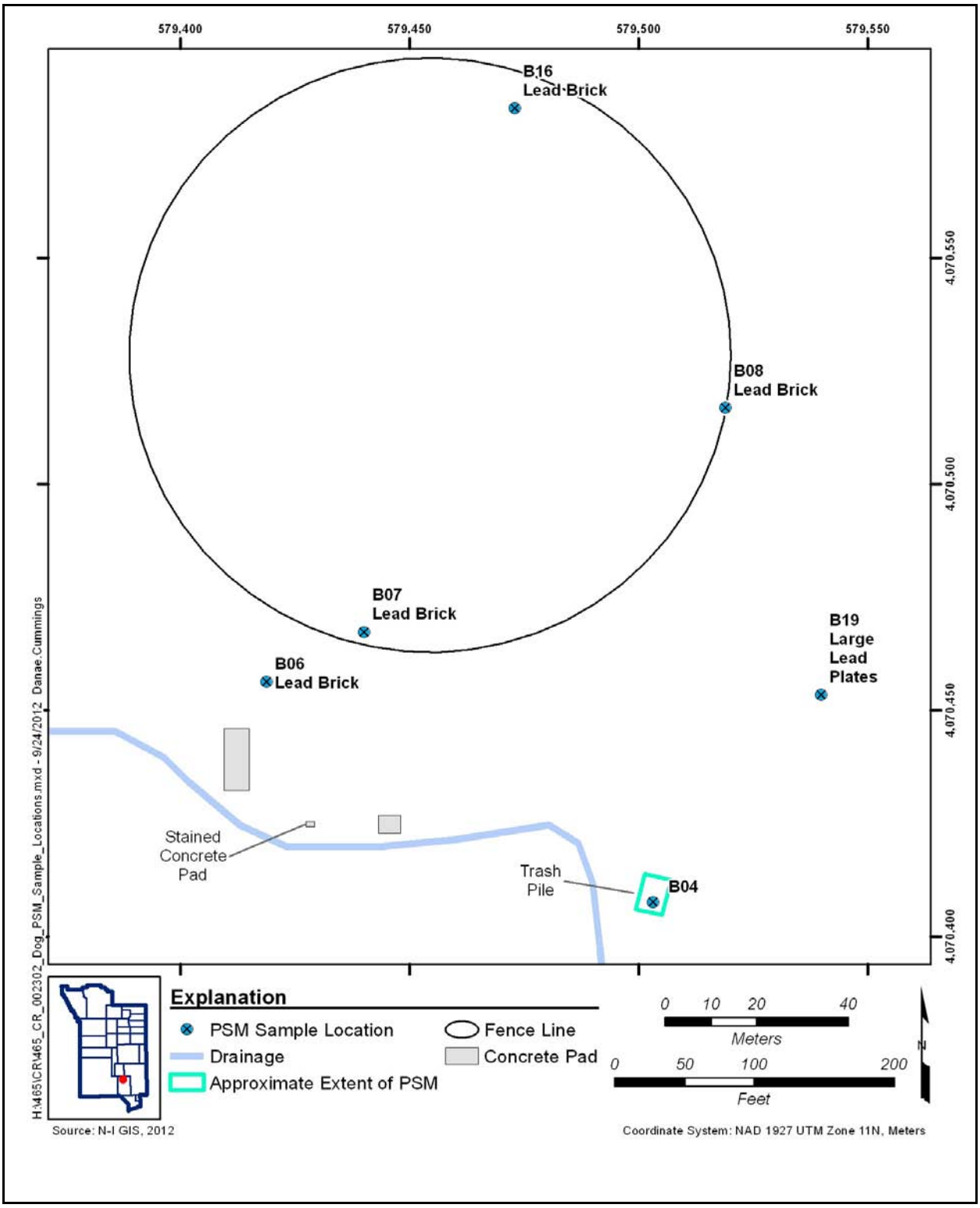


Figure 2-3
Location of PSM at CAS 00-23-02 (Dog Site)

Trash Pile. The trash pile contained a concentration of rusted metal debris on the ground surface in the southeast portion of the site (Figure 2-4). The debris includes metal cans, cables, and scrap metal. One soil sample from the center of the pile (location B04) and four step-out samples (locations B12 through B15) were collected and analyzed for chemical and radiological parameters as detailed in Table 2-2. The soil sample from the center of the trash pile exceeded the preliminary action levels (PALs) for lead and arsenic. The metal surface debris and contaminated soil at this location was excavated and disposed of off site as indicated in Section 3.0. Six confirmation soil samples (including one duplicate) were collected from the excavation at locations B23 through B27. These sample results showed that lead and arsenic in the remaining soil was less than FALs (see Table C.2-4). The sample locations at the trash pile are detailed in Figure C.2-3.

Concrete Pads. The small, stained concrete pad (6 ft by 4 ft by 7 inches [in.] thick) was located south of the fenced compound (Figure 2-5); two larger, unstained concrete pads are also in the vicinity (Figure 2-3). Samples of the small, stained concrete pad and two adjacent, unstained concrete pads were collected and analyzed for chemical and radiological parameters detailed in Table 2-2. The concrete samples from the stained pad contained concentrations of Cr (VI) above the soil FAL (see Table C.2-7). The small concrete pad was removed under a corrective action and disposed of off site as hazardous waste as indicated in Section 3.0. Removal of the pad revealed yellow stained soil. Three soil samples were collected underneath the pad, two within the stained area (locations B20 and B21) and one in the unstained area (location B22). The samples collected in the stained areas contained Cr (VI) in excess of the PAL of 5.6 milligrams per kilogram (mg/kg). On July 9 and 10, 2012, approximately 15 cubic yards (yd^3) of soil was removed from the area under a corrective action, and six confirmation samples were collected in the excavation at locations B28 through B33. Figure C.2-4 provides the soil sample locations at the concrete pad and excavation. Three of the six confirmation samples exceeded the Cr (VI) PAL. A Tier 2 evaluation was conducted for Cr (VI) and is presented in Appendix G. The confirmation sample Cr (VI) results that exceeded the PAL did not exceed the site-specific FAL established in the Tier 2 evaluation.

South of the stained concrete pad is a drainage feature that traverses the southern portion of the CAS. One soil sample of this drainage was collected (location B03) and analyzed in accordance with Table 2-2. None of the constituents analyzed were detected at concentrations exceeding a FAL (see Section C.2.6).

Figure 2-4
Trash Pile at CAS 00-23-02 (Dog Site)

Table 2-2
Samples Collected at the Dog Site
(Page 1 of 3)

Sample Location Number	Sample Location Description	Sample Number	Depth (cm bgs)	Matrix	Purpose	Analyses
B01	Stained concrete pad	465B001	0.0 - 2.0	Concrete	PSM	Set 1
		465B010	0.0 - 2.0	Concrete	PSM	Set 2, TCLP metals
B02	Stained concrete pad	465B002	0.0 - 2.0	Concrete	PSM	Set 1
B03	Drainage south of concrete pad	465B003	0.0 - 5.0	Soil	Environmental	Set 3, PCBs
B04	Trash pile center	465B004	0.0 - 5.0	Soil	Environmental	Set 1, TCLP metals
B05	Drainage east of trash pile	465B005	0.0 - 5.0	Soil	Environmental	Set 3, PCBs
B06	Lead brick	465B006	0.0 - 5.0	Soil	Environmental	RCRA metals, beryllium, Cr (VI)
		465B007			FD of 465B006	
	Lead brick - confirmation	465B013	0.0 - 5.0	Soil	Environmental	Lead
B07	Lead brick	465B008	0.0 - 5.0	Soil	Environmental	RCRA metals, beryllium, Cr (VI)
B08	Lead brick	465B009	0.0 - 5.0	Soil	Environmental	RCRA metals, beryllium, Cr (VI)
B09	Stained concrete pad	465B011	0.0 - 2.0	Concrete	PSM	Set 2
B10	Unstained concrete pad	465B012	0.0 - 2.0	Concrete	PSM	Cr (VI), TCLP metals
B11	Unstained concrete pad	465B014	0.0 - 2.0	Concrete	PSM	Cr (VI)
B12	Trash pile step-out	465B016	0.0 - 5.0	Soil	Environmental	Lead and arsenic
B13	Trash pile step-out	465B017	0.0 - 5.0	Soil	Environmental	Lead and arsenic
B14	Trash pile step-out	465B018	0.0 - 5.0	Soil	Environmental	Lead and arsenic
B15	Trash pile step-out	465B019	0.0 - 5.0	Soil	Environmental	Lead and arsenic
B16	Lead brick	465B015	0.0 - 5.0	Soil	Environmental	Lead
B17	Landfill/Disposal Trench	465B020	45.0 - 60.0	Soil	Environmental	RCRA metals, Cr (VI), gamma, isotopic Pu, isotopic U

Table 2-2
Samples Collected at the Dog Site
(Page 2 of 3)

Sample Location Number	Sample Location Description	Sample Number	Depth (cm bgs)	Matrix	Purpose	Analyses
B18	Landfill/Disposal Trench	465B021	45.0 - 60.0	Soil	Environmental	RCRA metals, Cr (VI), gamma, isotopic Pu, isotopic U
B19	Three lead plates - confirmation	465B022	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
B20	Stained concrete pad - confirmation	465B023	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
B21	Stained concrete pad - confirmation	465B024	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
B22	Stained concrete pad - confirmation	465B025	0.0 - 15.0	Soil	Environmental	Cr (VI)
B23	Trash pile - confirmation	465B026	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
	Trash pile - confirmation	465B027			FD of 465B026	
B24	Trash pile - confirmation	465B028	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
B25	Trash pile - confirmation	465B029	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
B26	Trash pile - confirmation	465B030	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
B27	Trash pile - confirmation	465B031	0.0 - 15.0	Soil	Environmental	RCRA metals, Cr (VI)
B28	Soil under concrete pad - confirmation	465B032	45.0 - 60.0	Soil	Environmental	RCRA metals, Cr (VI)
B29	Soil under concrete pad - confirmation	465B033	45.0 - 60.0	Soil	Environmental	RCRA metals, Cr (VI)
B30	Soil under concrete pad - confirmation	465B034	45.0 - 60.0	Soil	Environmental	RCRA metals, Cr (VI)
B31	Soil under concrete pad - confirmation	465B035	45.0 - 60.0	Soil	Environmental	RCRA metals, Cr (VI)
B32	Soil under concrete pad - confirmation	465B036	75.0 - 90.0	Soil	Environmental	RCRA metals, Cr (VI)
B33	Soil under concrete pad - confirmation	465B037	75.0 - 90.0	Soil	Environmental	RCRA metals, Cr (VI)

Table 2-2
Samples Collected at the Dog Site
(Page 3 of 3)

Sample Location Number	Sample Location Description	Sample Number	Depth (cm bgs)	Matrix	Purpose	Analyses
N/A	N/A	465B301	N/A	Water	Trip Blank	VOCs
		465B302	N/A	Water	Field Blank	Set 3, PCBs
465A02 (Drum)	Drum	465B501	N/A	Soil	Waste Management	Gamma, isotopic Pu, isotopic U, TCLP metals

Set 1 = VOCs, SVOCs, RCRA metals, beryllium, Cr (VI), HE, PCBs, gamma spectroscopy, isotopic U, isotopic Sr, isotopic Pu
Set 2 = Cr (VI), gamma spectroscopy, isotopic U, isotopic Sr, isotopic Pu
Set 3 = VOCs, SVOCs, RCRA metals, beryllium, Cr (VI), HE, gamma spectroscopy, isotopic U, isotopic Pu

bgs = Below ground surface
cm = Centimeter
FD = Field duplicate
HE = High explosives
N/A = Not applicable
PCB = Polychlorinated biphenyl
Pu = Plutonium
RCRA = *Resource Conservation and Recovery Act*
Sr = Strontium
SVOC = Semivolatile organic compound
TCLP = Toxicity Characteristic Leaching Procedure
U = Uranium
VOC = Volatile organic compound

Lead Debris. Lead bricks were identified at locations B06, B07, B08, and B16. Three large lead plates (Figure 2-6) were located on the east side of the site outside the fenced area (location B19). Each of the large lead plates measured approximately 21.5 in. by 15.5 in. by 3.5 in. thick. The lead debris from each location was determined to be PSM, removed under a corrective action, and managed as recyclable material. Soil samples at each lead debris location were collected and analyzed for the chemical and radiological parameters detailed in Table 2-2. Two soil samples (including one duplicate) were collected under the lead brick at location B06; both samples exceeded the FAL for lead (see Table C.2-4). Contaminated soil at this location was removed and disposed of as indicated in Section 3.0. One confirmation sample was collected at this location and confirmed the remaining soil at this location did not contain lead concentrations exceeding the FAL.

Closure activities at the Dog site included removal of identified PSM and impacted soil, confirmation sampling of potentially impacted areas, and establishment of URs. Disposition of wastes and recyclable material from the Dog site is discussed in further detail in Appendix C; waste disposal documentation is presented in Appendix D. In February 2012, as a best management practice (BMP), two partially plugged disposal boreholes at the site were plugged to the ground surface. The original

Figure 2-5
Stained Concrete Pad at CAS 00-23-02 (Dog Site)

Figure 2-6
Partially Buried Lead Debris at CAS 00-23-02 (Dog Site)

fill material placed into the disposal boreholes had settled, exposing a gap between the fill material and the ground surface. One of the boreholes was filled from 3 ft bgs to ground surface with a cement/sand slurry. The other borehole was filled with gravel from approximately 11 ft bgs to 3 ft bgs, then filled with a cement/sand slurry to the ground surface (Figures 2-7 and 2-8).

Figure 2-7
Open Disposal Borehole at CAS 00-23-02 (Dog Site)

2.1.1.3 CAS 00-23-03 (Charlie Prime and Anja Sites)

The Charlie Prime and Anja experiments involved a total of 12 and 16 test boreholes, respectively (DOE/NV, 2001). During the initial site visit, three test boreholes at the Charlie Prime site and two test boreholes at the Anja site were not visible on the surface. In order to confirm the location of these test boreholes, on September 8, 2011, geophysical surveys were completed using an EM-61 instrument. The geophysical surveys confirmed the location of the buried boreholes.

Radiological surveys at the Anja and Charlie Prime sites were completed on September 13, 2011, and September 14, 2011, respectively. The surveys were conducted using a FIDLER handheld gamma detector. The survey at Anja and Charlie Prime covered the approximately 1.5 acres within the fenced

Figure 2-8
Placement of Cement/Sand Slurry at Disposal Borehole at CAS 00-23-02 (Dog Site)

area at each site. The radiological surveys did not identify any elevated radiological activity distinguishable from background at either site. Results of the surveys and survey areas are shown on Figures 2-9 (Anja) and 2-10 (Charlie Prime).

The site visual surveys were conducted on December 2, 2011, at the Charlie Prime site and December 12, 2011, at the Anja site within the fenced areas and around the outside perimeter of the fence. Housekeeping debris was identified at the two sites, including metal debris, scrap wood, communication line, and cables; however, no PSM or biasing factors were identified requiring additional investigation. As a result, no environmental or PSM samples were collected at the Charlie Prime or Anja sites.

Closure activities at the Charlie Prime and Anja sites included establishment of URs. UR details may be found in Section 4.4. In February 2012, as a BMP, two open test boreholes at each site were plugged. At the Anja site, each borehole was filled with gravel from approximately 50 ft bgs to 10 ft bgs, then filled with a cement/sand slurry to the ground surface (Figure 2-11). At the Charlie

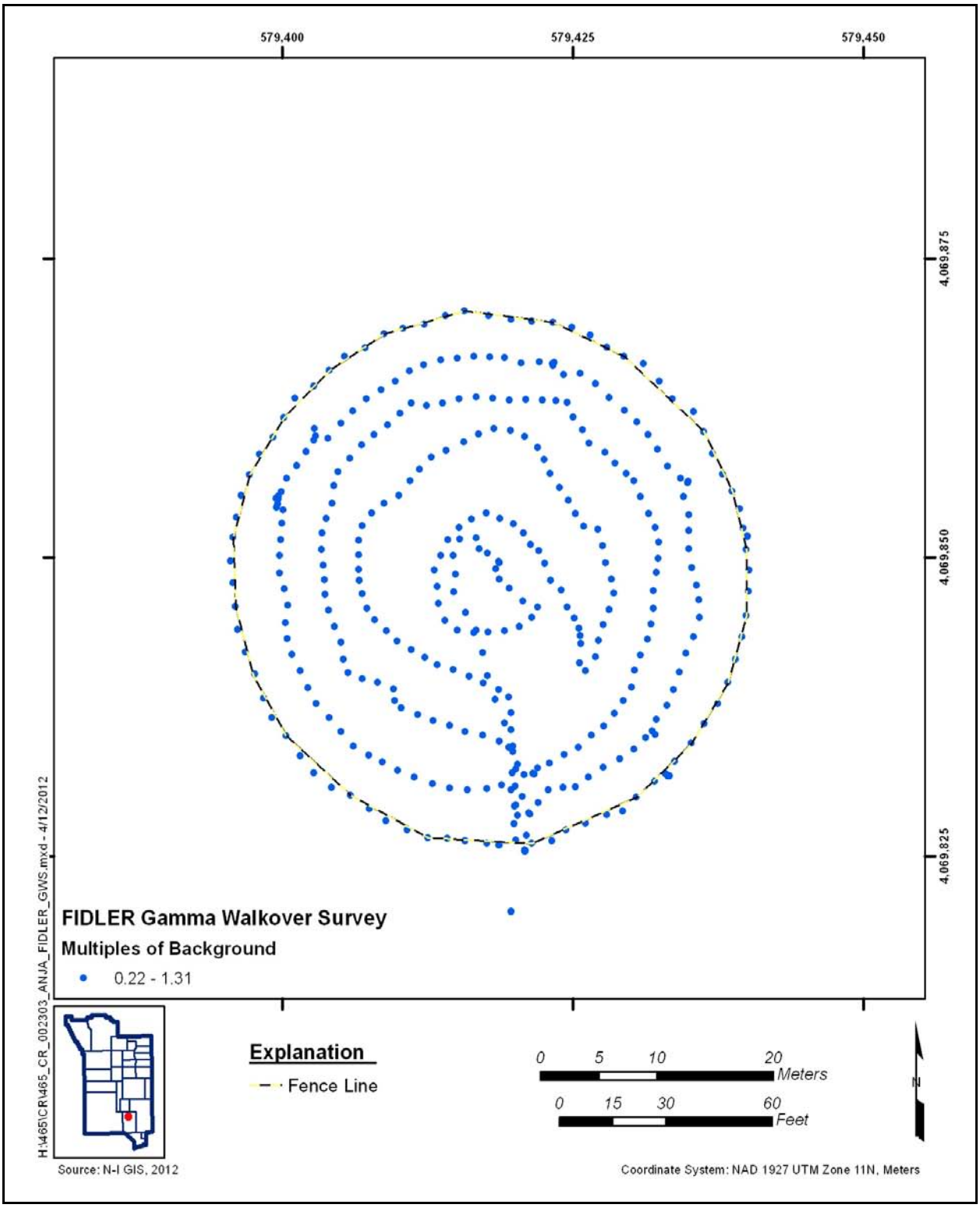


Figure 2-9
CAS 00-23-03 (Anja Site) FIDLER Survey

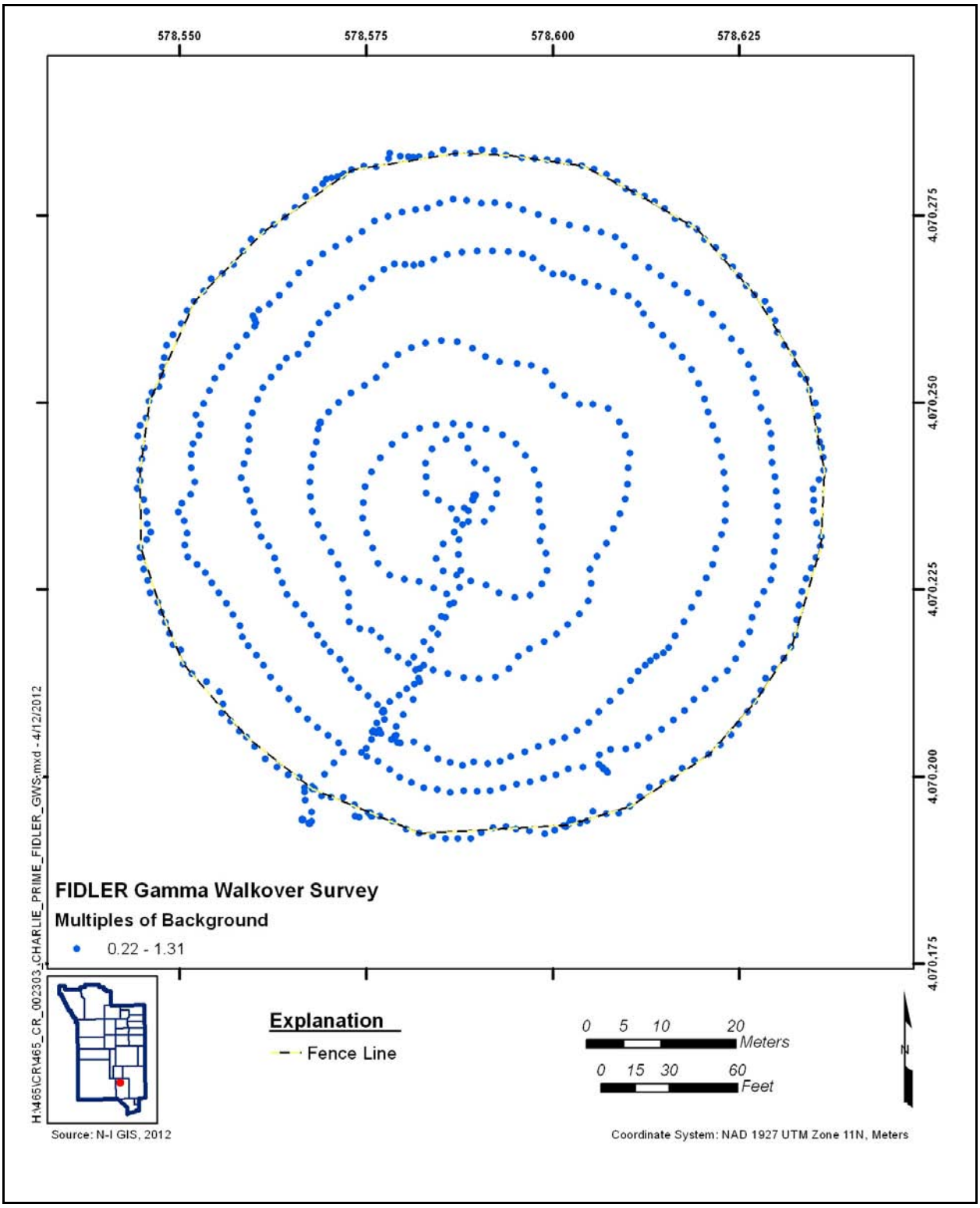


Figure 2-10
CAS 00-23-03 (Charlie Prime Site) FIDLER Survey

Figure 2-11
Placement of Cement/Sand Slurry at Borehole at CAS 00-23-03 (Anja Site)

Prime site, one borehole was filled with gravel from approximately 11 ft bgs to 10 ft bgs, then filled with a cement/sand slurry to the ground surface. The second borehole was filled with gravel from approximately 46 ft bgs to 11 ft bgs, then filled with a cement/sand slurry to the ground surface.

2.1.1.4 CAS 06-99-01 (Trailer 13 Site)

The Trailer 13 experiment involved a total of 23 test boreholes (DOE/NV, 2001). Two of these test boreholes were not visible on the surface. In order to confirm the location of these test boreholes, on September 8, 2011, geophysical surveys were completed using an EM-61 instrument. The geophysical surveys confirmed the location of the two buried boreholes.

A radiological survey of the Trailer 13 site was conducted on September 12, 2011. The survey was conducted using a FIDLER handheld gamma detector. The survey covered the approximately 8-acre site within the fenced area. The radiological walkover survey did not identify any elevated radiological activity distinguishable from background. Results of the survey and the survey area are shown on Figure 2-12.

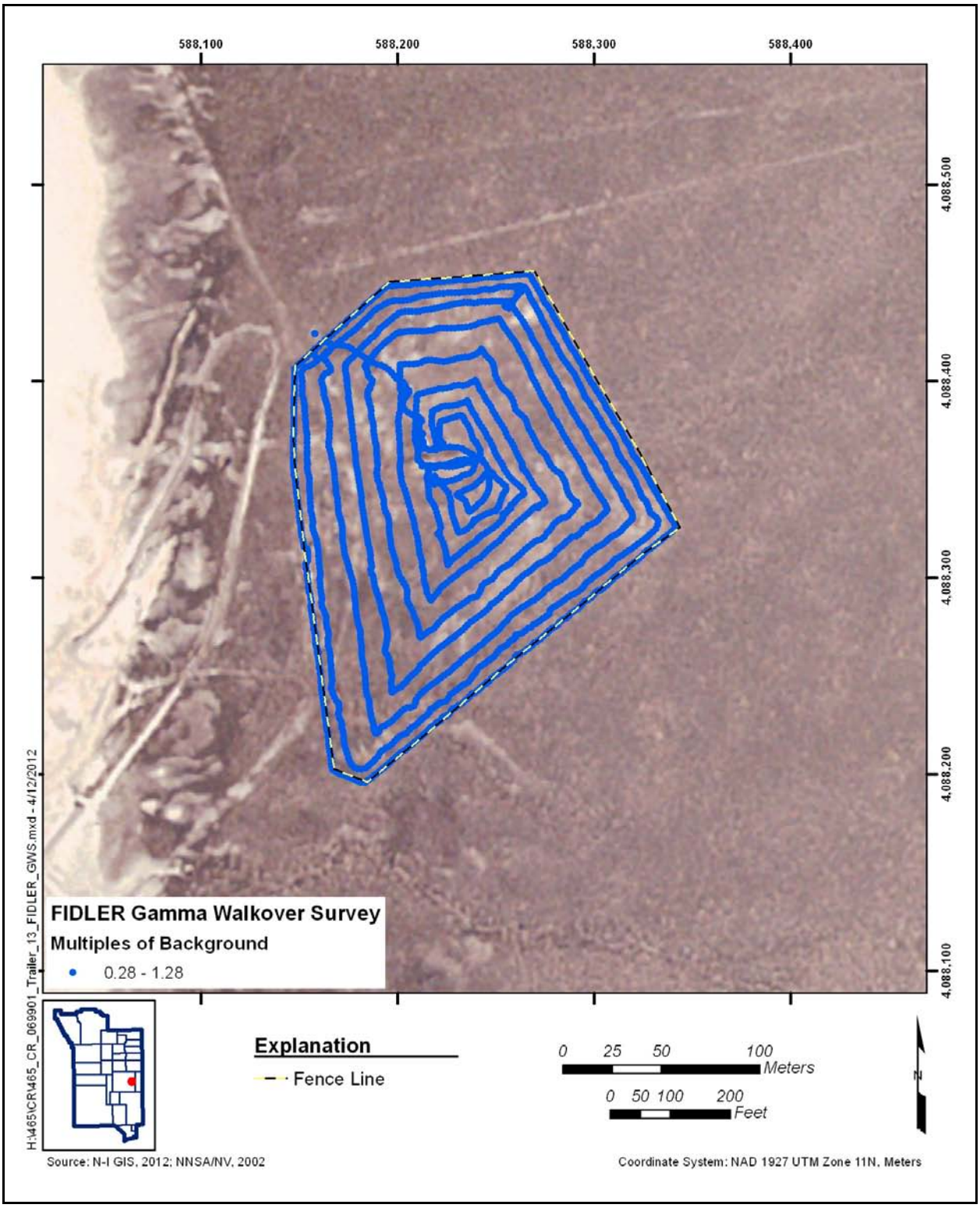


Figure 2-12
CAS 06-99-01 (Trailer 13 Site) FIDLER Survey

The site visual survey was conducted on December 12, 2011, at the Trailer 13 site within the fence and around the outside perimeter of the fence. The survey identified housekeeping debris including a wooden box, metal piping, metal scrap material, and abandoned communication cables. The visual survey did not identify any PSM or other biasing factors requiring additional investigation. As a result, no samples were collected at the Trailer 13 site.

Closure activities at the Trailer 13 site included establishment of URs. UR details may be found in Section 4.4.

2.1.2 Subsurface Release Component

Investigation of the subsurface release component included a limited field investigation of the landfill/disposal trench at the Dog site and the analysis of contaminant travel time in the subsurface for all of the CASs (see Appendix B).

2.1.2.1 Landfill/Disposal Trench at Dog Site

After the landfill/disposal trench was discovered at the Dog site, an ROTC to the CAU 465 SAFER Plan was submitted to NDEP. The ROTC was written to address revisions to the CSM. The landfill/disposal trench is located northeast of the trash pile, in the southeast portion of the Dog site. The landfill was initially identified during the site visual survey and was further investigated through geophysical surveys and exploratory excavation. Appendix F provides additional detail regarding the geophysical survey at the Dog site. A small “pothole” was dug into the landfill at the site of a subsurface anomaly identified by the geophysical surveys. Large pieces of lead and steel, including pipes, were removed with a backhoe (Figure 2-13). The metal debris was screened for radioactivity and one of the pipes was found to have elevated beta/gamma radiation levels. Upon encountering the radioactive contamination, fieldwork was suspended, the area was posted for radiological control, the CSM was reevaluated, and DOE/NV--1467-ROTC 1 was written (NNSA/NSO, 2012a). Disposition of the debris removed from the landfill/disposal trench is discussed in Appendix C.

Two subsurface soil samples were collected from the area (locations B17 and B18) and analyzed for chemical and radiological parameters detailed in Table 2-2. None of the constituents analyzed were detected in concentrations greater than the FAL (see Section C.2.6).

Figure 2-13
Debris Removed from Landfill/Disposal Trench at CAS 00-23-02 (Dog Site)

Closure activities at the landfill/disposal trench establishment of a UR. UR details may be found in Section 4.4.

2.1.2.2 Subsurface Water and Solute Travel Time Analysis

The purpose of the subsurface analysis was to assess the possibility of residual contamination within the unsaturated zone traveling to the water table and the regional lower carbonate aquifer (LCA) within a 1,000-year time frame. The LCA is regionally extensive and serves as an important water resource for most of southern Nevada. The water and solute travel time analysis is a first step in

evaluating the CAU 465 residual contamination's potential impacts to groundwater resources. This section presents a summary of the analysis; details of the analysis are provided in Appendix B.

As specified in Appendix B (DQO process) of the SAFER Plan (NNSA/NSO, 2011), a 1,000-year time period is evaluated and is specified in the UGTA FFACO guidance for determining groundwater contamination perimeter boundaries. If the travel times exceed the 1,000-year regulatory time period, no further analysis of groundwater impacts will be required. However, if the travel times are less than 1,000 years, then additional engineering or institutional controls and/or corrective actions will be evaluated. If engineering (e.g., installation of infiltration controls, soil cover), institutional (e.g., inclusion in existing UGTA monitoring program), and/or other corrective actions are determined to mitigate the COC contamination, adequate controls will be put in place.

The travel time to the water table and peak solute concentrations depends on the physical aspects of the subsurface environment, such as distance to the water table, geologic properties, net infiltration, and the solute's interaction with geologic media.

As the natural physical processes involved in the transport of radionuclides to groundwater are complex and variable, the evaluation described herein uses established numerical relationships that describe these physical processes. Conservative simplifying assumptions and conservative numerical input parameters are used in these numerical relationships that overestimate predictions of contaminant transport. This is done to compensate for uncertainties in the actual physical properties at each site and to provide an upper bound of possible contaminant transport velocities and distances.

This travel time analysis includes the following conservative and bounding assumptions:

- *Use of the highest estimated recharge rates.* The recharge rates used in this analysis are the highest obtained from available recharge models (see Section B.2.2). As transport of contaminants through the vadose zone is driven by the flow of water to groundwater, higher recharge flow rates will result in higher contaminant travel rates.

- *Restricted lateral water movement.* Lateral water movement will occur in the natural environment, but the amount of lateral movement is unknown. While restricting lateral movement is unrealistic, it is conservative in that it will underestimate the water travel distance as well as contaminant dilution and dispersion. This will result in underestimating the time needed to reach groundwater and overestimating contaminant concentrations.

- *Unlimited source term.* These calculations assume that the amount of contaminant is not limited throughout the evaluated time period (1,000 years). This is a somewhat conservative but reasonable assumption. While radiological decay is ignored, the half-life of plutonium is much greater than the evaluated time period.

- *No diffusion.* This assumption provides that the concentrations of contaminants at the leading contaminant boundary is the same concentration as at the contaminant source. This has the effect of preserving migration rates at the solubility limits of the contaminant, resulting in an overprediction of migration rates.

This evaluation approach used a one-dimensional (1-D) (downward only with no dispersion, diffusion, or dilution) analysis of water and solute travel rates through the unsaturated subsurface hydrological environment (i.e., vadose zone material) to groundwater. It was conducted by establishing a vertical flow rate of infiltrating water through the vadose zone (based on the steady-state aquifer recharge). The driving force for contaminant transport in the subsurface environment is infiltrating stormwater moving through the geologic matrix to groundwater. However, contaminants move through the vadose zone material at a slower rate than does water due to physical and chemical interaction with the vadose zone material. The ratio of the water flow rate to the contaminant migration rate is defined as the retardation factor. Therefore, the vertical migration rate of the contaminant will depend on the vertical flow rate of infiltrating water through the vadose zone and the retardation factor. The distance a contaminant will migrate through geologic material is the vertical migration rate of the contaminant multiplied by a specified time interval (e.g., 1,000 years). The time required for a contaminant to migrate through geologic material is defined as the thickness of the geologic layer (distance) divided by the vertical migration rate of the contaminant. The necessary information needed to resolve these calculations is developed and discussed in Appendix B.

As the geologic material overlying the regional aquifer comprises several layers with differing physical properties, potential contaminant migration times are calculated for each stratigraphic layer. The resulting contaminant migration times to reach groundwater and the contaminant migration depths in 1,000 years are presented in Section B.3.0.

2.1.2.2.1 Evaluation Criteria

The following criterion is used to answer the DQO question "Will a CAU 465 contaminant impact groundwater at a concentration exceeding regulatory levels for drinking water within the next 1,000 years?" Evaluation of potential impacts to the LCA is of primary concern because the LCA is regionally extensive and serves as an important water resource for much of southern Nevada. Evaluation of potential impacts to the perched water within the volcanic rock confining units at the Area 6 and 27 CASs is of less importance because the low permeability of the rock prevents the perched water from providing a sustainable water to supply wells and springs.

Determining the contaminant concentrations upon arrival to the perched water or LCA was not addressed in this document because none of the contaminants were shown to reach the perched water or LCA within the 1,000-year time frame. Rather, this document focuses on answering the question of how far the contaminants may migrate in the next 1,000 years and how many years it may take for the contaminants to reach the perched water and LCA (i.e., travel time).

Although the primary contaminants at CAU 465 are plutonium, uranium, and lead, the potential migration calculations were conducted only for plutonium and uranium. The reviewed literature indicates that lead is more mobile than uranium and less mobile than plutonium. Therefore, the expected potential migration distances and travel times presented in Section 2.1.2.2.2 will be bounded by the plutonium and uranium estimates.

2.1.2.2.2 Results of the Water and Solute Travel Time Analysis

Travel times are calculated by using the corresponding estimated recharge rate at the Area 6 and Area 27 sites, respectively, to determine water vertical velocities, and the retardation factor to determine contaminant vertical velocities. For each stratigraphic layer, travel distances are a product of the velocities and the 1,000-year time frame. Table 2-3 summarizes the calculated travel time for the sites in Areas 6 and 27, and Table 2-4 summarizes the 1,000-year travel distances.

Figures 2-14 and 2-15 illustrate the 1,000-year water, uranium, and plutonium travel distances through the Area 6 and 27 Sites stratigraphy, respectively. The movement of uranium and plutonium is highly retarded compared to the water movement.

Table 2-3
Calculated Water and Solute Travel Times

CAU 465 Site Location	Mobility Case	Water Travel Time		Uranium Travel Time		Plutonium Travel Time	
		(years)					
		Perched Water Table	Saturated LCA	Perched Water Table	Saturated LCA	Perched Water Table	Saturated LCA
Area 6	Base	16,527	46,979	113,909	1,967,973	2,613,960	152,947,110
Area 27	Base	1,417	10,668	15,882	268,451	1,303,513	21,333,789

Table 2-4
Calculated Water and Solute 1,000-Year Travel Distances

CAU 465 Site Location	Water Travel Distance (m)	Mobility Case	Uranium Travel Distance (m)	Plutonium Travel Distance (m)
Area 6	19.3	Base	3.8	1.9
Area 27	133.1	Base	12.6	3.5

m = Meter

2.1.2.2.3 Analysis Conclusions

The expected travel time for infiltrating water to reach the saturated LCA is approximately 47,000 years at Area 6 and approximately 10,700 years at Area 27. The sorptive processes associated with contaminant transport will increase travel times by more than one and two orders of magnitude for uranium and plutonium, respectively. These calculated water and solute travel times greatly exceed the UGTA 1,000-year regulatory time period, indicating that the distance between the CAU 465 residual contamination and the water table is sufficient for protecting the water resources below the CAU 465 CASs.

2.2 Deviations from SAFER Plan as Approved

Closure activities followed the approach specified in the CAU 465 SAFER Plan (NNSA/NSO, 2011), with the following deviations.

- Discovery of a landfill/disposal trench at the Dog site required a change to the original CSM for CAU 465. The basic elements of the CSM as shown in Table B.2-1 of the SAFER Plan (see Appendix A) are still valid, but the CSM was supplemented through

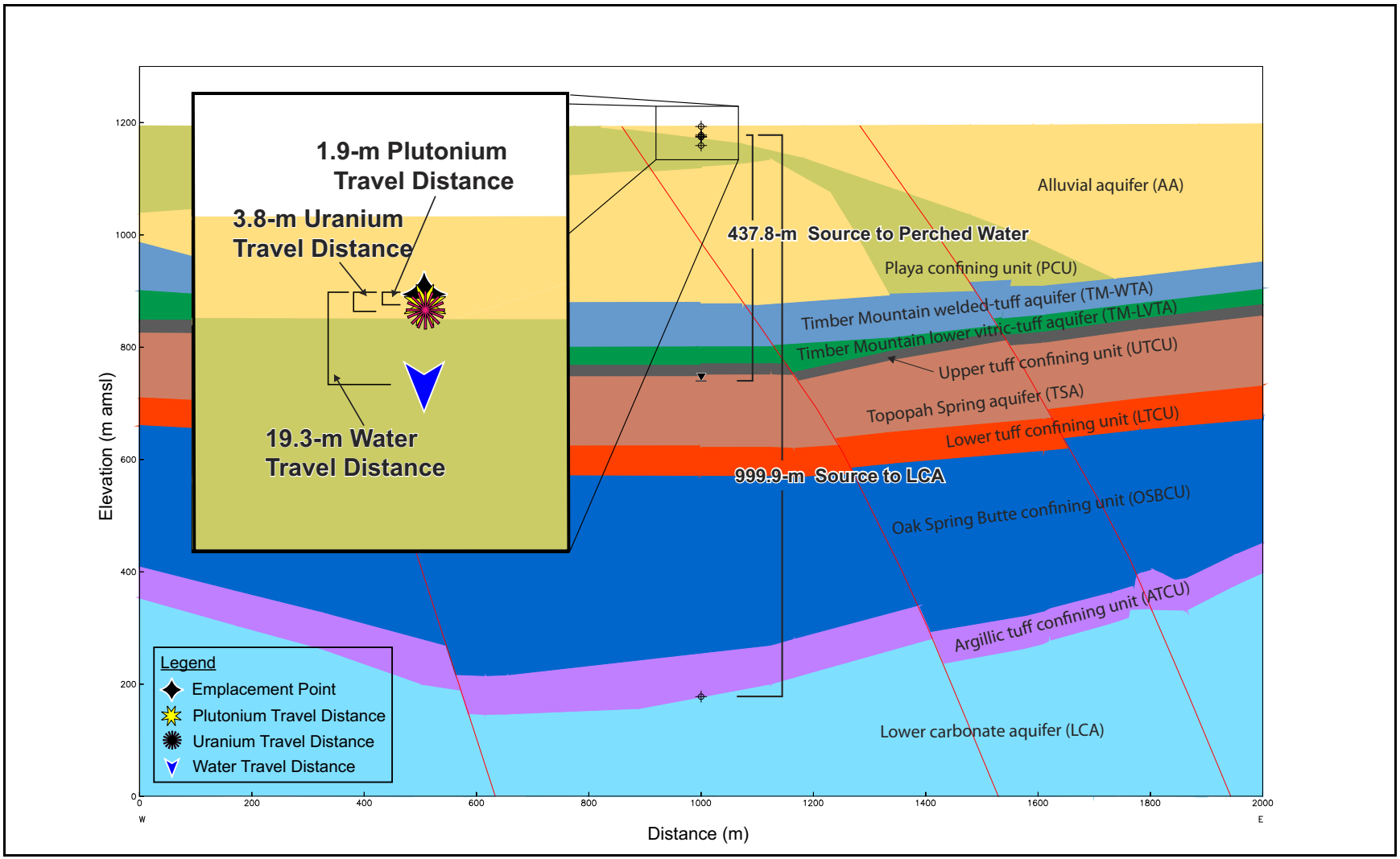


Figure 2-14
Area 6 Stratigraphy and 1,000-Year Contaminant Travel Distances

Note: Area 6 stratigraphy is estimated based upon the Yucca Flat hydrostratigraphic framework model (HFM) as described in Section B.2.1.

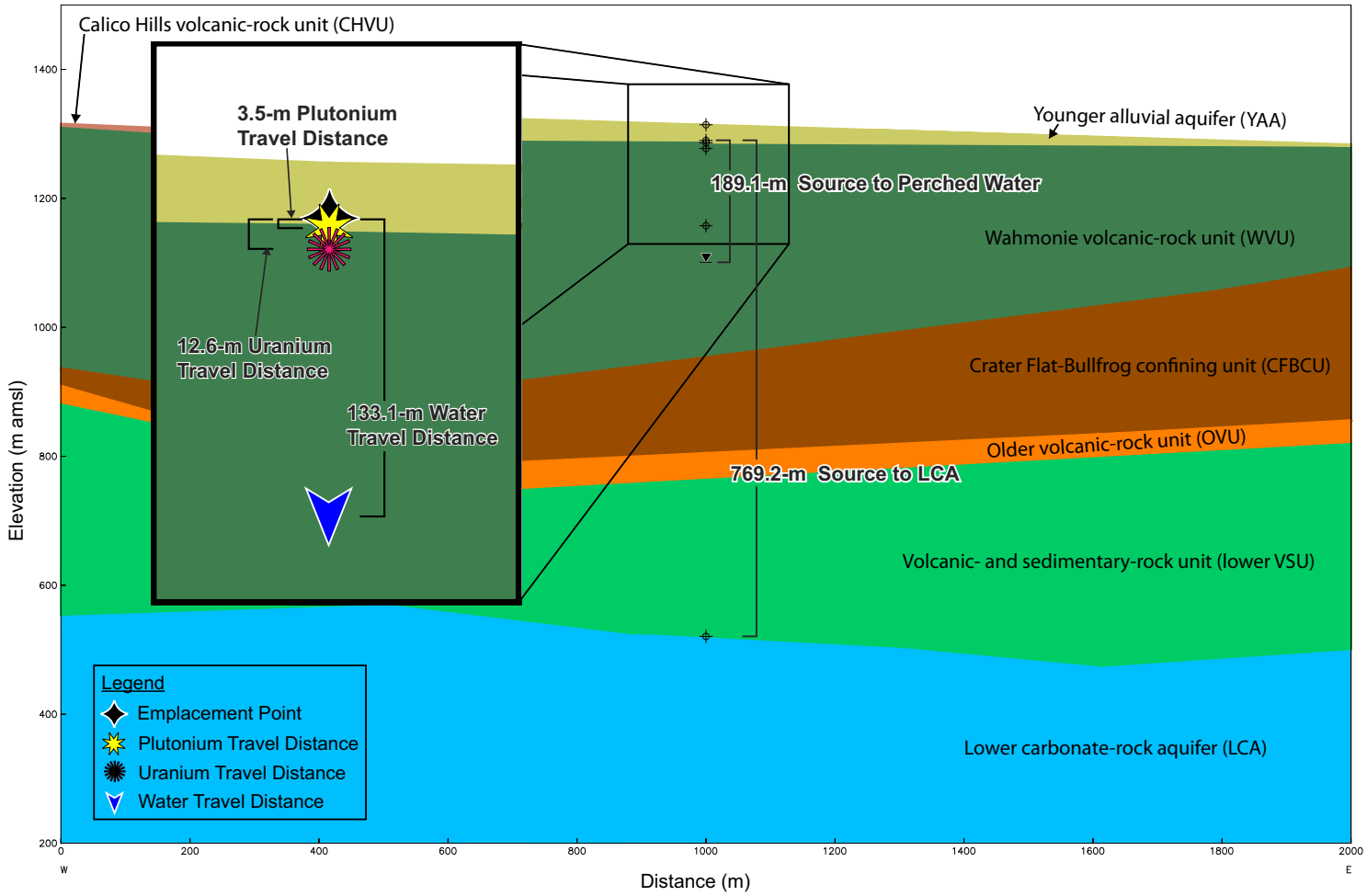


Figure 2-15
Area 27 Stratigraphy and 1,000-Year Contaminant Travel Distances

Note: Area 27 stratigraphy is estimated based upon the Death Valley Regional Flow System (DVRFS) HFM as described in Section B.2.1.

addition of the landfill/disposal trench as part of the subsurface release component. The contaminants in the landfill/disposal trench are presumed to be similar to those identified for the subsurface experiment boreholes and disposal boreholes (i.e., radionuclides and lead). Thus, no additional COPCs were added to the CAS due to the discovery of the landfill/disposal trench. The potential transport mechanisms, migration pathways, and exposure routes are also the same as previously identified in the SAFER Plan. This change to the CSM for CAU 465 was documented in DOE/NV--1467-ROTC 1 (NNSA/NSO, 2012a).

- The original decision rule considered the population parameter of any radionuclide in the Decision I population of interest exceeding the FAL at the groundwater interface within 1,000 years. The water and solute travel time analysis determined that the contaminant travel times in the vadose zone exceeded the 1,000-year regulatory time period. As a result, no further evaluation of groundwater impacts was necessary, but a revision to the decision rule was warranted (see Section 2.2 for a description of the deviation). The revised decision rule is a comparison of the travel time necessary for radionuclide contamination to migrate through the vadose zone to the groundwater interface to the 1,000-year regulatory time period. If the travel time exceeds the 1,000-year regulatory time period, no further analysis of groundwater impacts is required. However, if the travel time is less than 1,000 years and the contaminant concentration exceeds the FAL, then additional engineering or institutional controls and/or corrective actions will be evaluated. If engineering (e.g., installation of infiltration controls, soil cover), institutional (e.g., inclusion in existing UGTA monitoring program), and/or other corrective actions are determined to mitigate the COC contamination, adequate controls will be put in place.

2.3 Corrective Action Schedule as Completed

Closure activities were performed in the safest and most efficient manner possible. Sufficient flexibility was incorporated into the project schedule to account for minor difficulties (i.e., weather, equipment breakdown, security and resource issues, or equipment resources). Table 2-5 presents a summary of these activities.

Table 2-5
Corrective Action Schedule for CAU 465

Date	Activity
September 2011 to February 2012	Site mobilization, visual and radiological surveys, soil and PSM sampling, water and solute travel time analysis
February 2012	Well abandonment
May to July 2012	Housekeeping debris and PSM removal and shipment; confirmatory soil sampling; backfill of excavations; site contouring
July 2012	Demobilization

2.4 Site Plans/Survey Plat

No new construction was performed during closure activities at CAU 465. Additionally, there were no surface disturbing activities that significantly altered the grade or surface drainage patterns. Therefore, as-built drawings of site plans and survey plats were not generated.

3.0 Waste Disposition

The wastes and recyclable materials generated during the CAI and their final disposition are summarized in Table 3-1. Waste streams generated during the CAU 465 CAI included nonhazardous waste, RCRA hazardous waste, low-level radioactive waste, and recycled materials. All wastes and recyclable materials were managed in accordance with applicable state and federal regulations, DOE Orders, and the CAU 465 SAFER Plan (NNSA/NSO, 2011). The waste characterization data as well as details regarding the types, amounts, and disposition of these wastes are presented in Section C.3.0.

Table 3-1
CAU 465 Waste Streams and Disposal Pathways

Container Number	Description	Location	Waste Characterization	Volume/Weight	Disposal Pathway	Disposal Date	Disposal Document
465B01	Lead Bricks	B06, B07, B08, B16	Recyclable	500 lb	Recycle	TBD	BOL
465B02	Soil	B06	Non-hazardous Non-radioactive	8 gal	Consolidated into 465B04		
465B03	Stained Concrete Pad	B01, B02	Hazardous	2,300 lb	Offsite TSDF (U.S. Ecology)	06/13/2012	UHM 956283 FLE
465B04	Soil	B04	Hazardous	13,140 lb			
465B05	Trash Pile Debris	B04	Non-hazardous Non-radioactive	5 yd^3	Area 9, U10C Landfill	05/10/2012	LVF
465B06	Lead Plates	B19	Recyclable	1,500 lb	Recycle	TBD	BOL
465B07	Debris	Landfill/disposal trench	LLW	1 yd^3	Consolidated into 465B09		
465B08	Lead Fragment	Landfill/disposal trench	Recyclable	27 lb	Recycle	TBD	BOL
465B09	Housekeeping Debris	All CASs	LLW	20 yd^3	Area 5, RWMC	10/03/2012	CD
465B10	Soil	B20, B21, B22	Hazardous	10 yd^3	Offsite TSDF (U.S. Ecology)	08/09/2012	UHM 956292 FLE
465B11			Hazardous	5 yd^3			

BOL = Bill of lading
CD = Certificate of Disposal
gal = Gallon
lb = Pound
LLW = Low-level waste
LVF = Landfill Load Verification Form
RWMC = Radioactive waste management complex
TBD = To be determined
TSDF = Treatment, storage, and disposal facility
UHM = Uniform Hazardous Waste Manifest

4.0 Closure Verification Results

4.1 Surface Release Component

The surface release component at each CAS in CAU 465 was clean closed. Verification of clean closure was accomplished through completion of radiological and visual surveys at all CASs and confirmation soil sampling at the Dog site. The Dog Site was the only site at which potential surface releases were identified and confirmation soil samples were collected. Sampling locations at the Dog site were accessible, and sampling activities at planned locations were not restricted by buildings, storage areas, active operations, or aboveground and underground utilities. This section provides a summary of verification data from the closure activities; details may be found in Appendix C.

The SAFER Plan (NNSA/NSO, 2011) identified the type, quality, and quantity of data required to resolve the DQO decision statements. To verify that the dataset obtained as a result of this investigation supports the DQO decisions, a DQA was conducted. Section 4.3 provides a summary of the DQA.

4.1.1 CAS 00-23-01 (Charlie Site)

The radiological survey did not identify any elevated radiological activity distinguishable from background. Although the visual survey identified housekeeping debris within the fence—including metal debris, scrap wood, communication line, and cables—no PSM or biasing factors were identified requiring additional investigation.

As no PSM or surface contamination is present that exceed FALs, the corrective action of no further action was selected for the surface component of the Charlie site.

4.1.2 CAS 00-23-02 (Dog Site)

The radiological walkover survey did not identify any elevated radiological activity distinguishable from background. The visual survey identified a landfill/disposal trench and PSM. The PSM included a trash pile containing metal debris; a small, stained concrete pad; six lead bricks; and three lead plates. All PSM associated with the surface component were removed and disposed of under a corrective action of clean closure. Verification soil samples were collected after the PSM and

associated contaminated soil were removed. The results for all verification soil samples were below the FALs. As a BMP, two disposal boreholes were filled with gravel and plugged with a cement/sand slurry to prevent future intrusion of surface water (Section 2.1.1.2), and housekeeping debris was disposed of.

The results of the radiological and visual surveys, verification soil sampling, and the removal of PSM support the completion of the corrective action of clean closure for the surface component of the Dog site.

The landfill/disposal trench is included in the subsurface release component for the Dog site, for which closure in place with URs is the selected corrective action. Thus, collection of verification samples and/or completion of surveys was not required for site closure at this feature. Disposition of debris removed from the landfill/disposal trench is discussed in Appendix C.

4.1.3 CAS 00-23-03 (Charlie Prime and Anja Sites)

The radiological survey did not identify any elevated radiological activity distinguishable from background. The visual survey did not identify PSM or biasing factors requiring additional investigation. As a BMP, two open unused test boreholes at each site were filled with gravel and plugged with a cement/sand slurry to prevent future intrusion of surface water (Section 2.1.1.3), and housekeeping debris was removed and properly disposed of.

As no PSM or surface contamination is present that exceed FALs, the corrective action of no further action was selected for the surface component of the Charlie Prime and Anja sites.

4.1.4 CAS 06-99-01 (Trailer 13 Site)

The radiological survey did not identify any elevated radiological activity distinguishable from background. The visual survey did not identify PSM or biasing factors requiring additional investigation.

As no PSM or surface contamination is present that exceed FALs, the corrective action of no further action was selected for the surface component of the Trailer 13 site.

4.2 Subsurface Release Component

The subsurface release component at each site—which includes the contaminants from the subsurface hydronuclear experiments, disposal boreholes at the Dog site and Trailer 13 site, and the landfill/disposal trench at the Dog site—was closed in place. Closure was verified by completion of a water and solute travel time analysis. The water and solute travel time analysis confirmed the contaminant travel time to the LCA is greater than the 1,000-year time period criterion. The water and solute travel time analysis is presented in Appendix B.

4.3 Data Quality Assessment

The DQA process is the scientific evaluation of investigation results to determine whether the DQO criteria established in the SAFER Plan (NNSA/NSO, 2011) were met and whether DQO decisions can be resolved at the desired level of confidence. The DQO process ensures that the right type, quality, and quantity of data will be available to support the resolution of those decisions at an appropriate level of confidence. Using both the DQO and DQA processes helps to ensure that DQO decisions are sound and defensible.

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

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

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

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

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

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

4.3.1 Review DQOs and Sampling Design

This section contains a review of the DQO process presented in Appendix A. 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.

4.3.1.1 Decision I

Surface Release Component. The Decision I statement for the surface release component at each CAS as presented in the SAFER Plan (NNSA/NSO, 2011) is as follows: "Is any COC present in environmental media within the CAS?"

Decision I Rules

- 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, the contaminated material will be removed, or Decision II samples will be collected until an estimate of the extent of contaminated material has been made.

- If no COC associated with a release from the CAS is detected, then further assessment of the CAS is not required, and the CAA of no further action will be selected. If a COC associated with a release from the CAS is detected, then additional sampling will be conducted to determine the extent of COC contamination. If the extent of the contamination is defined and removal is feasible, then clean close the site by removing the contaminated media. If the extent of contamination has been determined and removal is not feasible, then the contaminated area will be closed in place with appropriate URs.

- 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 action will be necessary.

Population Parameter

For judgmental sampling results, the population parameter is the maximum observed sample result from each individual sample.

Subsurface Release Component. The Decision I statement for the subsurface release component at each CAS as presented in the SAFER Plan (NNSA/NSO, 2011) is as follows: "If there is a potential impact on groundwater, then implement engineering controls."

Decision I Rules

- If the population parameter of any radionuclide COPC in the Decision I population of interest (defined in Step 4 of the DQO process) exceeds the corresponding FAL within 1,000 years, then additional engineering controls and/or corrective actions will be evaluated. If the implementation of engineering controls (e.g., soil cover, run-on controls, surface water diversion controls) is sufficient to reduce COC contamination below FALs, then implement the necessary engineering controls. If the implementation of engineering controls is shown not to reduce COC contamination below FALs, and/or engineering controls are not feasible, then work will stop and a consensus be reached with NDEP on the path forward before the investigation of the CAS may continue. Based upon the deviation to the SAFER Plan described in Section 2.2, the revised decision rule compares the travel time for radionuclide contamination to migrate through the vadose zone to the groundwater interface at each site to the 1,000-year regulatory time period. If the travel time exceeds the 1,000-year regulatory time period, no further analysis of groundwater impacts is required. However, if the travel time is less than 1,000 years and the contaminant concentration exceeds the FAL, then additional engineering or institutional controls and/or corrective actions will be evaluated. If engineering (e.g., installation of infiltration controls, soil cover), institutional (e.g., inclusion in existing UGTA monitoring program), and/or other corrective actions are determined to mitigate the COC contamination, adequate controls will be put in place.

- If no COC associated with a release for the CAS is forecasted by the water and solute travel time analysis, then further assessment of the CAS is not required.

- If further assessment of the CAS is not required, then the CAA of closure in place with URs will be selected. The lateral extent of potential contamination defined below, will be used as the UR boundary for each CAS.

Population Parameter

For the CAU 465 subsurface component, the population parameter is the maximum forecasted radionuclide concentration in groundwater within 1,000 years. The maximum forecasted result of each individual radionuclide contaminant will be compared to the FALs to determine resolution of Decision I (Section 2.2).

The lateral extent of potential contamination for the experiment and disposal boreholes is defined as a 6-ft radius from the center of each borehole. The lateral extent of the potential contamination for the landfill/disposal trench at the Dog site is defined as the landfill dimensions as determined by geophysical surveys and exploratory excavation, plus a 3-ft buffer surrounding the landfill.

4.3.1.1.1 DQO Provisions To Limit False Negative Decision Error

Surface Release Component. A false negative decision error (where consequences are more severe) was controlled by meeting the following criteria:

1. Having a high degree of confidence that locations selected will identify COCs if present anywhere within the CAS.

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.

Criterion 1

The following field-survey techniques were used to select sample locations at CAU 465:

- **Surface area radiological surveys.** A radiological survey instrument was used to detect locations of elevated radioactivity.

- **Visual surveys.** Visual surveys were conducted to select appropriate sampling locations to identify other areas of contamination and PSM.

Criterion 2

All samples were submitted and analyzed for the chemical and radiological parameters listed in Table B.2-2 of the SAFER Plan (NNSA/NSO, 2011). Table 4-1 provides a reconciliation of samples analyzed to the planned analytical program for CAU 465.

Sample results were assessed against the acceptance criterion for the DQI of sensitivity as defined in the Soils Activity QAP (NNSA/NSO, 2012b). The sensitivity acceptance criterion defined in the SAFER Plan is that analytical detection limits will be less than the corresponding action level. This criterion was achieved for all analytical results.

Table 4-1
CAU 465 Analyses Performed

CAS	Analytes									
	Total VOCs	Total SVOCs	PCBs	HE	Beryllium	RCRA Metals	Gamma Spectroscopy	Isotopic U	Isotopic Pu	Isotopic Sr
00-23-01	--	--	--	--	--	--	--	--	--	--
00-23-02	RS	RS	RS	RS	RS	RS	RS	RS	RS	S
00-23-03	--	--	--	--	--	--	--	--	--	--
06-99-01	--	--	--	--	--	--	--	--	--	--

RS = Required and submitted
S = Not required but submitted
-- = Not required

Criterion 3

To satisfy the third criterion, the entire analytical dataset, as well as individual analytical sample results, were assessed against the acceptance criteria for the DQIs of precision, accuracy, representativeness, completeness, and comparability, as defined in the Soils Activity QAP (NNSA/NSO, 2012b). The DQI acceptance criteria are presented in Table 7-1 of the SAFER Plan (NNSA/NSO, 2011).

Precision

Precision of the dataset is evaluated using the relative percent difference (RPD) or normalized difference between duplicate samples. For radionuclides, the RPD was not calculated unless both the sample and its duplicate had concentrations of the target radionuclide exceeding five times their minimum detectable concentration (MDC). Otherwise radionuclide duplicate results were evaluated using the normalized difference. Table 4-2 provides the chemical and radiological precision analysis results for all contaminants that were qualified for precision. The only chemical contaminant qualified for precision was barium. The only radionuclide qualified for precision was U-234.

As shown in Table 4-2, the precision rate for barium and U-234 were above the SAFER Plan acceptance criterion of 80 percent (NNSA/NSO, 2011). Because the precision rates for all other

Table 4-2
Precision Measurements

Contaminant	Number of Measurements Qualified	Number of Measurements Performed	Percent within Criteria
Barium	2	24	91.7
U-234	1	8	87.5

contaminants met the acceptance criteria for precision, the dataset is determined to be acceptable for the DQI of precision.

Accuracy

For the purpose of determining data accuracy of sample analyses, environmental soil samples were evaluated and incorporated into the accuracy calculation. The results qualified for accuracy were associated with matrix spike (MS) recoveries that were outside control limits and could potentially be reported at concentrations lower or higher than actual concentrations. Table 4-3 provides the chemical accuracy analysis results for all contaminants qualified for accuracy. There were no radiological data qualified for accuracy.

Table 4-3
Accuracy Measurements

Contaminant	Number of Measurements Qualified	Number of Measurements Performed	Percent within Criteria
Arsenic	7	28	75
Selenium	7	24	70.8
Barium	20	24	16.7
Lead	6	30	80
Chromium	6	24	75
Silver	6	24	75
Cadmium	6	24	75

Of the samples qualified for accuracy, all of the results were associated with an MS recovery that exceeded the upper limits. However, there is negligible potential for a DQO decision error because the reported values are very small in comparison to the action levels (the laboratory reported values

are much less than 50 percent of the FAL). Therefore, use of the results that were qualified for reasons of accuracy will not result in a false negative decision error. As the accuracy rate for all other contaminants exceed 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 was used to address sampling and analytical requirements for CAU 465. 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 and locations that bound COCs). The sampling locations identified in the Criterion 1 discussion meet this criterion. Therefore, the analytical data acquired during the CAU 465 CAI are considered representative of the population parameters.

Completeness

The SAFER Plan (NNSA/NSO, 2011) defines acceptable criteria for completeness to be 80 percent of CAS-specific non-target contaminants identified in the SAFER Plan having valid results. Also, the dataset must be sufficiently complete to be able to make the DQO decisions. There were no data rejected during the validation process; therefore, the DQIs for completeness have been met.

Comparability

Field sampling, as described in the SAFER Plan (NNSA/NSO, 2011), was performed and documented in accordance with approved procedures that are in conformance with standard industry practices. Analytical methods and procedures approved by DOE were used to analyze, report, and validate the data. These methods and procedures are in conformance with applicable methods used in industry and government practices. Therefore, project datasets are considered comparable to other datasets generated using standard industry procedures, thereby meeting DQO requirements.

Subsurface Release Component. The forecast of a credible contaminant transport scenario must rely on the mathematical analysis being representative of reality, which depends on the accuracy of the conceptual model. The validity of the current conceptual model is believed to be sufficiently protective of a false negative decision error based upon existing characterization, geologic information, and professional judgment.

The false negative decision error for the water and solute travel time analysis was controlled by meeting the following criteria:

- Use of conservative inputs to the analysis (e.g., hydrologic properties, transport mechanisms)
- Use of robust and proven flow and transport characteristics
- Use of a model that represents the hydrogeologic framework, hydraulic properties, and contaminant characteristics to achieve a reasonable degree of correspondence between stratigraphic simulations and observations of the groundwater system.
- *Use of the highest estimated recharge rates.* The recharge rates used in this analysis are the highest obtained from available recharge models (see Section B.2.2). As transport of contaminants through the vadose zone is driven by the flow of water to groundwater, higher recharge flow rates will result in higher contaminant travel rates.
- *Restricted lateral water movement.* Lateral water movement will occur in the natural environment, but the amount of lateral movement is unknown. While restricting lateral movement is unrealistic, it is conservative in that it will underestimate the water travel distance as well as contaminant dilution and dispersion. This will result in underestimating the time needed to reach groundwater and overestimating contaminant concentrations.
- *Unlimited source term.* These calculations assume that the amount of contaminant is not limited throughout the evaluated time period (1,000 years). This is a somewhat conservative but reasonable assumption. While radiological decay is ignored, the half-life of plutonium is much greater than the evaluated time period.
- *No diffusion.* This assumption provides that the concentrations of contaminants at the leading contaminant boundary is the same concentration as at the contaminant source. This unrealistic but conservative assumption has the effect of preserving migration rates at the solubility limits of the contaminant, resulting in an over-prediction of migration rates.

4.3.1.1.2 DQO Provisions To Limit False Positive Decision Error

Surface Release Component. The false positive decision error was controlled by assessing the potential for false positive analytical results. QA/QC samples such as field blanks, trip blanks, laboratory control samples (LCSs), and method blanks were used to determine whether a false positive analytical result may have occurred. This provision is evaluated during the validation process, and appropriate qualifications are applied to the data results when applicable.

The use of certified clean sampling equipment and containers also minimized the potential for cross contamination that could lead to a false positive analytical result.

Subsurface Release Component. Due to the use of conservative assumptions (as presented above) and numerical input parameters (e.g., source term, recharge rates), the water and solute travel time analysis is expected to be overly conservative, and will overestimate predictions of contaminant transport.

4.3.1.2 Decision II

Surface Release Component. The Decision II statement for the surface release component at each CAS as presented in the SAFER Plan (NNSA/NSO, 2011) is as follows: "If a COC is present, is sufficient information available to meet the closure objectives?"

Decision Rules

- If the observed concentration of any COC in the Decision II population of interest exceeds the corresponding FAL, then additional samples will be collected. If sufficient information is available to define the extent of COC contamination and confirm that closure objectives were met, then further assessment of the CAS is not required. If sufficient information is not available to define the extent of contamination or confirm that closure objectives were met, then additional samples will be collected until the extent is defined.

- If valid analytical results are available for the waste characterization samples, then the decision will be that sufficient information exists to characterize the waste for disposal and determine potential remediation waste types, else collect additional waste characterization samples.

Population Parameter

The Decision II population parameter is an individual analytical result from a bounding sample. For Decision II, a single bounding sample result for any contaminant exceeding a FAL would cause a determination that the contamination is not bounded.

Subsurface Release Component. A Decision II statement for the subsurface release component at each CAS was not developed for the SAFER Plan (NNSA/NSO, 2011).

4.3.1.2.1 DQO Provisions To Limit False Negative Decision Error

A false negative decision error (where consequences are more severe) is controlled by meeting the following criteria:

1. Having a high degree of confidence that the sample locations selected will identify the extent of the COCs.

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.

4. Having a high degree of confidence that the potential waste streams are characterized.

Criterion 1

Soil sample results demonstrated that the vertical and lateral extent of COCs were defined. The extent sample locations are shown in Figures C.2-2 through C.2-4.

Two areas at the Dog site were identified as requiring further delineation of COCs (i.e., trash pile and a stained concrete pad). The surface soils at these locations identified lead, arsenic, and Cr (VI) at concentrations exceeding the PALs (see Section 2.1.1.2 for details).

The soil sample from the center of the trash pile at location B04, exceeded the PALs for lead and arsenic. Four step-out samples were collected at the trash pile to bound the extent of contamination (locations B12 through B15). After the contaminated soil was removed, confirmation samples were collected at five locations (B23 through B27). The confirmation samples indicated lead and arsenic at concentrations below the PALs.

- After the stained concrete pad was removed, three soil samples were collected from the soil underneath the pad. Two were collected in the stained areas (locations B20 and B21) and one from an unstained area (location B22). The two samples collected in the stained areas contained Cr (VI) in excess of the PALs. On July 9 and 10, 2012, approximately 15 yd^3 of soil was removed from the area, and six confirmation samples were collected from the sidewalls and within the excavation. The confirmation soil sample results on the north, west, and east sidewalls of the excavation (locations B28, B29, and B30) were less than the PAL for Cr (VI). The soil sample from the south wall of the excavation (location B31) and two samples from the bottom of the excavation (locations B32 and B33) exceeded the PAL for Cr (VI) but are less than the FAL (see Appendix G). The lateral extent of COCs is defined by soil samples

465B032, 465B033, and 465B034, which are less than the PALs on the north, east and west sidewalls of the excavation, respectively. The lateral extent is bounded on the south by sample 465B035, which is less than the FAL from the south wall of the excavation; and surface soil sample 465B003, which is less than the PAL at location B03 directly downgradient of the excavated area. The hard caliche layer at the bottom of the excavation and soil samples 465B036 and 465B037, which are less than the FAL, define the vertical extent of COCs.

Criterion 2

All samples were analyzed for the COCs present at the corresponding CAS:

- Lead, arsenic, and Cr (VI) were identified as COCs at the Dog site.

The second criterion for extent (sensitivity) was accomplished for all analyses.

Criterion 3

To satisfy the third criterion for extent, the entire dataset, as well as individual sample results, were assessed against the DQIs of precision, accuracy, representativeness, comparability, and completeness, as defined in the Soils Activity QAP (NNSA/NSO, 2012b). The DQI discussion is presented under Criterion 3 for Decision I.

4.3.1.2.2 DQO Provisions To Limit False Positive Decision Error

The false positive decision error was controlled by assessing the potential for false positive analytical results. QA/QC samples such as field blanks, trip blanks, LCSs, and method blanks were used to determine whether a false positive analytical result may have occurred. Of the 2 QA/QC samples submitted, no false positive analytical results were detected.

The use of certified clean sampling equipment and containers also minimized the potential for cross contamination that could lead to a false positive analytical result.

4.3.1.3 Sampling Design

Surface Release Component. The SAFER Plan (NNSA/NSO, 2011) made the following commitments for sampling:

- A judgmental sampling design was implemented for CAU 465. A biased sampling strategy was used to target areas with the greatest potential for contamination. Biased locations were determined in all cases based upon process knowledge, field instrumentation, visual inspection of the site, and other biasing factors (e.g., staining).

  Result. Soil and PSM samples were collected at biased locations based upon the presence of soil, debris piles, staining, and identified potential pathways to the soil such as drainages.

Subsurface Release Component. Numerical inputs to the water and solute travel time analysis were based upon conservative assumptions (see Appendix B). No sampling was required to complete the water and solute travel time analysis.

4.3.2 Conduct a Preliminary Data Review

Surface Release Component. A preliminary data review was conducted by reviewing QA reports and inspecting the data. The contract analytical laboratories generate a QA non-conformance report when data quality does not meet contractual requirements. All data received from the analytical laboratories met contractual requirements, and a QA non-conformance report was not generated. Data were validated and verified to ensure that the measurement systems performed in accordance with the criteria specified. The validated dataset quality was found to be satisfactory.

Subsurface Release Component. There were no data generated.

4.3.3 Select the Test and Identify Key Assumptions

Surface Release Component. The test for resolving DQO Decision I for the judgmental sampling design was the comparison of the maximum analyte result from each CAS to the corresponding FAL. The test for making DQO Decision II was the comparison of all COC analyte results from each bounding sample to the corresponding FALs.

The key assumptions that could impact a DQO decision for the surface component are listed in Table 4-4.

Table 4-4
Key Assumptions

Exposure Scenario	Site workers are only exposed to COCs through oral ingestion or inhalation of, or dermal contact (by absorption) with COCs absorbed onto the soils, or external exposure to radiation. Exposure to contamination is limited to site workers, construction/remediation workers. The investigation results did not reveal any potential exposures than those identified in the CSM.
Affected Media	Surface soil, shallow subsurface soil, and potentially perched (shallow) groundwater. Deep groundwater contamination is not a concern. Contaminants migrating to regional aquifers are not a concern (see Appendix B). The investigation results did not reveal any affected media other than those identified in the CSM.
Location of Contamination/Release Points	Release points are those identified in the SAFER Plan (NNSA/NSO, 2011). The investigation results did not reveal any locations of contamination or release points other than those identified in the SAFER Plan.
Transport Mechanisms	Surface transport may occur as a result of a spill or storm water runoff. Surface transport beyond shallow substrate is not a concern. The investigation results did not reveal any transport mechanisms other than those identified in the CSM.
Preferential Pathways	None. Open unspent boreholes were backfilled and plugged at Charlie Prime and Anja sites. Partially filled disposal boreholes at Dog site backfilled and plugged. The investigation results did not reveal any preferential pathways.
Lateral and Vertical Extent of Contamination	Subsurface contamination, if present, is contiguous and decreases with distance and depth from the source. Surface contamination may occur laterally as a result of a spill or storm water runoff. The area of contamination is contiguous. The extent of COC concentration decreases away from the area of contamination. The investigation results did not reveal any lateral and vertical extent of contamination other than those identified in the CSM.
Groundwater Impacts	None. The investigation results did not reveal any indicators that groundwater could be potentially impacted (see Appendix B).
Future Land Use	Occasional Use. The investigation results did not reveal any future land uses other than occasional.
Other DQO Assumptions	Contamination may be present in the soils adjacent to a feature due to runoff or intended use (e.g., decontamination pad). All detected contaminants were adjacent to features and decreased with distance.

Subsurface Release Component. The revised decision rule (based upon the deviation described in Section 2.2) for resolving DQO Decision I for the subsurface water and solute travel time analysis compares the travel times for radionuclide contamination to migrate through the vadose zone to the groundwater interface, and the 1,000-year regulatory time period. If the travel times exceed the 1,000-year regulatory time period, then no further analysis of groundwater impacts is required. A DQO Decision II statement was not developed for the subsurface component. The key assumptions that could impact a DQO decision for the subsurface component are listed in Table 4-4.

4.3.4 Verify the Assumptions

The results of the investigation support the key assumptions identified in the CAU 465 DQOs and Table 4-4.

4.3.4.1 Other DQO Commitments

Surface Release Component. The SAFER Plan (NNSA/NSO, 2011) made the following commitments for sampling:

- Decision II sampling will consist of defining the extent of contamination where COCs have been confirmed at the Decision I locations. If COCs in adjacent soils are not detected, then no further action is required. If a COC is detected in soil, then additional sampling will be conducted to determine the extent of COC contamination. If the extent of the contamination is defined and remediation is feasible, then the contaminated media will be removed. If the extent of contamination has been determined and remediation is not feasible, then the extent of contamination will be defined and the planned UR will be extended to include the contaminated area.

  Result. The Decision I sampling of the soil at the trash pile and in the area beneath the stained concrete pad confirmed the presence of lead and arsenic, and Cr (VI), respectively.

  - Four Decision II step-out samples were collected at the trash pile to determine the extent of contamination (locations B12 through B15). After approximately 10 yd^3 of contaminated soil was removed, confirmation samples were collected at five locations (B23 through B27). The confirmation samples indicated lead and arsenic at concentrations below the PALs.

  - After the stained concrete pad was removed, and approximately 15 yd^3 of Cr (VI)-contaminated soil underneath and in the vicinity of the pad was removed, six Decision II soil samples were collected (locations B28 through B33). The samples were

collected from underneath the former location of the stained Cr (VI)-contaminated concrete pad in the sidewalls and on the bottom of the excavated area. The soil sample results on the north, east, and west sidewalls of the excavation were less than the PAL for Cr (VI). The soil sample on the south wall and two samples from the bottom of the excavation exceeded the PAL for Cr (VI) but are less than the FAL (see Appendix G).

Subsurface Release Component. There were no additional DQO commitments for the subsurface component.

4.3.5 Draw Conclusions from the Data

This section resolves the two DQO decisions for each of the CAU 465 CASs.

4.3.5.1 Decision Rules for Decision I

Surface Release Component

Decision rule. If the concentration of any COPC in a target population exceeds the FAL for that COPC during the initial investigation, then that COPC is identified as a COC and Decision II sampling will be conducted.

- **Result.** The following COCs were identified as a result of Decision I sampling:
  - Lead, arsenic, and Cr (VI) at the Dog site.

Decision rule. If all COPC concentrations are less then the corresponding FALs, then the decision will be no further action.

- **Result.** No COCs were identified as a result of radiological and visual surveys at the Charlie site, the Charlie Prime and Anja sites, or the Trailer 13 site.

Subsurface Release Component

Decision rule. Based upon the deviation described in Section 2.2, the revised decision rule for the subsurface component compares the travel times for radionuclide contamination to migrate through the vadose zone to the groundwater interface, and the 1,000-year regulatory time period. If the travel times exceed the 1,000-year regulatory time period, then there is no impact to groundwater.

- **Result.** The calculated water and contaminant travel times greatly exceed the UGTA 1,000-year regulatory time period, indicating that the distance between the CAU 465 residual contamination and the LCA is sufficient for protecting the water resource below the CAU 465 CASs.

4.3.5.2 Decision Rules for Decision II

Surface Release Component

Decision rule. If the observed concentration of any COC in a Decision II sample exceeds the PALs, then additional samples will be collected to complete the determination of the extent.

- **Result.** Two areas were identified as requiring further delineation of COCs (i.e., trash pile and stained concrete pad). Samples to define the extent of contamination were collected from the Dog site as follows:

  - Soil samples in the center of the trash pile at location B04 exceeded the PALs for lead and arsenic. Four step-out samples were collected at the trash pile to bound the extent of contamination (locations B12 through B15). After the contaminated soil was removed, confirmation samples were collected at five locations (B23 through B27). The confirmation samples indicated lead and arsenic at concentrations below the FALs.

  - After the stained concrete pad was removed, three soil samples were collected from the soil underneath the pad. The samples collected in the stained areas contained Cr (VI) in excess of the PALs. On July 9 and 10, 2012, approximately 15 yd^3 of soil was removed from the area, and six confirmation samples were collected from the sidewalls and within the excavation. The confirmation soil sample results on the north, east, and west sidewalls of the excavation were less than the PAL for Cr (VI). The soil sample on the south wall and two samples form the bottom of the excavation exceeded the PAL for Cr (VI), but are less than the FAL (see Appendix G). The lateral extent of COCs is defined by soil samples 465B032, 465B033, and 465B034, which are less than the PAL on the north, east and west sidewalls of the excavation, respectively. The lateral extent is bounded on the south by sample 465B035, which is less than the FAL from the south wall of the excavation, and surface soil sample 465B003, which is less than the PAL at location B03 directly downgradient of the excavated area. The hard caliche layer at the bottom of the excavation and soil samples 465B036 and 465B037, which are less than the FAL, define the vertical extent of COCs.

Subsurface Release Component

A Decision II statement was not developed for the subsurface component.

4.4 Use Restrictions

To minimize future potential personnel exposure or mobilization of contaminants, a UR has been implemented for each CAU 465 CAS. As a BMP, an administrative UR was implemented for the area surrounding the former location of the Cr (VI)-contaminated concrete pad. An FFACO UR with the corrective action of closure in place has been implemented for the subsurface release component at each of the CAU 465 sites:

- CAS 00-23-01, Charlie Site
- CAS 00-23-02, Dog Site
- CAS 00-23-03, Charlie Prime and Anja Sites
- CAS 06-99-01, Trailer 13 Site

Five UR signs were installed on existing fences at each site. At the Dog site, one additional sign was placed at each of the six disposal boreholes located outside the fence, and four signs were placed around the landfill/disposal trench. UR signs for CAU 465 read as follows: “Warning, underground radiological and chemical contamination. FFACO Site CAU 465/CAS xx-xx-xx Hydronuclear Experiment. No activities that may alter or modify the containment control, including excavation or disturbance of material, are permitted in this area without U.S. Government permission. Before working in this area, contact Real Estate Services at 295-2528.” Specific information and map locations relating to the URs are presented in Appendix E.

Future land use related to the FFACO UR is restricted from any intrusive activity unless concurrence is obtained in advance and in writing from NDEP. Future activity that alters and/or modifies any barrier must be restored to an equivalent or more restrictive condition upon completion of the activity. Any future land use within the UR area that is inconsistent with the current land usage will require reevaluation of site controls.

5.0 Conclusions and Recommendations

Closure activities specified in the CAU 465 SAFER Plan (NNSA/NSO, 2011) were successfully performed. All cleanup activities are documented in this CR. Based upon the completion of closure activities, it is requested that NDEP provide a notice of completion for CAU 465, Hydronuclear. Upon closure approval, CAU 465 will be promoted from Appendix III to Appendix IV of the FFACO. Based on the results of the closure activities, no further corrective actions are necessary for CAU 465.

The DOE, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) provides the following recommendations:

- Implement an administrative UR for the area surrounding the former location of the Cr (VI)-contaminated concrete pad at the Dog site.
- Implement a corrective action of closure in place for the subsurface component at CAU 465, which includes the remaining subsurface contamination in the boreholes (at all CAU 465 CASs) and landfill/disposal trench (Dog site only).
- Implement an FFACO UR for the subsurface component at each CAU 465 CAS.
- A Notice of Completion is requested from NDEP for the closure of CAU 465.
- CAU 465 should be moved from Appendix III to Appendix IV of the FFACO, signifying closure.

6.0 References

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

EPA, see U.S. Environmental Protection Agency.

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 Underground Test Area and Soils Sites Strategy, was last modified May 2011, Revision No. 4.

N-I GIS, see Navarro-Intera Geographic Information Systems.

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-Intera Geographic Information Systems. 2012. ESRI ArcGIS Software.

U.S. Department of Energy, National Nuclear Security Administration Nevada Operations Office. 2002. *Nevada Test Site Orthophoto Site Atlas,* DOE/NV/11718--604. Aerial photos acquired Summer 1998. Prepared by Bechtel Nevada. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2011. *Streamlined Approach for Environmental Restoration for Corrective Action Unit 465: Hydronuclear, Nevada National Security Site, Nevada,* Rev. 0, DOE/NV--1467. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2012a. *Record of Technical Change to Streamlined Approach for Environmental Restoration for Corrective Action Unit 465: Hydronuclear, Nevada National Security Site, Nevada,* Rev. 0, DOE/NV--1467-ROTC 1. Las Vegas, NV.

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

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2012c. *Soils Risk-Based Corrective Action Evaluation Process,* DOE/NV--1475. Las Vegas, NV.

U.S. Department of Energy, Nevada Operations Office. 2001. "Bulletin: Historical Hydronuclear Experiments Conducted at the Nevada Test Site." March. Las Vegas, NV.

U.S. Environmental Protection Agency. 2006. *Guidance on Systematic Planning Using the Data Quality Objectives Process*, EPA QA/G-4, EPA/240/B-06/001. Washington, DC: Office of Environmental Information.

Appendix A

DQOs as Developed in the SAFER Plan

Note: This appendix contains the DQOs presented in SAFER Plan and consists of Appendix B of the SAFER Plan. Therefore, cross-references, page numbers, and header information in this appendix refer to the original document.

RECORD OF TECHNICAL CHANGE

Technical Change No. DOE/NV--1467-ROTC 1 Page 1 of 4

Activity Name Streamlined Approach for Environmental Restoration (SAFER) Plan for Corrective Action Unit (CAU) 465: Hydronuclear Date July 24, 2012

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

Mark Burmeister (Name) CAU 465 Task Manager (Title)

Description of Change:

Site investigation activities at CAU 465: Hydronuclear, Corrective Action Site (CAS) 00-23-02: Hydronuclear Experiment (Dog Site) began in September 2011. As part of the investigation, visual surveys were conducted with the purpose of identifying surface debris, soil staining, or other suspect conditions that could be associated with a release of contaminants. An area of fill material distinguishable from the surrounding soil and scattered surface debris was observed in the southeast portion of the site outside of the fenced compound. Of note were three partially buried lead plates in the northeast portion of the area and an aggregate of metal surface debris at the southwestern end. On February 28, 2012, a geophysical survey of the suspect area was conducted with an EM-61 instrument. Analysis of the survey data identified a pattern of buried metallic material suggestive of a landfill or disposal trench. In order to visually confirm the presence of buried debris, one exploratory excavation was dug into the feature on May 7, 2012. Large pieces of lead and steel, including pipes, were identified and removed from the excavation with a backhoe. The metal debris was screened for radioactivity and some of the pipes were found to have elevated beta/gamma radiation levels. Field operations were immediately suspended and the situation was reviewed. It was determined that the presence of a landfill/disposal trench located outside the fenced compound containing radioactively contaminated debris was an unexpected condition not considered in the data quality objectives (DQOs) process and not represented in the SAFER Plan conceptual site model (CSM). As such, further excavation was ceased in accordance with Section 3.2.5 of the SAFER Plan and participants in the DQO process were notified, and a path forward was proposed, discussed and agreed upon.

Each CAS was separated into two components in the SAFER Plan: surface release and subsurface release. Because the landfill/disposal trench is below the ground surface and any releases from the landfill would occur to subsurface soil, this feature is considered part of the subsurface CAS component for CAS 00-23-02 (Dog Site). Subsurface releases as described in the original SAFER Plan are potential releases of radiological and other contaminants from the subsurface hydronuclear experiments and disposal boreholes. The landfill/disposal trench is an additional contaminant source in the subsurface release component of CAS 00-23-02. It is presumed that the waste disposed in the landfill/disposal trench is associated with the hydronuclear experiments. The practice of burying uncontaminated and/or contaminated materials onsite at the Nevada National Security Site (NNSS) test sites was not uncommon during the testing era. The disposal of nonradioactive wastes in the twelve disposal boreholes at CAS 00-23-02 is direct evidence of this practice.

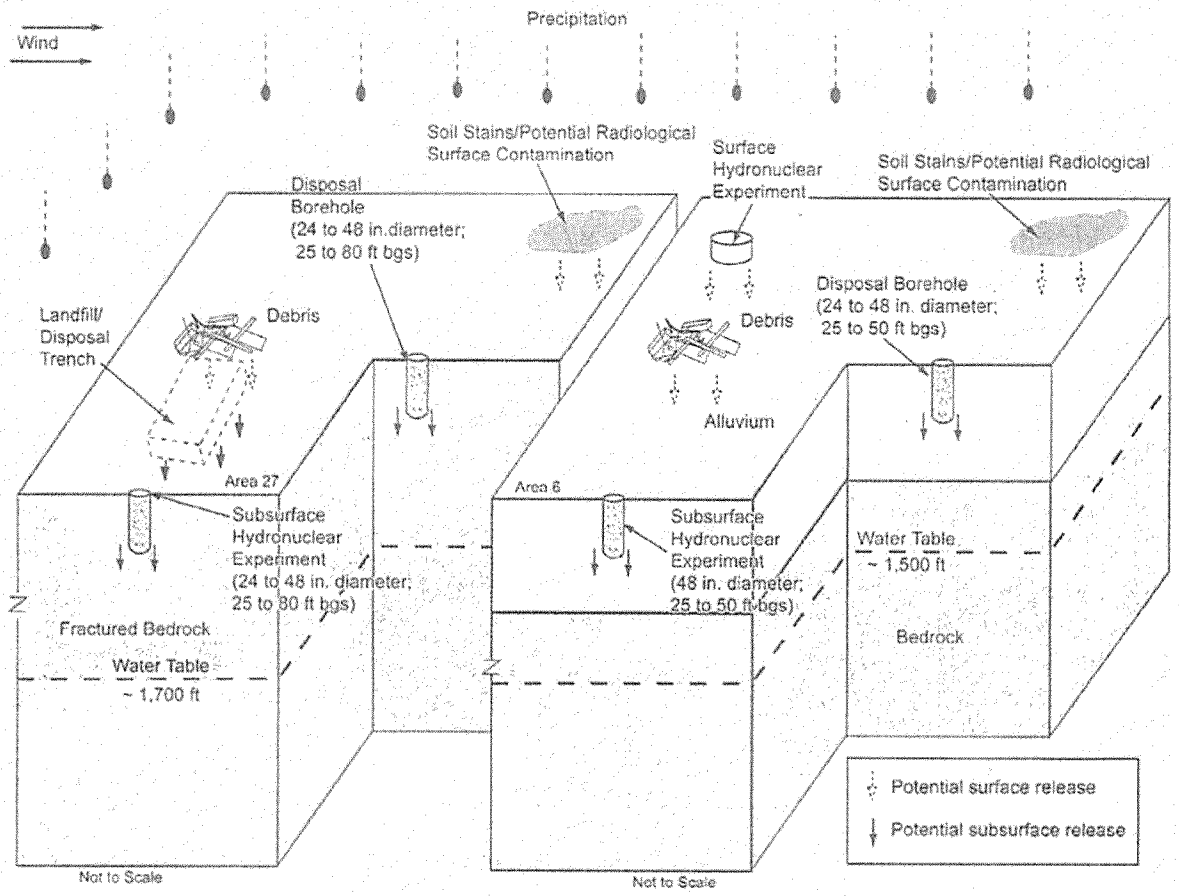
Discovery of a landfill/disposal trench at CAS 00-23-02 requires a change to the original CSM for CAU 465. The basic elements of the CSM as shown in Table B.2-1 are still valid, but the model will be supplemented through the addition of the landfill/disposal trench as part of the subsurface release component. The contaminants in the landfill/disposal trench are presumed to be similar to those identified for the subsurface experiment boreholes and disposal boreholes (i.e., radionuclides and lead). Thus, no additional contaminants of potential concern were added to the CAS due to the discovery of the landfill/disposal trench. The potential transport mechanisms, migration pathways, and exposure routes would also be the same as previously identified in the SAFER Plan.

The general closure strategy for the subsurface release component of CAS 00-23-02 does not require revision based on the

discovery of the landfill/disposal trench. The SAFER Plan states, "the subsurface CAS component consists of the remaining inventory (radiological and other metals) in the hydronuclear experiment and disposal boreholes. For the subsurface component, wastes will be left in place, and a corrective action of closure in place with use restrictions (URs) will be established to ensure protection of human health and the environment. Flow and transport models will be prepared to evaluate the potential for radiological and other metal contaminants to reach the groundwater below each of the CASs." The conservative radiological and chemical inventories utilized to complete the flow and transport analyses for the subsurface component bound the contaminants of potential concern associated with the disposal boreholes and landfill/disposal trench.

The SAFER Plan is revised as follows (revisions are in bold):

- Section 2.1.2, *CAS 00-23-02, Hydronuclear Experiment.* The first sentence is changed to read, "Corrective Action Site 00-23-02 (Dog Site) consists of 28 test boreholes that were used to conduct hydronuclear experiments, 12 disposal boreholes that were used to dispose of nonradioactive, classified materials associated with the hydronuclear experiments, **and a landfill/disposal trench outside the fenced compound also used to dispose of material associated with the experiments.**"
- Section 3.1, *Summary of DQO Analysis.* The first bullet on the page is revised to read, "The subsurface release component addresses releases of radiological and other contaminants from the subsurface hydronuclear experiments, disposal boreholes, **and the landfill/disposal trench (CAS 00-23-02 only).**"
- Figures 3-3 and B.2-1 (CAU 465 Conceptual Site Model) are revised to include the landfill/disposal trench (see **attached revised figure at the end of this Record of Technical Change [ROTC]**).
- Section 4.2, *Remediation* is revised to add the following bullet to the closure strategy for subsurface releases: **"Confirm the presence and determine the extent of buried debris in the landfill/disposal trench outside the fenced compound at CAS 00-23-02 (Dog Site) through visual and geophysical surveys and exploratory excavation, as needed.**"
- Appendix B, Section B.2.0, *Step 1 – State the Problem.* The problem statement for the subsurface component of CAU 465 is as follows: "Additional information on the potential impacts of the hydronuclear experiments, disposal boreholes, **and the landfill/disposal trench (outside the fenced compound)** to groundwater is needed to evaluate and recommend [Corrective Action Alternatives] CAAs."
- Appendix B, Table B.2-1, *Conceptual Site Model Description of Elements for Each CAS in CAU 465.* The statement in the second column next to "Location of Contamination/Release Point" is changed to read, "Surface soil at or near location(s) of release or stored waste/materials, and subsurface soil from hydronuclear experiments, disposal boreholes, **and the landfill/disposal trench outside the fenced compound (CAS 00-23-02 only).**"
- Appendix B, Section B.2.2.1, *Contaminant Release.* The first bullet is revised to read, "Releases to groundwater due to the remaining inventory of radiological and nonradiological materials in the boreholes utilized for hydronuclear experiments, the disposal boreholes, **and the landfill/trench (CAS 00-23-02 only)** (subsurface releases)."
- Appendix B, Section B.6.1, *Population Parameters, Subsurface Releases.* The following paragraph is added after the first paragraph: **"The lateral extent of potential contamination for the experiment and disposal boreholes is defined as a six foot radius from the center of each borehole. The lateral extent of the potential contamination for the landfill/disposal trench at CAS 00-23-02 is defined as the landfill dimensions as determined by geophysical surveys and exploratory excavation, plus a three foot buffer surrounding the landfill."**
- Appendix B, Section B.6.3.1, *Decision Rules, Subsurface Releases.* A third bullet is added to the subsurface release decision rules as follows: **"If further assessment of the CAS is not required, then the CAA of closure in place with URs will be selected. The lateral extent of potential contamination as defined in Section B.6.1, will be used as the UR boundary for each CAS."**



Conceptual Site Model for CAU 465 CASs

DDM

Justification:

The SAFER Plan states in Section 4.3, *Verification*: "If an unexpected condition indicates that conditions are significantly different than the corresponding CSM, the activity will be rescoped, and the decision makers will be notified." This ROTC is required based on the discovery of an unexpected condition (i.e., the existence of a landfill/disposal trench outside the fenced compound) at CAS 00-23-02 (Dog Site). The landfill/disposal trench is considered another potential release source for the subsurface release component of CAS 00-23-02 which requires revision to the CSM.

The task time will be Increased by approximately 60 days.

Applicable Activity-Specific Document(s):

Approved By:

/s/ Tiffany A. Lantow Date 8/6/2012
Activity Lead

/s/ Robert F. Boehlecke Date 8/7/12
Manager, EM Operations

/s/ Jeff Mac Dougall Date 8/7/12
NDEP

B.1.0 Introduction

The DQO process described in this appendix is a seven-step strategic systematic planning method used to plan data collection activities and define performance criteria for the CAU 465, Hydronuclear, investigation. The DQOs are designed to ensure that the data collected will provide sufficient and reliable information to determine the appropriate corrective actions, to verify the adequacy of existing information, to provide sufficient data to implement the corrective actions, and to verify that closure was achieved.

The CAU 465 CAI will be based on the DQOs presented in this appendix as developed by representatives of NDEP and NNSA/NSO. The seven steps of the DQO process presented in Sections B.2.0 through B.8.0 were developed in accordance with *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006) and the CAS-specific information presented in Section B.2.0.

The DQO process presents a judgmental approach for data collection (use of existing information to develop groundwater flow and transport models and field sampling). In general, the procedures used in the DQO process provide the following:

- A method to establish performance or acceptance criteria, which serve as the basis for designing a plan for collecting data of sufficient quality and quantity to support the goals of a study.
- Criteria that will be used to establish the final data collection design, such as
  - the nature of the problem that has initiated the study and a conceptual model of the environmental hazard to be investigated,
  - the decisions or estimates that need to be made and the order of priority for resolving them,
  - the type of data needed, and
  - an analytic approach or decision rule that defines the logic for how the data will be used to draw conclusions from the study findings.
- Acceptable quantitative criteria on the quality and quantity of the data to be collected, relative to the ultimate use of the data.

- A data collection design that will generate data meeting the quantitative and qualitative criteria specified. A data collection design specifies the type, number, location, and physical quantity of samples and data, as well as the QA and QC activities that will ensure that sampling design and measurement errors are managed sufficiently to meet the performance or acceptance criteria specified in the DQOs.

B.2.0 Step 1 - State the Problem

Step 1 of the DQO process defines the problem that requires study, identifies the planning team, and develops a conceptual model of the environmental hazard to be investigated. Corrective Action Unit 465 consists of the following potential release components:

- Subsurface releases—Potential releases of radiological and other contaminants from the subsurface hydronuclear experiments and disposal boreholes.
- Surface releases—Potential releases of radiological and nonradiological contaminants to surface soils that may have occurred during pre- and post-test activities.

The problem statement for the subsurface component of CAU 465 is as follows: "Additional information on the potential impacts of the hydronuclear experiments and disposal boreholes to groundwater is needed to evaluate and recommend CAAs."

The problem statement for the surface component of CAU 465 is as follows: "Existing information on the nature and extent of contamination from surface releases at CAU 465 is insufficient to recommend CAAs."

B.2.1 Planning Team Members

The DQO planning team consists of representatives from NDEP and NNSA/NSO. The DQO planning team met on July 6, 2011, for the DQO meeting. The primary decision makers are the NDEP and NNSA/NSO representatives.

B.2.2 Conceptual Site Model

The CSM is used to organize and communicate information about site characteristics. It reflects the best interpretation of available information at any point in time. The CSM is a primary vehicle for communicating assumptions about release mechanisms, potential migration pathways, or specific constraints. It provides a summary of how and where contaminants are expected to move and what impacts such movement may have. It is the basis for assessing how contaminants could reach receptors both in the present and future. The CSM describes the most probable scenario for current conditions at each site and defines the assumptions that are the basis for identifying appropriate

sampling strategy and data collection methods. Accurate CSMs are important as they serve as the basis for all subsequent inputs and decisions throughout the DQO process.

The CSM was developed for CAU 465 using information from the physical setting, potential contaminant sources, release information, historical background information, knowledge from similar sites, and physical and chemical properties of the potentially affected media and COPCs.

The CSM consists of the following:

- Potential contaminant releases, including media subsequently affected.
- Release mechanisms (the conditions associated with the release).
- Potential contaminant source characteristics, including contaminants suspected to be present and contaminant-specific properties.
- Site characteristics, including physical, topographical, and meteorological information.
- Migration pathways and transport mechanisms that describe the potential for migration and where the contamination may be transported.
- The locations of points of exposure where individuals or populations may come in contact with a COC associated with a CAS.
- Routes of exposure where contaminants may enter the receptor.

If additional elements are identified during the CAI that are outside the scope of the CSM, the situation will be reviewed and a recommendation will be made as to how to proceed. In such cases, NDEP and NNSA/NSO will be notified and given the opportunity to comment on, and concur with, the recommendation.

The applicability of the CSM to each CAS is summarized in Table B.2-1 and discussed below. Table B.2-1 provides information on CSM elements that will be used throughout the remaining steps of the DQO process. Figure B.2-1 represents site conditions applicable to the CSM and depicts the various potential surface and subsurface releases associated with CAU 465.

Table B.2-1
Conceptual Site Model Description of Elements for Each CAS in CAU 465

CAS Identifier	00-23-01	00-23-02	00-23-03	06-99-01
CAS Description	**Hydronuclear Experiment**	**Hydronuclear Experiment**	**Hydronuclear Experiment**	**Hydronuclear**
Site Status	Sites are inactive and/or abandoned.			
Exposure Scenario	Occasional Use			
Sources of Potential Soil Contamination	Release of radiological and nonradiological contaminants to surface and subsurface soils			
Location of Contamination/ Release Point	Surface soil at or near location(s) of release or stored waste/materials, and subsurface soil from hydronuclear experiments and disposal boreholes			
Amount Released	Unknown			
Affected Media	Surface and subsurface soil; debris such as concrete, steel, and wood			
Potential Contaminants	Radionuclides (gamma spectroscopy, isotopic U, isotopic Pu, VOCs, SVOCs, PCBs, HEs, metals plus beryllium)			
Transport Mechanisms	Percolation of precipitation through subsurface media serves as the driving force for the potential migration of contaminants to the water table. Surface water runoff may provide for the transportation of some contaminants within or outside the footprints of the CASs.			
Migration Pathways	Vertical transport expected to dominate over lateral transport because of small surface gradients			
Lateral and Vertical Extent of Contamination	Contamination, if present, is expected to be contiguous to the release points. Concentrations are expected to decrease with distance and depth from the source. Groundwater contamination is not expected. Lateral and vertical extent of COC contamination is assumed to be within the spatial boundaries.			
Exposure Pathways	The potential for contamination exposure is limited to industrial and construction workers, and military personnel conducting training. These human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact with or absorption of, soil and/or debris due to inadvertent disturbance of these materials, or irradiation by radioactive materials.			

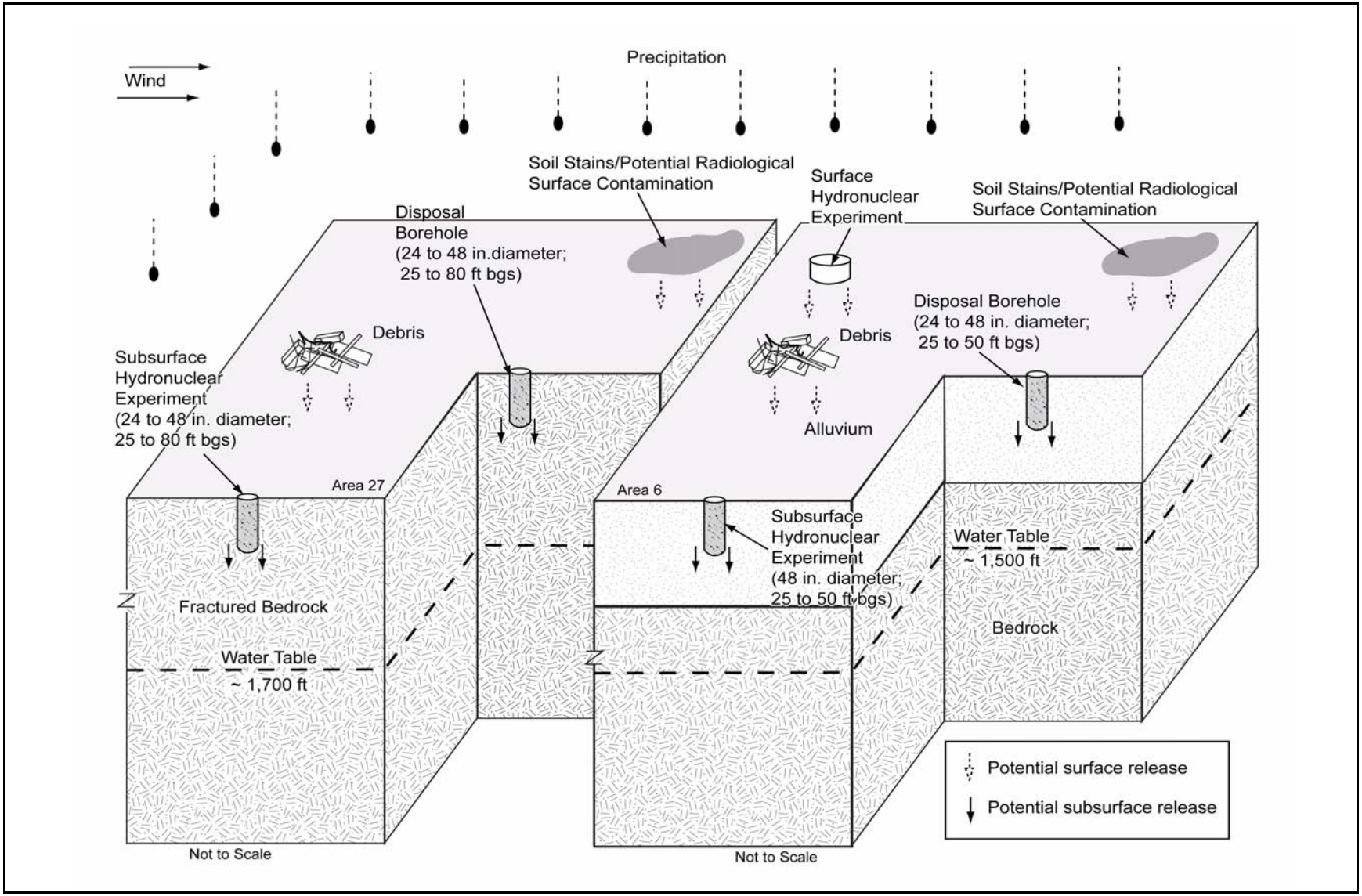


Figure B.2-1
Conceptual Site Model for CAU 465 CASs

UNCONTROLLED When Printed

B.2.2.1 Contaminant Release

Any contaminants released from CAU 465, regardless of physical or chemical characteristics, are expected to exist in the soil adjacent to their sources in lateral and vertical directions. The CSM accounts for the following potential releases:

- Releases to groundwater due to the remaining inventory of radiological and nonradiological materials in the boreholes utilized for hydronuclear experiments and the disposal boreholes (subsurface releases).
- Releases to surface soils due to spills, wastes, and other PSM (e.g., lead bricks) from historical operations conducted at each site in support of the hydronuclear experiments (surface releases).

B.2.2.2 Potential Contaminants

The COPCs were identified during the planning process through the review of site history, process knowledge, personal interviews, and inferred activities associated with the CASs. Because complete information regarding activities performed at the CAU 465 sites is not available, contaminants detected at similar NNSS sites were included in the contaminant list to reduce uncertainty. The list of COPCs is intended to encompass all the contaminants that could potentially be present at each CAS. The COPCs applicable to Decision I environmental samples for the surface component from each of the CASs of CAU 465 are defined as the constituents reported from the analytical methods stipulated in Table B.2-2. Because development of the flow and contaminant transport models will be completed utilizing existing data, there are no planned sampling or other field collection activities for the subsurface component. However, the COPCs associated with potential subsurface releases are identified in Table B.2-2.

For subsurface releases, a list of potential contaminants for the 1,000-year CAI time period was derived from the reported list of radioactive materials utilized to conduct the hydronuclear experiments: Pu-239/240, Am-241, U-235, and U-238 (DOE/NV, 2001). This group of radionuclides was considered the most significant for forecasting the 4-millirem (mrem) contaminant boundary over a 1,000-year time period. Lead also is included as a potential contaminant because it is known to have been used in significant quantities in underground nuclear testing for shielding and as a component in instrumentation. It was assumed that HEs and any VOC or SVOC RCRA

Table B.2-2
Analytical Program[a]

Constituents	CAU 465 (Subsurface Releases)	CAU 465 (Surface Releases)
Organic COPCs		
HE	--	X
PCBs	--	X
SVOCs	--	X
VOCs	--	X
Inorganic COPCs		
RCRA metals	X[b]	X
Total beryllium	--	X
Radionuclide COPCs		
Gamma spectroscopy[c]	X[d]	X
Isotopic U	X[d]	X
Isotopic Pu	X[d]	X

[a]The COPCs are the constituents reported from the analytical methods listed.
[b]Lead only.
[c]Results of gamma analysis will be used to determine whether further isotopic analysis is warranted.
[d]The radiological COPCs for subsurface releases are Am-241, U-234/235, U-238, Pu-239/240, and Pu-241.

X = Required analytical method
-- = Not required

constituents would be consumed during the explosion; therefore, only metals could remain as potential contaminants.

For potential surface releases, the COPCs include radionuclides (gamma, isotopic U, and isotopic Pu), RCRA metals, VOCs, SVOCs, PCBs, and HEs. The specific COPC is dependent upon the type of release identified and other biasing factors. For example, lead is a COPC because of the identified presence of lead bricks. Other potential releases identified by biasing factors (e.g., visual, radiological field screening) include those involving organic constituents (e.g., diesel spills); VOCs, SVOCs, and PCBs are groups of compounds that would contain organic COPCs. High explosives were utilized to initiate the hydronuclear experiments. Although it is highly likely that the explosives were completely consumed by the detonations, they are a potential COPC. Beryllium is included in the list of COPCs because beryllium is common to some test components.

B.2.2.3 Contaminant Characteristics

Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. In general, contaminants with large particle size, low solubility, high affinity for media, and/or high density can be expected to be found relatively close to release points. Contaminants with small particle size, high solubility, low affinity for media, and/or low density are found farther from release points or in low areas where evaporation of ponding will concentrate dissolved constituents.

B.2.2.4 Site Characteristics

Site characteristics are defined by the interaction of physical, topographical, and meteorological attributes and properties. Physical properties include permeability, porosity, hydraulic conductivity, degree of saturation, sorting, chemical composition, and organic content. Topographical and meteorological properties and attributes include slope stability, precipitation frequency and amounts, precipitation runoff pathways, drainage channels and ephemeral streams, and evapotranspiration potential. Migration pathways and transport mechanisms relevant to the present investigation are discussed in Section B.2.2.5.

The NNSS lies in the southern part of the Great Basin section of the Basin and Range physiographic province. There are numerous north–south-trending linear mountain ranges separated by broad, flat-floored, and gentle-sloped valleys. The general geology of the NNSS can be described in terms of three major rock units. The lowermost and oldest units are complexly folded and faulted sedimentary rocks of Paleozoic age. These are overlain in many places by volcanic tuffs and lavas of Tertiary age. Finally, the valleys or flats are covered by alluvium of late Tertiary and Quaternary age, which was derived from erosion of Tertiary and Paleozoic rocks (ERDA, 1977).

Area 6

Area 6 is located within Yucca Flat along the east side of the NNSS. Tertiary volcanics and Paleozoic carbonate rocks outcrop along the western edge of Area 6. Broad Quaternary alluvial plains and associated playa deposits, dominated by the Yucca Lake playa, are found in the central and eastern portions of Area 6. Corrective Action Site 06-99-01 (Trailer 13) is located along the southeast edge of Yucca Lake.

The hydrostratigraphic units in the vicinity of CAS 06-99-01 consist of a sequence of interbedded alluvial and playa deposits overlying a thick sequence of unsaturated volcanic rocks that overlie the regionally extensive Paleozoic carbonate aquifer (BN, 2006).

Corrective Action Site 06-99-01 is located in the Ash Meadows groundwater basin, where groundwater generally percolates downward through the alluvium and volcanic rocks to the Paleozoic carbonate aquifer. Groundwater generally flows to the south and southwest and eventually discharges at the large springs in Ash Meadows, about 25 mi southwest of Mercury (Winograd and Thordarson, 1975). The depth to groundwater at CAS 06-99-01 is approximately 1,500 ft bgs based on observations at Well TW-B (USGS/DOE, 2011).

Area 27

Geographically, Area 27 is located in the southern part of the NNSS, approximately midway between Jackass Flats and Frenchman Flat. Topographically, the CAU 465 CASs within Area 27 are located in a saddle between Skull Mountain to the west and rugged terrain to the east. The saddle is a drainage divide between Wahmonie Flat to the north and Rock Valley to the south. Area 27 is located in the transition zone between the northern edge of the Mojave Desert and the southern portion of the Great Basin Desert.

The rock formation that underlies Area 27 is, in general, an extrusive rock called the Oak Spring formation. The rocks are mostly volcanic in origin and are of Tertiary age. They may have covered the area completely at one time, but faulting and erosion have exposed older strata.

The Oak Spring formation has variations in color and lithology over short distances. In many places, these hills are composed of white slope-forming tuffaceous beds interbedded with, or capped by, thin, dark resistant extrusive masses. The Oak Spring formation consists of rhyolitic lava flows, tuff beds, and many other volcanic rock types (Johnson and Hibbard, 1957). The groundwater flux system in Area 27 generally directs subsurface flow to the southwest within the Ash Meadows component of the Death Valley groundwater basin. After crossing the NNSS boundary, the drainage passes near Amargosa Valley, Nevada, and Death Valley Junction, California. The depth to groundwater beneath the Area 27 CASs is estimated at approximately 1,700 ft bgs based on observations at Well TW-F (USGS/DOE, 2011).

Neither perennial streams nor wetlands exist in the vicinity of CAU 465, with the exception of Cane Spring located in Area 27. Cane Spring represents discharge from a perched aquifer that is recharged from fractures in the nearby mountains (NSTec, 2008).

B.2.2.5 Migration Pathways and Transport Mechanisms

Migration pathways include the lateral migration of potential contaminants across surface soils/sediments and vertical migration of potential contaminants through subsurface soils. In Area 6, surface water flow from the Trailer 13 site (CAS 06-99-01) is to the south-southwest into the Yucca Lake dry lake bed. The drainage patterns in Area 27 direct surface flow to the southwest. Rainfall typically collects in drainage channels that flow to lower elevations, infiltrates soil, or evaporates. Surface water flow from the CASs in Area 27 also is generally to the south. Both areas are generally dry but subject to infrequent, potentially intense, stormwater flows. Stormwater flow events can provide an intermittent mechanism for both vertical and horizontal transport of contaminants. Contaminated sediments entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable by hydrologists as sedimentation areas.

Infiltration and percolation of precipitation serves as a driving force for downward migration of contaminants. However, due to high potential evapotranspiration (annual potential evapotranspiration at the Area 3 Radiological Waste Management Site has been estimated at 62.6 in. [Shott et al., 1997]) and limited precipitation for this region (average of 5.64 in. per year as measured at Station A06 in Area 6 and approximately 7.74 in. per year as measured at Station CS in Area 5 [ARL/SORD, 2011]), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992). Environmental contamination is, therefore, expected to be limited to the area near release points.

B.2.2.6 Land Use and Exposure Scenarios

Human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact with or absorption of, groundwater, soil, or debris due to inadvertent disturbance of these materials, or irradiation by radioactive materials. Onsite workers and possibly site visitors may be potential receptors of contaminants from onsite water supply wells. These onsite receptors may be potentially

exposed to radionuclides and other hazardous materials in groundwater through ingestion, dermal contact, irradiation, or inhalation. The existing monitoring program of the water supply wells limits the potential for this exposure scenario.

The land use and exposure scenarios for the CAU 465 CASs are listed in Table B.2-3. These are based on current and future land use at the NNSS (DOE/NV, 1998). Although the CAU 465 CASs are located in areas near structures used for current activities, these sites are controlled access areas that preclude use as assigned work areas. Therefore, these sites are classified as Occasional Use Areas.

Table B.2-3
Land Use and Exposure Scenarios

CAS	Record of Decision Land Use Zone	Exposure Scenario
00-23-01 00-23-02 00-23-03	**Defense Industrial Zone** This land area is designated for stockpile management of weapons, including production, assembly, disassembly or modification, staging, repair, retrofit, and surveillance. Also included in this zone are permanent facilities for stockpile stewardship operations involving equipment and activities such as radiography, lasers, materials processing, and pulsed power.	**Occasional Use Area** Worker will be exposed to the site occasionally (up to 100 hours per year for 5 years). Site structures are not present for shelter and comfort of the worker.
06-99-01	**Reserved Zone (within the NNSS areas)** This land area includes areas and facilities that provide widespread flexible support for diverse short-term testing and experimentation. The reserved zone is also used for short-duration exercises and training, such as the Nuclear Emergency Search Team and Federal Radiological Monitoring and Assessment Center training and U.S. Department of Defense land-navigation exercises and training.	**Occasional Use Area** Worker will be exposed to the site occasionally (up to 100 hours per year for 5 years). Site structures are not present for shelter and comfort of the worker.

B.3.0 Step 2 - Identify the Goal of the Study

Step 2 of the DQO process states how environmental data will be used in meeting objectives and solving the problem, identifies study questions or decision statements, and considers alternative outcomes or actions that can occur upon answering the questions. Figures B.3-1 (subsurface releases) and B.3-2 (surface releases) depict the sequential flow of questions, answers, and action alternatives required to fulfill the objectives of the SAFER process.

B.3.1 Decision Statements

Subsurface Releases

For the subsurface component of CAU 465, the Decision I statement is as follows: "If there is a potential impact on groundwater, then implement engineering controls." For purposes of the flow and transport models, any COPC in groundwater determined to have a potential to exceed a FAL will result in that COPC being designated 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/NSO, 2006). If, through modeling, a COC is estimated to exceed FALs at the groundwater surface within 1,000 years, then additional engineering or institutional controls and/or corrective actions will be evaluated. If additional controls (e.g., installation of infiltration controls, soil cover) are determined to mitigate the COC contamination, adequate controls will be put in place.

Surface Releases

The Decision I statement for the surface component is as follows: "Is any COC present in environmental media within the CAS?" 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/NSO, 2006). If a COC is detected, then Decision II must be resolved.

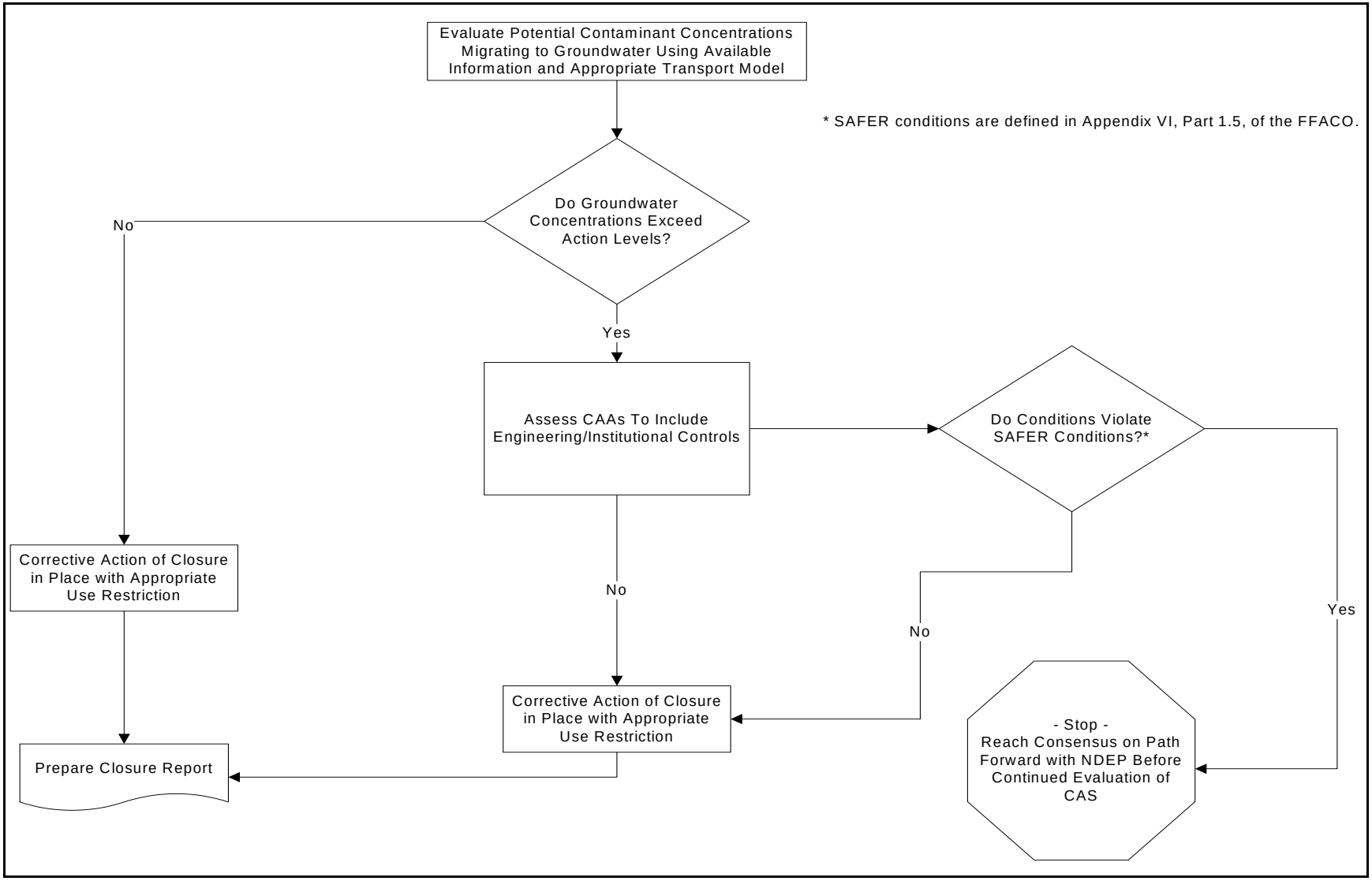


Figure B.3-1
SAFER Closure Decision Process for CAU 465 CASs (Subsurface Component)

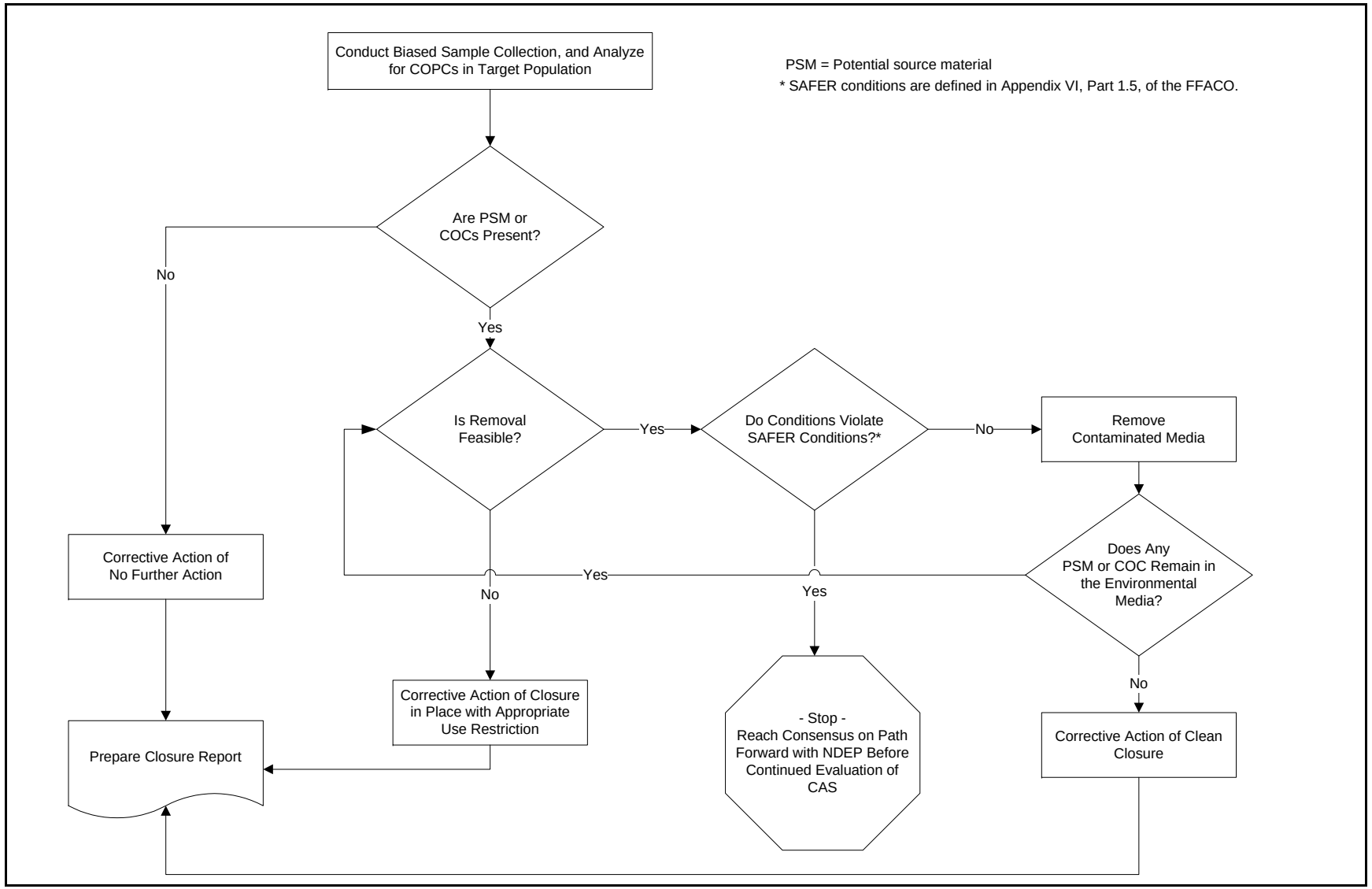


Figure B.3-2
SAFER Closure Decision Process for CAU 465 CASs (Surface Component)

The Decision II statement is as follows: "If a COC is present, is sufficient information available to meet the closure objectives?" Sufficient information is defined to include the following:

- The information that identifies the volume of media containing any COC bounded by analytical sample results in lateral and vertical directions.
- The information needed to characterize IDW for disposal.
- The information needed to determine potential remediation waste types.

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 was made that any physical waste containment would fail at some point and release the contaminants to the surrounding media. The following will be 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 not to 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 the waste and release of contaminants into soil) would be equal to the mass of the contaminant in the waste divided by the mass of the waste. If the resulting soil concentration exceeds the FAL, then the waste would be considered PSM.
    - For non-liquid wastes, the dose resulting from radioactive contaminants in soil (following degradation of the waste and release of contaminants into soil) would be calculated using the activity of the contaminant in the waste divided by the mass of the waste (for each radioactive contaminant) and calculating the combined resulting dose using the RESRAD computer code (Murphy, 2004). If the resulting soil concentration exceeds the FAL, then the waste would be considered PSM.

- For liquid wastes, the resulting concentration of contaminants in the surrounding soil would be calculated based on the concentration of contaminants in the waste and the liquid-holding capacity of the soil. If the resulting soil concentration exceeds the FAL, then the liquid waste would be considered PSM.

If sufficient information is not available to meet the closure objectives, then site conditions will be reevaluated and additional samples collected (as long as the scope of the CAI is not exceeded and any CSM assumption has not been shown to be incorrect).

B.3.2 Alternative Actions to the Decisions

This section identifies actions that may be taken to solve the problem depending on the possible outcomes of the CAI.

B.3.2.1 Alternative Actions to Decision I

Subsurface Releases

For the subsurface component of CAU 465, if the modeled contaminant concentrations in groundwater below the hydronuclear experiment and disposal boreholes do not exceed a FAL within 1,000 years, then the CAA of closure in place will be selected. If the modeled COC contamination in groundwater exceeds FALs within 1,000 years, then additional engineering or institutional controls and/or corrective actions will be evaluated for each CAS with COCs above FALs. If the implementation of engineering controls (e.g., soil cover, run-on controls, surface water diversion controls) is sufficient to reduce COC contamination below FALs, then closure in place and implementation of the necessary engineering controls will be implemented. If the implementation of engineering controls is shown not to reduce COC contamination below FALs, and/or engineering controls are not feasible, then work will stop and a consensus be reached with NDEP on the path forward before the investigation of the CAS may continue.

Surface Releases

For the surface component of CAU 465, if no COC associated with a release from the CAS is detected, then further assessment of the CAS component is not required, and the CAA of no further action will be selected. If a COC associated with a release from the CAS is detected, then additional sampling will be conducted to determine the extent of COC contamination. If the extent of the

contamination is defined and additional removal feasible, then clean close the site by removing the contaminated media until all contamination has been removed. If the extent of contamination has been determined and additional removal is not feasible, then the extent of contamination will be defined and the contaminated area closed in place with appropriate URs.

If the collection of verification samples confirms that all the contaminated media has been removed, then the clean closure objectives will have been met. If contamination still exists and additional removal would violate the conditions of the SAFER, then work will stop and a consensus be reached with NDEP on the path forward before the investigation of the CAS may continue.

B.3.2.2 Alternative Actions to Decision II

For the surface component, if sufficient information is available to define the extent of COC contamination and confirm that closure objectives were met, then further assessment of the CAS is not required. If sufficient information is not available to define the extent of contamination or confirm that closure objectives were met, then additional samples will be collected until the extent is defined.

B.4.0 Step 3 - Identify Information Inputs

Step 3 of the DQO process identifies the information needed, determines sources for information, and identifies sampling and analysis methods that will allow reliable comparisons with FALs.

B.4.1 Information Needs

Subsurface Releases

For the subsurface component of CAU 465, resolution of Decision I (evaluate potential impacts on groundwater) requires development of flow and contaminant transport models. Model development requires collection and/or analysis of the following:

- Existing geologic data
- Existing groundwater data
- Meteorological data
- Quantitative information on remaining source term
- Properties of contaminants

The selection of the model and specific input parameters to the selected model will be developed as part of the SAFER activity in conjunction with NDEP. The selection of the model and input parameters will be documented in the final CR for CAU 465.

Surface Releases

To resolve Decision I (determine whether a COC is present at a given CAS), samples need to be collected and analyzed following these two criteria:

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

To resolve Decision II (determine whether sufficient information is available to confirm that closure objectives were met at each CAS), samples must be collected and analyzed to meet the following criteria:

- Samples must be collected in areas contiguous to the contamination but where contaminant concentrations are below FALs.

- Samples of the waste or environmental media must provide sufficient information to characterize the IDW for disposal.

- Samples of the waste or environmental media must provide sufficient information to determine potential remediation waste types.

B.4.2 Sources of Information

Subsurface Releases

The information necessary to satisfy Decision I for the subsurface component of CAU 465 exists in current UGTA regional and site groundwater models, knowledge of source term and the contaminant characteristics, and understanding of contaminant transport mechanisms. This information will be integrated into models used to simulate contaminant transport in subsurface media.

Surface Releases

Information to satisfy Decision I and Decision II will be generated by collecting environmental samples using grab sampling, hand auguring, direct push, backhoe excavation, or other appropriate sampling methods. These samples will be submitted to analytical laboratories meeting the quality criteria stipulated in the Industrial Sites QAPP (NNSA/NV, 2002). Only validated data from analytical laboratories will be used to make DQO decisions. Sample collection and handling activities will follow standard procedures.

B.4.2.1 Sample Locations

Development of the flow and contaminant transport models will be completed utilizing existing data. It is not anticipated that any sampling or other field collection activities are necessary. Therefore, the following subsections apply only to the surface component.

Design of the sampling approaches for the surface component of CAU 465 must ensure that the data collected are sufficient for selection of the CAAs (EPA, 2002). To meet this objective, the samples collected from each site should be from locations that most likely contain a COC, if present (judgmental). These sample locations, therefore, can be selected by means of biasing factors used in judgmental sampling (e.g., a stain, likely containing a spilled substance). Because sufficient data are available to develop a judgmental sampling plan, this approach was used to develop plans for

sampling environmental media and PSM. Biasing factors include areas of elevated radiological readings, lead bricks, and stained soil and concrete.

B.4.2.1.1 Judgmental Approach for Sampling Location Selection

Decision I sample locations at CAU 465 will be determined based upon the likelihood of the soil containing a COC, if present at the CAS. These locations will be selected based on field-screening techniques, biasing factors, the CSM, and existing information. Analytical suites for Decision I samples will include the COPCs identified in Table B.2-2.

Field-survey techniques will be used to select appropriate sampling locations by providing semiquantitative data that can be used to comparatively select samples to be submitted for laboratory analyses from several screening locations. Field screening may also be used for health and safety monitoring and to assist in making certain health and safety decisions. The following field-screening methods and biasing factors may be used to select biased sample locations at CAU 465:

- Walkover radiological surveys: A radiological survey instrument will be used over approximately 100 percent of the CAS boundaries, as permitted by terrain and field conditions, to detect locations of elevated radioactivity.
- Preselected areas based on process knowledge of the site: Locations for which evidence such as historical photographs, experience from previous investigations, or input from interviewees, exists that a release of hazardous or radioactive substances may have occurred.
- Experience and data from investigations of similar sites.
- Visual indicators such as discoloration, textural discontinuities, disturbance of native soils, or any other indication of potential contamination. Stains are any discolored soil, material, or other surface and typically indicate the presence of an organic liquid such as oil.
- Presence of debris, waste, or equipment.
- Odor.
- Physical and chemical characteristics of contaminants.
- Other biasing factors: Factors not previously defined for the CAI, but become evident once the investigation of the site is under way.

Decision II sample step-out locations will be selected based on the CSM, biasing factors, and existing data. Analytical suites will include those parameters that exceeded FALs (i.e., COCs) in prior samples. Biasing factors to support Decision II sample locations include Decision I biasing factors plus available analytical results.

B.4.2.2 Analytical Methods

Analytical methods are available to provide the data needed to resolve the decision statements. The analytical methods and laboratory requirements (e.g., detection limits, precision, and accuracy) are provided in Tables 3-3 and 3-4.

B.5.0 Step 4 - Define the Boundaries of the Study

Step 4 of the DQO process defines the target population of interest and its relevant spatial boundaries, specifies temporal and other practical constraints associated with sample/data collection, and defines the sampling units on which decisions or estimates will be made.

B.5.1 Target Populations of Interest

Subsurface Releases

The population of interest to resolve Decision I for the subsurface component at CAU 465 is the groundwater extending vertically beneath the hydronuclear experiment and disposal boreholes within the CAS boundary that contains contaminant concentrations above a FAL.

Surface Releases

The population of interest to resolve Decision I ("Is any COC present in environmental media within the CAS?") is any location within the site that is contaminated with any contaminant above a FAL. The populations of interest to resolve Decision II ("If a COC is present, is sufficient information available to evaluate potential CAAs?") are as follows:

- Each one of a set of locations bounding contamination in lateral and vertical directions.
- IDW or environmental media that must be characterized for disposal.
- Potential remediation waste.
- Environmental media where natural attenuation or biodegradation or construction/evaluation of barriers is considered.

B.5.2 Spatial Boundaries

Spatial boundaries are the maximum lateral and vertical extent of expected contamination at each CAS, as shown in Table B.5-1. Contamination found beyond these boundaries may indicate a flaw in the CSM and may require reevaluation of the CSM before the investigation could continue. Each CAS is considered geographically independent, and intrusive activities are not intended to extend into the boundaries of neighboring CASs or existing URs from previously investigated CAUs.

Table B.5-1
Spatial Boundaries of CAU 465 CASs

CAS	Spatial Boundaries
00-23-01 00-23-02 00-23-03 06-99-01	The lateral boundary for surface releases is 500 ft (to allow for migration due to erosion); the vertical boundary (depth) is limited to 10 ft bgs.
	The lateral boundary for subsurface releases is the CAS boundary; the vertical boundary is the depth to the groundwater interface.
	The boundary for lead bricks is within 5 ft laterally and 10 ft bgs vertically from the bricks.

B.5.3 Practical Constraints

Practical constraints such as military activities at the NNSS, nature of classified materials, and/or access restrictions may affect the ability to investigate CAU 465.

B.5.4 Define the Sampling Units

The scale of decision making in Decision I is defined as the CAS component. Any COC detected at any location within the CAS component will cause the determination that the CAS component is contaminated and needs further evaluation. The scale of decision making for Decision II is defined as a contiguous area contaminated with any COC originating from the CAS. Resolution of Decision II requires this contiguous area to be bounded laterally and vertically.

B.6.0 Step 5 - Develop the Analytic Approach

Step 5 of the DQO process specifies appropriate population parameters for making decisions, defines action levels and generates an "If … then … else" decision rule that defines the conditions under which possible alternative actions will be chosen. This step also specifies the parameters that characterize the population of interest, specifies the FALs, and confirms that the analytical detection limits are capable of detecting FALs.

B.6.1 Population Parameters

Subsurface Releases

For the CAU 465 subsurface component, the population parameter is the maximum forecasted radionuclide concentration in groundwater within 1,000 years. The maximum forecasted result of each individual radionuclide contaminant will be compared to the FALs to determine resolution of Decision I.

Surface Releases

For judgmental sampling results, the population parameter is the observed concentration of each contaminant from each individual analytical sample. Each sample result will be compared to the FALs to determine the appropriate resolution to Decision I and Decision II. For Decision I, a single sample result for any contaminant exceeding a FAL would cause a determination that a COC is present within the CAS component.

The Decision II population parameter is an individual analytical result from a bounding sample. For Decision II, a single bounding sample result for any contaminant exceeding a FAL would cause a determination that the contamination is not bounded.

B.6.2 Action Levels

The PALs presented in this section are to be used for site-screening purposes. They are not necessarily intended to be used as cleanup action levels or FALs. However, they are useful in screening out contaminants that are not present in sufficient concentrations to warrant further

evaluation and therefore streamline the consideration of remedial alternatives. The RBCA process used to establish FALs is described in the *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). This process conforms with Section 445A.227 of the NAC, which lists the requirements for sites with soil contamination (NAC, 2008a). Section 445A.22705 of the NAC (NAC, 2008b) 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 neccessary remediation standards.

This RBCA process defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses:

- Tier 1 evaluation—Sample results from source areas (highest concentrations) are compared to action levels based on generic (non-site-specific) conditions (i.e., the PALs established in the SAFER Plan). 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 SSTLs using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 SSTLs 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. Total concentrations of TPH will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemicals of concern will be compared to the SSTLs.

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

The comparison of maximum forecasted results derived from the groundwater flow and transport models, and laboratory results to FALs and the evaluation of potential corrective actions will be included in the investigation report. The FALs will be defined and presented (along with the basis for their definition) in the investigation report.

B.6.2.1 Subsurface Releases

The radionuclide PALs for groundwater are defined as the concentrations of radionuclides corresponding to a human dose of 4 mrem/yr, or concentrations equal to drinking water standards (maximum contaminant levels) for other contaminants. The 4-mrem/yr dose regulatory limit is based

on the SDWA (CFR, 2011), and multiple radionuclides may contribute to the total dose. The total dose is the sum of the doses of all contributing radionuclides using a drinking water scenario (Adams, 1996a, 1996b). The individual contributions from each contaminant to the dose must be less than the regulatory limit. The PAL for lead was obtained from 40 CFR 141.80 (CFR, 2011).

B.6.2.2 Surface Releases

B.6.2.2.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the EPA Region 9 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2011). Background concentrations for RCRA metals and zinc will be used instead of screening levels when natural background concentrations exceed the screening level (e.g., arsenic on the NNSS). Background is considered the average concentration plus two standard deviations of the average concentration for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by the EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the investigation report.

B.6.2.2.2 Radionuclide PALs

The PAL for radioactive contaminants is a TED of 25 mrem/yr based upon the Industrial Area exposure scenario. The Industrial Area exposure scenario is described in the *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). For subsurface releases, the TED is calculated as the sum of external dose and internal dose. External dose is determined directly from TLD measurements. Internal dose is determined by comparing analytical results from soil samples to RRMGs that were established using the RESRAD computer code (Murphy, 2004). The RRMGs presented in Table B.6-1 are radionuclide-specific values for radioactivity in surface soils. The RRMG is the value, in picocuries per gram for surface soil, for a particular radionuclide that would result in an internal dose of 25 mrem/yr to a receptor (under the appropriate exposure scenario) independent of any other radionuclide (assuming that no other radionuclides contribute dose). The

internal dose associated with any specific radionuclide would be established using the following equation:

Internal dose (mrem/yr) = [Analytical result (pCi/g) / RRMG] × 25 mrem/yr

When more than one radionuclide is present, the internal dose will be calculated as the sum of the internal doses for each radionuclide. In the RESRAD calculation, several input parameters are not specified so that site-specific information can be used. Specific input parameters used to calculate the RRMGs for each exposure scenario where an area of contamination equal to 1000 m^2 and a depth of contamination equal to 5 cm.

Table B.6-1
Residual Radioactive Material Guideline Values

Radionuclide	Exposure Scenario (pCi/g)		
	Industrial Area	Remote Work Area	Occasional Use Area
Am-241	2,816	16,120	45,550
Co-60	551,300	7,229,000	74,210,000
Cs-137	140,900	1,955,000	27,560,000
Eu-152	1,177,000	13,240,000	81,740,000
Eu-154	846,900	9,741,000	63,530,000
Eu-155	5,588,000	66,450,000	475,100,000
Nb-94	3,499,000	39,660,000	249,200,000
Pu-238	2,423	13,880	39,220
Pu-239/240	2,215	12,680	35,820
Sr-90	59,470	807,500	9,949,000
Th-232	2,274	13,410	38,520
U-234	19,600	137,900	447,000
U-235	20,890	149,600	492,200
U-238	21,200	155,400	336,100

B.6.3 Decision Rules

B.6.3.1 Subsurface Releases

The decision rules applicable to Decision I are as follows:

- If the population parameter of any radionuclide COPC in the Decision I population of interest (defined in Step 4) exceeds the corresponding FAL within 1,000 years, then additional engineering controls and/or corrective actions will be evaluated. If the implementation of engineering controls (e.g., soil cover, run-on controls, surface water diversion controls) is sufficient to reduce COC contamination below FALs, then implement the necessary engineering controls. If the implementation of engineering controls is shown not to reduce COC contamination below FALs, and/or engineering controls are not feasible, then work will stop and a consensus be reached with NDEP on the path forward before the investigation of the CAS may continue.

- If no COC associated with a release for the CAS is forecasted by the flow and transport models, then further assessment of the CAS is not required.

B.6.3.2 Surface Releases

The decision rule applicable to both Decision I and Decision II is as follows:

- If COC contamination is inconsistent with the CSM or extends beyond the spatial boundaries identified in Section B.5.2, then work will be suspended and the investigation strategy reconsidered, else the decision will be to continue sampling to define the extent.

The decision rules for Decision I are as follows:

- If the population parameter of any COPC in the Decision I population of interest (defined in Step 4) exceeds the corresponding FAL, then that contaminant is identified as a COC, the contaminated material will be removed, or Decision II samples will be collected until an estimate of the extent of contaminated material has been made.

- If no COC associated with a release from the CAS is detected, then further assessment of the CAS is not required, and the CAA of no further action will be selected. If a COC associated with a release from the CAS is detected, then additional sampling will be conducted to determine the extent of COC contamination. If the extent of the contamination is defined and additional removal feasible, then clean close the site by removing the contaminated media until all contamination has been removed. If the extent of contamination has been determined and additional removal is not feasible, then the contaminated area will be closed in place with appropriate URs and the extent of contamination defined.

- 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 action will be necessary.

The decision rules for Decision II are as follows:

- If the population parameter (the observed concentration of any COC) in the Decision II population of interest (defined in Step 4) exceeds the corresponding FAL, then additional samples will be collected to complete the Decision II evaluation. If sufficient information is available to define the extent of COC contamination and confirm that closure objectives were met, then further assessment of the CAS is not required. If sufficient information is not available to define the extent of contamination or confirm that closure objectives were met, then additional samples will be collected until the extent is defined.

- If valid analytical results are available for the waste characterization samples defined in Section B.8.0, then the decision will be that sufficient information exists to characterize the IDW for disposal and determine potential remediation waste types, else collect additional waste characterization samples.

B.7.0 Step 6 - Specify Performance or Acceptance Criteria

Step 6 of the DQO process defines the decision hypotheses, specifies controls against false rejection and false acceptance decision errors, examines consequences of making incorrect decisions from the test, and places acceptable limits on the likelihood of making decision errors.

B.7.1 Decision Hypotheses

The baseline condition (i.e., null hypothesis) and alternative condition for Decision I are as follows:

- Baseline condition—A COC is present.
- Alternative condition—A COC is not present.

The baseline condition (i.e., null hypothesis) and alternative condition for Decision II are as follows:

- Baseline condition—The extent of a COC has not been defined.
- Alternative condition—The extent of a COC has been defined.

Decisions and/or criteria have false negative or false positive errors associated with their determination. The impact of these decision errors and the methods that will be used to control these errors are discussed in the following subsections. In general terms, confidence in DQO decisions based on judgmental sampling results will be established qualitatively by the following:

- Develop and achieve concurrence of CSMs (based on process knowledge) by stakeholder participants during the DQO process.
- Conduct validity testing of CSMs based on investigation results.
- Evaluate data quality based on DQI parameters.

B.7.2 False Negative Decision Error

B.7.2.1 Subsurface Releases

The false negative decision error would mean deciding that the forecasted maximum concentration of a COPC in groundwater within 1,000 years is less than FALs when it is actually greater. If this were the case, the potential consequence is an increased risk to human health and the environment.

B.7.2.1.1 False Negative Decision Error for CAU Groundwater Models

The objective of the flow and contaminant transport models is to forecast the concentrations of subsurface contaminants using a mathematical model. The forecast of a credible contaminant transport scenario must rely on the mathematical model being representative of reality, which depends on the accuracy of the conceptual model. The validity of the current conceptual model is believed to be sufficiently accurate based upon existing characterization and geologic information, and professional judgment.

The false negative decision error for the flow and contaminant transport models is controlled by meeting the following criteria:

- Use of conservative inputs to the model (e.g., hydrologic properties, transport mechanisms)
- Use of a robust and proven model
- Use of conservative estimates for source term (i.e., assumed the worst-case scenario of source term based on historical information)
- Use of a model that represents the hydrogeologic framework, hydraulic properties, and contaminant characteristics to achieve a reasonable degree of correspondence between model simulations and observations of the groundwater system

B.7.2.2 Surface Releases

The false negative decision error would mean deciding that a COC is not present when it actually is (Decision I), or deciding that the extent of a COC has been defined when it has not (Decision II). In both cases, the potential consequence is an increased risk to human health and the environment.

B.7.2.2.1 False Negative Decision Error for Judgmental Sampling

In judgmental sampling, the selection of the number and location of samples is based on knowledge of the feature or condition under investigation and on professional judgment (EPA, 2002). Judgmental sampling conclusions about the target population depend upon the validity and accuracy of professional judgment.

The false negative decision error (where consequences are more severe) for judgmental sampling designs is controlled by meeting these criteria:

- For Decision I, having a high degree of confidence that the sample locations selected will identify COCs if present anywhere within the CAS. For Decision II, having a high degree of confidence that the sample locations selected will identify the extent of COCs.
- Having a high degree of confidence that analyses conducted will be sufficient to detect any COCs present in the samples.
- Having a high degree of confidence that the dataset is of sufficient quality and completeness.

To satisfy the first criterion, Decision I samples must be collected in areas most likely to be contaminated by COCs (supplemented by random samples where appropriate). Decision II samples must be collected in areas that represent the lateral and vertical extent of contamination (above FALs). The following characteristics must be considered to control decision errors for the first criterion:

- Source and location of release
- Chemical nature and fate properties
- Physical transport pathways and properties
- Hydrologic drivers

These characteristics were considered during the development of the CSMs and selection of sampling locations. The field-screening methods and biasing factors listed in Section B.4.2.1 will be used to further ensure that appropriate sampling locations are selected to meet these criteria. Radiological survey instruments and field-screening equipment will be calibrated and checked in accordance with the manufacturer's instructions and approved procedures. The investigation report will present an assessment of the DQI of representativeness that samples were collected from those locations that best represent the populations of interest as defined in Section B.5.1.

To satisfy the second criterion, Decision I samples will be analyzed for the chemical and radiological parameters listed in Section 3.2. Decision II samples will be analyzed for those chemical and radiological parameters that identified unbounded COCs. The DQI of sensitivity will be assessed for all analytical results to ensure that all sample analyses had measurement sensitivities (detection limits) that were less than or equal to the corresponding FALs. If this criterion is not achieved, the

affected data will be assessed (for usability and potential impacts on meeting site characterization objectives) in the investigation report.

To satisfy the third criterion, the entire dataset, as well as individual sample results, will be assessed against the DQIs of precision, accuracy, comparability, and completeness as defined in the Industrial Sites QAPP (NNSA/NV, 2002) and in Section 7.2. The DQIs of precision and accuracy will be used to assess overall analytical method performance as well as the need to potentially "flag" (qualify) individual contaminant results when corresponding QC sample results are not within the established control limits for precision and accuracy. Data qualified as estimated for reasons of precision or accuracy may be considered to meet the constituent performance criteria based on an assessment of the data. The DQI for completeness will be assessed to ensure that all data needs identified in the DQO have been met. The DQI of comparability will be assessed to ensure that all analytical methods used are equivalent to standard EPA methods so that results will be comparable to regulatory action levels that have been established using those procedures. Strict adherence to established procedures and QA/QC protocols protects against false negatives. Site-specific DQIs are discussed in more detail in Section 7.2.

To provide information for the assessment of the DQIs of precision and accuracy, the following QC samples will be collected as required by the Industrial Sites QAPP (NNSA/NV, 2002):

- Field duplicates (minimum of 1 per matrix per 20 environmental samples)
- Laboratory QC samples (minimum of 1 per matrix per 20 environmental samples, or 1 per CAS per matrix if less than 20 collected)

B.7.3 False Positive Decision Error

B.7.3.1 Subsurface Releases

The false positive decision error would mean deciding that a COC is present when it is not, or a COC is unbounded when it is not, resulting in increased costs for additional modeling or implementation of unnecessary engineering or institutional controls.

False positive results could be due to overly conservative estimates for the source term and/or inaccurate inputs to the models (e.g., representation of hydrogeologic properties, groundwater levels). To control against false positive error,

- determination of source term will be based on available historical and technical data regarding quantities of radionuclides utilized in performance of the hydronuclear experiments, and
- readily accepted, established, and approved procedures will be utilized to generate the flow and contaminant transport models.

B.7.3.2 Surface Releases

The false positive decision error would mean deciding that a COC is present when it is not, or a COC is unbounded when it is not, resulting in increased costs for unnecessary sampling and analysis.

False positive results are typically attributed to laboratory and/or sampling/handling errors that could cause cross contamination. To control against cross contamination, decontamination of sampling equipment will be conducted in accordance with established and approved procedures, and only clean sample containers will be used. To determine whether a false positive analytical result may have occurred, the following QC samples will be collected as required by the Industrial Sites QAPP (NNSA/NV, 2002):

- Trip blanks (one per sample cooler containing VOC environmental samples)
- Equipment blanks (one per sampling event for each type of decontamination procedure)
- Source blanks (one per source lot per sampling event)
- Field blanks (minimum of one per CAS, additional if field conditions change)

B.8.0 Step 7 - Develop the Plan for Obtaining Data

Step 7 of the DQO process selects and documents a design that will yield data that will best achieve performance or acceptance criteria. In order to resolve Step 7 of the DQO process, the following actions will be implemented:

- Flow and contaminant transport models will be generated to evaluate impacts on groundwater.
- A judgmental sampling scheme will be implemented to select sample locations and evaluate analytical results for CAU 465.

Section B.8.1 contains information about collecting the necessary existing data to generate the flow and contaminant transport models. Section B.8.2 contains general information about collecting Decision I and Decision II samples under judgmental sampling designs and information about CAS-specific sampling activities, including proposed sample locations.

B.8.1 Subsurface Releases: Development of the Flow and Contaminant Transport Models

The objective of the CAI is to compile and evaluate current relevant data to forecast the concentrations of subsurface contaminants using a mathematical model. The stated purpose of the flow and transport models is to forecast maximum contaminant concentrations at the groundwater surface beneath the CAU 465 CASs during a period of 1,000 years. For each contaminant, the model will forecast the concentration at selected time steps from 0 to 1,000 years.

Due to both geographic and geologic differences, two models will be generated: one model for CASs 00-23-01, 00-23-02, and 00-23-03 in Area 27; and one model for CAS 06-99-01 in Area 6. The COPCs are based upon the known inventories of radiological materials (Tables 2-1 and 2-6). Although some components containing lead and other metals are known to have been left in the boreholes following the experiments, they are not believed to be in sufficient quantity and composition (e.g., leachable) to impact groundwater. Lead as a potential contaminant is assumed to be representative of other inorganic, nonradioactive, hazardous constituents, and is therefore considered a COPC.

The relevant data for the flow and transport models will come from the following sources:

- Data used to prepare this SAFER Plan, including data from relevant wells and springs
- Historical and technical data from the Weapons Program
- Data from ongoing groundwater monitoring activities

Following data gathering and compilation, the data are screened for quality. The screening process includes data documentation evaluation and data quality evaluation. The selection of the model and specific input parameters to the selected model will be developed as part of the SAFER activity in conjunction with NDEP. The selection of the model and input parameters will be documented in the final CR for CAU 465.

B.8.2 Surface Releases: Field Sampling

B.8.2.1 Decision I Sampling

A judgmental sampling design will be implemented for the Decision I investigation of the CAU 465 CASs. Because individual sample results, rather than an average concentration, will be used to compare to FALs at the CASs, statistical methods to generate site characteristics will not be used. Adequate representativeness of the entire target population may not be a requirement to developing a sampling design. If good prior information is available on the target site of interest, then the sampling may be designed to collect samples only from areas known to have the highest concentration levels on the target site. If the observed concentrations from these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006).

All sample locations will be selected to satisfy the DQI of representativeness in that samples collected from selected locations will best represent the populations of interest as defined in Section B.5.1. To meet this criterion for judgmentally sampled sites, a biased sampling strategy will be used for Decision I samples to target areas with the highest potential for contamination, if it is present anywhere in the CAS. Sample locations will be determined based on process knowledge, previously acquired data, or the field-screening and biasing factors listed in Section B.4.2.1. If biasing factors are present in soils below locations where Decision I samples were collected, additional Decision I soil samples will be collected at depth intervals selected by the Site Supervisor based on biasing

factors to a depth where the biasing factors are no longer present. The Site Supervisor has the discretion to modify the judgmental sample locations, but only if the modified locations meet the decision needs and criteria stipulated in this DQO.

The samples collected from each CAU 465 CAS should be from locations that most likely contain a COC, if present. Decision I sample locations at all of the CAU 465 CASs will be determined based upon the likelihood of the soil containing a COC, if present at the CAS. These locations will be selected based on field-survey techniques, biasing factors, the CSM, and existing information.

The following field-survey techniques will be used to select sample locations at CAU 465:

- Walkover surface area radiological surveys—A radiological survey instrument will be used over approximately 100 percent of the CAS boundary in Areas 6 and 27, as permitted by terrain and field conditions, to detect locations of elevated radioactivity.
- Visual field surveys—Visual field surveys will be conducted to select appropriate sampling locations to identify other areas of contamination and PSM.

Stains, Spills, and Debris

Collect a minimum of one sample within each identified area of potential contamination. Samples will be submitted for analysis according to the following:

- Lead brick(s) identified at CAS 00-23-02 will be removed and staged for disposition. Collect a minimum of one soil sample for total lead. If there are other biasing factors (e.g., elevated field radiological readings), then sample for gamma, isotopic Pu, and isotopic U.
- Collect a minimum of one sample each of stained soil and stained concrete pad at CAS 00-23-02. Decision I samples for soil will include VOCs, SVOCs, metals, PCBs, and HEs. Decision I samples for concrete will include VOCs, SVOCs, metals, and PCBs. If there are other biasing factors (e.g., elevated field radiological readings), then sample for gamma, isotopic Pu, and isotopic U.
- Other areas at all CAS locations where a potential release has been identified based upon biasing factors, including stains, spills, and debris (PSM). Collect a minimum of one sample at each location. Samples will be submitted for analysis based upon site conditions and process knowledge.

Drainages

Collect a minimum of one sample within each identified area of potential contamination as follows:

- In areas at all CAS locations where a potential release has been identified based upon visual and/or radiological surveys, investigate downgradient washes and drainages. Collect a minimum of one sample at each soil/sediment accumulation area. Samples will be submitted for analysis based upon site conditions and process knowledge.

B.8.2.2 Decision II Sampling

To meet the DQI of representativeness for Decision II samples (i.e., Decision II sample locations represent the population of interest as defined in Section B.5.1), judgmental sampling locations at each CAS will be selected based on the outer boundary sample locations where COCs were detected, the CSM, and other field-screening and biasing factors listed in Section B.4.2. In general, sample locations will be arranged in a triangular pattern around the Decision I location or area at distances based on site conditions, process knowledge, and biasing factors. If COCs extend beyond the initial step-outs, Decision II samples will be collected from incremental step-outs. Initial step-outs will be at least as deep as the vertical extent of contamination defined at the Decision I location, and the depth of the incremental step-outs will be based on the deepest contamination observed at all locations. A clean sample (i.e., COCs less than FALs) collected from each step-out direction (lateral or vertical) will define the extent of contamination in that direction. The number, location, and spacing of step-outs may be modified by the Site Supervisor, as warranted by site conditions.

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Appendix B

CAU 465 Hydronuclear Experiment
Water and Solute Travel Time Calculations

B.1.0 Introduction

This appendix addresses the potential for residual nuclear materials from the hydronuclear experiments addressed by CAU 465 to impact groundwater (i.e., the LCA or any perched water aquifers). These experiments are located within Areas 6 and 27 of the NNSS and involved various amounts of plutonium, enriched uranium, depleted uranium, natural uranium, and uranium oxide. HE was used in the experiments, but no nuclear yield was achieved. The experiments were all conducted in boreholes except for one that was conducted in a containment vessel. There are no known direct releases of radioactive materials to surface soil from these experiments (DOE/NV, 2001).

The HE detonations were designed to be efficient (high order); therefore, very little HE is assumed to remain after the detonations. The only other potential contaminant associated with the experiments that could be present in any appreciable amount is lead, which was used for shielding.

In Area 6, a total of 23 experiments were conducted in 20 boreholes (except for 1 experiment in a surface containment vessel) between September 1954 and September 1960. The minimum borehole depth was 25 ft, and the maximum borehole depth was 50 ft. A total mass of 930 lb (422 kilograms [kg]) of HE and less than 100 grams (g) of plutonium and 172 kg of depleted uranium was parsed among the Area 6 experiments, with differing amounts of HE and nuclear materials used in individual experiments (DOE/NV, 2001).

In Area 27, a total of 76 experiments were conducted in 76 boreholes between August 1960 and January 1966. The minimum borehole depth was 45 ft, and the maximum borehole depth was 80 ft. A total mass of 3,962 lb (1,797 kg) of HE, 38 kg of plutonium, 11 kg of enriched uranium, 433 kg of depleted uranium, 117 kg of natural uranium, and 66 kg of uranium oxide was parsed among the Area 27 experiments, with differing amounts of HE and nuclear materials used in individual experiments (DOE/NV, 2001).

B.1.1 Basis for Evaluating Contaminant Transport

Because the natural physical processes involved in the transport of radionuclides to groundwater are complex and variable, this evaluation uses established numerical relationships that describe these physical processes. Conservative simplifying assumptions and conservative numerical input

parameters are used in these numerical relationships that overestimate predictions of contaminant transport. This is done to compensate for uncertainties in the actual physical properties at each site and to provide an upper bound of possible contaminant transport velocities and distances.

This evaluation approach used a 1-D (downward only with no dispersion, diffusion, or dilution) analysis of water and solute travel rates through the unsaturated subsurface hydrological environment (i.e., vadose zone material) to groundwater. It was conducted by establishing a vertical velocity of infiltrating water through the vadose zone (based on the steady-state aquifer recharge). The movement of infiltrating water through the vadose zone is the driver for contaminant transport. However, contaminants move through the vadose zone material at a slower rate than does water due to physical and chemical interaction with the vadose zone material. The ratio of the water velocity to the contaminant velocity is defined as the retardation factor. Therefore, the vertical velocity of the contaminant will depend on the vertical velocity of infiltrating water through the vadose zone and the retardation factor. The potential vertical velocity of infiltrating water through the vadose zone under saturated conditions is calculated as

$$v_w = \frac{q}{n_e} \qquad \text{(B.1-1)}$$

where

v_w = vertical velocity of pore water (L/t)
q = steady-state recharge rate (L/t)
n_e = effective porosity (dimensionless [–])

The effective porosity is defined as the interconnected water-filled pore spaces that can conduct water through the geologic matrix. The interconnected water-filled pore space can be grossly estimated as the entire volume of soil water (i.e., volumetric) under saturated conditions. Within the vadose zone, air occupies a fraction of the pore space, and the water vertical velocity can be faster than that identified for saturated flow (Equation B.1-1). The water vertical velocity for unsaturated flow is calculated as

$$v_w = \frac{q}{\theta} \qquad \text{(B.1-2)}$$

where

v_w = vertical velocity of pore water (L/t)
q = steady-state recharge rate (L/t)
θ = volumetric water content (dimensionless [–])

The potential vertical contaminant velocity is calculated as

$$v_c = \frac{v_w}{R_f} \quad \text{(B.1-3)}$$

where

v_c = vertical velocity of the contaminant (L/t)
v_w = vertical velocity of pore water (L/t)
R_f = retardation factor (dimensionless [–])

Combining these two equations results in the following equation for the vertical contaminant velocity:

$$v_c = \frac{q}{\theta \; x \; R_f} \quad \text{(B.1-4)}$$

where

v_c = vertical velocity of the contaminant (L/t)
q = steady-state recharge rate (L/t)
θ = volumetric water content (dimensionless [–])
R_f = retardation factor (dimensionless [–])

The distance a contaminant will migrate through geologic material is defined as the vertical contaminant velocity multiplied by a specified time interval in the following equation:

$$d_i = v_c \times t \quad \text{(B.1-5)}$$

where

d_i = distance (of the contaminant into the geologic layer [L])
v_c = vertical velocity of the contaminant (L/t)
t = specified time interval to be evaluated (t) (see Section B.1.2)

The time required for a contaminant to migrate through geologic material is defined as the thickness of the geologic layer (distance) divided by the vertical velocity of the contaminant (speed) in the following equation:

$$t = \frac{d_i}{v_c} \quad \text{(B.1-6)}$$

where

t = time required for a contaminant to migrate through a geologic layer (t)
d_i = thickness of the geologic layer (L)
v_c = vertical velocity of the contaminant (L/t)

The information needed to resolve these equations is developed and discussed in Section B.2.0. Because the geologic material overlying the regional aquifer comprises several layers with differing physical properties, potential contaminant migration times are calculated for each stratigraphic layer. The resulting contaminant migration times to reach groundwater and the contaminant migration depths in 1,000 years are calculated in Section B.3.0. Because there are uncertainties associated with the input parameters presented in Section B.2.0, a sensitivity assessment of the most uncertain parameters is presented in Section B.4.0. Section B.5.0 presents the conclusions of this water and solute travel time evaluation.

B.1.2 Evaluation Criteria

The following criterion is used to answer the study question "Will residual contaminants from the hydronuclear experiments impact groundwater?":

- Does the estimated concentration of any contaminant exceed regulatory levels for drinking water at the groundwater interface within 1,000 years?

The 1,000-year time period is specified in the UGTA Strategy contained in Appendix VI to the FFACO (1996, as amended) for determining groundwater contamination perimeter boundaries. Contaminant forecast reliability is inversely proportional to the length of forecast time period, and this analysis assumes that 1,000 years is the limit of the forecast reliability period and regulatory concern.

This document focuses on answering the simple question of whether contaminant travel to the perched water or LCA will occur within 1,000 years. Determining the contaminant concentrations upon arrival to the perched water or LCA is not addressed in this document because the calculated arrival times exceed 1,000 years. The travel time to the LCA is of primary concern because the LCA is regionally extensive and serves as an important water resource for much of southern Nevada.

The travel time to the perched water within the volcanic rock confining units at the Areas 6 and 27 CASs is of less importance because the low permeability of the rock prevents the perched water from providing a sustainable water supply to wells and springs.

B.1.3 Evaluation Assumptions

This travel time analysis includes the following conservative and bounding assumptions:

- **Use of the highest estimated recharge rates.** The recharge rates used in this analysis are the highest obtained from available recharge models (see Section B.2.2). Because transport of contaminants through the vadose zone is driven by the flow of water to groundwater, higher recharge flow rates will result in higher contaminant travel rates.

- **Restricted lateral water movement.** Lateral water movement will occur in the natural environment, but the amount of lateral movement is unknown. While restricting lateral movement is unrealistic, it is conservative in that it will underestimate the water travel distance as well as contaminant dilution and dispersion. This will result in underestimating the time needed to reach groundwater and overestimating contaminant concentrations.

- **Unlimited source term.** These calculations assume that the amount of contaminant is not limited throughout the evaluated time period (1,000 years). This is a conservative but reasonable assumption. While radiological decay is ignored, the half-life of plutonium is much greater than the evaluated time period.

B.2.0 Hydrogeologic Data

The input parameters needed to resolve the contaminant transport calculations are listed in Table B.2-1 with the corresponding sections that define the values for these parameters. The rationale used in developing a value for each parameter is also explained in the referenced section. The effect that changes in these input parameter values have on contaminant travel distances and times (sensitivity analysis) is presented in Section B.4.0.

Table B.2-1
Contaminant Transport Calculation Input Parameters

Parameter	Definition	Section
d_i	Distance (L)	B.2.1
q	Steady-state recharge rate (L/t)	B.2.2
θ	Volumetric water content (dimensionless [-])	B.2.3
V_w	Vertical velocity of pore water (L/t)	B.2.4
R_f	Retardation factor (dimensionless [-])	B.2.5

B.2.1 Stratigraphic Data and Water Elevations

This section develops the values to be used for the thickness of the geologic layer input parameter. Because the geological material between the contaminant source and the underlying aquifers comprises several layers of differing material, thickness values are established for each layer.

The hydronuclear site in Area 6 (CAS 06-99-01) is located adjacent to the southeast border of the Yucca Lake playa. Yucca Flat is a topographically closed extensional basin that tilts southward, with ground surface elevations on the floor of the basin decreasing from about 1,460 m in the north to about 1,195 m on the Yucca Lake playa to the south.

The hydronuclear experiment sites in Area 27 (CASs 00-23-01, 00-23-02, and 00-23-03) are located in close proximity to one another in the north-central part of Area 27 at an elevation of 1,314 m.

The tuff confining units at the CASs in Areas 6 and 27 act as a confining layer above the LCA. The LCA water potentiometric elevation exceeds the LCA stratigraphic layer top by several hundred

meters, and a higher perched water table is found within the volcanic rock (N-I, 2012). The saturated volcanic rocks above the LCA at the CASs in Areas 6 and 27 are generally unproductive as a water resource, and the travel time to the saturated LCA is the primary concern. The presence of confining conditions and perched water at each CAS indicates that the volcanic rock is not extensively fractured and that groundwater flow is primarily occurring in the rock matrix.

Wells or boreholes very near the CASs in Areas 6 and 27 providing rock stratigraphy observations down to the saturated LCA are not available. The emplacement boreholes at each CAS are shallow and only extend to the experiment emplacement depth. Therefore, estimation of stratigraphy from both Areas 6 and 27 must rely on geologic models that incorporate geologic and geophysical data, and the knowledge of geoscientists. The following three-dimensional (3-D), CAU-scale, NNSS-scale, and regional-scale hydrostratigraphic framework models (HFMs) are available for estimating stratigraphy at the CASs in Areas 6 and 27:

1. **The Yucca Flat HFM.** A 3-D HFM for the groundwater flow system at CAU 97, Yucca Flat/Climax Mine, is documented in *A Hydrostratigraphic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Unit 97: Yucca Flat–Climax Mine, Lincoln and Nye Counties, Nevada* (BN, 2006).

2. **The NNSS-scale HFM.** A 3-D HFM for the groundwater flow system at the NNSS is documented in the *Groundwater Flow Model Documentation Package (Underground Test Area Subproject Phase I Data Analysis Task, Volume VI)* (IT, 1996).

3. **The Death Valley Regional Ground-Water Flow System (DVRFS) HFM.** A 3-D HFM for the groundwater flow system in the Death Valley region is documented in the *Death Valley Regional Ground-Water Flow System, Nevada and California—Hydrogeologic Framework and Transient Ground-Water Flow Model* (Belcher et al., 2004).

The Yucca Flat HFM model area includes Yucca Flat and Climax Mine former nuclear testing areas and proximal areas. The model area is approximately 1,250 square kilometers (km^2) in size. A diverse set of geological and geophysical data collected over the past 50 years was used to develop a structural model and hydrostratigraphic system for the basin. These data were integrated by the use of the EarthVision software to develop the 3-D HFM. Fifty-six stratigraphic units in the model area were grouped into 25 hydrostratigraphic units (HSUs) based on each unit's propensity toward aquifer or aquitard characteristics.

The NNSS-scale HFM encompasses the groundwater flow system underlying the NNSS, along with a large part of southern Nevada and part of Inyo County in eastern California. The area extends over 80,650 km^2. Cross-sectional hydrostratigraphy, maps of the geographic extent of the units, surface geology, and digital elevations were combined to generate contoured upper surfaces of each HSU. The Geographic Information Systems (GIS)-based environmental resource management applications (ERMA) computer system was used to integrate the geologic data. The ERMA model was later converted into the EarthVision software by UGTA staff.

The DVRFS HFM incorporates decades of groundwater flow studies performed at the NNSS and the Yucca Mountain site. The model area includes the entire groundwater flow system in the Death Valley region and extends over a large area of southern Nevada and the adjacent area of California, encompassing approximately 100,000 km^2. Several software packages were used to interpret and analyze geologic data, but the HFM itself was constructed by the use of the Landmark Graphics Stratamodel software. The model developed with the Stratamodel software was later converted into the EarthVision software by UGTA staff.

The Yucca Flat basin is well characterized compared to other areas on the NNSS. A total of 656 nuclear tests were performed in Yucca Flat, and each test included a subsurface characterization effort with several boreholes. The Yucca Flat HFM includes the most current understanding of stratigraphy within the Yucca Flat basin, and the stratigraphic units defined in this HFM were used as analog HSUs for stratigraphy at the Area 6 CAS. The rock below the Area 6 CAS down to the saturated LCA, which is located 1,193 m bgs, includes alluvium and Tertiary volcanics. The rock includes clay-rich bedded tuffs, sediments and paleocolluvium, thick zeolitized tuff confining units with reduced permeability, thin and fractured welded tuff, and porous vitric-tuff aquifers (BN, 2006).

At the Area 27 CASs, the number of boreholes that penetrate the saturated LCA is limited and the subsurface is less characterized. Nonetheless, the NNSS-scale HFM and the DVRFS HFM incorporate data from near the CASs in Area 27 and knowledge of NNSS geoscientists. The DVRFS HFM provides the most current understanding of the Area 27 stratigraphy and more detail than the NNSS-scale HFM. The stratigraphic units defined in the DVRFS HFM were used as analog HSUs for the stratigraphy at the Area 27 CASs. The layered rock sequence down to the saturated LCA, which is located 794 m bgs, is similar to that at the Yucca Lake playa, but the depth to the saturated LCA is

much less, and welded-tuff aquifers may be absent. Most of the volcanic rock is zeolitized tuff with reduced permeability (Belcher et al., 2004).

Water elevations used in the analysis are extracted from the UGTA Borehole Index Database (N-I, 2012), containing U.S. Geological Survey (USGS) and UGTA water-level data. For the Area 6 CAS, the LCA potentiometric surface is from Well USGS C located approximately 2.3 kilometers (km) south, and the perched volcanic water table is from USGS Test Well B Ex located approximately 4.4 km north. For the Area 27 CASs, the LCA potentiometric surface and perched volcanic water table elevations are from the nearby Well USGS HTH F located approximately 1.6 km south of the CASs. The device emplacement depth is assumed to be the maximum borehole depth at each CAS. Figure B.2-1 summarizes the thicknesses of the stratigraphic layers below the maximum emplacement depth and distances to perched water and the LCA at the Areas 6 and 27 CASs, respectively.

B.2.2 Steady-State Recharge Rate

This section develops the values used for the steady-state recharge rate (q) input parameter. This parameter value is developed by using several models and selecting the most conservative predicted value for each site.

The climate at the NNSS is one of the most arid within the United States. The potential evapotranspiration (PET) is the maximum water loss to the atmosphere that can occur. The PET greatly exceeds the average annual precipitation, and the net infiltration (aquifer recharge) is a small fraction of precipitation. For example, the Yucca Flat average rainfall based on a 47-year record is 160 millimeters per year (mm/yr), and the PET is 1,480 mm/yr (SNJV, 2009).

Processes such as runoff and evapotranspiration reduce the quantity of precipitation that flows through the unsaturated geologic material (vadose zone) to recharge groundwater. Precipitation-derived recharge is the driving mechanism that moves contamination down toward the water table. Recharge models take into account the processes that influence precipitation and

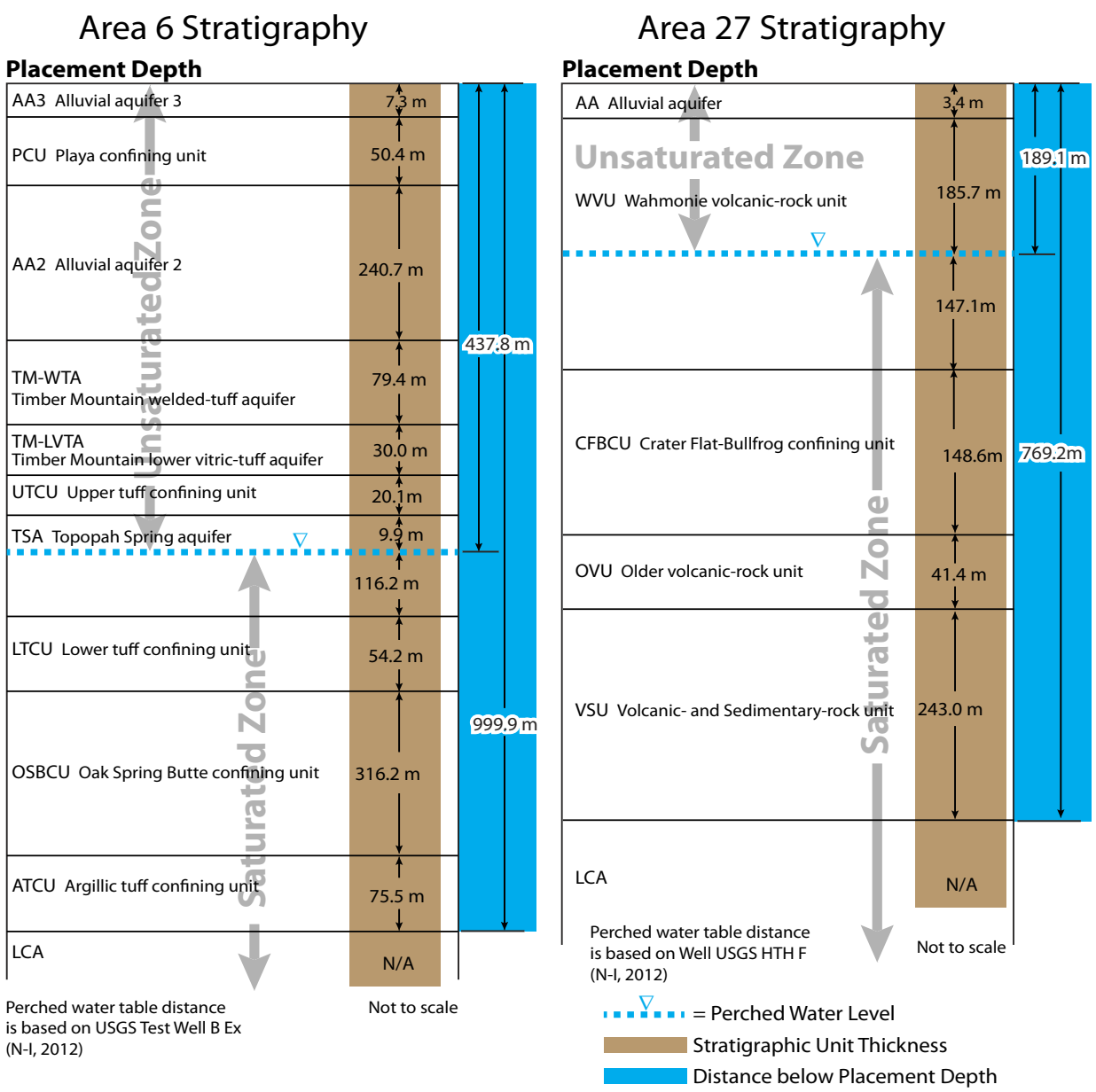

Figure B.2-1
Areas 6 and 27 Stratigraphy

recharge. The Rainier Mesa hydrologic data document (SNJV, 2008) examines four recharge models using the most realistic assumptions. These are as follows:

1. **The UGTA revised model** (SNJV, 2004) uses the empirical Maxey-Eakin recharge method. This method relies on the concept that fixed percentages of precipitation become recharge in different elevation or precipitation zones. The UGTA revised model also allows some fraction of the estimated recharge in upland areas to be redistributed along adjacent downstream washes.

2. **The USGS distributed-parameter watershed model** (Hevesi et al., 2003) uses a spatially distributed soil-water budget method. This method considers physical processes affecting soil drainage, runoff, and evapotranspiration. The USGS distributed-parameter watershed model presented in the Rainier Mesa hydrologic data document (SNJV, 2008) includes re-infiltration of runoff.

3. **The USGS DVRFS model** (Belcher et al., 2004) is the USGS distributed-parameter watershed model with infiltration values scaled during calibration of the DVRFS model.

4. **The Desert Research Institute (DRI) chloride mass-balance model** (Russell and Minor, 2002) uses an elevation-dependent chloride mass-balance method. This method estimates recharge from the increase in the chloride concentration in the soil water or spring discharge water relative to the chloride concentration in precipitation. The model was calibrated and verified against regional spring measurements, and superimposes additional limits on infiltration based on observations that infiltration is negligible in thick alluvium or below a certain elevation.

Variability in recharge predicted by the four recharge models is considerably larger at the Area 27 CASs than at the Area 6 CAS. The recharge predicted by the models is 0 to 20 mm/yr for the Area 27 CASs and 0 to 5 mm/yr for the Area 6 CAS. The recharge rates used in this analysis are assumed to be the highest of the four models very near each CAS. Therefore, 5 mm/yr for the Area 6 CAS and 20 mm/yr for the Area 27 CASs are used in this evaluation. Table B.2-2 summarizes the recharge rates predicted by the models. Figure B.2-2 illustrates the areal recharge rates estimated by each recharge model.

Table B.2-2
Recharge Rates Predicted by Recharge Models

Model	Area 6		Area 27	
	(mm/yr)			
	Minimum	Maximum	Minimum	Maximum
UGTA Revised Model	0	0	2	5
USGS Distributed-Parameter Watershed Model	0	0	0	20
USGS DVRFS Model	0	5	2	10
DRI Chloride Mass-Balance Model	0	0	2	5

B.2.3 Volumetric Water Content

This section develops the values to be used for the volumetric water content (θ) input parameter. Because the geological material between the contaminant source and the underlying aquifers comprises several layers of differing material, volumetric water content values are established for each layer.

Under unsaturated conditions, relative hydraulic conductivity ($K(h)$), volumetric water content (θ), and matric potential head (h) are interrelated. The matric potential head is negative relative to saturated conditions due to the surface tension of water in pore capillaries and on grain surfaces. Characterization of unsaturated flow requires two constitutive relationships for each material type identified in the subsurface: (1) the moisture characteristic curve, which is the relationship between the matric potential and water content, and (2) the hydraulic conductivity curve, which is the relationship between the matric potential and the unsaturated hydraulic conductivity.

The van Genuchten (1980) equation was used to represent the constitutive relationships between the hydraulic properties. The equation for the moisture characteristic curve is

$$\theta = \theta_r + \frac{(\theta_s - \theta_r)}{[1 + (\alpha h)^n]^{1-\frac{1}{n}}} \qquad \text{(B.2-1)}$$

where

θ = volumetric water content (dimensionless [–])
θ_r = residual volumetric water content (–)
θ_s = saturated volumetric water content (–)
α = inverse air-entry potential (L^{-1})
h = matric potential head (length [L])
n = pore-size distribution index parameter (–)

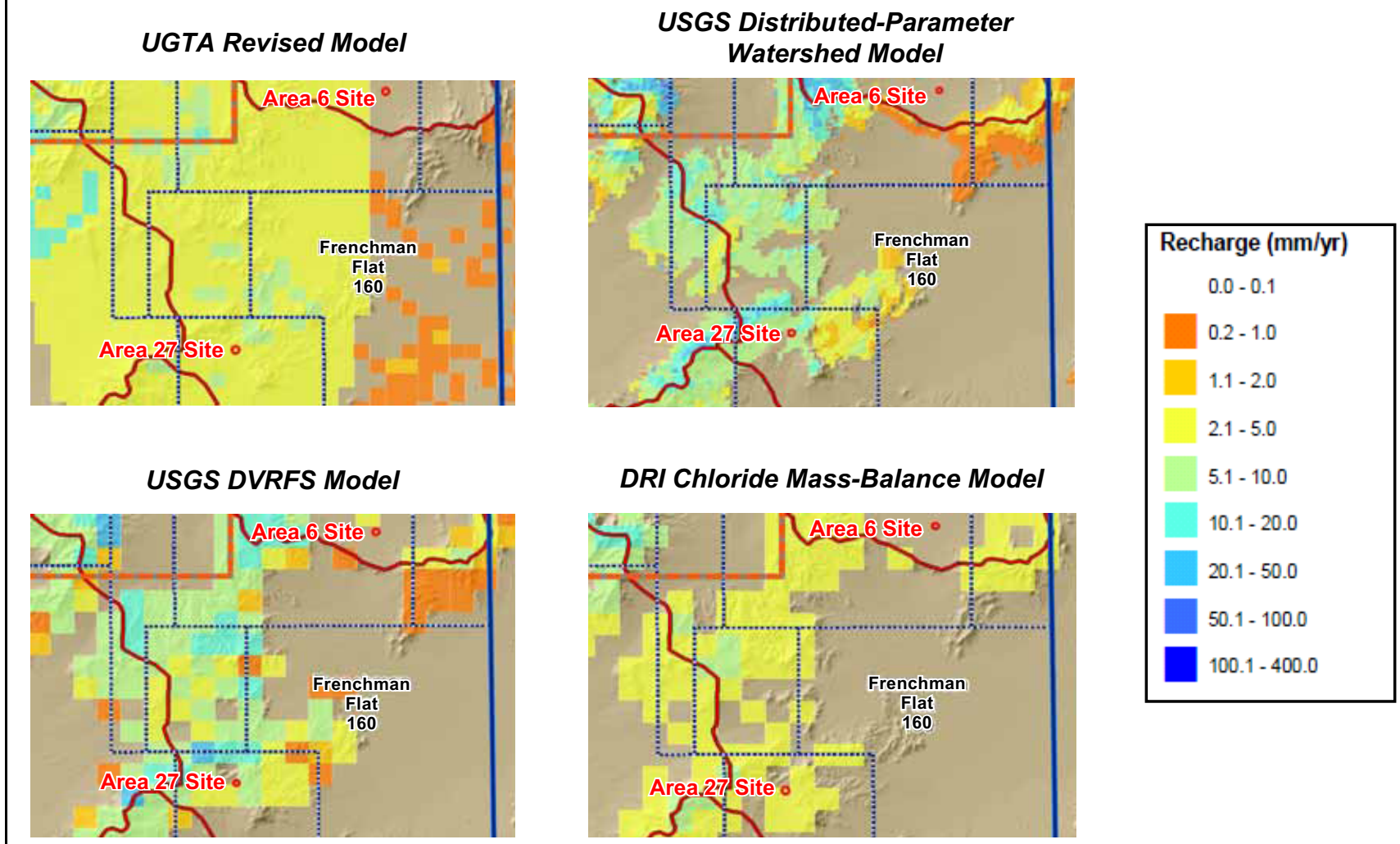

Figure B.2-2
Areal Recharge Rates Estimated by Recharge Models
Source: Modified from SNJV, 2008

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When the van Genuchten function is combined with the Mualem conductivity model (Mualem, 1976), the equation for the hydraulic conductivity curve is

$$K(h) = K_s \frac{\{1-(\alpha h)^{n-1}[1+(\alpha h)^n]^{1-1/n}\}^2}{[1+(\alpha h)^n]^{0.5(1-1/n)}} \quad \text{(B.2-2)}$$

where

$K(h)$ = unsaturated hydraulic conductivity (length per time [L/t])
K_s = saturated hydraulic conductivity (L/t)

Equations B.2-1 and B.2-2 illustrate that water content and matric potential head in the unsaturated zone are nonlinear functions of the recharge passing through them. Under steady-state flow conditions, the rock water content will correspond to an unsaturated hydraulic conductivity that is equivalent to the recharge rate. The water content for each rock layer is calculated by solving Equation B.2-2 for matrix potential head and then solving equation Equation B.2-1 for volumetric water content.

Kwicklis et al. (2009) performed an analysis of core-scale data from boreholes at Rainier Mesa. Hydraulic properties and mineralogic data were measured for 28 cores from borehole UE12t #1 and 32 cores from borehole RME #1. The cores represented ash-flow and fallout tuffs subjected to varying degrees of welding and post-depositional alteration. Kwicklis et al. (2009) used the data to calculate representative parameter sets for individual stratigraphic units and HSUs at Rainier Mesa.

Bechtel Nevada (BN) (1998) presents characterization data from the Area 3 Radioactive Waste Management Site (RWMS) at Yucca Flat. These data included measurements of alluvium unsaturated flow properties from within and adjacent to the collapse craters. The Yucca Flat hydrologic source term document (SNJV, 2009) describes unsaturated flow transport modeling of detonations within the alluvium at Yucca Flat using the RWMS 3 data.

In general, there are very few or no measurements of subsurface moisture characteristics for the NNSS. The volumetric water contents in this analysis are determined using the available unsaturated data with similar lithologies to each of the Areas 6 and 27 stratigraphic layers. Rainier Mesa analog HSUs are assigned to each of the Areas 6 and 27 Tertiary volcanic rock layers and moisture characteristics from Kwicklis et al. (2009) are used. The alluvium and PCU soil moisture

characteristics are taken from the Stoller-Navarro Joint Venture (SNJV) (2009) and BN (1998) documents. Tables B.2-3 and B.2-4 summarize the hydraulic properties and Rainier Mesa analog HSUs assigned to the stratigraphic layers for the CAU 465 CASs in Areas 6 and 27, respectively.

Table B.2-3
CAU 465 Area 6 Hydraulic Properties

HSU	Rainier Mesa Analog HSU	K_s (mm/yr)	θ_s (–)	θ_r (–)	α (1/m)	n (–)	Calculated Water Content at Recharge Rate of 5 mm/yr (–)
AA3[a]	N/A	195,689	0.412	0.142	1.03	1.789	0.188
PCU[b]	N/A	2,664	0.43	0.248	0.253	2.15	0.303
AA2[a]	N/A	195,689	0.412	0.142	1.03	1.789	0.188
TM-WTA[c]	TM-WTA	3,700	0.208	0.0017	0.2155	1.384	0.122
TM-LVTA2[c]	TM-LVTA	8,960	0.366	0.0225	0.4706	1.911	0.117
UTCU[c]	BRCU	19.5	0.324	0.0	0.03049	1.308	0.320
TSA[c]	TM-WTA	3,700	0.208	0.0017	0.2155	1.384	0.122
LTCU[c]	OSBCU	66.1	0.292	0.0047	0.05198	1.368	0.292
OSBCU[c]	OSBCU	66.1	0.292	0.0047	0.05198	1.368	0.292
ATCU[c]	ATCU	212	0.264	0.0	0.05496	1.194	0.264

[a]Alluvium unit hydraulic properties are from SNJV (2009) Table 5-1.
[b]PCU hydraulic properties are for the lowest K_s sample from BN (1998).
[c]Tertiary volcanic rock HSU hydraulic properties are from Kwicklis et al. (2009) Table 6.

BRCU = Belted Range confining unit

Table B.2-4
CAU 465 Area 27 Hydraulic Properties

HSU	Rainier Mesa Analog HSU	K_s (mm/yr)	θ_s (–)	θ_r (–)	α (1/m)	n (–)	Calculated Water Content at Recharge Rate of 5 mm/yr (–)
AA[a]	N/A	195,689	0.412	0.142	1.03	1.789	0.202
WVU[b]	TM-LVTA	8,960	0.366	0.0225	0.4706	1.911	0.149
CFBCU[b]	BRCU	19.5	0.324	0.0	0.0305	1.308	0.324
OVU[b]	OSBCU	66.1	0.292	0.0047	0.0520	1.368	0.292
VSU[b]	OSBCU	66.1	0.292	0.0047	0.0520	1.368	0.292

[a]Alluvium unit hydraulic properties are from SNJV (2009) Table 5-1.
[b]Tertiary volcanic rock HSU hydraulic properties are from Kwicklis et al. (2009) Table 6.

B.2.4 Vertical Velocity of Pore Water

This section develops the vertical velocity of pore water (v_w) values that are used to calculate contaminant travel distances and arrival times. As the geological material between the contaminant source and the underlying aquifers comprises several layers of differing material, vertical velocities of pore water are established for each layer.

As described in Equation B.1-2, the vertical velocity of pore water is calculated as the steady-state recharge rate (as developed in Section B.2.2) divided by the volumetric water content (as developed in Section B.2.3). The vertical velocity for each stratigraphic layer for the CAU 465 CASs is presented in Tables B.2-5 and B.2-6 for Areas 6 and 27, respectively, with the calculated or saturated water content. If the stratigraphic layer extends below the perched water table, the porosity is assumed to be the water content.

Table B.2-5
CAU 465 Area 6 Vertical Velocity of Pore Water

HSU	Rainier Mesa Analog HSU	Water Content at Recharge Rate of 5 mm/yr (–)	Pore Water Vertical Velocity (mm/yr)
AA3[a]	N/A	0.188	26.7
PCU[b]	N/A	0.303	16.5
AA2[a]	N/A	0.188	26.7
TM-WTA[c]	TM-WTA	0.122	41.0
TM-LVTA2[c]	TM-LVTA	0.117	42.7
UTCU[c]	BRCU	0.320	15.6
Unsaturated TSA[c]	TM-WTA	0.122	41.0
Saturated TSA[c]	TM-WTA	0.208	24.0
LTCU[c]	OSBCU	0.292	17.1
OSBCU[c]	OSBCU	0.292	17.1
ATCU[c]	ATCU	0.264	18.9

[a]Alluvium unit hydraulic properties are from SNJV (2009) Table 5-1.
[b]PCU hydraulic properties are for the lowest K_s sample from BN (1998).
[c]Tertiary volcanic rock HSU hydraulic properties are from Kwicklis et al. (2009) Table 6.

Table B.2-6
CAU 465 Area 27 Vertical Velocity of Pore Water

HSU	Rainier Mesa Analog HSU	Water Content at Recharge Rate of 20 mm/yr (–)	Pore Water Vertical Velocity (mm/yr)
AA	N/A	0.202	99.0
Unsaturated WVU	TM-LVTA	0.149	134.3
Saturated WVU	TM-LVTA	0.366	54.6
CFBCU	BRCU	0.324	61.7
OVU	OSBCU	0.292	68.5
VSU	OSBCU	0.292	68.5

B.2.5 Retardation Factor

This section develops the values to be used for the retardation factor (R_f) input parameter. Because the geological material between the contaminant source and the underlying aquifers comprises several layers of differing material, retardation factors are established for each layer.

Sorption is a physiochemical process at the mineral-water interfaces that retard contaminant mobility within the geologic matrix. Calculating the contaminant retardation factors requires knowledge of the bulk density and water content of the matrix along with a partition (or distribution) coefficient (K_d) parameter. The K_d parameter combines a variety of molecular-scale processes (e.g., surface complexation and ion exchange) into an effective relationship between the amount of contaminant sorbed to the rock and the amount of contaminant in solution. The K_d parameter value is defined as

$$K_d = \frac{Mass\ of\ adsorbed\ solute\ per\ gram\ of\ solid\ phase}{Mass\ of\ solute\ per\ milliliter\ of\ solution} \quad \text{(B.2-3)}$$

The K_d values are applicable to specific contaminants in specific geologic material. The partition coefficients of uranium, lead, and plutonium as a function of pH are summarized by the U.S. Environmental Protection Agency (EPA) (2009). The adsorption of lead increases with higher soil pH levels, as is typically at the NNSS. For example, alluvium groundwater pH has be measured

at values ranging from 7.4 to 8.3 at Yucca Flat (SNJV, 2007). The EPA (2009) K_d values within the pH range of Yucca Flat alluvium groundwater are as follows:

- Uranium K_d values range from approximately 0.080 to 80,000 milliliters per gram (mL/g), with an average value of 3,000 mL/g.
- Lead K_d values range from approximately 700 to 4,000 mL/g, with an average value of 2,000 mL/g.
- Plutonium K_d values range from approximately 100 to 2,000 mL/g, with an average value of 1,000 mL/g.

Decker et al. (2003) evaluated the temperature dependence of lead sorption on small number of Pahute Mesa and Rainier Mesa tuff samples, and Papelis and Um (2003) evaluated lead sorption and desorption on a small number of Frenchman Flat volcanic tuff samples. The lead K_d values from these two studies range from approximately 1,000 to 90,000 mL/g. The lead K_d values in the reviewed literature indicate that the retardation of lead at the Areas 6 and 27 CASs will be similar to that for plutonium, and that the expected mobility of lead is bounded by the expected mobility of uranium and plutonium. Therefore, lead will not be included in this evaluation.

The contaminant's retardation factor is related to bulk density, water content, and the K_d parameter as follows:

$$R_f = 1 + \frac{K_d \rho_b}{\theta} \quad \text{(B.2-4)}$$

where

R_f = retardation factor (–)
ρ_b = bulk density (grams per cubic centimeter [g/cm^3])
θ = volumetric water content (dimensionless [–])

The K_d parameter values for the volcanic rock are taken from a Rainier Mesa hydrologic source term study (Tompson, 2011, Table 2-14) for each analog HSU. The K_d parameter values provided by Tompson (2011) included uncertainty in surface complexation and ion exchange constants and are presented as distributions. The volcanic rock bulk density values are taken from a core-scale data analysis performed for Rainier Mesa by Kwicklis et al. (2009, Table 6). The alluvium K_d distributions are from Frenchman Flat alluvium data presented in the Yucca Flat transport data document

(SNJV, 2007, Table 11-6). The alluvium bulk density is calculated from the matrix porosity and particle density as follows:

$$\rho_b = (1 - \theta_s) \times \rho_p \quad \text{(B.2-5)}$$

where

ρ_b = bulk density (grams per cubic centimeter [g/cm^3])
θ_s = saturated volumetric water content (dimensionless [–])
ρ_p = particle density (grams per cubic centimeter [g/cm^3])

Using the saturated volumetric water content (θ_s) values presented in Tables B.2-3 and B.2-4 as equivalent to total porosity, and a particle density value of 2.49 g/cm^3 (BN, 1998), the bulk density along with the log10 K_d distribution for each stratigraphic layer at each site is presented in Tables B.2-7 and B.2-8.

Table B.2-7
CAU 465 Area 6 Transport Properties

HSU	Bulk Density ρ_b (g/cm^3)	Uranium		Plutonium	
		Log10 K_d Distribution (mL/g)			
		Average	Standard Deviation	Average	Standard Deviation
AA3[a]	1.46	-0.11	0.33	0.23	0.30
PCU[a]	1.42	-0.11	0.33	0.23	0.30
AA2[a]	1.46	-0.11	0.33	0.23	0.30
TM-WTA[b]	2.01	-0.83	0.27	1.13	0.37
TM-LVTA[b]	1.37	0.05	0.27	2.01	0.37
UTCU[b]	1.61	0.38	0.30	2.24	0.37
TSA[b]	2.01	-0.83	0.27	1.13	0.37
LTCU[b]	1.80	0.90	0.28	2.82	0.37
OSBCU[b]	1.80	0.90	0.28	2.82	0.37
ATCU[b]	2.14	1.37	0.28	3.28	0.37

[a]Alluvium and playa confining K_d values are from a Yucca Flat transport data document (SNJV, 2007, Table 2-14).
[b]Tertiary volcanic rock HSU K_d values are from a Rainier Mesa hydrologic source term document (Tompson, 2011, Table 11-6).

Table B.2-8
CAU 465 Area 27 Transport Properties

HSU	Bulk Density ρ_b (g/cm^3)	Uranium		Plutonium	
		Log10 K_d Distribution (mL/g)			
		Average	Standard Deviation	Average	Standard Deviation
AA[a]	1.46	-0.11	0.33	0.23	0.30
WVU[b]	1.37	0.05	0.27	2.01	0.37
CFBCU[b]	1.61	0.38	0.30	2.24	0.37
OVU[b]	1.8	0.90	0.28	2.82	0.37
VSU[b]	1.8	0.90	0.28	2.82	0.37

[a]Alluvium K_d values are from a Yucca Flat transport data document (SNJV, 2007, Table 2-14).
[b]Tertiary volcanic rock HSU K_d values are from a Rainier Mesa hydrologic source term document (Tompson, 2011, Table 11-6).

The transport of actinides can be more rapid than the K_d parameter suggests. Sorption onto inorganic colloids can facilitate unretarded plutonium transport with the bulk water movement (Tompson, 2011). Colloid sorption and transport can reduce the apparent K_d by one to two orders of magnitude (Tompson, 2011). The alluvium plutonium K_d values are reduced by a factor of 10 to reflect the guidance provided by Tompson (2011) that 90 percent of aqueous plutonium may be colloid associated and not truly aqueous. The fine grain structure of the volcanic rock matrix likely prohibits colloid-facilitated plutonium transport in the volcanic rock; thus, the K_d values are not reduced.

Retardation factors for uranium and plutonium are presented in Table B.2-9.

Table B.2-9
CAU 465 Retardation Factors

CASs Location	HSU	Rainier Mesa Analog HSU	Calculated Water Content	Uranium		Plutonium	
				K_d	Retardation Factor (R_f)	K_d	Retardation Factor (R_f)
Area 6	AA3	N/A	0.188	0.8	7.0	1.7	14.2
	PCU	N/A	0.303	0.8	4.6	1.7	9.0
	AA2	N/A	0.188	0.8	7.0	1.7	14.2
	TM-WTA	TM-WTA	0.122	0.1	3.4	13.5	223.2
	TM-LVTA2	TM-LVTA	0.117	1.1	14.1	102.3	1,197.2
	UTCU	BRCU	0.32	2.4	13.1	173.8	875.1
	Unsaturated TSA	TM-WTA	0.122	0.1	3.4	13.5	223.2
	Saturated TSA	TM-WTA	0.208	0.1	2.4	13.5	223.2
	LTCU	OSBCU	0.292	7.9	50.0	660.7	4,073.8
	OSBCU	OSBCU	0.292	7.9	50.0	660.7	4,073.8
	ATCU	ATCU	0.264	23.4	191.0	1,905.5	15,446.8
Area 27	AA	N/A	0.202	0.8	6.6	1.7	13.3
	Unsaturated WVU	TM-LVTA	0.149	1.1	11.3	102.3	942.5
	Saturated WVU	TM-LVTA	0.366	1.1	5.2	102.3	384.0
	CFBCU	BRCU	0.324	2.4	12.9	173.8	864.5
	OVU	OSBCU	0.292	7.9	50.0	660.7	4,073.8
	VSU	OSBCU	0.292	7.9	50.0	660.7	4,073.8

B.3.0 Contaminant Transport Calculations

This section develops the travel times to the perched water and LCA, and the 1,000-year travel distances calculated using the equations presented in Section B.1.1 and the data presented in Section B.2.0.

B.3.1 Contaminant Travel Times to Perched Water and LCA

The travel time required for pore water to migrate through each HSU is defined as the thickness of the geologic layer (Section B.2.1) divided by the vertical velocity of the pore water (Section B.2.4), in addition to the travel time through any upper geologic layer. The vertical velocities of pore water and the corresponding thicknesses of each HSU along with the resulting cumulative travel times for the Areas 6 and 27 locations are presented in Tables B.3-1 and B.3-2, respectively. Based on the thicknesses of the HSUs and the conservatively high estimates of vertical velocities of the pore water, the estimated time for pore water to reach the perched water table is approximately 16,527 years at the Area 6 site and approximately 1,417 years at the Area 27 site. The estimated time for pore water to reach the saturated LCA is approximately 46,979 years at Area 6 and approximately 10,668 years at Area 27.

Using the conservative estimates of the vertical water velocities of pore water presented in Section B.2.4 and the retardation factors presented in Section B.2.5, the potential vertical velocity of the contaminant in each HSU is defined in Equation B.1-3 as the vertical velocity of the pore water divided by the retardation factor. The potential travel time required for a contaminant to migrate through each HSU is defined in Equation B.1-6 as the thickness of the geologic layer (Section B.2.1) divided by the potential vertical velocity of the contaminant (Section B.2.4), in addition to the travel time through any upper geologic layer. The potential vertical velocities of the contaminants and the corresponding thicknesses of each HSU along with the resulting cumulative travel times for the Areas 6 and 27 locations are presented in Tables B.3-1 and B.3-2, respectively.

Table B.3-1
Area 6 Vertical Velocities and Travel Times

HSU	Thickness below Emplacement Depth	Water Velocity (V_w)	Cumulative Water Travel Time	Uranium Velocity (V_c)	Cumulative Uranium Travel Time	Plutonium Velocity (V_c)	Cumulative Plutonium Travel Time
	m	mm/yr	years	mm/yr	years	mm/yr	years
AA3[a]	7.3	26.7	274	3.79	1,929	1.87	3,894
PCU[b]	50.4	16.5	3,327	3.56	16,093	1.84	31,255
AA2[a]	240.7	26.7	12,358	3.79	79,682	1.87	159,646
TM-WTA[c]	79.4	41	14,296	11.92	86,340	0.18	592,156
TM-LVTA2[c]	30	42.7	14,999	3.02	96,266	0.04	1,434,006
UTCU[c]	20.1	15.6	16,286	1.20	113,079	0.02	2,560,033
Unsaturated TSA[c]	9.9	41	16,527	11.92	113,909	0.18	2,613,960
Saturated TSA[c]	116.2	24	21,361	9.90	125,652	0.18	3,248,927
LTCU[c]	54.2	17.1	24,526	0.34	283,807	0.004	16,143,543
OSBCU[c]	316.2	17.1	42,992	0.34	1,206,473	0.004	91,370,066
ATCU[c]	75.5	18.9	46,979	0.10	1,967,973	0.001	152,947,110

[a]Alluvium unit hydraulic properties are from SNJV (2009) Table 5-1.
[b]PCU hydraulic properties are for the lowest K_s sample from BN (1998).
[c]Tertiary volcanic rock HSU hydraulic properties are from Kwicklis et al. (2009) Table 6.

Table B.3-2
Area 27 Vertical Velocities and Travel Times

HSU	Thickness below Emplacement Depth	Water Velocity (V_w)	Cumulative Water Travel Time	Uranium Velocity (V_c)	Cumulative Uranium Travel Time	Plutonium Velocity (V_c)	Cumulative Plutonium Travel Time
	m	mm/yr	years	mm/yr	years	mm/yr	years
AA[a]	3.4	99.0	34	14.98	227	7.46	456
Unsaturated WVU[b]	185.7	134.3	1,417	11.86	15,882	0.14	1,303,513
Saturated WVU[b]	147.1	54.6	4,109	10.51	29,880	0.14	2,337,311
CFBCU[c]	148.6	61.7	6,516	4.78	60,983	0.07	4,418,528
OVU[b]	41.4	68.5	7,121	1.37	91,184	0.02	6,880,876
VSU[b]	243	68.5	10,668	1.37	268,451	0.02	21,333,789

[a]Alluvium unit hydraulic properties are from SNJV (2009) Table 5-1.
[b]PCU hydraulic properties are for the lowest K_s sample from BN (1998).
[c]Tertiary volcanic rock HSU hydraulic properties are from Kwicklis et al. (2009) Table 6.

B.3.2 Contaminant 1,000-Year Travel Distances

The distance a contaminant will migrate through each HSU is defined as the vertical velocity of the contaminant multiplied by a specified time interval (Equation B.1-5). The potential travel distances of infiltrating water and the contaminants within the UGTA 1,000-year regulatory time period are presented in Table B.3-3. Based on the potential contaminant velocities shown in Table B.3-1 and Table B.3-2, only uranium at Area 27 has the potential to reach a deeper HSU. The calculated travel times to the perched water table or LCA greatly exceed the UGTA 1,000-year regulatory time period. Uranium and plutonium are not expected to move more than 3.8 and 1.9 m, respectively, below the Area 6 CAS emplacement depths. Uranium and plutonium are not expected to move more than 12.6 and 3.5 m, respectively, below the Area 27 CASs emplacement depths.

Table B.3-3
Calculated Water and Solute 1,000-Year Travel Distances

CAU 465 CASs Location	Travel Distance (m)		
	Water	Uranium	Plutonium
Area 6	19.3	3.8	1.9
Area 27	133.1	12.6	3.5

Figures B.3-1 and B.3-2 illustrate the stratigraphic layers; contact elevations; water table elevations; and the potential 1,000-year water, uranium, and plutonium travel distances at the CAU 465 CASs in Areas 6 and 27, respectively.

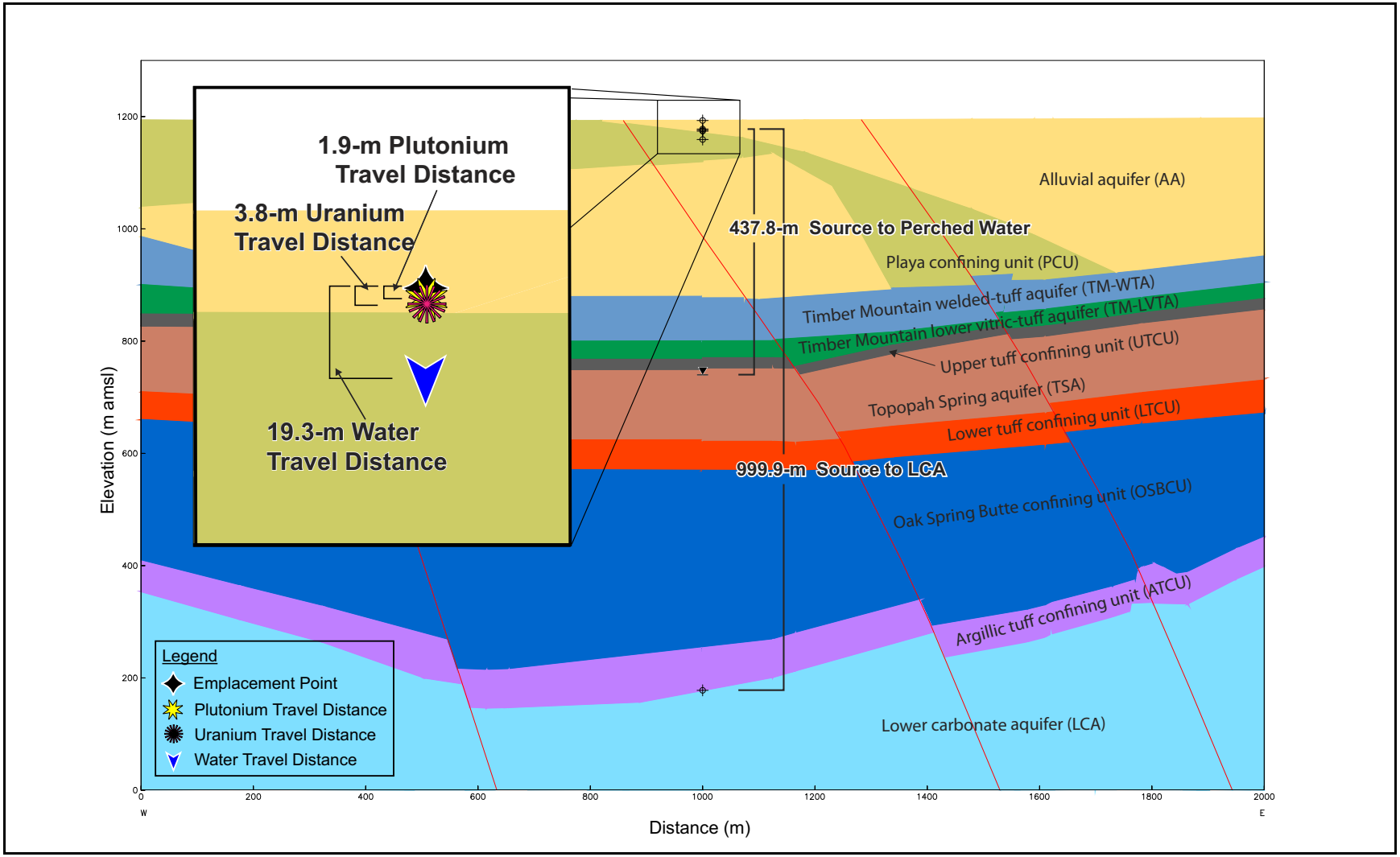

Figure B.3-1
Area 6 Stratigraphy and 1,000-Year Contaminant Travel Distances
Note: Area 6 stratigraphy is estimated based upon the Yucca Flat HFM as described in Section B.2.1.

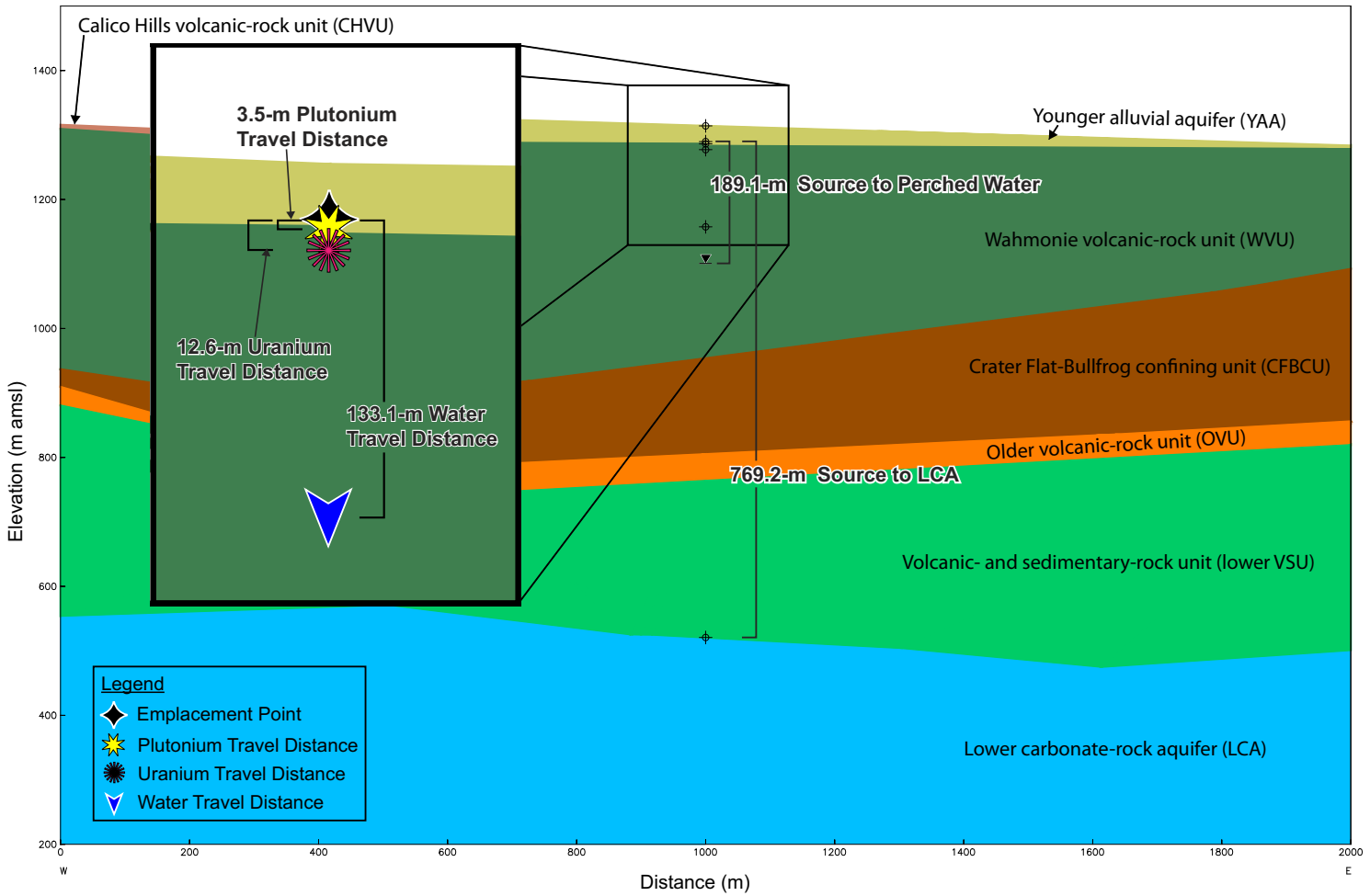

Figure B.3-2
Area 27 Stratigraphy and 1,000-Year Contaminant Travel Distances
Note: Area 27 stratigraphy is estimated based upon the DVRFS HFM as described in Section B.2.1.

B.4.0 Parameter Sensitivity

This section evaluates the travel time calculation sensitivity to the most uncertain parameters. The parameters with the most uncertainty are K_d and recharge rate as K_d is the factor most affecting the retardation rates and the recharge rate is the driver for vertical flow velocities. The other input parameters do not have as much uncertainty and do not have as much impact to contaminant travel times. For example, the tuff confining unit (TCU) hydrogeologic unit (HGU) matrix porosity has a normal distribution with a mean of 0.35 and standard deviation of 0.062. The corresponding 95th confidence interval porosity range is approximately four times the standard deviation, providing a range of 0.23 to 0.47. Equation B.2-5 illustrates that bulk density is strongly a function of porosity, and variability will be similar to the porosity variability.

B.4.1 Recharge Rate Travel Time Sensitivity

Equations B.1-4 and B.1-6 illustrate that the water travel time is inversely proportional to the recharge rate and will increase with lower recharge rates. Although this analysis uses the highest estimated recharge rate from the NNSS data, a range of recharge rates are used to demonstrate sensitivity of water travel time to the recharge rate; specifically, a “low,” “base,” and “high” recharge rate are evaluated. The low, base, and high values are the 5th, 50th, and 100th percentile value assuming that the recharge rates have a uniform distribution between the minimum and maximums from the infiltration models at each location (Section B.2.2). The Area 6 CAS recharge sensitivity values are 0.25, 2.5, and 5 mm/yr. The Area 27 CASs recharge sensitivity values are 1, 10, and 20 mm/yr. Table B.4-1 summarizes the water travel time sensitivity to recharge rate. The water travel time to the LCA at the Area 6 CAS increases from 46,979 to 939,576 years as the recharge rate is decreased from 5 to 0.25 mm/yr. The water travel time to the LCA at the Area 27 CASs increases from 10,668 to 213,367 years as the recharge rate is decreased from 20 to 1 mm/yr. The travel times do not directly scale to the change in recharge rate because the water content is a nonlinear function of recharge.

Table B.4-1
CAU 465 Areas 6 and 27 Water Travel Time Sensitivity

CAU 465 CASs Location	Recharge Rate (mm/yr)	Travel Time (years)	
		Perched Water Table	Saturated LCA
Area 6	0.25	330,542	939,576
	2.5	33,054	93,958
	5	16,527	46,979
Area 27	1	28,338	213,367
	10	2,834	21,337
	20	1,417	10,668

B.4.2 K_d Parameter Travel Time Sensitivity

Equations B.1-4, B.1-6, and B.2-4 illustrate that the water travel time will increase with larger K_d parameter values. The travel time sensitivity to the K_d parameter is evaluated by using range of K_d values for uranium and plutonium. Specifically, a "low," "base," and "high" mobility cases are evaluated using the conservative recharge rate (highest value from the infiltration models). The base K_d values are the mean of the log K_d distribution, and the low and high values are one log-scale standard deviation below and above the base K_d values. Tables B.4-2 and B.4-3 summarize the transport properties evaluated for each HSU at the CAU 465 CASs in Areas 6 and 27. Tables B.4-4 and B.4-5 summarize the travel time and travel distance sensitivity to the K_d parameter.

Table B.4-2
CAU 465 Area 6 Transport Properties
(Page 1 of 2)

HSU	ρ_b (g/cm^3)	Uranium			Plutonium		
		Mobility K_d (mL/g)					
		Low	Base	High	Low	Base	High
AA3[a]	1.46	1.7	0.8	0.4	3.4	1.7	0.9
PCU[a]	1.42	1.7	0.8	0.4	3.4	1.7	0.9
AA2[a]	1.46	1.7	0.8	0.4	3.4	1.7	0.9
TM-WTA	2.01	0.3	0.1	0.1	31.6	13.5	5.8
TM-LVTA	1.37	2.1	1.1	0.6	239.9	102.3	43.7

Table B.4-2
CAU 465 Area 6 Transport Properties
(Page 2 of 2)

HSU	ρ_b (g/cm^3)	Uranium			Plutonium		
		Mobility K_d (mL/g)					
		Low	Base	High	Low	Base	High
UTCU	1.61	4.8	2.4	1.2	407.4	173.8	74.1
TSA	2.01	0.3	0.1	0.1	31.6	13.5	5.8
LTCU	1.80	15.1	7.9	4.2	1,548.8	660.7	281.8
OSBCU	1.80	15.1	7.9	4.2	1,548.8	660.7	281.8
ATCU	2.14	44.7	23.4	12.3	4,466.8	1,905.5	812.8

[a]Alluvium unit and PCU transport properties are from the Yucca Flat transport data document (SNJV, 2007).

Table B.4-3
CAU 465 Area 27 Transport Properties

HSU	ρ_b (g/cm^3)	Uranium			Plutonium		
		Mobility K_d (mL/g)					
		Low	Base	High	Low	Base	High
AA[a]	1.46	1.7	0.8	0.4	3.4	1.7	0.9
WVU	1.37	2.1	1.1	0.6	239.9	102.3	43.7
CFBCU	1.61	4.8	2.4	1.2	407.4	173.8	74.1
OVU	1.8	15.1	7.9	4.2	1,548.8	660.7	281.8
VSU	1.8	15.1	7.9	4.2	1,548.8	660.7	281.8

[a]Alluvium unit transport properties are from the Yucca Flat transport data document (SNJV, 2007).

Table B.4-4
Calculated Water and Solute Travel Times

CAU 465 CASs Location	Mobility Case	Water		Uranium		Plutonium	
		Travel Time (years)					
		Perched Water Table	Saturated LCA	Perched Water Table	Saturated LCA	Perched Water Table	Saturated LCA
Area 6	Low	16,527	46,979	218,502	3,723,475	6,054,106	358,428,473
	Base			113,909	1,967,973	2,613,960	152,947,110
	High			63,603	1,051,184	1,135,528	65,282,032
Area 27	Low	1,417	10,668	28,406	503,376	3,053,681	49,996,796
	Base			15,882	268,451	1,303,513	21,333,789
	High			9,172	145,579	556,896	9,106,707

Table B.4-5
Calculated Water and Solute 1,000-Year Travel Distances

CAU 465 CASs Location	Mobility Case	Travel Distance (m)		
		Water	Uranium	Plutonium
Area 6	Low	19.3	1.9	1.0
	Base		3.8	1.9
	High		7.0	3.5
Area 27	Low	133.1	7.1	3.4
	Base		12.6	3.5
	High		21.4	3.7

B.5.0 Summary and Conclusions

An analysis was performed to determine whether residual contamination from the CAU 465 CASs may impact the regional LCA water resource. The water and contaminant travel time through the unsaturated zone and the saturated volcanic rock above the LCA was calculated at the CAU 465 CASs in Areas 6 and 27 using conservative and bounding assumptions.

Assessing the contaminant travel time through the subsurface at the CAU 465 CASs in Areas 6 and 27 required estimating the state of the subsurface, including rock stratigraphy, water table depth, *in situ* water content, and recharge rate. Direct observations from boreholes at each site were not available, and these data were largely taken from UGTA modeling studies.

The recharge rates used in this study are conservatively estimated to the highest possible from the reviewed data. The expected water travel time to the saturated LCA is approximately 46,979 years at the Area 6 CAS and approximately 10,668 years at the Area 27 CASs. The sorptive processes (retardation factors) associated with contaminant transport will increase travel times by approximately one and two orders of magnitude for uranium and plutonium, respectively. The calculated travel times greatly exceed the UGTA 1,000-year regulatory time period, indicating that the distance between the CAU 465 residual contamination and the LCA is sufficient for protecting the water resources below the CAU 465 CASs.

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Appendix C

Confirmation Sampling Test Results

C.1.0 Introduction

This appendix presents the CAI activities and analytical results for the surface release component for CAU 465 (Figure 1-2). A separate water and solute travel time analysis was performed for the subsurface release component. Results of the water and solute travel time analysis are presented in Appendix B.

CAU 465 comprises the following four CASs:

- CAS 00-23-01, Hydronuclear Experiment (Charlie site)
- CAS 00-23-02, Hydronuclear Experiment (Dog site)
- CAS 00-23-03, Hydronuclear Experiment (Charlie Prime and Anja sites)
- CAS 06-99-01, Hydronuclear (Trailer 13 site)

Information regarding the history of each site, planning, and the scope of the CAI is presented in the CAU 465 SAFER Plan (NNSA/NSO, 2011).

C.1.1 Project Objectives

The primary objective of the investigation was to provide sufficient information to validate the assumptions used to select the corrective actions and to verify that closure objectives were met for each CAS in CAU 465. This objective was achieved by determining the presence of COCs and the vertical and lateral extent of the COCs, if present.

C.1.2 Contents

This appendix contains information and data in sufficient detail to justify that no further corrective action is required at CAU 465. The contents of this appendix are as follows:

- Section C.2.0 provides the CAI results.
- Section C.3.0 summarizes waste management activities.
- Section C.4.0 discusses the QA and QC procedures followed and results of the QA/QC activities.
- Section C.5.0 lists the cited references.

The complete field documentation and laboratory data—including field activity daily logs, sample collection logs, analysis request/chain-of-custody forms, soil sample descriptions, laboratory certificates of analyses, analytical results, and surveillance results—are retained in project files as hard copy files or electronic media.

C.2.0 CAI Results

Field investigation and sampling activities for the CAU 465 CAI were conducted from September 2011 through July 2012. The investigation and sampling program was managed in accordance with the requirements set forth in the SAFER Plan (NNSA/NSO, 2011). Field activities were performed in compliance with safety documents that are consistent with the DOE Integrated Safety Management System. Samples were collected and documented in accordance with approved protocols and procedures. QC samples (e.g., field blanks, trip blanks, and duplicate samples) were collected as required by the Soils Activity QAP (NNSA/NSO, 2012c) and the SAFER Plan (NNSA/NSO, 2011). During field activities, waste minimization practices were followed in accordance with approved procedures, including segregation of waste by waste stream.

C.2.1 Investigation Overview

The investigation activities performed at CAU 465 were based on field investigation activities discussed in the SAFER Plan (NNSA/NSO, 2011). As discussed in the SAFER Plan, each CAS was divided into two components: the surface release component and the subsurface release component. This appendix discusses the investigation and sampling activities associated with the surface release component.

The surface release component investigation for each CAS included conducting radiological and visual surveys. The radiological surveys were conducted using a handheld FIDLER in conjunction with a Global Positioning System (GPS) receiver and datalogger. The radiological surveys at each CAS did not identify radioactivity in excess of background activity. The visual surveys identified housekeeping debris at each CAS and PSM at the Dog site. All housekeeping debris was field screened for radioactivity and visually assessed for potential releases. Based on knowledge of historical site operations, field screening, and visual inspection, none of the housekeeping debris was identified as PSM. Housekeeping debris that was easily accessible was removed from each CAS and dispositioned. The PSM and potentially impacted soil identified at the Dog site was sampled using the judgmental sampling scheme defined in the SAFER Plan and is described in the following subsections.

Sample locations at the Dog site were based on visual biasing factors, such as staining and the presence of potential PSM (e.g., lead bricks). The PSM and associated soil was sampled using handheld sampling implements and field screened for radioactivity. Decision I sample locations were accessible and sampling activities at planned locations were not restricted. Laboratory analytical results determined the need for step-out (Decision II) sampling locations at some PSM locations. Step-out sample locations were accessible and remained within anticipated spatial boundaries except where otherwise noted.

The following PSM was identified at the Dog site:

- A trash pile contaminated with arsenic and lead
- A small, stained concrete pad contaminated with Cr (VI)
- Lead debris (lead bricks and lead plates)

Figure C.2-1 shows the locations of the PSM identified at the Dog site. The trash pile was located in the southeast portion of the site. The stained concrete pad was located south of the fenced compound; two unstained concrete pads are also in the vicinity. Lead bricks and lead plates were identified both within and outside the compound fence line. Lead bricks were identified at locations B06, B07, B08, and B16; and three large lead plates were located on the east side of the site outside the fenced area at location B19.

The samples collected during investigation activities at the Dog site are shown in Tables 2-2 and C.2-1. Sample locations are presented in Figure C.2-2. The following subsections detail the collection and analytical results of these investigation samples; samples collected solely in support of waste characterization are discussed in Section C.3.0.

C.2.2 Soil Sampling

Surface soil samples from underneath the trash pile, lead bricks, and lead plates were collected and analyzed for chemical and radiological parameters detailed in Table 2-2. Soil samples in the center of the trash pile at location B04, and under the lead brick at location B06, exceeded the FALs for lead and arsenic, and lead, respectively.

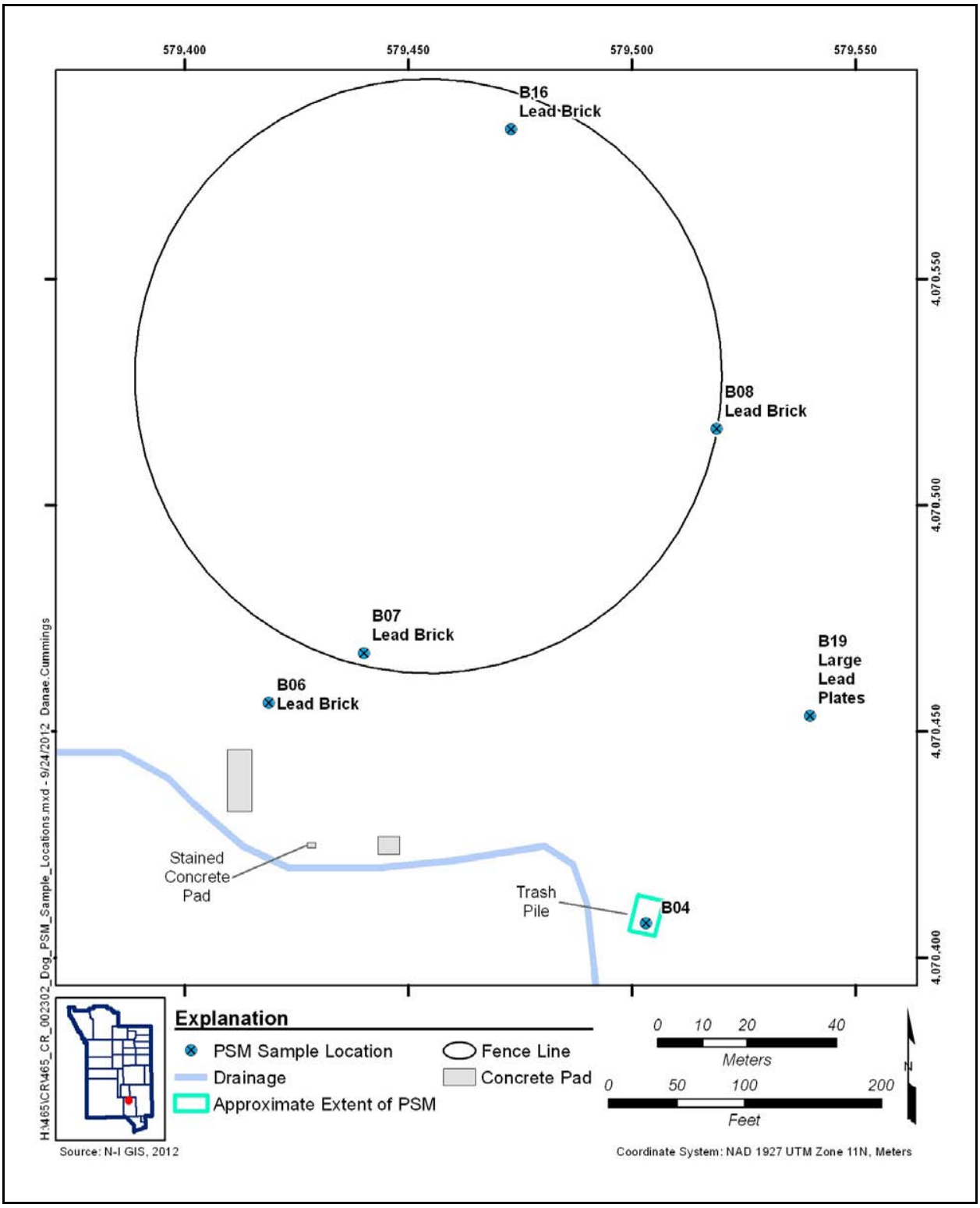

Figure C.2-1
Location of PSM at CAS 00-23-02 (Dog Site)

Table C.2-1
Samples Collected at CAS 00-23-02 (Dog Site)
(Page 1 of 2)

Sample Location	Sample Number	Sample Matrix	Purpose	HE	Gamma	Cr (VI)	Metals	PCBs	Plutonium	Strontium	SVOCs	TCLP Metals	Uranium	VOCs
B01	465B001	Concrete	PSM	X	X	X	X	X	X	X	X	--	X	X
	465B010	Concrete	PSM	--	X	X	--	--	X	X	--	X	X	--
B02	465B002	Concrete	PSM	X	X	X	X	X	X	X	X	--	X	X
B03	465B003	Soil	Environmental	X	X	X	X	X	X	--	X	--	X	X
B04	465B004	Soil	Environmental	X	X	X	X	X	X	X	X	X	X	X
B05	465B005	Soil	Environmental	X	X	X	X	X	X	--	X	--	X	X
B06	465B006	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
	465B007	Soil	FD of 465B006	--	--	X	X	--	--	--	--	--	--	--
	465B013	Soil	Environmental	--	--	--	X[a]	--	--	--	--	--	--	--
B07	465B008	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B08	465B009	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B09	465B011	Concrete	PSM	--	X	X	--	--	X	X	--	--	X	--
B10	465B012	Concrete	PSM	--	--	X	--	--	--	--	--	X	--	--
B11	465B014	Concrete	PSM	--	--	X	--	--	--	--	--	--	--	--
B12	465B016	Soil	Environmental	--	--	--	X[b]	--	--	--	--	--	--	--
B13	465B017	Soil	Environmental	--	--	--	X[b]	--	--	--	--	--	--	--
B14	465B018	Soil	Environmental	--	--	--	X[b]	--	--	--	--	--	--	--
B15	465B019	Soil	Environmental	--	--	--	X[b]	--	--	--	--	--	--	--
B16	465B015	Soil	Environmental	--	--	--	X[a]	--	--	--	--	--	--	--
B17	465B020	Soil	Environmental	--	X	X	X	--	X	--	--	--	X	--
B18	465B021	Soil	Environmental	--	X	X	X	--	X	--	--	--	X	--
B19[c]	465B022	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B20	465B023	Soil	Environmental	--	X	X	X	--	X	--	--	--	X	--
B21	465B024	Soil	Environmental	--	X	X	X	--	X	--	--	--	X	--
B22	465B025	Soil	Environmental	--	X	X	--	--	X	--	--	--	X	--
B23[c]	465B026	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
	465B027	Soil	FD of 465B026	--	--	X	X	--	--	--	--	--	--	--

Table C.2-1
Samples Collected at CAS 00-23-02 (Dog Site)
(Page 2 of 2)

Sample Location	Sample Number	Sample Matrix	Purpose	HE	Gamma	Cr (VI)	Metals	PCBs	Plutonium	Strontium	SVOCs	TCLP Metals	Uranium	VOCs
B24[c]	465B028	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B25[c]	465B029	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B26[c]	465B030	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B27[c]	465B031	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B28[c]	465B032	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B29[c]	465B033	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B30[c]	465B034	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B31[c]	465B035	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B32[c]	465B036	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
B33[c]	465B037	Soil	Environmental	--	--	X	X	--	--	--	--	--	--	--
N/A	465B301	Water	Trip Blank	--	--	--	--	--	--	--	--	--	--	X
N/A	465B302	Water	Field Blank	X	X	X	X	X	X	--	X	--	X	X
465A02 (Drum)	465B501	Soil	Waste Management	--	X	--	--	--	X	--	--	X	X	--

[a]Analyzed for lead only.
[b]Analyzed for lead and arsenic only.
[c]Samples collected from soil surface after soil or concrete was removed.

X = Analyzed
-- = Not analyzed

Trash Pile. The trash pile contained a concentration of rusted metal debris on the ground surface in the southeast portion of the Dog site. The debris includes metal cans, cables, and scrap metal (Figure 2-4). One soil sample from the center of the pile (location B04) and four step-out samples (locations B12 through B15) were collected. The soil sample from the center of the trash pile exceeded the FALs for lead and arsenic. The metal surface debris and contaminated soil at this location was excavated and disposed of off site. Six confirmation soil samples (including one duplicate) were collected from the excavation at locations B23 through B27. These sample results showed that lead and arsenic in the remaining soil was less than FALs (see Table C.2-4). The sample locations at the trash pile are detailed in Figure C.2-3.

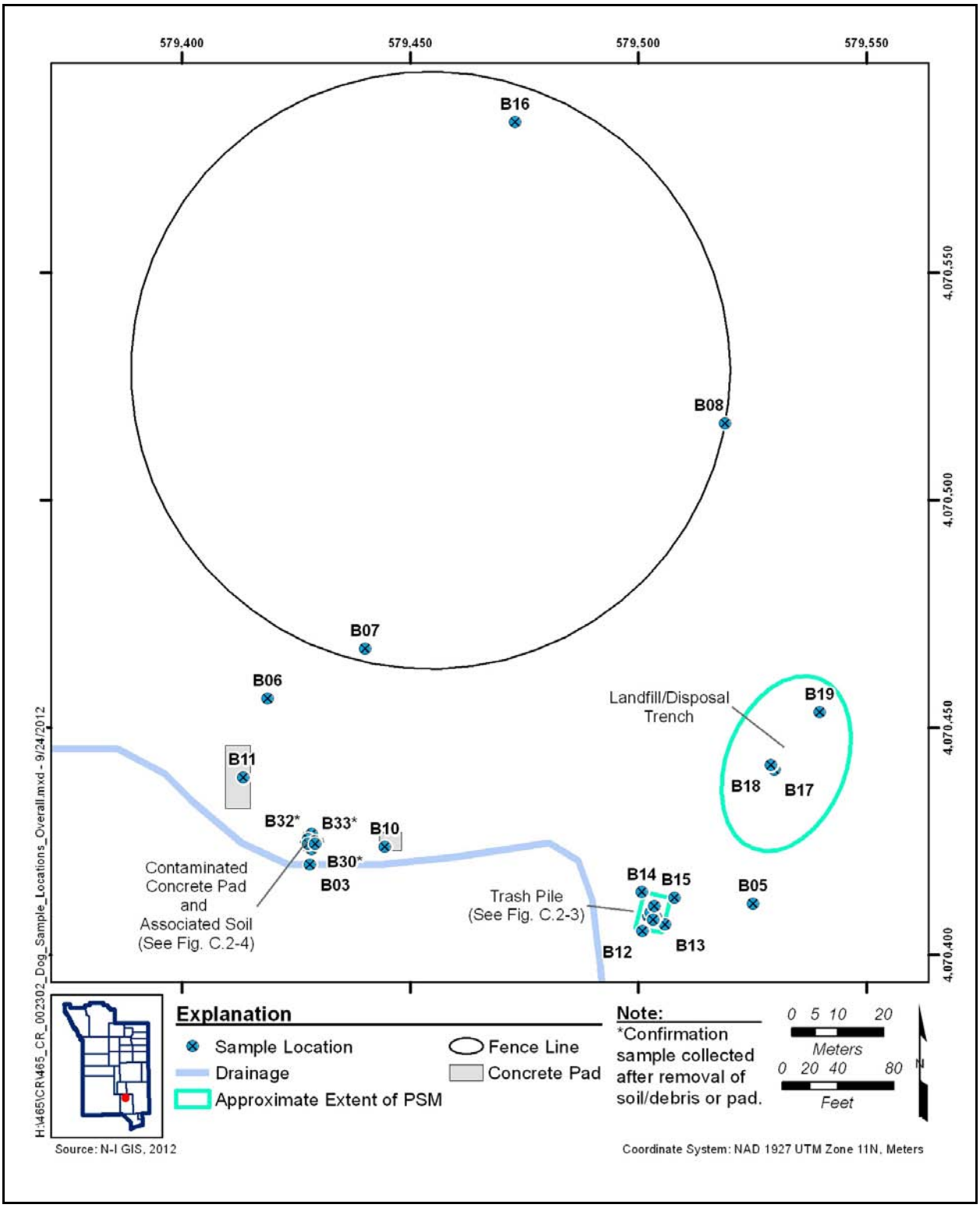

Figure C.2-2
CAS 00-23-02 (Dog Site) Sample Locations

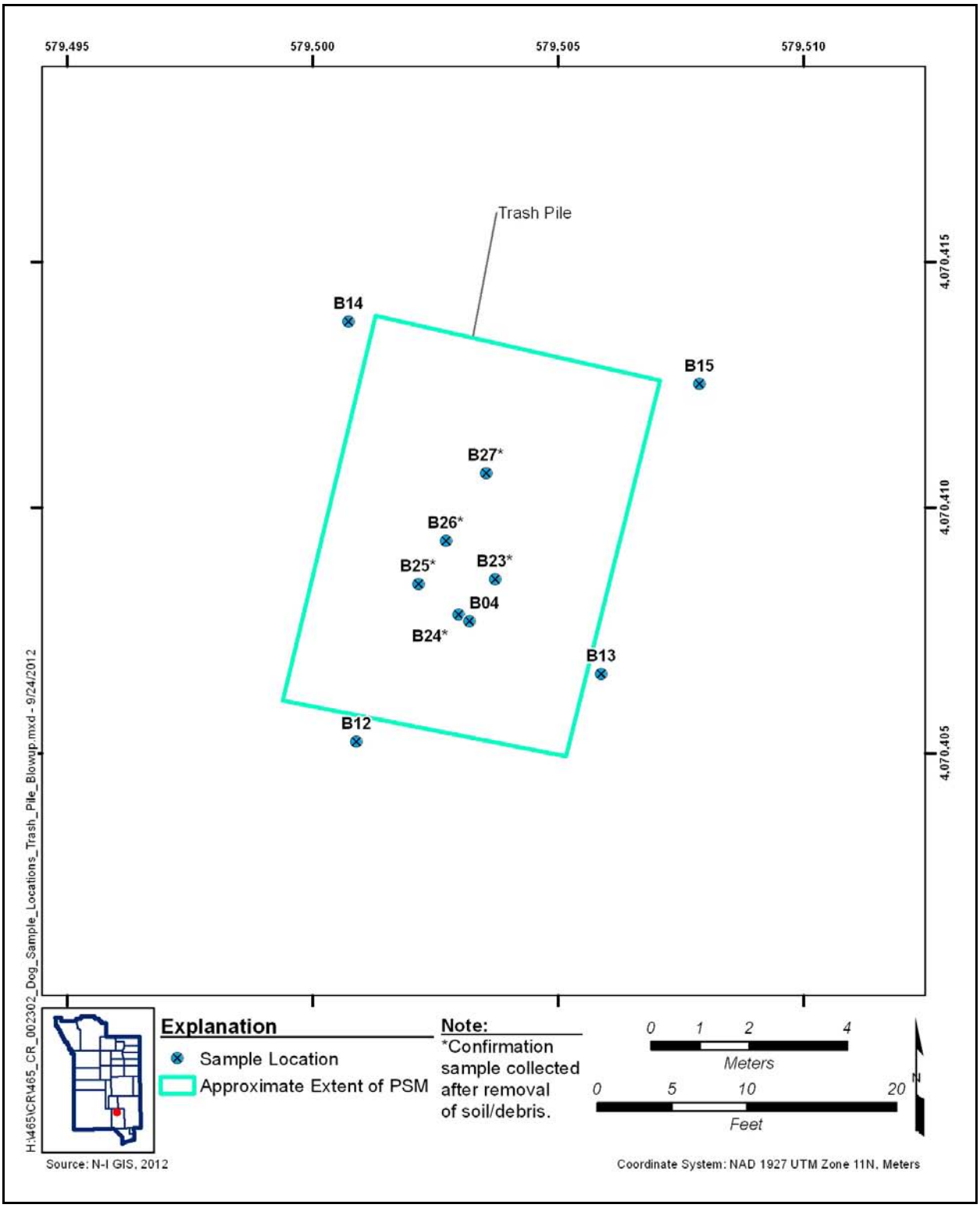

Figure C.2-3
Soil Sample Locations at Trash Pile at CAS 00-23-02 (Dog Site)

Lead Debris. Lead bricks were identified at locations B06, B07, B08, and B16. Three large lead plates (Figure 2-6) were located on the east side of the site outside the fenced area (location B19). Each of the large lead plates measured approximately 21.5 in. by 15.5 in. by 3.5 in. thick. The lead debris from each location was determined to be PSM, removed under a corrective action, and managed as recyclable material. Soil samples at each lead debris location were collected. Two soil samples (including one duplicate) were collected under the lead brick at location B06; both samples exceeded the FAL for lead (see Table C.2-4). Contaminated soil at this location was removed and disposed of as indicated in Section 3.0. One confirmation sample was collected at this location and confirmed the remaining soil did not contain lead concentrations exceeding the FAL.

C.2.3 PSM Sampling

The visual survey at the Dog site identified a small concrete pad with dark staining south of the fence (Figure 2-5). The pad was sampled at three locations (B01, B02, and B09) to determine whether the pad was a potential source for release to the surface soil. Locations B01 and B02 were in the stained areas of the pad; location B09 was in an unstained portion of the same concrete pad (Figure C.2-4). Two adjacent, larger unstained concrete pads were also sampled (locations B10 and B11) (Figure C.2-2). The objective in collecting the unstained concrete samples was to compare their results to the stained concrete results in order to distinguish the stain constituents from compounds inherent to the concrete pad itself. The samples of the concrete pads were collected using a handheld scabbling power tool.

The concrete samples from the stained pad contained concentrations of Cr (VI) above the soil PALs. Based on the assumptions detailed in Section C.2.5, the results of non-soil PSM samples may be compared directly to soil PALs, assuming that the entire volume of contaminants in the concrete has the potential to leach to the surrounding soil. The small concrete pad was removed, revealing yellow stained soil. Three soil samples were collected underneath the pad, two within the stained area (locations B20 and B21) and one in the unstained area (location B22). The samples collected in the stained areas contained Cr (VI) in excess of the FALs (see Table C.2-4). On July 9 and 10, 2012, approximately 15 yd^3 of soil was removed from the area, and six confirmation samples were collected in the excavation at locations B28 through B33. Figure C.2-4 provides the soil sample locations at the concrete pad and excavation. As indicated in Table C.2-4, the confirmation soil sample results were

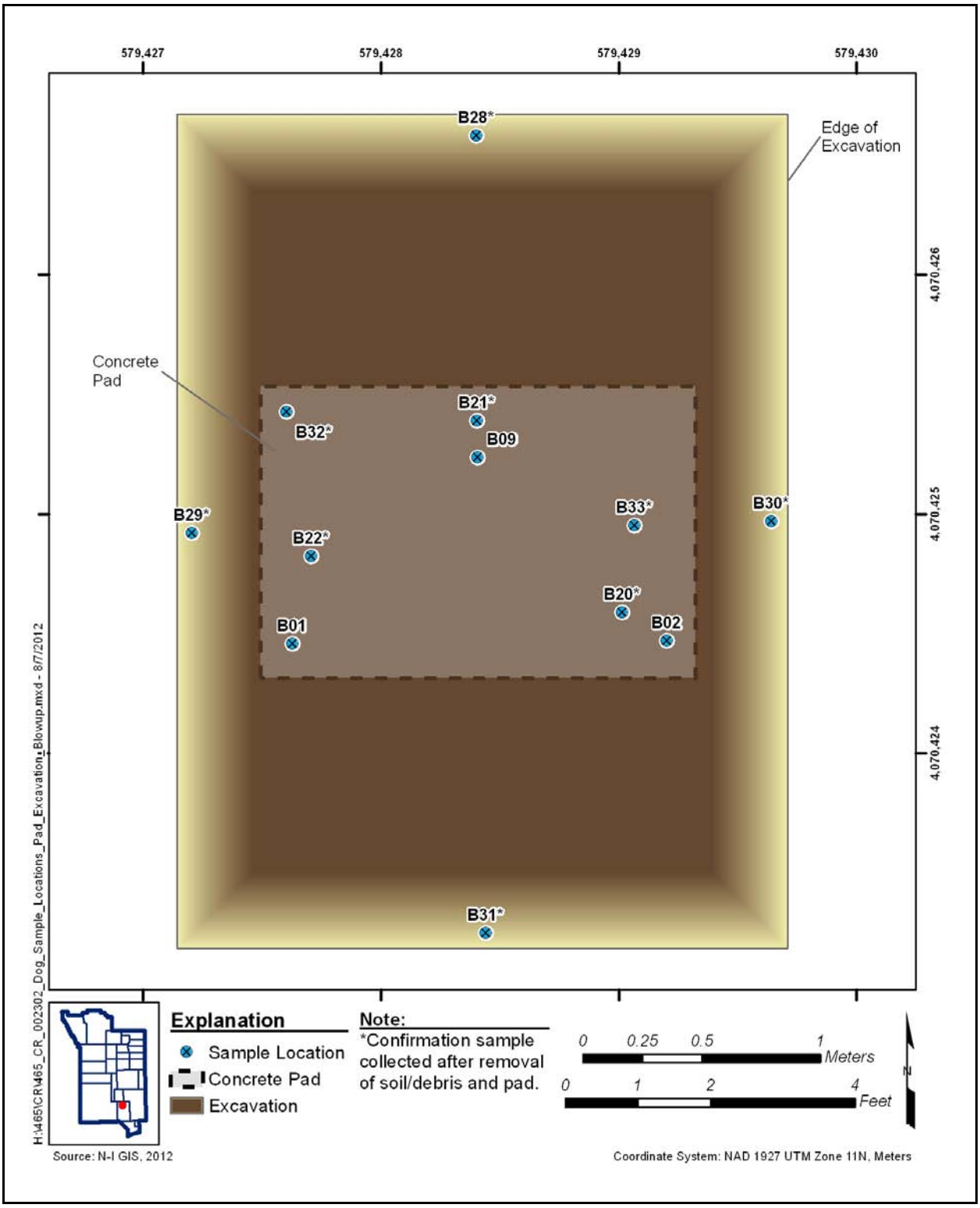

Figure C.2-4
Stained Concrete Pad and Associated Soil Sample Locations
at CAS 00-23-02 (Dog Site)

below the FAL of 48.1 mg/kg for Cr (VI). Appendix G describes the calculation of the FAL for Cr (VI).

South of the stained concrete pad is a drainage feature that traverses the southern portion of the CAS. One soil sample of this drainage was collected (location B03), and none of the constituents analyzed were detected at concentrations exceeding a FAL (see Section C.2.6).

C.2.4 Laboratory Analytical Information

Radiological and chemical analyses were performed by General Engineering Laboratories of Charleston, South Carolina. The analytical suites and laboratory analytical methods used to analyze investigation samples may be found in the CAU 465 SAFER Plan (NNSA/NSO, 2011). The complete laboratory data packages are available in the project files.

Validated analytical data for CAU 465 investigation samples have been compiled and evaluated to confirm the presence of contamination and define the extent of contamination, if present. The analytical parameters are CAS-specific and were selected through the application of site process knowledge in accordance with the DQOs.

C.2.5 Comparison to Action Levels

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/NSO, 2012d). Multiple constituent analyses are presented in Appendix G.

If COCs are present, corrective action must be considered for the CAS. The FALs for the CAU 465 investigation are defined for each CAS in Appendix G. Results that are equal to or greater than FALs are identified by bold text in the analytical results tables in the following subsections.

The presence of a COC would require a corrective action. A corrective action may also be necessary if there is a potential for wastes that are present at a site (i.e., PSM) to release COCs into site environmental media.

To evaluate PSM for the potential to result in the introduction of a COC to the surrounding environmental media, the following conservative assumptions were made:

- Any physical waste containment would fail at some point and release the contents to the surrounding media.
- The resulting concentration of contaminants in the surrounding media would be equal to the concentration of contaminants in the waste.
- Any liquid waste containing a contaminant exceeding the RCRA toxicity characteristic concentration would cause a COC to be present in the surrounding media if the liquid was released.
- Any non-liquid waste containing a contaminant exceeding an equivalent FAL concentration would cause a COC to be present in the surrounding media.

C.2.6 Soil Sample Results

The following subsections provide analytical results for the samples collected to complete investigation activities as outlined in the SAFER Plan (NNSA/NSO, 2011). Investigation samples were analyzed for the SAFER Plan-specified COPCs, which included VOCs, SVOCs, beryllium, RCRA metals, HE, PCBs, gamma-emitting radionuclides, isotopic U, and isotopic Pu. Table C.2-1 lists the sample-specific analytical suite for samples collected at the Dog site. Analytical results are reported in this appendix if they were detected above the MDCs. An evaluation was conducted on all contaminants detected above MDCs by comparing individual concentration or activity results against the FALs. The FALs were established as the PALs for all constituents except Cr (VI) (see Appendix G).

The soil samples collected at the Dog site are shown in Table C.2-1; the sample locations are shown in Figures C.2-2 through C.2-4. Soil samples were analyzed for one or more of the following: VOCs, SVOCs, PCBs, RCRA metals (including Cr [VI]), beryllium, HE, gamma spectroscopy, isotopic Pu, and isotopic U.

C.2.6.1 Volatile Organic Compounds

Acetone was the only VOC detected in soil samples above the MDCs but was not detected above the FAL (Table C.2-2). The FALs were established at the PAL concentrations for VOCs.

Table C.2-2
Soil Sample Results for VOCs Detected above MDCs

Sample Location	Sample Number	Depth (cm bgs)	COPCs (mg/kg)
			Acetone
FAL			630,000
B04	465B004	0.0 - 5.0	0.00205 (J)
B05	465B005	0.0 - 5.0	0.00427 (J)

J = Estimated value.

C.2.6.2 Semivolatile Organic Compounds

No SVOCs were detected in soil samples above the MDCs.

C.2.6.3 Polychlorinated Biphenyls

Two PCBs, Aroclor 1254 and Aroclor 1260, were detected above the MDCs in one soil sample collected at the Dog site (Table C.2-3). The soil sample was collected underneath the trash pile at location B04. Neither of the PCBs exceeded the FALs in this sample. The FALs were established at the PAL concentrations for PCBs.

Table C.2-3
Soil Sample Results for PCBs Detected above MDCs

Sample Location	Sample Number	Depth (cm bgs)	COPCs (mg/kg)	
			Aroclor 1254	Aroclor 1260
FALs			0.74	0.74
B04	465B004	0.0 - 5.0	0.00412	0.00422 (J)

J = Estimated value.

C.2.6.4 RCRA Metals and Beryllium

Table C.2-4 presents the analytical results for RCRA metals and beryllium in soil samples collected at the Dog Site. Soil sample results exceeded the PALs at three locations: trash pile (B04), the lead brick (B06), and underneath the Cr (VI)-contaminated concrete pad (B20 and B21).

Table C.2-4
Soil Sample Results for Metals Detected above MDCs
(Page 1 of 2)

Sample Location	Sample Number	Depth (cm bgs)	COPCs (mg/kg)								
			Arsenic	Barium	Beryllium	Cadmium	Cr (VI)	Lead	Mercury	Selenium	Silver
FALs			**23**	**190,000**	**2,000**	**800**	**48.1**	**800**	**43**	**5,100**	**5,100**
B03	465B003	0.0 - 5.0	1.16	100 (J)	--	--	0.172 (J)	10.5	--	--	9.46
B04	465B004	0.0 - 5.0	**37**	1160 (J)	--	29.2	2.3	**5,580**	0.165	0.747 (J)	737
B05	465B005	0.0 - 5.0	1.56	163 (J)	--	--	--	18.1	--	--	2.97
B06	465B006	0.0 - 5.0	2.14	158 (J)	0.309 (J)	--	0.621	**2,020**	0.0129 (J-)	--	0.774
	465B007	0.0 - 5.0	1.45	147 (J)	0.24 (J)	--	--	**1,730**	0.00931 (J-)	--	--
	465B013	0.0 - 5.0	--	--	--	--	--	23.8	--	--	--
B07	465B008	0.0 - 5.0	2.17	155 (J)	0.576	--	0.16 (J)	576	0.0188 (J-)	--	0.884
B08	465B009	0.0 - 5.0	3.82	166 (J)	0.55	--	--	692	0.0109 (J-)	--	--
B12	465B016	0.0 - 5.0	1.57	--	--	--	--	19.9	--	--	--
B13	465B017	0.0 - 5.0	1.94	--	--	--	--	36	--	--	--
B14	465B018	0.0 - 5.0	1.68	--	--	--	--	11	--	--	--
B15	465B019	0.0 - 5.0	2.08	--	--	--	--	10.3	--	--	--
B16	465B015	0.0 - 5.0	--	--	--	--	--	15.5	--	--	--
B17	465B020	45.0 - 60.0	4.48	242 (J)	--	3.19	--	237	0.012	--	0.66
B18	465B021	45.0 - 60.0	6.41	134 (J)	--	0.413 (J)	--	202	0.0111 (J)	--	0.639
B19	465B022	0.0 - 15.0	2.98 (J)	167 (J)	--	0.12 (J)	--	444 (J)	0.0104 (J)	--	0.741
B20	465B023	0.0 - 15.0	2.02	176	--	0.658	**324**	36.6 (J)	0.00814 (J-)	--	1.92
B21	465B024	0.0 - 15.0	1.57	206	--	0.165 (J)	**955**	16.5 (J)	--	--	1.11
B22	465B025	0.0 - 15.0	--	--	--	--	3.86	--	--	--	--

Table C.2-4
Soil Sample Results for Metals Detected above MDCs
(Page 2 of 2)

Sample Location	Sample Number	Depth (cm bgs)	COPCs (mg/kg)								
			Arsenic	Barium	Beryllium	Cadmium	Cr (VI)	Lead	Mercury	Selenium	Silver
FALs			**23**	**190,000**	**2,000**	**800**	**48.1**	**800**	**43**	**5,100**	**5,100**
B23	465B026	0.0 - 15.0	2.44 (J)	98.4 (J)	--	0.168 (J)	--	10.7 (J)	0.0224	--	0.97
	465B027	0.0 - 15.0	3.13 (J)	104 (J)	--	0.134 (J)	--	28 (J)	0.0179	--	1.24
B24	465B028	0.0 - 15.0	2.1 (J)	117 (J)	--	0.137 (J)	0.221 (J)	10.9 (J)	0.074	--	1.24
B25	465B029	0.0 - 15.0	2.89 (J)	107 (J)	--	0.127 (J)	--	9.27 (J)	0.05	--	0.931
B26	465B030	0.0 - 15.0	2.61 (J)	110 (J)	--	0.222 (J)	--	14.9 (J)	0.119	--	2.23
B27	465B031	0.0 - 15.0	3.18 (J)	109 (J)	--	0.132 (J)	--	27 (J)	0.0467	--	1.94
B28	465B032	45.0 - 60.0	2.28	72.5 (J)	--	--	3.95	7.92 (J)	--	--	0.46 (J)
B29	465B033	45.0 - 60.0	3.46	123 (J)	--	--	2.89	7.76 (J)	0.0102 (J)	--	0.731 (J)
B30	465B034	45.0 - 60.0	2.47	102 (J)	--	--	1.53	6.32 (J)	0.00459 (J)	--	0.658 (J)
B31	465B035	45.0 - 60.0	2.5	127 (J)	--	0.276 (J)	25.1	15.3 (J)	0.0071 (J)	--	1.29 (J)
B32	465B036	75.0 - 90.0	3.34	131 (J)	--	0.302 (J)	13.4	11.2 (J)	0.0188	--	1.5 (J)
B33	465B037	75.0 -90.0	3.25	124 (J)	--	--	9.38	8.32 (J)	0.0169	--	0.641 (J)

Bold indicates value exceeds the FAL.

J = Estimated value
J- = The result is an estimated quantity, but the result may be biased low.
-- = Not detected above MDCs.

Soil Associated with Trash Pile. Soil sample 465B004 was collected from the center of the trash pile at sample location B04 and exceeded the FALs for arsenic and lead. Debris on the ground surface was removed and disposed of off site. Four step-out samples (465B016 through 465B019) were collected at locations B12 through B15 at the trash pile and analyzed for RCRA metals. None of the four step-out sample results exceeded the FALs. On May 21, 2012, approximately 5 yd^3 of soil and debris was removed from the trash pile. Five confirmation soil samples and one duplicate (465B026 through 465B031) were collected from the excavation at locations B23 through B27, and analyzed for total arsenic and lead (Figure C.2-3). The concentration of arsenic and lead in the confirmation soil samples was less than the FALs.

Soil Associated with Lead Brick. Soil samples 465B006 and 465B007 (FD of 465B006) were collected from underneath the location of a lead brick (B06) and exceeded the PAL for lead. Less than 0.1 yd^3 of soil was removed from location B06. A confirmation soil sample from the bottom of the excavation was collected (465B013) and analyzed for total lead. The concentration of lead in the confirmation soil sample was less than the FAL.

Soil Associated with Cr (VI)-Contaminated Concrete Pad. The small, stained concrete pad (6 ft by 4 ft by 7 in. thick) was located south of the fenced compound; two larger, unstained concrete pads are also in the vicinity. Samples of the small, stained concrete pad and two adjacent, unstained concrete pads were collected. The concrete samples from the stained pad contained concentrations of Cr (VI) above the soil PAL. The small concrete pad was removed and disposed of off site as hazardous waste. Section C.2.7 discusses the sample results for the concrete pad. Removal of the pad revealed yellow stained soil. Three soil samples were collected underneath the pad, two within the stained area (465B023, 465B024) and one in the unstained area (465B025). The samples collected in the stained areas contained Cr (VI) in excess of the PAL. On July 9 and 10, 2012, approximately 15 yd^3 of soil was removed from the area, and six confirmation samples (465B032 through 465B037, including one duplicate) were collected in the excavation. The samples were collected from underneath the former location of the stained Cr (VI)-contaminated concrete pad in the sidewalls and on the bottom of the excavated area at locations B28 through B33 (Figure C.2-4). The soil sample results on the north, east, and west sidewalls of the excavation were less than the PAL for Cr (VI). The soil sample on the south wall and two samples from the bottom of the excavation exceeded the

PAL. A Tier 2 evaluation was conducted for Cr (VI) and is presented in Appendix G. The three confirmation sample Cr (VI) results that exceeded the PAL did not exceed the site-specific FAL established in the Tier 2 evaluation.

For RCRA metals and beryllium, with the exception of Cr (VI), the FALs were established at the PAL concentrations.

C.2.6.5 High Explosives

No HEs were detected in soil samples above the MDCs.

C.2.6.6 Radionuclides

Analytical results for radionuclides in soil samples collected at this CAS that were detected above MDCs are presented in Tables C.2-5 and C.2-6. None of the radionuclides exceeded the PALs. For radionuclides, the FALs were established at the PAL concentrations.

Table C.2-5
Soil Sample Results for Gamma-Emitting Radionuclides
Detected above MDCs

Sample Location	Sample Number	Depth (cm bgs)	COPCs (pCi/g)	
			Ac-228	Am-241
FAL[a]			22.34	2,687
B03	465B003	0.0 - 5.0	1.3	--
B04	465B004	0.0 - 5.0	1.9	--
B05	465B005	0.0 - 5.0	1.41	--
B17	465B020	45.0 - 60.0	1.85	--
B18	465B021	45.0 - 60.0	1.74	--
B20	465B023	0.0 - 15.0	1.86	0.36 (J)
B21	465B024	0.0 - 15.0	1.57	--
B22	465B025	0.0 - 15.0	1.26	--

[a]FAL is the Industrial Area Exposure Scenario, Internal and External Dose from NNSA/NSO (2012d).

Ac = Actinium
Am = Americium
pCi/g = Picocuries per gram

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

Table C.2-6
Soil Sample Results for Isotopes Detected above MDCs

Sample Location	Sample Number	Depth (cm bgs)	COPCs (pCi/g)			
			Pu-239/240	U-234	U-235	U-238
FAL[a]			7,645	49,460	289.7	1,667
B03	465B003	0.0 - 5.0	--	0.618	--	0.658
B04	465B004	0.0 - 5.0	0.141	0.924 (J)	0.102	0.963
B05	465B005	0.0 - 5.0	--	0.974	0.0598	1.64
B17	465B020	45.0 - 60.0	--	3.26	0.399	19
B18	465B021	45.0 - 60.0	--	4.31	0.737	27.6
B20	465B023	0.0 - 15.0	0.0557	0.589	--	0.643
B21	465B024	0.0 - 15.0	--	0.522	--	0.582
B22	465B025	0.0 - 15.0	--	0.547	--	0.679

[a]FAL is the Industrial Area Exposure Scenario, Internal and External Dose from NNSA/NSO (2012d).

-- = Not detected above MDCs.

C.2.7 PSM Sample Results

A total of six PSM concrete samples were collected at the Dog site. Four of the concrete samples (465B001, 465B002, 465B010, and 465B011) were collected from the small, stained concrete pad located south of the fenced compound. Two larger, unstained concrete pads are also in the vicinity (Figure C.2-2). One sample from each of the large concrete pads was collected (465B012 and 465B014). Concrete samples were analyzed for one or more of the following: VOCs, SVOCs, RCRA metals (including Cr [VI]), beryllium, HE, PCBs, gamma spectroscopy, isotopic U, isotopic Sr, and isotopic Pu. Due to the small number of PSM samples, the analytical data for all six concrete samples are presented in one table (Table C.2-7).

C.2.7.1 Volatile Organic Compounds

Six VOCs were detected in two concrete samples above the MDCs: 1,2,4-trimethylbenzene, 2-butanone, 4-isopropyltoluene, acetone, toluene, and total xylenes. These two samples were collected at the stained locations (B01 and B02) on the small concrete pad. None of these VOCs were detected above the PAL. The FALs were established at the PAL concentrations for VOCs.

Table C.2-7
PSM Sample Results Detected above MDCs
(Page 1 of 2)

Sample Location	Sample Number	Sample Matrix	Contaminant	Result	Unit	FAL
B01	465B001	Concrete	Ac-228	0.564	pCi/g	22.34[a]
			Cs-137	0.196	pCi/g	81.45[a]
			Arsenic	6.92	mg/kg	23
			Barium	87.3	mg/kg	190,000
			Cadmium	29	mg/kg	800
			Chromium	1,390	mg/kg	N/A
			Cr (VI)	**680**	mg/kg	48.1
			Lead	34.5 (J+)	mg/kg	800
			Mercury	0.0131 (J-)	mg/kg	43
			U-234	0.361 (J)	pCi/g	49,460[a]
			U-238	0.414	pCi/g	1,667[a]
			1,2,4-Trimethylbenzene	0.00176	mg/kg	260
			2-Butanone	0.00387 (J)	mg/kg	200,000
			Acetone	0.00928	mg/kg	630,000
			Total Xylenes	0.00064 (J)	mg/kg	2,700
	465B010	Concrete	Cr (VI)	**616**	mg/kg	48.1
			U-234	0.302 (J)	pCi/g	49,460[a]
			U-238	0.301	pCi/g	1,667[a]
B02	465B002	Concrete	Arsenic	4.86	mg/kg	23
			Barium	500	mg/kg	190,000
			Chromium	1,970	mg/kg	N/A
			Cr (VI)	**165**	mg/kg	48.1
			Lead	14.4 (J+)	mg/kg	800
			Benz(a)anthracene	0.0158 (J)	mg/kg	2.1
			Chrysene	0.0573 (J)	mg/kg	210
			Phenanthrene	0.025 (J)	mg/kg	170,000
			Pyrene	0.0455 (J)	mg/kg	17,000
			U-234	0.483 (J)	pCi/g	49,460[a]
			U-238	0.426	pCi/g	1,667[a]

Table C.2-7
PSM Sample Results Detected above MDCs
(Page 2 of 2)

Sample Location	Sample Number	Sample Matrix	Contaminant	Result	Unit	FAL
B02	465B002	Concrete	1,2,4-Trimethylbenzene	0.00058 (J)	mg/kg	260
			2-Butanone	0.00183 (J)	mg/kg	200,000
			Acetone	0.00834	mg/kg	630,000
			p-Isopropyltoluene	0.00044 (J)	mg/kg	11,000
			Toluene	0.001	mg/kg	45,000
			Total Xylenes	0.00152	mg/kg	2,700
B09	465B011	Concrete	Cr (VI)	5	mg/kg	48.1
			U-234	0.265 (J)	pCi/g	49,460[a]
			U-238	0.313	pCi/g	1,667[a]
B10	465B012	Concrete	Cr (VI)	0.457	mg/kg	48.1
B11	465B014	Concrete	Cr (VI)	0.744	mg/kg	48.1

[a]FAL is the Industrial Area Exposure Scenario, Internal and External Dose from NNSA/NSO (2012d).

Bold indicates value exceeds the FAL.

Cs = Cesium

J = Estimated value.
J+ = The result is an estimated quantity, but the result may be biased high.
J- = The result is an estimated quantity, but the result may be biased low.

C.2.7.2 Semivolatile Organic Compounds

Four SVOCs were detected in one concrete sample above the MDCs: benzo(a)anthracene, chrysene, phenanthrene, and pyrene. None of these SVOCs were detected above the PAL. The FALs were established at the PAL concentrations for SVOCs.

C.2.7.3 High Explosives and PCBs

No HEs or PCBs were detected above the MDCs in the concrete samples collected at the Dog site.

C.2.7.4 RCRA Metals and Beryllium

Analytical results for RCRA metals and beryllium in concrete samples collected at the Dog site that were detected above MDCs are presented in Table C.2-7.

Cr (VI)-Contaminated Concrete Pad. The sample results from the stained portion of the small concrete pad (locations B01 and B02) confirmed that this pad is PSM for Cr (VI). This conclusion is based on the assumption that the entire volume of Cr (VI) in the concrete has the potential to leach to the surrounding soil and contaminate the soil at a concentration above the FAL. With the exception of Cr (VI), the FALs were established at the PAL concentrations for metals (the FAL for Cr [VI] is discussed in Appendix G). The small concrete pad was removed and disposed of off site, as detailed in Section C.3.0. Characterization of the soil underneath the concrete pad is discussed in Section C.2.6.4.

C.2.7.5 Radionuclides

Analytical results for radionuclides in concrete samples collected at the Dog site that were detected above MDCs are presented in Table C.2-7. None of the radionuclides exceeded the PALs. For radionuclides, the FALs were established at the PAL concentrations.

C.2.7.6 Nature and Extent of Contamination

Based on the analytical results for samples collected at the Dog site, the only COCs identified were arsenic, lead, and Cr (VI) in soil and Cr (VI) in concrete (PSM). The arsenic and lead in soil was detected at locations where metallic debris was identified on the ground surface. Specifically, at the location of a lead brick (B06) and a trash pile containing metal debris (B04). The Cr (VI) was detected in concrete samples taken at locations of dark staining (B01, B02), and underneath the concrete pad. After removal of the surface debris—including lead bricks, metal cans, and the small concrete pad—confirmation soil samples were collected underneath the debris locations. These sample results did not exceed the metal FALs and confirmed that the existing metals contamination has been removed.

C.2.7.7 Revised CSM

A landfill/disposal trench was identified during visual surveys at the Dog site. Because this feature was not discussed in the SAFER Plan (NNSA/NSO, 2011) and represented an unexpected site condition, the CSM was reviewed and revised, and NDEP was notified. The landfill/disposal trench was added to the subsurface release component of the Dog site. The ROTC (NNSA/NSO, 2012b) discusses the landfill/disposal trench and identifies the impacts of this feature on the DQO process.

C.3.0 Waste Management

The following subsections describe the waste management activities completed during the CAI and closure activities at CAU 465. The types of waste generated included nonhazardous, RCRA-regulated hazardous, and low-level radioactive waste. Recyclable material was also generated. All wastes and recyclable materials were managed in accordance with federal and state regulations, permit limitations, and disposal facility waste acceptance criteria. Waste management activities were conducted as specified in the CAU 465 SAFER Plan (NNSA/NSO, 2011). A summary of the waste streams generated, waste characterization, and waste disposition is provided in Table C.3-1. Waste disposal documentation is presented in Appendix D.

Site controls were in place to prevent the introduction of hazardous constituents to these waste streams. All waste streams were field screened as generated to comply with the radiological release limits of Table 4-2 of the *Nevada National Security Site Radiological Control Manual* (NNSA/NSO, 2012a).

C.3.1 Waste Characterization and Disposal

Waste generated during the investigation was segregated into the following waste streams:

- Disposable personal protective equipment (PPE) and sampling equipment
- Recyclable lead
- Soil
- Concrete
- Debris

Waste characterization was accomplished using process knowledge, associated samples (e.g., soil), and limited direct waste/PSM sampling. Available analytical results are compared to the regulatory limits for RCRA-regulated hazardous waste, waste acceptance criteria for the NNSS landfills, and the limits in the *Nevada Test Site Performance Objective for the Certification of Nonradioactive Hazardous Waste* (POC) (BN, 1995). The POC limits have been established for NNSS hazardous waste generators to ensure that all hazardous waste being shipped off site contains no "added radioactivity."

Table C.3-1
CAU 465 Waste Streams and Disposal Pathways

Container Number	Description	Location	Waste Characterization	Volume/Weight	Disposal Pathway	Disposal Date	Disposal Document
465B01	Lead Bricks	B06, B07, B08, B16	Recyclable	500 lb	Recycle	TBD	BOL
465B02	Soil	B06	Non-hazardous Non-radioactive	8 gal	Consolidated into 465B04		
465B03	Stained Concrete Pad	B01, B02	Hazardous	2,300 lb	Offsite TSDF (U.S. Ecology)	06/13/2012	UHM 956283 FLE
465B04	Soil	B04	Hazardous	13,140 lb			
465B05	Trash Pile Debris	B04	Non-hazardous Non-radioactive	5 yd^3	Area 9, U10C Landfill	05/10/2012	LVF
465B06	Lead Plates	B19	Recyclable	1,500 lb	Recycle	TBD	BOL
465B07	Debris	Landfill/disposal trench	LLW	1 yd^3	Consolidated into 465B09		
465B08	Lead Fragment	Landfill/disposal trench	Recyclable	27 lb	Recycle	TBD	BOL
465B09	Housekeeping Debris	All CASs	LLW	20 yd^3	Area 5, RWMC	10/03/2012	CD
465B10	Soil	B20, B21, B22	Hazardous	10 yd^3	Offsite TSDF (U.S. Ecology)	08/09/2012	UHM 956292 FLE
465B11			Hazardous	5 yd^3			

C.3.1.1 Disposable PPE and Sampling Equipment

PPE and disposable sampling equipment generated during the CAI were determined to be nonhazardous, nonradioactive waste based on process knowledge, visual inspection, and radiological field screening. The waste was bagged, labeled, and placed in the roll-off located at Building 23-153 and subsequently disposed of at the Area 9, U10C industrial waste landfill on the NNSS.

C.3.1.2 Recyclable Lead

Six lead bricks, one lead block, and three lead plates were removed from the ground surface and shallow subsurface during closure activities. These materials are not considered waste because they will be recycled. The lead material is currently being stored at NNSS Building 23-153 awaiting transport to an offsite recycling facility.

C.3.1.3 Soil

Soil from the area surrounding and underneath identified PSM was removed during the CAI. Soil excavated at the trash pile location (B04) was characterized using a biased sample collected at the center of the pile. This sample (465B004) was analyzed for parameters outlined in Table 2-2 and TCLP metals. The sample contained lead at a concentration of 374 mg/L, which is greater than the regulatory limit of 5 mg/L.

After the small concrete pad was removed, excavated soil was characterized using two biased soil samples collected from underneath the pad (465B023 and 465B024). These samples were analyzed for parameters outlined in Table 2-2 and were found to contain Cr (VI) in excess of regulatory limits. Soil managed as hazardous waste was disposed of off site at a permitted hazardous waste facility.

Soil contaminated with lead from under the lead brick at location B06 was characterized using a direct sample of the waste (465B501), which was analyzed for radiological parameters and TCLP metals. This sample did not exceed regulatory limits, and the soil was characterized as nonhazardous, nonradioactive waste. Due to the small volume of soil, this waste stream was combined with soil excavated from the trash pile for disposal.

C.3.1.4 Concrete

One small concrete pad measuring approximately 6 ft by 4 ft by 7 in. thick was removed during closure activities. The pad was characterized using direct samples collected from the pad. Three concrete samples were collected (465B001, 465B002, and 465B010) and analyzed for the parameters in Table 2-2. Sample 465B010 was also analyzed for TCLP metals. This sample contained Cr (VI) at a concentration of 30.4 mg/L, which is greater than the regulatory limit of 5 mg/L. As a result, the concrete pad was removed and managed as hazardous waste. The pad was disposed of off site at a permitted hazardous waste facility.

C.3.1.5 Debris

This waste stream consists of housekeeping debris (scrap metal, wood, communication line/cables) from each CAS and metal debris (metal cans, wire) from the trash pile at the Dog site. The debris was characterized using process knowledge and radiological screening survey results.

Housekeeping Debris. Some of the housekeeping debris had elevated radiological readings, so as a conservative measure, the entire housekeeping waste stream was managed as low-level radioactive waste. This waste was disposed of at the NNSS Area 5 RMWC.

Trash Pile Debris. The debris collected from the trash pile did not show elevated radiological readings and was managed as nonhazardous, nonradioactive waste. This debris was disposed of in the NNSS Area 9 U10C landfill.

C.4.0 Quality Assurance

This section contains a summary of QA/QC measures implemented during the sampling and analysis activities conducted in support of the CAU 465 CAI. The following subsections discuss the data validation process, QC samples, and nonconformances. A detailed evaluation of the DQIs is presented in Section 4.3.

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 samples, 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, 2012c).

C.4.1 Data Validation

Data validation was performed in accordance with the Soils QAP and approved protocols and procedures. All laboratory data from samples collected and analyzed for CAU 465 were evaluated for data quality in a tiered process described in Sections C.4.1.1 through C.4.1.3. 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 project files as a hard copy and electronic media.

One hundred percent of the data analyzed as part of this investigation were subjected to Tier I and Tier II evaluations. A Tier III evaluation was performed on approximately 5 percent of the data analyzed.

C.4.1.1 Tier I Evaluation

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

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

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

C.4.1.2 Tier II Evaluation

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

- Correct detection limits achieved.
- Sample date, preparation date, and analysis date for each sample.
- Holding time criteria met.
- QC batch association for each sample.
- Cooler temperature upon receipt.
- Sample pH for aqueous samples, as required.
- Detection limits properly adjusted for dilution, as required.
- Blank contamination evaluated and applied to sample results/qualifiers.
- MS/matrix spike duplicate (MSD) percent recoveries (%R) and RPDs evaluated and qualifiers applied to laboratory results, as necessary.
- FD RPDs evaluated using professional judgment and qualifiers applied to laboratory results, as necessary.
- Laboratory duplicate RPDs evaluated and qualifiers applied to laboratory results, as necessary.
- Surrogate %R evaluated and qualifiers applied to laboratory results, as necessary.
- LCS %R evaluated and qualifiers applied to laboratory results, as necessary.

- Initial and continuing calibration evaluated and qualifiers applied to laboratory results, as necessary.
- Internal standard evaluation.
- Mass spectrometer tuning criteria.
- Organic compound quantitation.
- Inductively coupled plasma interference check sample evaluation.
- Graphite furnace atomic absorption QC.
- Inductively coupled plasma serial dilution effects.
- Recalculation of 10 percent of laboratory results from raw data.

Tier II evaluation for radiochemical analysis examines, but is not limited to, as follows:

- Correct detection limits achieved.
- Blank contamination evaluated and, if significant, qualifiers are applied to sample results.
- Certificate of Analysis consistent with data package documentation.
- Quality control sample results (duplicates, LCSs, laboratory blanks) evaluated and used to determine laboratory result qualifiers.
- Sample results, uncertainty, and MDCs evaluated.
- Detector system calibrated with National Institute of Standards and Technology (NIST)-traceable sources.
- Calibration sources preparation was documented, demonstrating proper preparation and appropriateness for sample matrix, emission energies, and concentrations.
- Detector system response to daily or weekly background and calibration checks for peak energy, peak centroid, peak full-width half-maximum, and peak efficiency, depending on the detection system.
- Tracers NIST-traceable, appropriate for the analysis performed, and recoveries that met QC requirements.

- Documentation of all QC sample preparation complete and properly performed.
- Spectra lines, photon emissions, particle energies, peak areas, and background peak areas support the identified radionuclide and its concentration.

C.4.1.3 Tier III Evaluation

The Tier III review is an independent examination of the Tier II evaluation. A Tier III review of 5 percent of the sample analytical data was performed by TechLaw, Inc., of Lakewood, Colorado. Tier II and Tier III results were compared and where differences are noted, data were reviewed and changes were made accordingly. This review included the following additional evaluations:

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

  - second column and/or second detector confirmation,
  - mass spectra interpretation,
  - Interference check samples and serial dilutions,
  - post-digestion spikes and method of standard additions, and
  - breakdown evaluations.

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

C.4.2 Field QC Samples

Field QC samples consisted of one trip blank, one field blank, and two FDs collected and submitted for the analyses shown in Table C.2-1. The QC samples were assigned individual sample numbers and sent to the laboratory "blind." Additional samples were selected by the laboratory to be analyzed as laboratory duplicates.

C.4.2.1 Laboratory QC Samples

Analysis of method QC blanks were performed on each sample delivery group (SDG) for inorganics. Analysis for surrogate spikes and preparation blanks (PBs) were performed on each SDG for organics only. Initial and continuing calibration and LCSs were performed for each SDG. The results of these analyses were used to qualify associated environmental sample results. Documentation of data qualifications resulting from the application of these guidelines is retained in project files as both hard copy and electronic media.

The laboratory included a PB, LCS, and a laboratory duplicate sample with each batch of field samples analyzed for radionuclides.

C.4.3 Field Nonconformances

There were no field nonconformances identified for the CAI.

C.4.4 Laboratory Nonconformances

Laboratory nonconformances are generally due to inconsistencies in the analytical instrumentation operation, sample preparations, extractions, missed holding times, and fluctuations in internal standard and calibration results. There were no laboratory nonconformances.

C.5.0 References

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.

N-I GIS, see Navarro-Intera Geographic Information Systems.

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

Navarro-Intera Geographic Information Systems. 2012. ESRI ArcGIS Software.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2010. *Nevada Test Site Radiological Control Manual*, DOE/NV/25946--801, Rev. 1. Prepared by Radiological Control Managers' Council. Las Vegas, NV.

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2011. *Streamlined Approach for Environmental Restoration for Corrective Action Unit 465: Hydronuclear, Nevada National Security Site, Nevada*, Rev. 0, DOE/NV--1467. 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. *Record of Technical Change to Streamlined Approach for Environmental Restoration for Corrective Action Unit 465: Hydronuclear, Nevada National Security Site, Nevada*, Rev. 0, DOE/NV--1467-ROTC 1. Las Vegas, NV.

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

U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office. 2012d. *Soils Risk-Based Corrective Action Evaluation Process*, DOE/NV--1475. Las Vegas, NV.

Appendix D

Waste Disposition Documentation

(5 Pages)

NSTec Form FRM-0918

(3) ✓

08/23/06 Rev. 0 Page 1 of 2

NTS LANDFILL LOAD VERIFICATION

SWO USE (Select One) AREA ☐ 23 ☐ 6 ☒ 9 ☒ **LANDFILL**

For waste characterization, approval, and/or assistance, contact Solid Waste Operation (SWO) at 5-7898.

REQUIRED: WASTE GERERATOR INFORMATION

(This form is for rolloffs, dump trucks, and other onsite disposal of materials.)

Waste Generator: Mark Heser (NI, WO) (M/S - NSF 176) (Fax 5-5393) Phone Number: (o)5-2124; (c)496-0150

Location / Origin: NNSS - Mercury, Building 23-153 - Bulk debris collected in 20 yd3 roll-off (Container ID 153R11).

Waste Category: (check one)		☐ Commercial	☒ Industrial	
Waste Type: (check one)	☐ NTS	☐ Putrescrible	☒ FFACO-onsite	☐ WAC Exception
	☐ Non-Putrescible	☐ Asbestos Containing Material	☐ FFACO-offsite	☐ Historic DOE/NV
Pollution Prevention Category: (check one)		☒ Environmental management	☐ Defense Projects	☐ YMP
Pollution Prevention Category: (check one)		☐ Clean-Up	☒ Routine	
Method of Characterization: (check one)		☒ Sampling & Analysis	☒ Process Knowledge	☐ Contents

Prohibited Waste at all three NTS landfills: Radioactive waste; RCRA waste; Hazardous waste; Free liquids, PCBs above TSCA regulatory levels, and Medical wastes (needles, sharps, bloody clothing).

Additional Prohibited Waste at the Area 9 U10C Landfill: Sewage Sludge, Animal carcasses, Wet garbage (food waste); and Friable asbestos

REQUIRED: WASTE CONTENTS ALLOWABLE WASTES

Check all allowable wastes that are contained within this load:

NOTE: Waste disposal at the Area 6 Hydrocarbon Landfill must have come into contact with petroleum hydrocarbons or coolants, such as: gasoline (no benzene, lead); jet fuel; diesel fuel; lubricants and hydraulics; kerosene; asphaltic petroleum hydrocarbon; and ethylene glycol.

Acceptable waste at any NTS landfill:

☒ Paper	☐ Rocks / unaltered geologic materials	☒ Empty containers	☐ Asphalt	☒ Metal	☒ Wood
☐ Soil	☐ Rubber (excluding tires)	☐ Demolition debris	☒ Plastic	☐ Wire	☐ Cable
☐ Cloth	☐ Insulation (non-Asbestosform)	☐ Cement & concrete			

☒ Manufactured items: (swamp coolers, furniture, rugs, carpet, electronic components, PPE, etc.)

Additional waste accepted at the Area 23 Mercury Landfill: ☐ Office Waste ☐ Food Waste ☐ Animal Carcasses

☐ Asbestos ☐ Friable ☐ Non-Friable (contact SWO if regulated load) Quantity: _____

Additional waste accepted at the Area 9 U10c Landfill:

☐ Non-friable asbestos	☐ Drained automobiles and military vehicles	☐ Solid fractions from sand/oil/water
☐ Light ballasts (contact SWO)	☐ Drained fuel filters (gas & diesel)	☐ Deconned Underground and Above Ground Tanks
☐ Hydrocarbons (contact SWO)	☐ Other _____	

Additional waste accepted at the Area 6 Hydrocarbon Landfill: ☐ _____

☐ Septic sludge	☐ Rags	☐ Drained fuel filters (gas & diesel)	☐ Crushed non-teme plated oil filters
☐ Plants	☐ Soil	☐ Sludge from sand/oil/water separators	☐ PCBs below 50 parts per million

REQUIRED: WASTE GENERATOR SIGNATURE

Initials: _____ (if initialed, no radiological clearance is necessary.)

The above mentioned waste was generated outside of a Controlled Waste Management knowledge, does not contain radiological materials.

To the best of my knowledge, the waste described above contains only those materials site. I have verified this through the waste characterization method identified above an prohibited and allowable waste items. I have contacted Property Management and have is approved for disposal in the landfill.

Print Name: Mark Heser

Signature: /s/ Mark Heser Date: 2/27/2012

Note: "Food waste, office trash and animal carcasses do not require a radiological clearance. Freon-containing appliances must have signed removal certification statement with Load Verification."

Radiological Survey Release for Waste Disposal

RCT Initials

JH **This container/load meets the criteria for no added man-made radioactive material**

____ **This container/load meets the criteria for Radcon Manual Table 4.2 release limits.**

____ **This container/load is exempt from survey due to process knowledge and origin.**

SIGNATURE: /s/ Signature on File **DATE:** 2-27-12

BN-0646 (10/05)

SWO USE ONLY

Load Weight (net from scale or estimate): 4000 Signature of Certifier: /s/ Signature on File

Waste Category Definitions	
Commercial Waste:	Office waste, putrescible waste
Industrial Waste:	Waste generated from activities associated with the fabrication or demolition of on-site structures. Solid waste derived from industrial manufacturing processes (i.e., construction and demolition waste).
Waste Types Definitions	
NTS:	Waste generated from construction, demolition, and/or routine activities within the Nevada Test Site boundaries. Waste that does not meet another waste type definition listed below.
Non-Putrescible:	Waste that is not directly associated with construction or demolition activities, such as office waste
Putrescible:	Waste that will decompose, decay, and become putrid (i.e. food waste and animal carcasses).
Asbestos Containing Material:	Waste that contains asbestos. Regulated asbestos (friable) will not be accepted without a shipping paper.
FFACO-onsite:	Waste generated, within the NTS boundaries, from activities directed by the Federal Facilities Agreement and Consent Order.
FFACO-offsite:	Waste generated, outside of the NTS boundaries, from activities directed by the Federal Facilities Agreement and Consent order (e.g., CNTA, TTR, NLV, and some UGTA project locations).
WAC exception	Waste that does not meet the waste acceptance criteria, as defined within the current NTS landfill permits, and has been given approval from the NDEP for disposal into an NTS landfill.
Historic DOE/NV	Waste generated from historical releases associated with the DOE/NV Waste Management Project Office (precursor to the Yucca Mountain Project Office), which occurred prior to November 30, 1989.
Pollution Prevention Category Definitions	
Environmental Management:	Waste generated from an Environmental Management project (e.g., waste generated from Environmental Restoration or International Technologies projects).
Industrial Waste:	Defense Projects: Waste generated from Defense Projects (e.g., waste generated from DTRA, LANL, Sandia, and/or any other non-Environmental Management directed project.
Routine:	Routine operations waste generated from: any type of production, analytical, and/or research and development laboratory operation; "work-for-others," and/or any periodic and recurring work that is considered on-going processes, are also considered routine operations.
Clean-up:	Clean-up/stabilization waste generated from one-time operations. Waste generated from: environmental restoration projects-, decontamination and decommissioning/ transition operations-, and TSCA regulated wastes. Clean-up/stabilization activities may span several years. The waste is a direct result of past operations and activities, rather than a current process. Newly generated wastes produced during clean-up operations (usually resulting from common activities such as handling, sampling, treatment, repackaging, shipping, etc.) are considered clean-up waste.
Radiological Limitations	
Area 23 Landfill:	See "Performance Objective for Certification of Non-Radioactive Hazardous Waste".
Area 6 and Area 9 Landfills:	See permit limits.

Rec'd 6/18/12 cg

Please print or type. (Form designed for use on elite (12-pitch) typewriter.) Form Approved. OMB No. 2050-0039

UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator ID Number	2. Page 1 of	3. Emergency Response Phone	4. Manifest Tracking Number
NV3890090001	1	(702)295-0311	000956283 FLE

GENERATOR

5. Generator's Name and Mailing Address

NSTEC FOR USDOE
P.O. BOX 98521, M/S NNSS116
LAS VEGAS NV 89193
Generator's Phone: (702)295-7365

Generator's Site Address (if different than mailing address)

NSTEC FOR USDOE
NEVADA NATIONAL SECURITY SITE, HWY 95
MERCURY NV 89023

6. Transporter 1 Company Name: B & P ENVIRONMENTAL SERVICES — U.S. EPA ID Number: CAT000624247

7. Transporter 2 Company Name — U.S. EPA ID Number

8. Designated Facility Name and Site Address — U.S. EPA ID Number

U.S. ECOLOGY
HWY 95, 12 MI. SOUTH OF BEATTY
BEATTY NV 89003
Facility's Phone: (800)239-3943

NVT330010000

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes		
RQ	1. NA3077, Hazardous waste, solid, n.o.s. (cadmium, lead), 9, III (lead)	1	CM	20	Y	D008		
X	2. NA3077, Hazardous waste, solid, n.o.s. (cadmium, chromium), 9, III	1	CM	20	Y	D006	D007	
	3.							
	4.							

14. Special Handling Instructions and Additional Information

1. ERG 171; BIN 5982, #NS-NSS-12-0071; PROFILE 13-1019. 2. ERG 171, BIN 5180, #NS-NSS-12-0072. PROFILE #13-1817. LOAD #12008.

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name	Signature	Month	Day	Year
CIRILO CARLOS GONZALES ON BEHALF OF USDOE	/s/ Cirilo Carlos Gonzales	6	13	12

INT'L

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter signature (for exports only): Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials

Transporter 1 Printed/Typed Name	Signature	Month	Day	Year
CHES JETER	/s/ Ches Jeter	06	13	12
Transporter 2 Printed/Typed Name	Signature	Month	Day	Year

DESIGNATED FACILITY

18. Discrepancy

18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator) — U.S. EPA ID Number

Facility's Phone:

18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.
H132	H132		

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a

Printed/Typed Name	Signature	Month	Day	Year
Tyler Young	/s/ Tyler Young	6	13	12

EPA Form 8700-22 (Rev. 3-05) Previous editions are obsolete. DESIGNATED FACILITY TO GENERATOR

UNCONTROLLED When Printed

Received 8/23/12

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UNIFORM HAZARDOUS WASTE MANIFEST

1. Generator ID Number	2. Page 1 of	3. Emergency Response Phone	4. Manifest Tracking Number
NV3890090001	1	(702) 295-0311	000956292 FLE

GENERATOR

5. Generator's Name and Mailing Address

NSTEC FOR USDOE
P.O. BOX 98521, M/S NNSS-110
LAS VEGAS NV 89193
Generator's Phone: (702)295-7085

Generator's Site Address (if different than mailing address)

NSTEC FOR USDOE
NEVADA NATIONAL SECURITY SITE, HWY 95
MERCURY NV 89023

6. Transporter 1 Company Name: MP ENVIRONMENTAL — U.S. EPA ID Number: CAT000624247

7. Transporter 2 Company Name — U.S. EPA ID Number:

8. Designated Facility Name and Site Address — U.S. EPA ID Number: NVT330010000

U.S. ECOLOGY
HWY 95, 12 MI. SOUTH OF BEATTY
BEATTY NV 89003
Facility's Phone: (800)239-3943

9a. HM	9b. U.S. DOT Description (including Proper Shipping Name, Hazard Class, ID Number, and Packing Group (if any))	10. Containers No.	10. Containers Type	11. Total Quantity	12. Unit Wt./Vol.	13. Waste Codes		
X	1. NA3077, Hazardous waste, solid, n.o.s. (chromium, lead), 9, III.	2	CM	20	Y	D007		
	2.							
	3.							
	4.							

14. Special Handling Instructions and Additional Information

1. ERG 171. BIN 6392, #NS-NSS-12-0109, GEN.DATE 7/9/12; BIN 6391, #12-0110, GEN.DATE 7/10/12; PROFILE #13-1019. NNSS LOAD #12011.

15. **GENERATOR'S/OFFEROR'S CERTIFICATION:** I hereby declare that the contents of this consignment are fully and accurately described above by the proper shipping name, and are classified, packaged, marked and labeled/placarded, and are in all respects in proper condition for transport according to applicable international and national governmental regulations. If export shipment and I am the Primary Exporter, I certify that the contents of this consignment conform to the terms of the attached EPA Acknowledgment of Consent.
I certify that the waste minimization statement identified in 40 CFR 262.27(a) (if I am a large quantity generator) or (b) (if I am a small quantity generator) is true.

Generator's/Offeror's Printed/Typed Name: CIRILO CARLOS GONZALES ON BEHALF OF USDOE — Signature: /s/ Cirilo Carlos Gonzales — Month 08 Day 09 Year 12

INT'L

16. International Shipments ☐ Import to U.S. ☐ Export from U.S. Port of entry/exit:
Transporter signature (for exports only): Date leaving U.S.:

TRANSPORTER

17. Transporter Acknowledgment of Receipt of Materials

Transporter 1 Printed/Typed Name: Gregory Snelson — Signature: /s/ Gregory Snelson — Month 08 Day 09 Year 12

Transporter 2 Printed/Typed Name — Signature — Month Day Year

DESIGNATED FACILITY

18. Discrepancy

18a. Discrepancy Indication Space ☐ Quantity ☐ Type ☐ Residue ☐ Partial Rejection ☐ Full Rejection

Manifest Reference Number:

18b. Alternate Facility (or Generator) — U.S. EPA ID Number

Facility's Phone:

18c. Signature of Alternate Facility (or Generator) — Month Day Year

19. Hazardous Waste Report Management Method Codes (i.e., codes for hazardous waste treatment, disposal, and recycling systems)

1.	2.	3.	4.
H132			

20. Designated Facility Owner or Operator: Certification of receipt of hazardous materials covered by the manifest except as noted in Item 18a

Printed/Typed Name: Tyler Young — Signature: /s/ Tyler Young — Month 8 Day 9 Year 12

EPA Form 8700-22 (Rev. 3-05) Previous editions are obsolete. DESIGNATED FACILITY TO GENERATOR

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Certificate of Disposal

This is to certify that the Waste Stream No. LITN-000000006, Revision 15, shipment number **ITL13003**, with container number **465B09** was shipped and received at the Nevada National Security Site Radioactive Waste Management Complex in Area 5 for disposal as stated below.

Mark Heser	NI	Waste Coordinator
Shipped by	Organization	Title
/s/ Mark Heser		10/3/12
Signature		Date
Stephen E Wolf	NSTec	Waste Specialist
Received by	Organization	Title
/s/ Stephen E. Wolf		10-03-2012
Signature		Date

Appendix E

Use Restrictions

E.1.0 Use Restrictions

URs were established at each of the sites within CAU 465. The following subsections document URs established at the four CAU 465 CASs 00-23-01, 00-23-02, 00-23-03 and 06-99-01.

E.1.1 CAS 00-23-01 (Charlie Site) URs

The UR signs at CAS 00-23-01 will state the following information:

WARNING

UNDERGROUND RADIOLOGICAL AND CHEMICAL CONTAMINATION

FFACO Site CAU 465/CAS 00-23-01 Hydronuclear Experiment

No activities that may alter or modify the containment control, including excavation or disturbance of material, are permitted in this area without U.S. Government permission.

Before working in this area, Contact Real Estate Services at 702-295-2528

E.1.2 CAS 00-23-02 (Dog Site) URs

The UR signs at CAS 00-23-02 will state the following information:

WARNING

UNDERGROUND RADIOLOGICAL AND CHEMICAL CONTAMINATION

FFACO Site CAU 465/CAS 00-23-02 Hydronuclear Experiment

No activities that may alter or modify the containment control, including excavation or disturbance of material, are permitted in this area without U.S. Government permission.

Before working in this area, Contact Real Estate Services at 702-295-2528

E.1.3 CAS 00-23-03 (Charlie Prime and Anja Sites) URs

The UR signs at CAS 00-23-02 will state the following information:

WARNING

UNDERGROUND RADIOLOGICAL AND CHEMICAL CONTAMINATION

FFACO Site CAU 465/CAS 00-23-03 Hydronuclear Experiment

No activities that may alter or modify the containment control, including excavation or disturbance of material, are permitted in this area without U.S. Government permission.

Before working in this area, Contact Real Estate Services at 702-295-2528

E.1.4 CAS 06-99-01 (Trailer 13 Site) URs

The UR signs at CAS 06-99-01 will state the following information:

WARNING

UNDERGROUND RADIOLOGICAL AND CHEMICAL CONTAMINATION

FFACO Site CAU 465/CAS 06-99-01 Hydronuclear

No activities that may alter or modify the containment control, including excavation or disturbance of material, are permitted in this area without U.S. Government permission.

Before working in this area, Contact Real Estate Services at 702-295-2528

Attachment E-1 of this appendix provides details of each UR.

Attachment E-1

Use Restrictions

(13 Pages)

Use Restriction Information

CAU Number/Description: 465 Hydronuclear
Applicable CAS Number/Description: CAS 00-23-01 Hydronuclear Experiment (Charlie Site)

Contact (DOE AL/Activity): Tiffany Lantow/Soils Activity

FFACO Use Restriction Physical Description:

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

UR Points	Northing	Easting
Center of Circle (radius of 100 ft [30.48 m])	4,070,833.0	578,067.3

Depth: From 6 inches below ground surface to an indeterminate depth. No surface limitation.

Survey Source (GPS, GIS, etc): GIS

Basis for FFACO UR(s):

Summary Statement: CAS 00-23-01 (Charlie Site) was the location of subsurface hydronuclear experiments in 24 boreholes. This FFACO Use Restriction is to protect site workers from inadvertent exposure to the subsurface contaminants listed below. Subsurface soils contaminated with radionuclides and metals are assumed to be present within hydronuclear experiment boreholes at concentrations exceeding risk-based action levels. Personnel are restricted from intrusive activities in these locations that would potentially expose workers to subsurface contamination. Any intrusive activities will require the prior notification and approval of the NDEP.

Contaminants Table:

Maximum Concentration of Contaminants for CAU 465 CAS 00-23-01, Hydronuclear Experiment (Charlie Site)			
Constituent	**Maximum Concentration**	**Industrial Action Level**	**Units**
High Explosives	Unknown	Varies	mg/kg
Lead	Unknown	800	mg/kg
Plutonium	Unknown	Varies	pCi/g
Uranium	Unknown	Varies	pCi/g

Site Controls: The UR is established at the boundary identified by the coordinates listed above and shown in the attached figure. Site controls include signs placed around the perimeter of the use-restricted area.

Description: The UR is recorded in the FFACO database, NNSA/NSO Facility Information Management System, and the NNSA/NSO CAU/CAS files.

Inspection/Maintenance Frequency: Annual post-closure inspections will be conducted to ensure postings are in place, intact and legible.

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:** 11/5/2012

Note: Effective upon acceptance of closure documents by NDEP.

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CAU 465, CAS 00-23-01
Hydronuclear Experiment
(Charlie Site)

Explanation

FFACO UR Boundary

0 40 80 160
Meters

0 125 250 500
Feet

N

Source: N-I GIS, 2012; NNSA/NV, 2002

Coordinate System: NAD 1983 UTM Zone 11N, Meter

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UNCONTROLLED When Printed

Use Restriction Information

CAU Number/Description: 465 Hydronuclear
Applicable CAS Number/Description: CAS 00-23-02 Hydronuclear Experiment (Dog Site)

Contact (DOE AL/Activity): Tiffany Lantow/Soils Activity

FFACO Use Restriction Physical Description:

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

UR Points	Northing	Easting
Center of Circle (radius of 220 ft [67.18 m])	4,070,728.1	579,377.4
Center of disposal borehole #1 (radius of 6 ft [1.83 m])	4,070,786.1	579,503.0
Center of disposal borehole #2 (radius of 6 ft [1.83 m])	4,070,784.8	579,562.2
Center of disposal borehole #3 (radius of 6 ft [1.83 m])	4,070,729.4	579,500.2
Center of disposal borehole #4 (radius of 6 ft [1.83 m])	4,070,724.3	579,561.9
Center of disposal borehole #5 (radius of 6 ft [1.83 m])	4,070,664.5	579,501.8
Center of disposal borehole #6 (radius of 6 ft [1.83 m])	4,070,664.3	579,561.3
South corner landfill disposal trench	4,070,584.6	579,429.1
West corner landfill/disposal trench	4,070,620.7	579,404.1
North corner landfill/disposal trench	4,070,680.3	579,448.5
East corner landfill/disposal trench	4,070,669.3	579,479.9

Depth: From 6 inches below ground surface to an indeterminate depth. No surface limitation.

Survey Source (GPS, GIS, etc): GIS

Basis for FFACO UR(s):

Summary Statement: CAS 00-23-02 (Dog Site) was the location of subsurface hydronuclear experiments in 28 test boreholes, 12 disposal boreholes, and a landfill/disposal trench (located outside the compound fence). This FFACO Use Restriction is to protect site workers from inadvertent exposure to the subsurface contaminants listed below. Subsurface soils contaminated with radionuclides and metals are assumed to be present within hydronuclear experiment boreholes, disposal boreholes, and a landfill/disposal trench at concentrations exceeding risk-based action levels. Personnel are restricted from intrusive activities in these locations that would potentially expose workers to subsurface contamination. Any intrusive activities will require the prior notification and approval of the NDEP.

Contaminants Table:

Maximum Concentration of Contaminants for CAU 465 CAS 00-23-02, Hydronuclear Experiment (Dog Site)			
Constituent	**Maximum Concentration**	**Industrial Action Level**	**Units**
High Explosives	Unknown	Varies	mg/kg
Lead	Unknown	800	mg/kg
Plutonium	Unknown	Varies	pCi/g
Uranium	Unknown	Varies	pCi/g

Site Controls: The UR is established at the boundaries identified by the coordinates listed above and shown in the attached figure. Site controls include signs placed around the perimeter fence surrounding the experiment boreholes, the disposal boreholes, and the landfill/ disposal trench.

Use Restriction Information

Administrative Use Restriction Physical Description*:

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

UR Points	Northing	Easting
Southeast corner	4,070,617.4	579,352.2
Southwest corner	4,070,617.4	579,346.1
Northwest corner	4,070,622.3	579,346.1
Northeast corner	4,070,622.5	579,352.2

Depth: Surface to an indeterminate depth

Survey Source (GPS, GIS, etc): GIS

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

Basis for Administrative UR(s):

Summary Statement: This administrative use restriction is to protect site workers from inadvertent exposure to the contaminants listed in the table below. The analytical results and locations of all samples collected are presented in the CR for CAU 465. Site workers under the current land use at this time are not exposed to the contamination present for a sufficient time to exceed risk-based action levels. However, as a Best Management Practice, this administrative use restriction will prevent future, more intensive use of the area. Personnel are restricted from performing work in this location that would result in a more intensive use of the area than current land use. Permissible activities that are consistent with the current land use include site visits, maintenance of fencing and signs, and security patrols. Any activities to be conducted within this area that are not consistent with current land use requires prior notification and approval from NDEP. This administrative UR boundary may be reevaluated if there is a change in usage of this area.

Contaminants Table:

Maximum Concentration of Contaminants for CAU 465 CAS 00-23-02, Hydronuclear Experiment (Dog Site)			
Constituent	**Maximum Concentration**	**Industrial Action Level**	**Units**
Hexavalent Chromium	25.1	48.1	mg/kg

Site Controls: The administrative UR is established at the boundary identified by the coordinates listed above and depicted in the attached figure.

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

Description: These URs are recorded in the FFACO database, NNSA/NSO Facility Information Management System, and the NNSA/NSO CAU/CAS files.

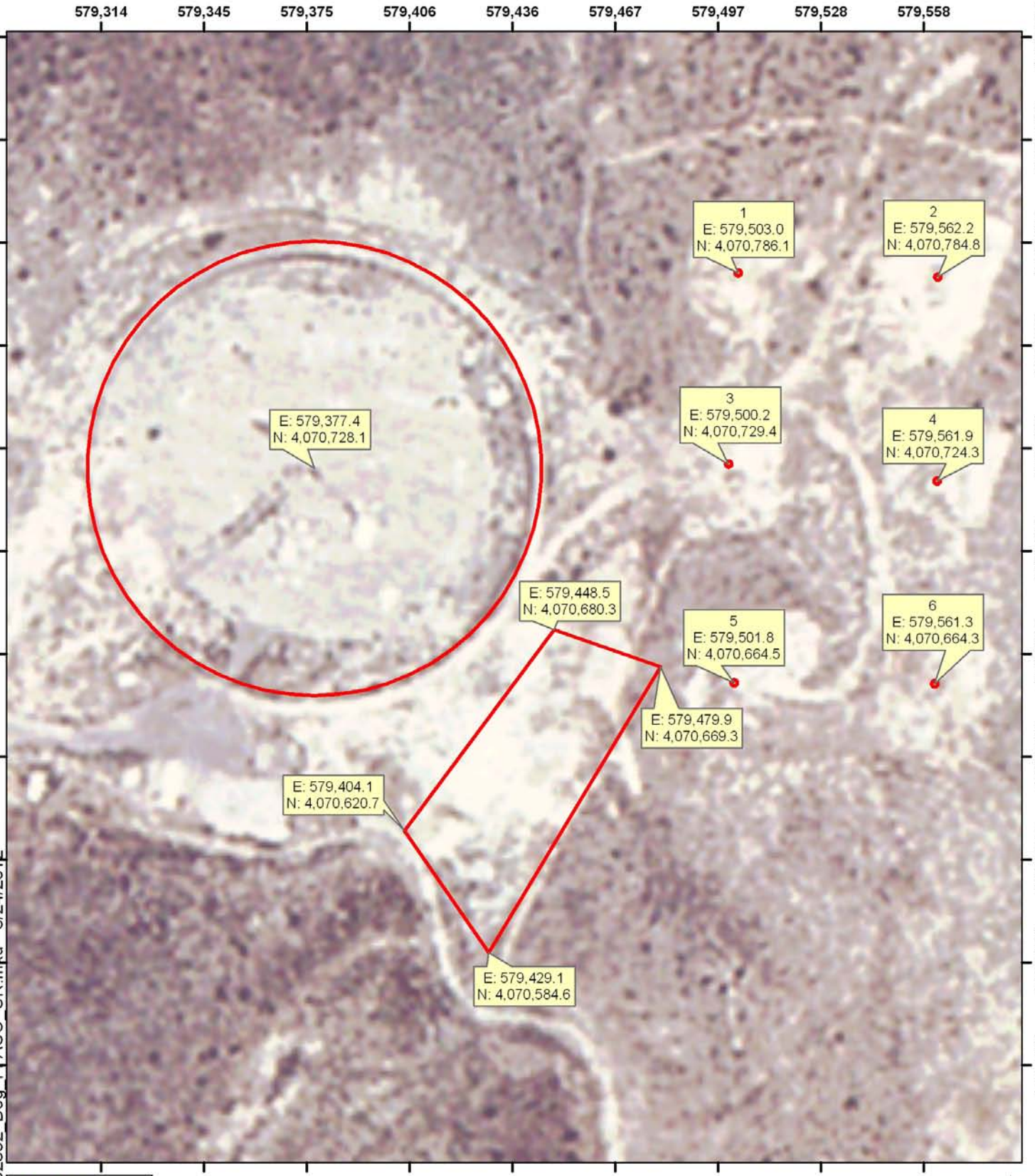
Inspection/Maintenance Frequency: Annual inspections will be conducted to ensure postings are in place, intact and legible.

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:** 11/5/2012

Note: Effective upon acceptance of closure documents by NDEP.



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CAU 465, CAS 00-23-02
Hydronuclear Experiment
(Dog Site)

Explanation

FFACO UR Boundary

0 20 40 80
Meters

0 62.5 125 250
Feet

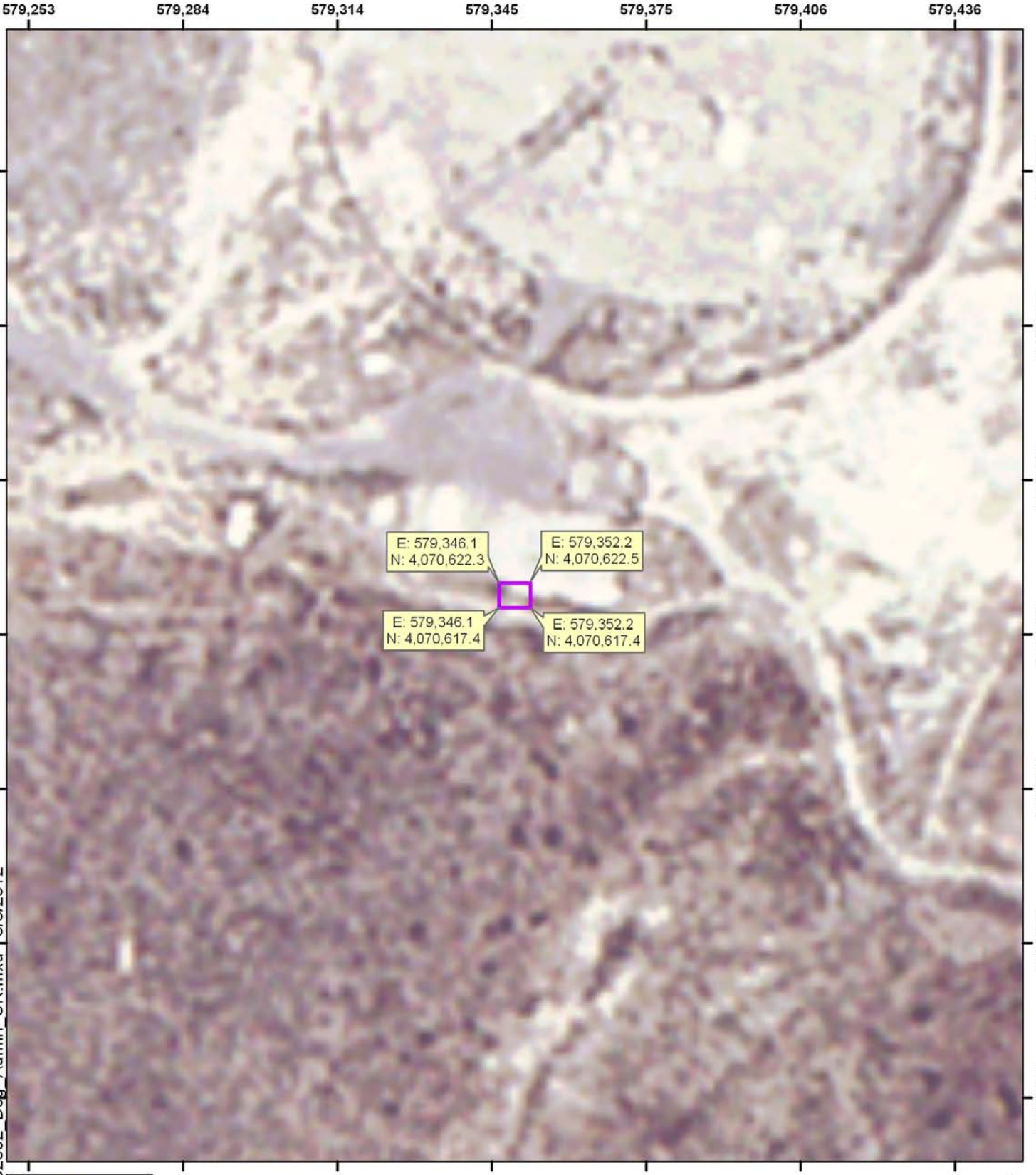
N

UNCONTROLLED When Printed

Source: N-I GIS, 2012; NNSA/NV, 2002

Coordinate System: NAD 1983 UTM Zone 11N, Meter

UNCONTROLLED When Printed



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CAU 465, CAS 00-23-02
Hydronuclear Experiment
(Dog Site)

Explanation

Administrative UR Boundary

0 12.5 25 50
Meters

0 40 80 160
Feet

N

UNCONTROLLED When Printed

Source: N-I GIS, 2012; NNSA/NV, 2002

Coordinate System: NAD 1983 UTM Zone 11N, Meter

UNCONTROLLED When Printed

Use Restriction Information

CAU Number/Description: 465 Hydronuclear
Applicable CAS Number/Description: CAS 00-23-03 Hydronuclear Experiment (Charlie Prime and Anja Sites)

Contact (DOE AL/Activity): Tiffany Lantow/Soils Activity

FFACO Use Restriction Physical Description:

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

UR Points	Northing	Easting
Charlie Prime-Center of Circle (radius of 128 ft [39.01 m])	4,070,433.4	578,509.7
Anja-Center of Circle (radius of 79 ft [24.08 m])	4,070,044.2	579,336.6

Depth: From 6 inches below ground surface to an indeterminate depth. No surface limitation.

Survey Source (GPS, GIS, etc): GIS

Basis for FFACO UR(s):

Summary Statement: CAS 00-23-03 (Charlie Prime and Anja Sites) was the location of subsurface hydronuclear experiments. The Charlie Prime site consists of 12 test boreholes, 10 of which were used to conduct hydronuclear experiments. Sixteen boreholes were drilled at the Anja site. Of these, 14 were used to conduct subsurface hydronuclear experiments, leaving 2 unexpended boreholes. This FFACO Use Restriction is to protect site workers from inadvertent exposure to the subsurface contaminants listed below. Subsurface soils contaminated with radionuclides and metals are assumed to be present within hydronuclear experiment boreholes at concentrations exceeding risk-based action levels. Personnel are restricted from intrusive activities in these locations that would potentially expose workers to subsurface contamination. Any intrusive activities will require the prior notification and approval of the NDEP.

Contaminants Table:

Maximum Concentration of Contaminants for CAU 465 CAS 00-23-03, Hydronuclear Experiment (Charlie Prime and Anja Sites)			
Constituent	**Maximum Concentration**	**Industrial Action Level**	**Units**
High Explosives	Unknown	Varies	mg/kg
Lead	Unknown	800	mg/kg
Plutonium	Unknown	Varies	pCi/g
Uranium	Unknown	Varies	pCi/g

Site Controls: The UR is established at the boundary identified by the coordinates listed above and shown in the attached figures. Site controls include signs placed around the perimeter of the use-restricted area.

Description: The UR is recorded in the FFACO database, NNSA/NSO Facility Information Management System, and the NNSA/NSO CAU/CAS files.

Inspection/Maintenance Frequency: Annual post-closure inspections will be conducted to ensure postings are in place, intact and legible.

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.

Use Restriction Information

Comments: None.

Submitted By: /s/ Tiffany A. Lantow **Date:** 11/5/2012

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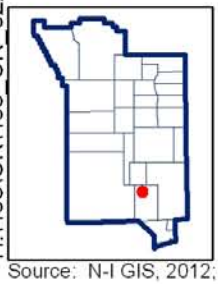


CAU 465, CAS 00-23-03
Hydronuclear Experiment
(Charlie Prime Site)

Explanation

FFACO UR Boundary

0 40 80 160
Meters

0 125 250 500
Feet

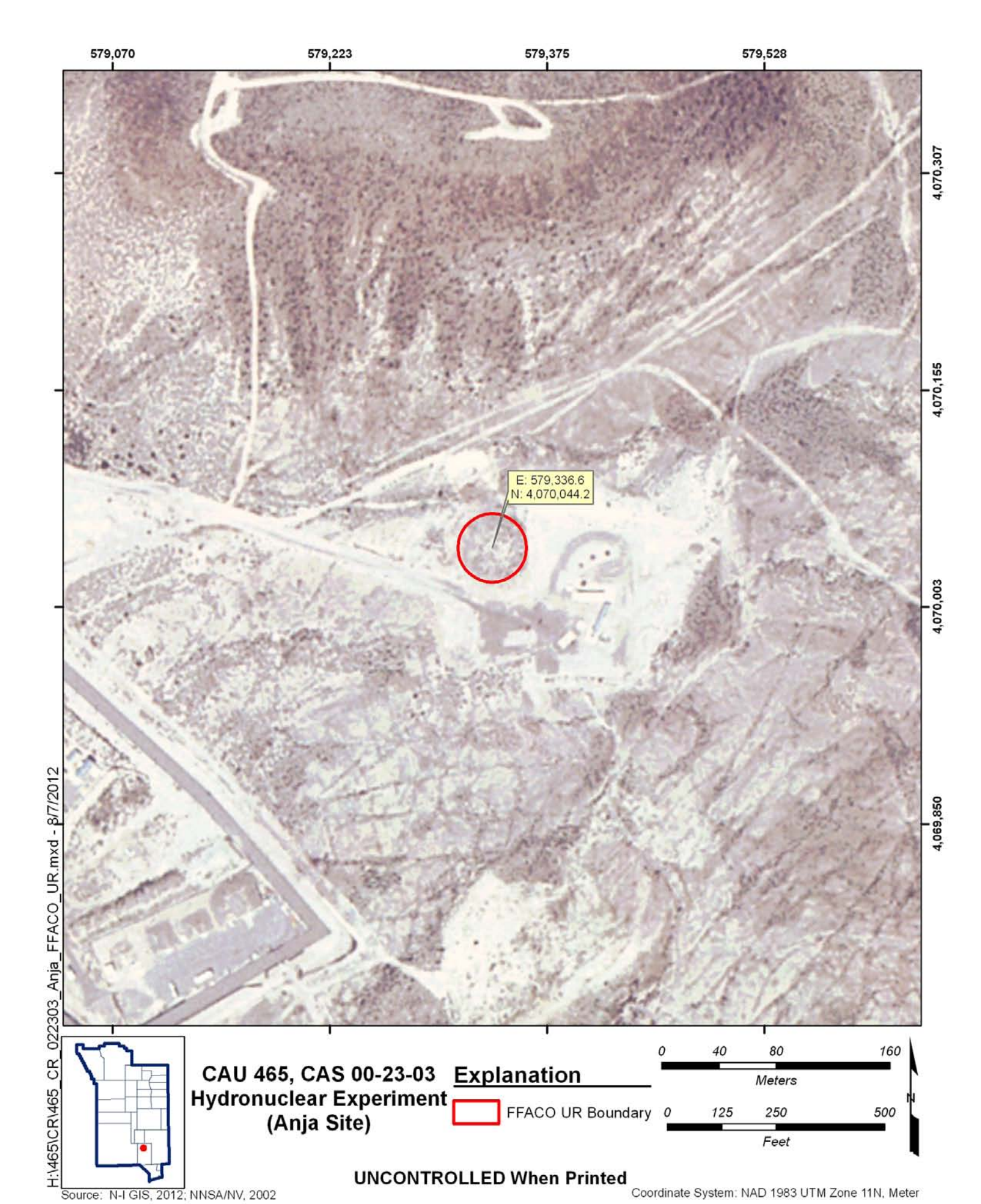
N

UNCONTROLLED When Printed

Source: N-I GIS, 2012; NNSA/NV, 2002

Coordinate System: NAD 1983 UTM Zone 11N, Meter

UNCONTROLLED When Printed



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Use Restriction Information

CAU Number/Description: 465 Hydronuclear
Applicable CAS Number/Description: CAS 06-99-01 Hydronuclear (Trailer 13 Site)

Contact (DOE AL/Activity): Tiffany Lantow/Soils Activity

FFACO Use Restriction Physical Description:

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

UR Points	Northing	Easting
Southeast corner	4,088,392.6	588,106.3
Southwest corner	4,088,400.1	588,086.9
West corner	4,088,603.1	588,068.7
Northwest corner	4,088,646.1	588,117.0
Northeast corner	4,088,652.5	588,190.0
East corner	4,088,521.5	588,264.2

Depth: From 6 inches below ground surface to an indeterminate depth. No surface limitation.

Survey Source (GPS, GIS, etc): GIS

Basis for FFACO UR(s):

Summary Statement: CAS 06-99-01 (Trailer 13 Site) was the location of subsurface hydronuclear experiments in 22 boreholes. This FFACO Use Restriction is to protect site workers from inadvertent exposure to the subsurface contaminants listed below. Subsurface soils contaminated with radionuclides and metals are assumed to be present within hydronuclear experiment boreholes at concentrations exceeding risk-based action levels. Personnel are restricted from intrusive activities in these locations that would potentially expose workers to subsurface contamination. Any intrusive activities will require the prior notification and approval of the NDEP.

Contaminants Table:

Maximum Concentration of Contaminants for CAU 465 CAS 06-99-01, Hydronuclear Experiment (Trailer 13 Site)			
Constituent	**Maximum Concentration**	**Industrial Action Level**	**Units**
High Explosives	Unknown	Varies	mg/kg
Lead	Unknown	800	mg/kg
Plutonium	Unknown	Varies	pCi/g
Uranium	Unknown	Varies	pCi/g

Site Controls: The UR is established at the boundary identified by the coordinates listed above and shown in the attached figure. Site controls include signs placed around the perimeter of the use-restricted area.

Description: The UR is recorded in the FFACO database, NNSA/NSO Facility Information Management System, and the NNSA/NSO CAU/CAS files.

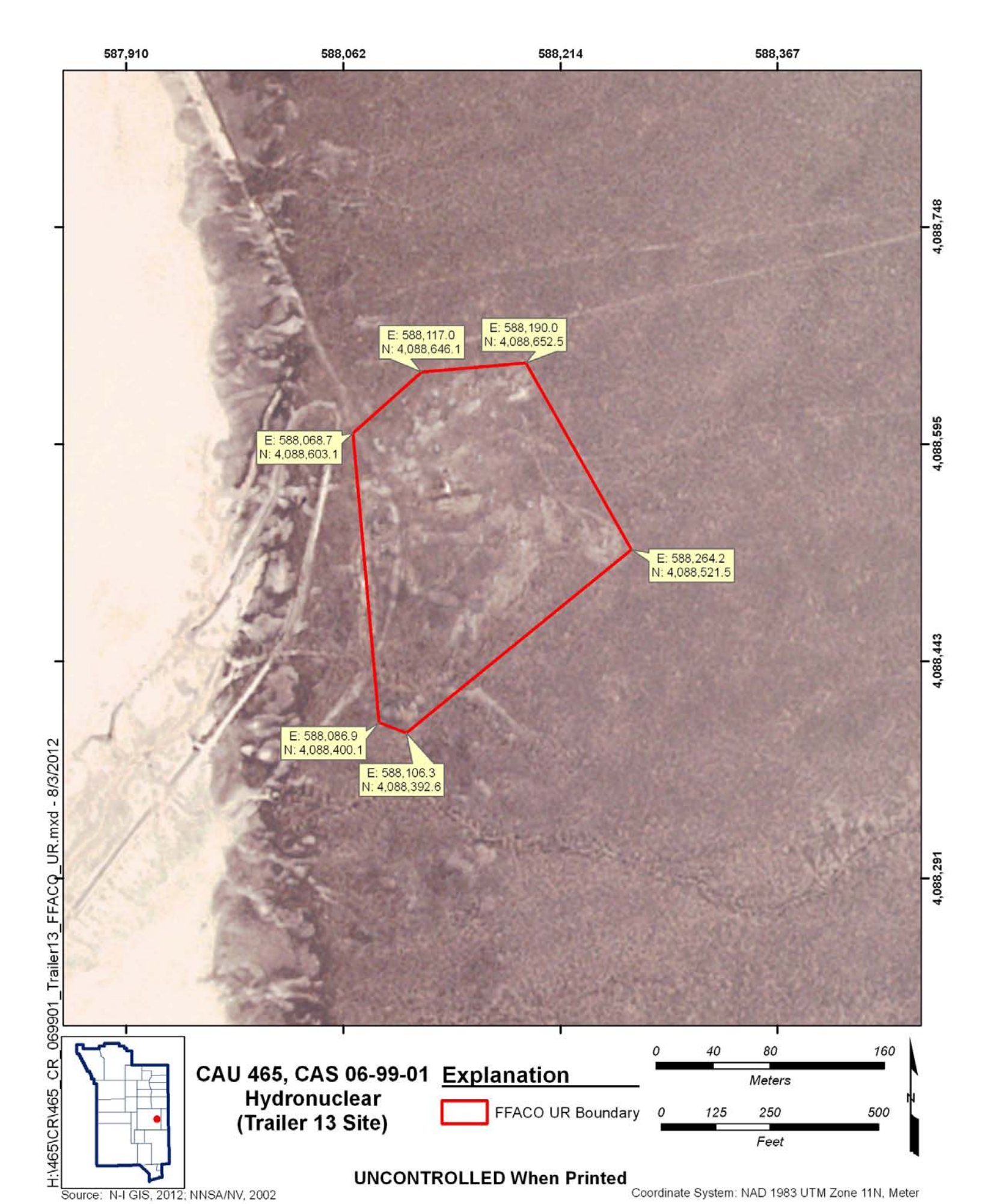
Inspection/Maintenance Frequency: Annual post-closure inspections will be conducted to ensure postings are in place, intact and legible.

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.

Use Restriction Information

Comments: None.

Submitted By: /s/ Tiffany A. Lantow **Date:** 11/5/2012



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Appendix F

Geophysical Survey Results, CAS 00-23-02 (Dog Site)

(6 Pages)

Technical Memorandum: Conduct of Geophysical Survey at Corrective Action Unit 465 – January 12, 2012

Introduction

A geophysical survey was conducted on January 12, 2012 at one site within Corrective Action Unit (CAU) 465. The survey was completed at an area with metallic debris lying on and partially exposed at the surface. The objective of the survey was to detect metallic debris potentially buried at the site. An EM61-MK2 time domain metal detector produced by Geonics Limited of Mississauga, Ontario, Canada was used to conduct the survey. The survey was conducted with the coils mounted on wheels as shown in Figure 1.

The EM61-MK2 detects both ferrous and non-ferrous conductive objects with excellent spatial resolution. Each system includes a single transmitter coil and two receiver coils. The coils are one meter by one-half meter in size. Figure 1 is a photo of the equipment with the coils mounted on wheels. The lowermost coil doubles as both a transmitter and receiver with the transmission occurring at 75 Hertz. When not transmitting, the same coil acts as a receiver. The uppermost coil is only used to receive.

Figure 1 Photo of the EM61-MK2 with Wheels Supporting Coils (Geonics, 2011)

A primary magnetic field, generated by current supplied to the transmitter coil, induces eddy currents in nearby conductive objects. The induced eddy currents decay with time at

a rate that is dependent on the characteristics of the object, producing a secondary magnetic field with the same rate of decay. The time-decay of the secondary magnetic field generates a signal within each of the two receiver coils, thereby confirming the presence of conductive material. Four time gates (channels) of data are collected. The earlier time gates (channels) improve the detection of smaller targets (Geonics, 2011). The signal detected is reported in units of millivolts (mV). With the coils mounted on wheels, as shown in Figure 1, the lowermost coil is approximately 40 centimeters above the ground surface.

An Archer 14802 Field personal computer (PC) with integrated Hemisphere XF101 global positioning system (GPS) receiver from Juniper Systems, Inc. of Logan, Utah was used to collect the data produced by the EM61-MK2A. The data-logger shown mounted on the EM61-MK2 in Figure 1 is an older Allegro unit now replaced by the Archer Field PC. The Archer Field PC with integrated GPS receiver is similar in size to the older Allegro data-logger. To improve positioning accuracy, a model 150-1013-00 patch antennae was connected to the integrated GPS receiver and mounted on the top coil of the EM61-MK2A.

Conduct of the Geophysical Survey

The survey was run using the EM61-MK2A and Archer Field PC with integrated GPS receiver, as noted above. The data was reduced using the DAT61MK2 software provided by Geonics. This software allows the user to reduce the “raw” data files saved in the Archer Field PC to files containing the UTM WGS 84 coordinates of the data points, in meters, and the four time gate data values (channels of data) generated by the EM61-MK2. The UTM WGS 84 coordinates were transformed to UTM NAD 27 coordinates using Arc Map software. The data was then transferred to Version 7 of the Surfer program by Golden Software of Golden, CO (Golden Software, 2011) for contouring and visualization. All contouring was accomplished using the default kriging routine in Surfer.

The strength of the signal, in mV, detected by the EM61MK2 is relative. It is a function of how large an object is, how conductive it is, and its distance from the receiver coils (i.e. depth of burial). As such, a small piece of highly conductive material at ground surface would yield a much stronger response than a larger poorly conductive object also on the surface. In addition, the same piece of highly conductive material will yield a stronger signal on the surface than it will if buried and, consequently, further from the coils.

The intent of the survey was to run it such that each traverse was immediately adjacent to the last causing the coils to pass directly over the entire area surveyed. In practice, the vegetation and topography present caused some deviation from this plan. However, each pass with the unit was close enough to the last that the instrument would have detected any significant metallic debris (i.e. larger than metallic washers) present. The survey was conducted at a slow pace with the EM61-MK2 and GPS unit programmed to collect data once per second.

Survey at CAU 465

Figure 2 shows the results of the survey conducted on January 12, 2012. The Figure shows the channel 2 data for the eastern portion of the area surveyed and includes all points of elevated instrument response observed during the survey. The locations of the metallic debris observed either on or partially exposed at the surface are indicated on the figure. Each of the locations is numbered. Table 1 lists the locations and gives the NAD27 coordinates in meters as well as brief descriptions of the objects.

Table 1 Coordinates and Descriptions of Metallic Debris Observed

Point Number	NAD 27 Easting (m)	NAD 27 Northing (m)	Debris Description
1	579,514.3000	4,070,401.3000	METAL STRAP
2	579,517.1000	4,070,404.0000	METAL STRAP
3	579,510.9000	4,070,404.5000	METAL STRAP
4	579,495.6000	4,070,408.2000	PAINT CAN
5	579,516.5000	4,070,409.9000	METAL DEBRIS
6	579,506.4000	4,070,424.1000	METAL NUTS
7	579,531.3000	4,070,435.3000	METAL BOLT
8	579,533.4000	4,070,437.1000	METAL DRUM
9	579,535.3000	4,070,450.7000	WIRE ROPE
10	579,537.9995	4,070,452.6599	LARGE PIECES OF LEAD
11	579,544.4000	4,070,458.8000	WIRE ROPE
12	579,519.4000	4,070,468.3000	METAL CAN
13	579,545.2000	4,070,472.2000	METAL DEBRIS
14	579,536.3000	4,070,474.0000	METAL PIPE
15	579,534.5000	4,070,477.4000	METAL BOLT

The survey revealed one main area of elevated instrument response with several smaller areas located both north and south. The main area is some 30 meters (m) long and 10 m wide oriented northeast to southwest and generally centered on a point located at approximately 579,530 m east and 4,070,442 m north. This central point is coincident with the main elevated instrument response which was not associated with any metallic debris observed at the surface and is marked on the figure by an arrow showing the location.

Due to the view chosen to show the data, not every item of metallic debris listed above is associated with an elevated instrument response on Figure 2. Point 6 is an example. To highlight the main area of elevated instrument response, a lower limit for the signal strength of 500 mV was chosen for the figure. The objects, like that found at Point 6, yielded instrument responses of less than 500 mV.

To further investigate the area, a backhoe was brought in on May 07, 2012 to conduct exploratory excavation beginning with the main point of elevated instrument response not associated with metallic debris at the surface. The excavation revealed metallic pipes and plates buried at the site.

Conclusions

Although some of the elevated instrument response shown in Figure 2 is due to the metallic debris found on or partially exposed at the surface, the main area of elevated response is due to the metallic pipes and plates buried at the site. Once any of the metallic debris listed in Table 1 is removed, the site can be resurveyed to determine whether or not the debris removed was the sole cause of the elevated instrument response. However, removal of the debris listed in Table 1 will not significantly alter the results of survey for the main area of elevated instrument response.

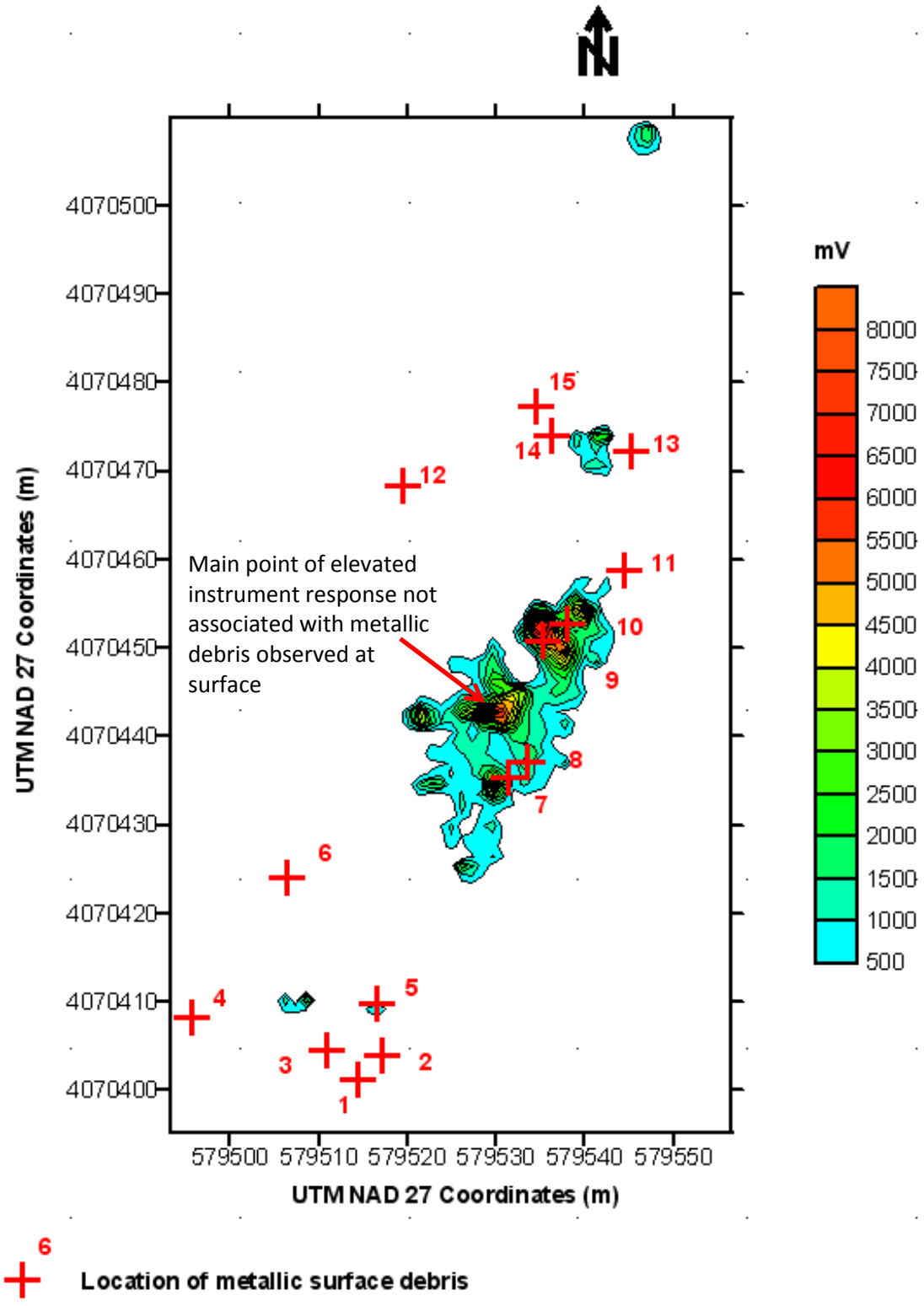

Figure 2 EM61-MK2A Instrument Response Detected at CAU 465 on January 12, 2012

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Appendix G

Risk Evaluation

G.1.0 Risk Assessment

The RBCA process used to establish FALs is described in the Soils RBCA document (NNSA/NSO, 2012). This process conforms with *Nevada Administrative Code* (NAC) Section 445A.227, which lists the requirements for sites with soil contamination (NAC, 2012a). For the evaluation of corrective actions, NAC Section 445A.22705 (NAC, 2012b) requires the use of ASTM International (ASTM) Method E1739 (ASTM, 1995) to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary." For the evaluation of corrective actions, the FALs are established as the necessary remedial standard.

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

- **Tier 1 evaluation.** Sample results from source areas (highest concentrations) are compared to risk-based screening levels (RBSLs) based on generic (non-site-specific) conditions (i.e., the PALs established in the CAU 465 SAFER Plan [NNSA/NSO, 2011]). 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 Site-Specific Target Levels (SSTLs) using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 SSTLs 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. Total concentrations of total petroleum hydrocarbons will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemicals of concern will be compared to the SSTLs.

- **Tier 3 evaluation.** Conducted by calculating Tier 3 SSTLs 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/NSO, 2012) is summarized in Figure G.1-1.

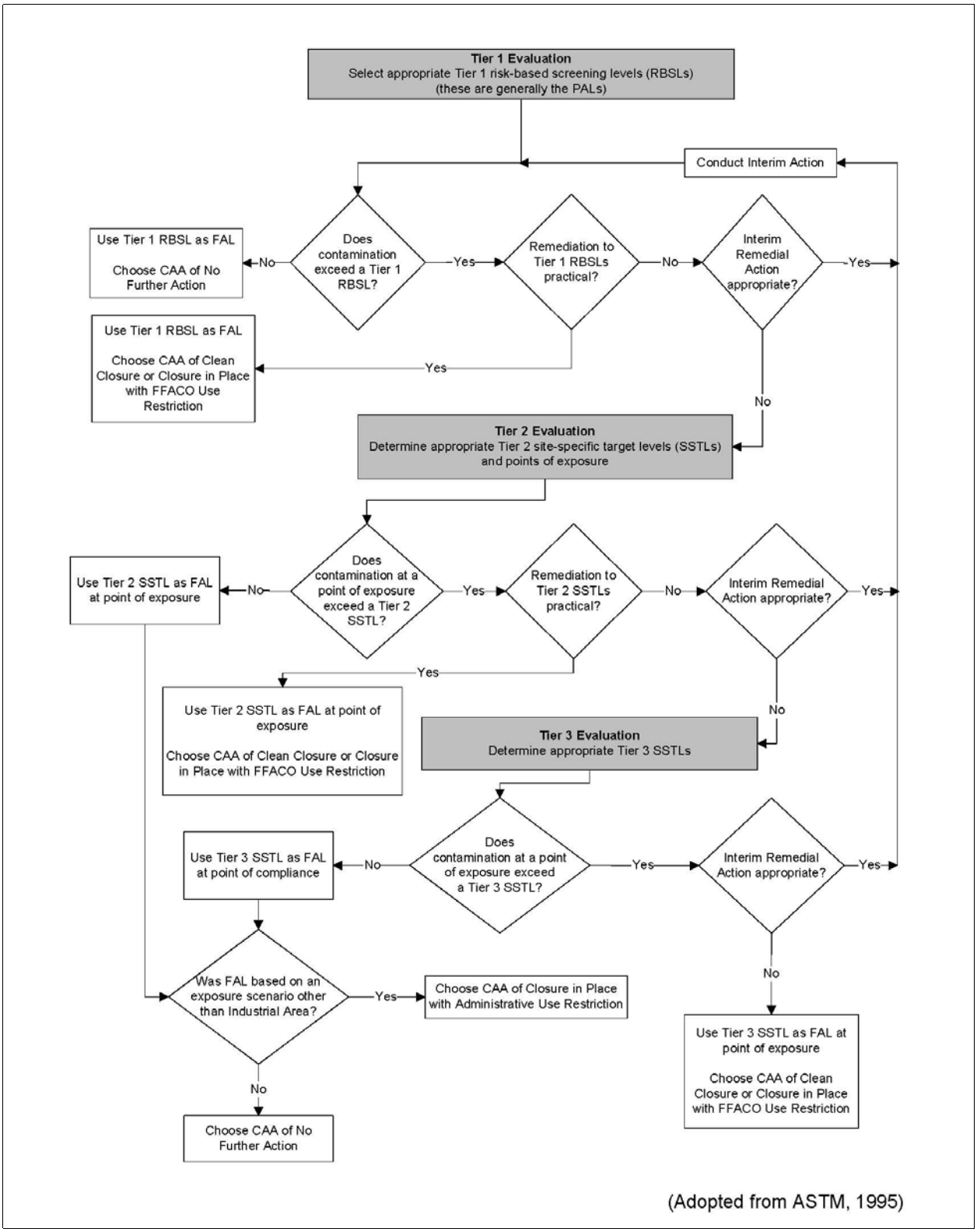

Figure G.1-1
RBCA Decision Process

G.1.1 Scenario

CAU 465, Hydronuclear, comprises the following four CASs within Areas 6 and 27 of the NNSS:

- 00-23-01, Hydronuclear Experiment
- 00-23-02, Hydronuclear Experiment
- 00-23-03, Hydronuclear Experiment
- 06-99-01, Hydronuclear

The hydronuclear sites consist of a series of shallow boreholes ranging from 25 to 80 ft deep used to conduct hydronuclear experiments (in which conventional explosives were used to assess the safety of nuclear weapons). These experiments are also sometimes referred to as "equation of state" experiments. As a result of the hydronuclear experiments, radiological materials—including plutonium; depleted, enriched, and natural uranium; and uranium oxide—along with metals (e.g., silver, lead) are present at the bottom of the boreholes. Several of the boreholes at two CAS locations are known to have been used for the disposal of nonradioactive classified materials associated with the hydronuclear experiments. As such, the COCs associated with these materials are the same as those associated with the experiments. A total of 99 experiments were conducted: 76 experiments in Area 27, and 23 experiments in Area 6. All but one experiment was conducted subsurface (DOE/NV, 2001).

G.1.2 Site Assessment

The CAI at CAU 465 involved a judgmental sampling strategy in which surface and shallow subsurface samples were collected. Samples of PSM that could potentially release a COC to environmental media were also collected. Radiological and visual surveys were also performed to support the CAI.

PSM identified through sampling or based upon presumed knowledge (e.g., lead bricks, lead plates), was removed and disposed of. Corrective actions were performed at the following PSM locations at the Dog site:

- Trash pile
- Stained concrete pad
- Lead debris

A summary of investigation and closure activities at each surface release component PSM location is presented below. There was no PSM or other biasing factors identified at the other CASs that required any additional investigation.

Trash Pile. The trash pile contained a concentration of rusted metal debris on the ground surface in the southeast portion of the Dog site. The debris includes metal cans, cables, and scrap metal. Five soil samples from the trash pile were collected and analyzed for chemical and radiological parameters. The soil sample from the center of the trash pile (location B04) exceeded the PALs for lead and arsenic. The metal surface debris and contaminated soil at this location was removed and disposed of. Confirmation soil samples were collected from the excavation, which showed that lead and arsenic in the remaining soil was less than PALs.

Concrete Pads. A small, stained concrete pad (6 ft by 4 ft by 7 in. thick) was located south of the fenced compound; two larger, unstained concrete pads are also in the vicinity. Samples of the small, stained concrete pad and two adjacent, unstained concrete pads were collected and analyzed for chemical and radiological parameters. The concrete samples from the stained pad contained concentrations of Cr (VI) above the soil PAL. The small concrete pad was removed, revealing yellow stained soil. Three soil samples were collected underneath the pad, two within the stained area and one in the unstained area. The samples collected in the stained areas contained Cr (VI) in excess of the PALs. Approximately 15 yd^3 of soil was removed from the area, and confirmation samples were collected in the excavation. Three of the six confirmation soil sample results were less than the PAL. The remaining three samples had Cr (VI) concentrations that exceeded the PAL but were less than the FAL.

Lead Debris. Lead bricks were identified at four locations at the Dog site. Three large lead plates were located on the east side of the site outside the fenced area. The lead debris from each location was removed and managed as recyclable material. Soil samples at each lead debris location were collected and analyzed for chemical and radiological parameters. The soil sample collected under the lead brick at location B06 exceeded the PAL for lead. Contaminated soil at this location was removed and disposed of. One confirmation sample was collected at this location and confirmed the remaining soil at location B06 was less than PALs.

Contamination is assumed to be present in the subsurface (boreholes and landfill/disposal trench) that will require corrective action and, therefore, is not included in this risk evaluation. The remaining discussion will address only the surface contamination left at the site after the corrective action removals. The maximum concentration of each contaminant in samples from remaining surface soil at the Dog site, and their corresponding PALs, are presented in Table G.1-1.

Table G.1-1
Maximum Reported Values for Tier 1 Comparison

Parameter	Maximum Reported Value	Sample Number	Depth (cm bgs)	Location	PALs	Units
Acetone	0.00427 (J)	465B005	0.0 - 5.0	B05	630,000	mg/kg
Arsenic	6.41	465B021	45.0 - 60.0	B18	23	mg/kg
Barium	242	465B020	45.0 - 60.0	B17	190,000	mg/kg
Beryllium	0.576	465B008	0.0 - 5.0	B07	2,000	mg/kg
Cadmium	3.19	465B020	45.0 - 60.0	B17	800	mg/kg
Cr (VI)	**25.1**	465B035	45.0 - 60.0	B31	5.6	mg/kg
Lead	692	465B009	0.0 - 5.0	B08	800	mg/kg
Mercury	0.119	465B030	0.0 - 15.0	B26	43	mg/kg
Silver	9.46	465B003	0.0 - 5.0	B03	5,100	mg/kg
Ac-228	1.85	465B020	45.0 - 60.0	B17	22.34[a]	pCi/g
U-234	4.31	465B021	45.0 - 60.0	B18	49,460[a]	pCi/g
U-235	0.737	465B021	45.0 - 60.0	B18	289.7[a]	pCi/g
U-238	27.6	465B021	45.0 - 60.0	B18	1,667[a]	pCi/g

[a]PAL is the Industrial Area Exposure Scenario, Internal and External Dose from NNSA/NSO (2012).

Bold indicates value exceeds the PAL.

J = Estimated value

G.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, none of the CASs present an immediate threat to human health, safety, and the environment; therefore, no interim response actions are necessary at these sites. Based on this information, all four CASs are determined to be Classification 3 sites as defined by ASTM Method E1739 (ASTM, 1995) and may pose long-term threats to human health, safety, or the environment.

G.1.4 Development of Tier 1 Lookup Table of RBSLs

Tier 1 action levels are defined as the PALs listed in the SAFER Plan (NNSA/NSO, 2011) as established during the DQO process. The PALs represent a very conservative estimate of risk, are preliminary in nature, and are generally used for site screening purposes. Although the PALs are not intended to be used as FALs, FALs may be defined as the Tier 1 action level (i.e., PAL) value if implementing a corrective action based on the Tier 1 action level would be appropriate.

The PALs are based on the Industrial Area exposure scenario, which assumes that a full-time industrial worker is present at a particular location for his or her entire career (250 days per year, 8 hours per day for a duration of 25 years). The 25-millirem-per-year dose-based Tier 1 action level for radiological contaminants is implemented by calculating the dose a site worker would receive if exposed to the site contaminants over an annual exposure period of 2,000 hours.

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

- EPA Region 9 Regional Screening Levels (RSLs), Screening Levels for Chemical Contaminants for Industrial Soils (EPA, 2012a).
- Background concentrations for RCRA metals will be 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 the *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 will be used to establish an action level; otherwise, an established value from another source may be chosen.

The PALs were developed based on an industrial scenario. Because CAU 465 sites are not assigned work stations and are considered to be in a remote or occasional use area, the use of an industrial scenario is overly conservative and is not representative of current land use.

G.1.5 Exposure Pathway Evaluation

For all CASs, 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 at the CASs. The potential exposure pathways would be through worker contact with the contaminated soil or various debris currently present at the site. The limited migration demonstrated by the analytical results, elapsed time since the releases, and depth to groundwater support the selection and evaluation of only surface and shallow subsurface contact as the complete exposure pathways. Ingestion of groundwater is not considered to be a significant exposure pathway.

G.1.6 Comparison of Site Conditions with Tier 1 RBSLs

All confirmation soil samples collected at the Dog site had constituent concentrations less than corresponding Tier 1 action levels (i.e., PALs) except for three samples collected underneath the stained concrete pad. The maximum Cr (VI) concentration of these three samples is shown in Table G.1-1.

G.1.7 Evaluation of Tier 1 Results

For all contaminants at CAU 465, with the exception of Cr (VI), the FALs were established as the Tier 1 RBSLs. It was determined that no further action is required for these contaminants (excluding Cr [VI]).

A Cr (VI)-contaminated concrete pad exceeding the soil PAL for Cr (VI) was removed. Approximately 15 yd^3 of Cr (VI)-contaminated soil above the PAL for Cr (VI) was also removed and disposed of as hazardous waste. The bottom of the excavation is hard-packed caliche. Three of the six confirmation soil sample results (465B035 through 465B037) exceeded the PAL for Cr (VI) (Table C.2-4).

The risk to receptors from contaminants at CAU 465 is due to chronic exposure to contamination and is directly related to the amount of time a receptor is exposed to the contaminants. Activities at the CAU 465 sites are strictly controlled through a formal work control process. This process requires facility managers to authorize all work activities. As such, the facility manager is aware of all

activities conducted at the site. The facility manager responsible for the area of CAU 465 identified that the only work activities currently conducted at the sites are inspections by security guards. 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). In order to estimate the amount of time a site worker might spend conducting current or future activities, the NNSA/NSO and/or management and operating contractor departments responsible for these activities were consulted. Under the current land use at each of the CAU 465 CASs, the following workers were identified as being potentially exposed to site contamination:

- **Security guard.** Periodic surveillance of the CAU 465 Hydronuclear sites is conducted by NNSS security staff. These workers typically perform periodic "drive-through" site inspections of the general areas where the CASs are located. Although they are routinely advised to avoid areas containing radiological contamination and the sites will be posted with warning signs, there is a potential that they might inadvertently enter into these CAS areas. It was conservatively assumed that this type of worker would spend up to 1 week per year (40 hours) in one or more of these CASs.

- **Inspection and maintenance worker.** This includes workers sent to conduct the annual inspection of the postings and fencing around the four CASs. The UR requires a periodic inspection to ensure that the fencing is intact and the signs are legible. This will require two people to spend up to 10 hours per year at each CAS.

- **Trespasser.** This includes 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 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 each of the CAU 465 CASs, the most exposed worker would be the security guard, who would not be exposed to site contamination for more than 40 hours per year. Therefore, using a Tier 1 RBSL based on an assumed exposure time of 2,000 hours is not reasonable for risk decisions at this site.

G.1.8 Tier 1 Remedial Action Evaluation

As the most exposed worker may be present at these sites for only a few hours per year, it is not reasonable to assume that any worker would be present at this site for 2,000 hours per year. Therefore,

it was determined that it is not reasonable to remediate this site to the Tier 1 RBSL, and a Tier 2 evaluation will be conducted for Cr (VI).

G.1.9 Tier 2 Evaluation

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

G.1.10 Development of Tier 2 SSTLs

A site-specific soil Tier 2 SSTL was calculated for Cr (VI) using site-specific inputs to standard risk procedures. This calculation process is described in the Soils RBCA document (NNSA/NSO, 2012). The EPA Region 9 RSL Calculator (EPA, 2012b) is used to calculate concentration limits using carcinogenic or systemic toxicity values under specific exposure conditions. The calculator uses the latest human health toxicity values (i.e., cancer slope factors or non-cancer reference doses), default exposure assumptions, and physical and chemical properties. The calculator was used to assess site-specific risk by changing the default parameters to reflect site-specific risk conditions. Parameters used in the calculation of this Tier 2 SSTL are defined in the Soils RBCA document.

One of the site-specific input parameters used in the SSTL calculation is the exposure scenario. In the CAU 465 DQOs, it was conservatively determined that the Occasional Use Area exposure scenario (as listed in Section 3.1.1 of the CAU 465 SAFER Plan [NNSA/NSO, 2011]) would be appropriate in calculating receptor exposure time based on current land use at all CAU 465 CASs. 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. Site workers under this scenario are assumed to be on the site for an equivalent of 80 hours per year. The use of this scenario provides a more conservative (longer) exposure to site contaminants than the 40 hours per year exposure time for the most exposed worker (based on current and projected future land use). However, because the maximum Cr (VI) concentration detected at CAU 465 does not exceed the SSTL as calculated using the more conservative Remote Work Area exposure scenario, it was determined to base the Tier 2 SSTL on the Remote Work Area exposure scenario. This exposure scenario assumes that a worker would be exposed to maximum site contamination for 112 hours per year.

G.1.11 Comparison of Site Conditions with Tier 2 SSTLs

The Tier 2 action levels are typically 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. 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 CAS. However, for CAU 465, the Tier 2 action levels were conservatively compared to the maximum contaminant concentration from a single point location (the area surrounding the location of the former Cr [VI]-contaminated concrete pad).

As shown in Table G.1-1, the maximum concentration for Cr (VI) of 25.1 mg/kg was less than corresponding Tier 2 SSTL of 48.1 mg/kg. The FAL for Cr (VI) was established as the Tier 2 SSTL.

G.1.12 Tier 2 Remedial Action Evaluation

Based on the Tier 2 evaluation of Cr (VI), contamination in the currently remaining soil at this site does not pose an unacceptable risk to human health and the environment. Therefore, no further action is required for surface soil contamination at CAU 465.

As all contaminant FALs were established as Tier 1 or Tier 2 action levels, a Tier 3 evaluation was not considered necessary.

G.2.0 Recommendations

As all of the site contaminant concentrations in surface soils from the analysis of CAU 465 samples were less than the corresponding FALs at all locations, it was determined that contamination at these locations does not pose a significant risk to human health or the environment and, therefore, does not warrant corrective actions. However, contamination is assumed to be present in the boreholes and landfill at CAU 465 that exceeds risk-based criteria and requires corrective action. Additional protective measures may be implemented as BMPs (i.e., administrative URs).

The decision for no corrective action for surface soil contamination at CAU 465 was based on a FAL that assumed a site worker exposure period of 112 hours per year. Therefore, to protect site workers from an exposure greater than the exposure level used to make the decision (Remote Work Area), it is recommended that an administrative UR be implemented to prevent future site activities to those that will not result in an exposure to site workers greater than the Remote Work Area exposure scenario. The UR is included in Appendix E.

G.3.0 References

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Appendix H

Nevada Division of Environmental Protection Comments

(1 Page)

ndep
NEVADA DIVISION OF ENVIRONMENTAL PROTECTION
protecting the future for generations

STATE OF NEVADA
Department of Conservation & Natural Resources
DIVISION OF ENVIRONMENTAL PROTECTION

Brian Sandoval, Governor
Leo M. Drozdoff, P.E., Director
Colleen Cripps, Ph.D., Administrator

October 24, 2012

Robert F. Boehlecke, Manager
Environmental Management Operations
National Nuclear Security Administration
Nevada Site Office
P. O. Box 98518
Las Vegas, NV 89193-8518

RE: Review of Draft Closure Report (CR) for Corrective Action Unit (CAU) 465: Hydronuclear, Nevada National Security Site, Nevada
Federal Facility Agreement and Consent Order

Dear Mr. Boehlecke,

The Nevada Division of Environmental Protection, Bureau of Federal Facilities (NDEP) staff has received and reviewed the draft CR for Corrective Action Unit (CAU) 465: Hydronuclear. NDEP's review of this document did not indicate any deficiencies.

If you have any questions regarding this matter contact me at (702) 486-2850 ext. 233.

Sincerely,

/s/ Jeff MacDougall

Jeff MacDougall, Ph.D., C.P.M.
Supervisor
Bureau of Federal Facilities

THM/JJM/JW/TZ/SP:*jjm*

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