Nevada
Environmental
Restoration
Project

DOE/NV--1465

National Nuclear Security Administration

Corrective Action Decision Document/Closure Report for Corrective Action Unit 365: Baneberry Contamination Area Nevada National Security Site, Nevada

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Project

U.S. Department of Energy
National Nuclear Security Administration
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CORRECTIVE ACTION DECISION DOCUMENT/ CLOSURE REPORT FOR CORRECTIVE ACTION UNIT 365: BANEBERRY CONTAMINATION AREA NEVADA NATIONAL SECURITY SITE, NEVADA

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

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Signature: /s/ Joseph P. Johnston
Date: 9/26/2011

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CORRECTIVE ACTION DECISION DOCUMENT/CLOSURE REPORT FOR
CORRECTIVE ACTION UNIT 365:
BANEBERRY CONTAMINATION AREA
NEVADA NATIONAL SECURITY SITE, NEVADA

Approved by: /s/ Kevin J. Cabble Date: 9-26-11

Kevin J. Cabble
Federal Sub-Project Director
Soils Sub-Project

Approved by: /s/ Robert F. Boehlecke Date: 9/26/11

Robert F. Boehlecke
Federal Project Director
Environmental Restoration Project

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List of Acronyms and Abbreviations

Ac	Actinium
Ag	Silver
Am	Americium
ANPR	Advance Notice of Proposed Rulemaking
ASTM	ASTM International
bgs	Below ground surface
BMP	Best Management Practice
CAA	Corrective action alternative
CADD	Corrective action decision document
CAI	Corrective action investigation
CAIP	Corrective action investigation plan
CAS	Corrective action site
CAU	Corrective action unit
CED	Committed effective dose
CFR	*Code of Federal Regulations*
Ci	Curies
CLP	Contract Laboratory Program
cm	Centimeter
Cm	Curium
Co	Cobalt
COC	Contaminant of concern
COPC	Contaminant of potential concern
cps	Counts per second
CR	Closure Report
Cs	Cesium
CSM	Conceptual site model

List of Acronyms and Abbreviations *(Continued)*

CZ	Contamination zone
day/yr	Days per year
DOE	U.S. Department of Energy
DQA	Data quality assessment
DQI	Data quality indicator
DQO	Data quality objective
EML	Environmental Measurements Laboratory
EPA	U.S. Environmental Protection Agency
FAL	Final action level
FD	Field duplicate
FFACO	*Federal Facility Agreement and Consent Order*
FSL	Field-screening level
FSR	Field-screening result
ft	Foot
gal	Gallon
GPS	Global Positioning System
GWS	Gamma walkover survey
g/yr	Grams per year
GZ	Ground zero
HASL	Health and Safety Laboratory
hr/day	Hours per day
hr/yr	Hours per year
IA	Industrial Area
ICRP	International Commission on Radiological Protection
ID	Identification
in.	Inch

List of Acronyms and Abbreviations *(Continued)*

LCS	Laboratory control sample
LVF	Load Verification Form
m	Meter
m^2	Square meter
MDC	Minimum detectable concentration
mg/day	Milligrams per day
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mi	Mile
M&O	Management and operating
mrem	Millirem
mrem/IA-yr	Millirem per Industrial Area year
mrem/OU-yr	Millirem per Occasional Use Area year
mrem/RW-yr	Millirem per Remote Work Area year
mrem/yr	Millirem per year
m/s	Meters per second
m/yr	Meters per year
N/A	Not applicable
NAC	*Nevada Administrative Code*
NAD	North American Datum
Nb	Niobium
NDEP	Nevada Division of Environmental Protection
NIOSH	National Institute for Occupational Safety and Health
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

List of Acronyms and Abbreviations (Continued)

NRDS	Nuclear Rocket Development Station
OU	Occasional Use Area
PAL	Preliminary action level
PCB	Polychlorinated biphenyl
pCi/g	Picocuries per gram
PPE	Personal protective equipment
PRG	Preliminary Remediation Goal
PSM	Potential source material
Pu	Plutonium
QA	Quality assurance
QAPP	Quality Assurance Project Plan
QC	Quality control
R^2	Correlation coefficient
RBCA	Risk-based corrective action
RBSL	Risk-based screening level
RCRA	*Resource Conservation and Recovery Act*
RESRAD	Residual Radioactive
RIDP	Radionuclide Inventory and Distribution Program
RPD	Relative percent difference
RRMG	Residual radioactive material guideline
RW	Remote Work Area
SCL	Sample collection log
SDG	Sample delivery group
Sr	Strontium
SSTL	Site-specific target level
SVOC	Semivolatile organic compound

List of Acronyms and Abbreviations (Continued)

TCLP	Toxicity Characteristic Leaching Procedure
TED	Total effective dose
Th	Thorium
TLD	Thermoluminescent dosimeter
UCL	Upper confidence limit
UR	Use restriction
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
VSP	Visual Sample Plan
yd^3	Cubic yard
μR/hr	Microroentgens per hour

Executive Summary

This Corrective Action Decision Document (CADD)/Closure Report (CR) has been prepared for Corrective Action Unit (CAU) 365, Baneberry Contamination Area, located within Area 8 of the Nevada National Security Site, Nevada, in accordance with the *Federal Facility Agreement and Consent Order* (FFACO). Corrective Action Unit 365 comprises one corrective action site (CAS), CAS 08-23-02, U-8d Contamination Area.

The purpose of this CADD/CR is to provide justification and documentation supporting the recommendation that no further corrective action is needed for CAU 365 based on the implementation of the corrective action of closure in place with a use restriction (UR). Corrective action investigation (CAI) activities were performed from January 18, 2011, through August 2, 2011, as set forth in the *Corrective Action Investigation Plan for Corrective Action Unit 365: Baneberry Contamination Area.*

The purpose of the CAI was to fulfill data needs as defined during the data quality objective (DQO) process. The CAU 365 dataset of investigation results was evaluated based on a data quality assessment. This assessment demonstrated the dataset is complete and acceptable for use in supporting the DQO decisions.

Investigation results were evaluated against final action levels (FALs) established in this document. A radiological dose FAL of 25 millirem per year was established based on the Remote Work Area exposure scenario (336 hours of annual exposure). Radiological doses exceeding the FAL were found to be present to the southwest of the Baneberry crater. It was also assumed that radionuclide levels present within the crater and fissure exceed the FAL. Corrective actions were undertaken that consisted of establishing a UR and posting warning signs for the crater, fissure, and the area located to the southwest of the crater where soil concentrations exceeded the FAL.

These URs were recorded in the FFACO database; the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Facility Information Management System; and the NNSA/NSO CAU/CAS files.

Therefore, NNSA/NSO provides the following recommendations:

- No further corrective actions beyond what are described in this document are necessary for CAU 365.
- A Notice of Completion to NNSA/NSO is requested from the Nevada Division of Environmental Protection for closure of CAU 365.
- Corrective Action Unit 365 should be moved from Appendix III to Appendix IV of the FFACO.

1.0 Introduction

This Corrective Action Decision Document (CADD)/Closure Report (CR) presents information supporting closure of Corrective Action Unit (CAU) 365, Baneberry Contamination Area, located at the Nevada National Security Site (NNSS), Nevada. The corrective actions described in this document were implemented in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management. The NNSS is located approximately 65 miles (mi) northwest of Las Vegas, Nevada.

Corrective Action Unit 365 includes one corrective action site (CAS), CAS 08-23-02, U-8d Contamination Area, shown on Figure 1-1. This CAS will be hereafter referred to in this document as Baneberry.

A detailed discussion of the history of Baneberry is presented in the *Corrective Action Investigation Plan* (CAIP) *for Corrective Action Unit 365: Baneberry Contamination Area* (NNSA/NSO, 2010).

1.1 Purpose

This report provides documentation and justification for the closure of the Baneberry site. This includes a description of investigation activities, an evaluation of the data, and a description of corrective actions that were performed. The investigative activities were conducted in accordance with the CAIP except as noted herein. The corrective actions include the implementation of use restrictions (URs) for areas of soil contamination that exceed the final action levels (FALs). Based on the implementation of these corrective actions, no further corrective actions are necessary at Baneberry. The CAIP provides information relating to site history as well as the scope and planning of the investigation. Therefore, this information will not be repeated in this document.

Baneberry consists of one inactive site located in Area 8. The site has been investigated because of a release of radionuclides to the surrounding soil surface and the associated fissure from the Baneberry test. Designed as an underground weapons-related test, the Baneberry test, with a yield of 10 kilotons, was buried at a depth of 912 feet (ft) below ground surface (bgs). The test was conducted on December 18, 1970, as part of Operation Emery.

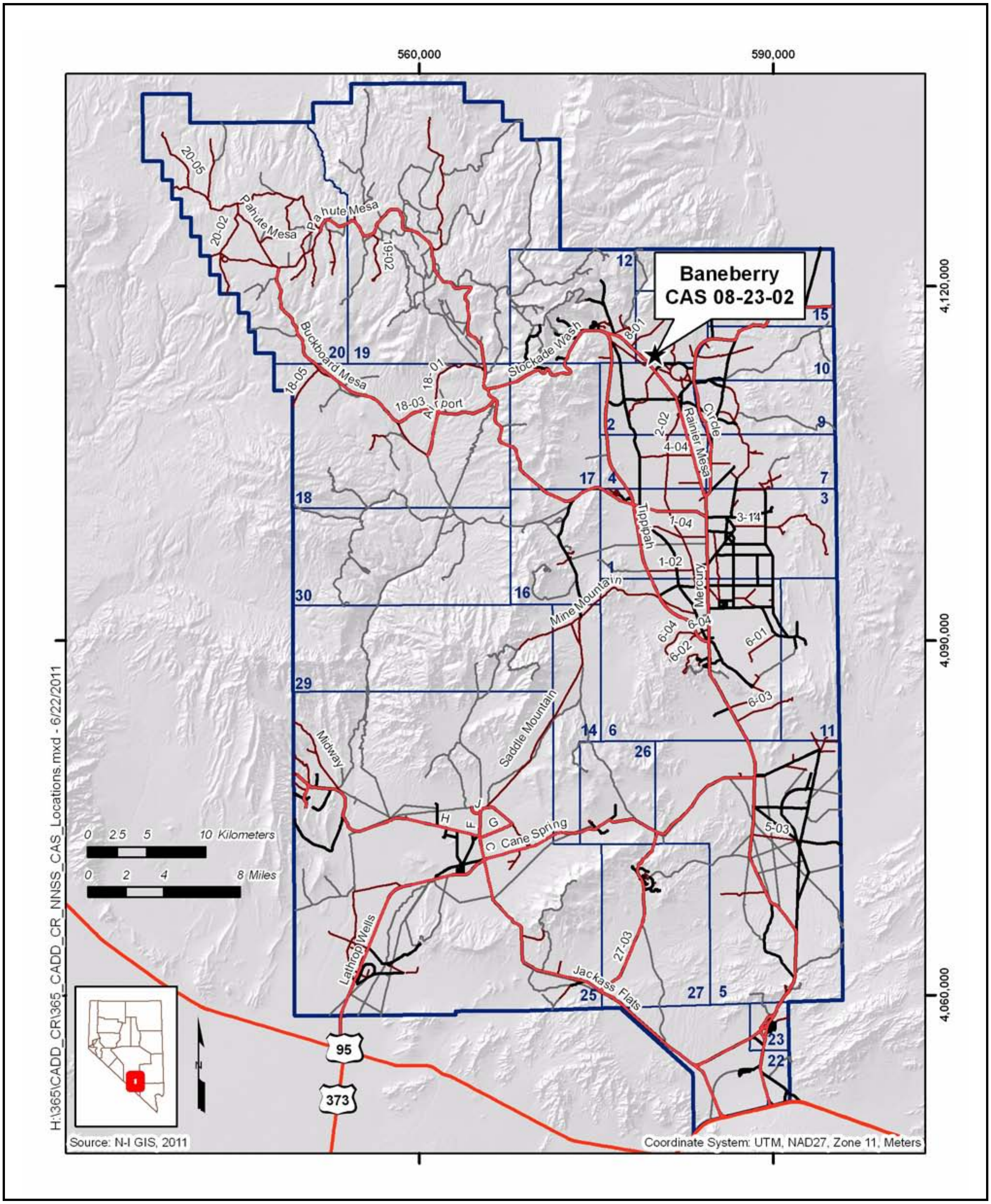

Figure 1-1
CAU 365, CAS Location Map

Although the Baneberry test was designed for containment, a release occurred 3.5 minutes after detonation because of containment failure. The release vented from a radially oriented fissure located 91 meters (m) (300 ft) directly southwest of ground zero (GZ) (AEC, 1973). Significant venting occurred for approximately 2 hours and then steadily decreased over a 24-hour period, resulting in a release of 6.7×10^6 curies (Ci) of fission products (Schoengold, DeMarre, and Kirkwood, 1996). A crater formed 16.5 minutes after detonation that stemmed approximately one-half of the flow from the section of the fissure located within the crater. At other underground tests that vented through emplacement holes or fissures, the formation of the crater reduced or stopped seepage entirely. Baneberry was in marked contrast to this observation, supplying evidence that the release path was outside the emplacement chimney (AEC, 1971).

The crater and fissure that vented are clearly visible at the site. The crater measures an average of 455 ft in diameter and is 78 ft deep (AEC, 1971). The surface expression of the fissure extends approximately 50 ft radially from the crater edge and is approximately 10 to 15 ft wide.

Contamination was released to the atmosphere along the fissure and deposited in an annular pattern around GZ with a bias toward the north, the prevailing wind direction at the time of detonation, and to the southwest in alignment with the fissure. This is illustrated by the contamination plume depicted in Figure A.3-1.

1.2 Scope

The corrective action investigation (CAI) for Baneberry was completed by demonstrating, through analytical results from environmental soil and thermoluminescent dosimeter (TLD) sampling, the nature and extent of contaminants of concern (COCs) at the site. For radiological releases, COCs are defined as the presence of radionuclides that jointly result in a dose to a receptor exceeding 25 millirem per year (mrem/yr) (based on the appropriate exposure scenario).

The collection of samples was not feasible within the crater and fissure areas as a result of technical and safety considerations required for sampling. The potential for additional crater subsidence precludes investigating the extent of fissure contamination within the crater. Therefore, it was assumed that COCs exist in the subsurface within the fissure and under the crater at Baneberry. The scope of the investigation activities at Baneberry included performing visual surveys, conducting radiological surveys, collecting soil samples, and collecting TLD samples. The scope of the corrective action activities included evaluating corrective action alternatives (CAAs), establishing and posting URs, and documenting and justifying closure activities. In addition, removal of debris identified during the CAI was performed as a Best Management Practice (BMP).

1.3 CADD/CR Contents

This document is divided into the following sections and appendices:

Section 1.0, "Introduction," summarizes the document purpose, scope, and contents.

Section 2.0, "Corrective Action Investigation Summary," summarizes the investigation field activities and the results of the investigation, and justifies that no further corrective action is needed.

Section 3.0, "Recommendation," provides the basis for requesting that Baneberry be moved from Appendix III to Appendix IV of the FFACO.

Section 4.0, "References," provides a list of all referenced documents used in the preparation of this CADD/CR.

Appendix A, *Corrective Action Investigation Results*, provides a description of the project objectives, field investigation and sampling activities, investigation results, waste management, and quality assurance (QA). Section A.3.0 provides specific information regarding field activities, sampling methods, and laboratory analytical results from the investigation.

Appendix B, *Data Assessment*, provides a data quality assessment (DQA) that reconciles data quality objective (DQO) assumptions and requirements to the investigation results.

Appendix C, *Risk Assessment*, presents an evaluation of risk associated with the establishment of FALs.

Appendix D, *Closure Activity Summary*, provides details on the completed closure activities, and includes the required verification activities and supporting documentation.

Appendix E, *Evaluation of Corrective Action Alternatives*, provides a discussion of the results of the CAI, the alternatives considered, evaluation of alternatives, and the rationale for the recommended alternative.

Appendix F, *Sample Analytical Data*, provides tabular compilations of validated analytical results that provide a basis for the internal radiological dose estimates and TLD sample data that provide a basis for the external radiological dose estimates.

Appendix G, *Sample Location Coordinates*, presents the northing and easting coordinates for each sample plot, the biased sample locations, and other points of interest.

Appendix H, *Nevada Division of Environmental Protection* (NDEP) *Comments*, contains responses to NDEP comments on the draft version of this document.

1.3.1 Applicable Programmatic Plans and Documents

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

- CAIP for CAU 365, Baneberry Contamination Area (NNSA/NSO, 2010)
- *Industrial Sites Quality Assurance Project Plan* (QAPP) (NNSA/NV, 2002a)
- FFACO (1996, as amended)

1.3.2 Data Quality Assessment Summary

The CAIP for CAU 365, Baneberry Contamination Area (NNSA/NSO, 2010), contains the DQOs as agreed to by stakeholders. The DQO process ensured that the right type, quality, and quantity of data were available to support the resolution of those decisions with an appropriate level of confidence. A DQA was conducted that evaluated the degree of acceptability and usability of the reported data in the decision-making process. This DQA is presented in Appendix B and summarized in Section 2.2.2. Using both the DQO and DQA processes helps ensure that DQO decisions are sound and defensible.

Based on this evaluation, the nature and extent of COCs at Baneberry have been adequately identified to implement the corrective actions. Information generated during the investigation support the conceptual site model (CSM) assumptions, and the data collected met the DQOs and support their intended use in the decision-making process.

2.0 Corrective Action Investigation Summary

The following sections summarize the investigation activities and investigation results, and justify why no further corrective action is required at Baneberry. Detailed investigation activities and results for Baneberry are presented in Appendix A of this document.

2.1 Investigation Activities

Corrective action investigation activities were conducted as set forth in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) from January 18, 2011, through August 2, 2011. The purpose of the Baneberry CAI was to provide the additional information needed to resolve the following project-specific DQOs:

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

The scope of the CAI included the following activities:

- Perform visual surveys.
- Perform radiological surveys.
- Collect environmental samples for laboratory analysis.
- Collect quality control (QC) samples.
- Place, collect, and analyze TLDs.

To facilitate site investigation and the evaluation of DQO decisions for different CSM components, the releases at Baneberry are classified into one of the following two categories:

- **Primary releases**—This release scenario is specific to the atmospheric deposition of radionuclide contamination onto the soil surface that has not been displaced through excavation or migration. The contamination associated with the primary releases is limited to the top 5 centimeters (cm) of soil. Surface deposition of radionuclides that have been distributed at the NNSS from atmospheric nuclear releases has been found to be concentrated in the upper 5 cm of undisturbed soil (McArthur and Kordas, 1983, 1985; Gilbert et al., 1977; Tamura, 1977). Therefore, for the purposes of this document, surface is defined as the upper 5 cm of soil.

- **Other releases—**This release scenario includes any contamination from site activities not specific to the atmospheric deposition of radionuclides. This includes radionuclide contaminants that were initially deposited onto the soil surface (as in the primary release category) but have subsequently been displaced through excavation or migration within washes or drainages. This category also includes radionuclides that were deposited under mechanisms other than atmospheric deposition. Included in this category are the injection of radionuclides into native material throughout the fissure during the venting of the Baneberry test and the placement of deposited contamination into soil piles due to surface scraping or exploratory excavations following the test. Chemical or radiological contamination discovered during the investigation through the identification of biasing factors that are not a part of a previously identified release also is included as a release under this scenario. The depth of radiological contamination from other releases is dependent upon the nature of the release or subsequent movement through excavation or migration. Investigation of other releases is accomplished through measurements of soil radioactivity using a judgmental sampling scheme at depths dependent upon the nature of the release, or by conservative assumptions that radioactivity is present at depth based on process knowledge.

For the primary release at Baneberry, TLD and sample plot locations were established judgmentally based on aerial radiation surveys and the results of the gamma walkover surveys (GWSs). Within each sample plot, probabilistic sample locations were established based on a randomized grid. For other releases at Baneberry, judgmental sample locations were determined based on biasing criteria such as elevated radiological readings, disturbed areas, sediment accumulation areas, and stained soil.

Confidence in judgmental sampling scheme decisions was established qualitatively through validation of the CSM and verification that the selected plot locations meet the DQO criteria. Confidence in probabilistic sampling scheme decisions was established by validating the CSM, justifying that sampling locations are representative of the plot area, and demonstrating that a sufficient number of samples were collected to justify statistical inferences (e.g., averages and 95 percent upper confidence limits [UCLs]).

The potential external dose at each TLD location was determined from the results of a TLD placed at a height of 1 m above the soil surface. The net external dose (the gross TLD dose reading minus the background dose) was divided by the number of hours the TLD was exposed to site contamination resulting in an hourly dose rate. That hourly dose rate was then multiplied by the number of hours per year (hr/yr) that a site worker would be present at the site (i.e., the annual exposure duration) to establish the maximum potential annual external dose a site worker could receive. The appropriate annual exposure duration in hours is based on the exposure scenario used (as defined in this section).

The potential internal dose at each sample location was determined based on the laboratory analytical results of soil samples and residual radioactive material guidelines (RRMGs) that were calculated using the Residual Radioactive (RESRAD) computer code (Yu et al., 2001) (see Attachment C-1). The RRMGs are the activity concentrations of individual radionuclides in surface soil that would cause a receptor to receive an internal dose equal to the radiological FAL. The internal doses from the individual radionuclides are then summed to produce the total potential internal dose.

The potential internal dose at each TLD location where soil samples were not collected was conservatively estimated using the potential external dose from the TLD and the ratio of internal dose to external dose from the sample plot with the maximum internal dose. This was done under the conservative assumption that the internal dose at any Baneberry location would constitute the same percentage of the total dose as the internal dose at the soil sample plot with the maximum internal dose. Therefore, the ratio of the internal to external dose was determined at the soil sample plot with the highest internal dose by dividing the internal dose by the external dose. This ratio was then multiplied by the external dose measured at each TLD location where soil samples were not collected to estimate the internal dose at that location.

The calculated total effective dose (TED) (the sum of internal and external doses) for each sample location is an estimation of the true radiological dose (true TED). The TED is defined in Title 10 of the *Code of Federal Regulations* (CFR), Part 835 (CFR, 2011) as the sum of the effective dose (for external exposures) and the committed effective dose (for internal exposures).

Because a measured TED is an estimate of the true (unknown) TED, it is uncertain how well the calculated TED represents the true TED. If the measured TED were significantly different than the true TED, a decision based on the measured TED could result in a decision error. To reduce the probability of making a false negative decision error at probabilistic sample locations, a conservative estimate of the true TED is used to compare to the FAL instead of the measured TED. This conservative estimate (overestimation) of the true TED was calculated as the 95 percent UCL of the average TED measurements. By definition, there will be a 95 percent probability that the true TED is less than the 95 percent UCL of the measured TED.

As described in Appendix C, the TED to a receptor from site contamination is a function of the time the receptor is present at the site and exposed to the radioactively contaminated soil. Therefore, TED is reported in this document based on the following three exposure scenarios:

- **Industrial Area—**This scenario addresses exposure to industrial workers exposed daily to contaminants in soil during an average workday. This scenario assumes that this is the regular assigned work area for the worker who will be on the site for an entire career (10 hours per day [hr/day], 225 days per year [day/yr] for 25 years). The TED calculated using this exposure scenario is the TED an industrial worker receives during 2,250 hours of annual exposure to site contaminants and is expressed in terms of millirem per Industrial Area year (mrem/IA-yr).

- **Remote Work Area—**This scenario assumes noncontinuous work activities at a site. This scenario addresses exposure to industrial workers exposed to contaminants in soil during a portion of an average workday. This scenario assumes that this is an area where the worker regularly visits but is not an assigned work area where the worker spends an entire workday. A site worker under this scenario is assumed to be on the site for an equivalent of 336 hr/yr (8 hr/day for 42 day/yr) for an entire career (25 years). The TED calculated using this exposure scenario is the TED a remote area worker receives during 336 hours of annual exposure to site radioactivity and is expressed in terms of millirem per Remote Work Area year (mrem/RW-yr).

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

Investigation activities at Baneberry included performing visual inspections, conducting Global Positioning System (GPS)-assisted GWSs, staging TLDs, and collecting soil samples. During the visual inspections, biasing factors were observed at one drum within a cellar structure and at one location of deteriorating dry-cell batteries. These areas were sampled, and the drum and batteries were removed and disposed of as a BMP.

The GWSs were conducted over the area surrounding the crater and the area north and south of the crater to identify locations of elevated radiological readings that would indicate the locations of the fallout plume from the fissure. The results of the GWSs showed that the highest gamma radiation readings corresponded to locations where the fissure is observed and confirmed that the fallout plume was positioned as expected. Two 100-square-meter (m^2) plots were then established at the areas containing the highest anomalous readings that best represent the site as detected during the GWSs (see Section A.3.1.2) and sampled. Also observed during the GWSs were elevated readings in the northernmost drainage identified for study. Based upon this information, TLDs were placed and samples collected at downstream sediment locations. At locations A101 and A102 (see Figure A.3-1), soil samples at depth exceeded the surface field-screening level (FSL). For the samples at depth, a TLD-equivalent dose was calculated. As a TLD measures external dose from only surface contamination, it cannot be used to directly measure external dose for subsurface sample locations. Therefore, the external portion of TED for the subsurface sample locations was established by using RESRAD and analytical results from the soil samples to estimate external dose for both surface and subsurface locations. The calculated ratio of the RESRAD-calculated subsurface to surface external doses was used to increase the TLD-measured surface external dose to estimate a TLD-equivalent subsurface external dose for subsurface samples from locations A101 and A102.

Thermoluminescent dosimeters were installed at locations within Baneberry to measure external radiological doses in a grid pattern around GZ. Vectors aligned and perpendicular to the plume also were established for TLD placement based on aerial radiation surveys and GWSs. Sampling activities were conducted to determine internal doses at soil sample plots. The sampling activities consisted of the collection of composite surface soil samples from the two 100-m^2 sample plots. Refer to Section A.3.1 for additional information about soil and TLD sampling strategies at Baneberry. Results of the TLD and soil sampling effort are reported in Sections 2.2 and A.3.2.

The CSM and associated discussion for this site are provided in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010). The contamination pattern of the radionuclides at Baneberry is consistent with the CSM in that radiological contamination is greatest at the release point (fissure) and generally decreases with distance. Contamination is biased to the north, downwind of the release, and southwest as a result of the release from venting in that direction. Information gathered during the CAI supports and validates the CSM as presented in the CAIP; therefore, modification to the CSM was not necessary.

2.2 Results

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

The preliminary action levels (PALs) and FALs for radioactivity are based on an annual dose limit of 25 mrem/yr. These dose limits are specific to the annual dose a receptor could potentially receive from the Baneberry release. As such, it is dependent upon the cumulative annual hours of exposure to site contamination. The PALs for radioactivity were established in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) based on a dose limit of 25 mrem/yr over an annual exposure time of 2,250 hours (i.e., the Industrial Area exposure scenario that a site worker would be exposed to site contamination for 10 hr/day, 225 day/yr). The FALs for radioactivity were established in Appendix C based on a dose limit of 25 mrem/yr over an annual exposure time of 336 hours (i.e., the Remote Work Area exposure scenario that a site worker would be exposed to site contamination for 8 hr/day, 42 day/yr). To be comparable to these action levels, the Baneberry investigation results are presented in terms of the dose a receptor would receive from site contamination under the Industrial Area (mrem/IA-yr), Remote Work Area (mrem/RW-yr), and Occasional Use Area (mrem/OU-yr) exposure scenarios.

2.2.1 Summary of Analytical Data

Results for both the primary and other releases are presented in the following sections. For radioactivity, results are reported as TED based on the Remote Work Area exposure scenario comparable to the radiological FAL. The FALs as established in Appendix C are based on the annual exposure duration of the Remote Work Area scenario (336 hr/yr). Calculation of the TED for each sample was accomplished through summation of internal and external doses as described in Section A.3.2.3. Discussions of the results for samples collected at Baneberry are grouped by the nature of the release.

Primary Release

The average TED and the 95 percent UCL of the TED at each location for each of the three exposure scenarios are presented in Table 2-1. Figures A.3-4 and A.3-8 present the 95 percent UCL of the

Table 2-1
Baneberry TEDs at Sample Locations
(Page 1 of 4)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A01	0.00	0.00	0.00	0.00	0.00	0.00
A02	0.00	0.00	0.00	0.00	0.00	0.00
A03	3.57	5.29	0.53	0.79	0.13	0.19
A04	4.37	7.70	0.65	1.15	0.16	0.27
A05	4.28	4.59	0.64	0.68	0.15	0.16
A06	2.93	4.54	0.44	0.68	0.10	0.16
A07	5.69	6.84	0.85	1.02	0.20	0.24
A08	9.18	12.29	1.37	1.83	0.33	0.44
A09	1.88	3.74	0.28	0.56	0.07	0.13
A10	6.02	7.44	0.90	1.11	0.21	0.26
A11	10.78	12.93	1.61	1.93	0.38	0.46
A12	4.63	8.50	0.69	1.27	0.16	0.30
A13	2.79	6.64	0.42	0.99	0.10	0.24
A14	2.40	4.56	0.36	0.68	0.09	0.16
A15	3.97	5.36	0.59	0.80	0.14	0.19
A16	3.69	6.09	0.55	0.91	0.13	0.22
A17	16.44	17.50	2.46	2.61	0.58	0.62
A18	7.62	10.37	1.14	1.55	0.27	0.37
A19	4.42	8.74	0.66	1.30	0.16	0.31
A20	3.36	6.42	0.50	0.96	0.12	0.23
A21	3.89	6.52	0.58	0.97	0.14	0.23
A22	4.99	5.77	0.74	0.86	0.18	0.21
A23	**36.11**	**38.36**	5.39	5.73	1.28	1.36
A24	**57.84**	**60.00**	8.64	8.96	2.06	2.13
A25	8.71	10.40	1.30	1.55	0.31	0.37
A26	3.32	5.42	0.50	0.81	0.12	0.19
A27	3.64	5.72	0.54	0.85	0.13	0.20

Table 2-1
Baneberry TEDs at Sample Locations
(Page 2 of 4)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A28	3.43	5.45	0.51	0.81	0.12	0.19
A29	0.44	2.60	0.07	0.39	0.02	0.09
A30	1.97	6.90	0.29	1.03	0.07	0.25
A31	11.60	13.12	1.73	1.96	0.41	0.47
A32	**52.16**	**57.39**	7.79	8.57	1.85	2.04
A33	**39.41**	**41.71**	5.88	6.23	1.40	1.48
A34	**351.69**	**364.79**	**52.50**	**54.46**	12.50	12.97
A35	**66.76**	**70.38**	9.97	10.51	2.37	2.50
A36	10.80	13.59	1.61	2.03	0.38	0.48
A37	4.58	6.81	0.68	1.02	0.16	0.24
A38	5.26	6.35	0.79	0.95	0.19	0.23
A39	3.00	5.56	0.45	0.83	0.11	0.20
A40	3.21	8.44	0.48	1.26	0.11	0.30
A41	3.05	7.19	0.46	1.07	0.11	0.26
A42	3.35	6.68	0.50	1.00	0.12	0.24
A43	1.19	3.01	0.18	0.45	0.04	0.11
A44	3.80	6.32	0.57	0.94	0.14	0.22
A45	**32.27**	**33.81**	4.82	5.05	1.15	1.20
A46	8.03	9.12	1.20	1.36	0.29	0.32
A47	0.00	0.00	0.00	0.00	0.00	0.00
A48	0.00	0.00	0.00	0.00	0.00	0.00
A49	0.00	0.00	0.00	0.00	0.00	0.00
A50	0.00	0.00	0.00	0.00	0.00	0.00
A51	**51.78**	**60.32**	7.73	9.00	1.84	2.14
A52	2.84	6.62	0.42	0.99	0.10	0.24
A53	0.85	3.80	0.13	0.57	0.03	0.14
A54	0.00	0.00	0.00	0.00	0.00	0.00

Table 2-1
Baneberry TEDs at Sample Locations
(Page 3 of 4)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A55	0.00	0.00	0.00	0.00	0.00	0.00
A56	0.99	5.75	0.15	0.86	0.04	0.20
A57	8.40	12.46	1.25	1.86	0.30	0.44
A58	**24.91**	**31.13**	3.72	4.65	0.89	1.11
A59	0.00	0.00	0.00	0.00	0.00	0.00
A60	8.63	12.05	1.29	1.80	0.31	0.43
A61	**29.87**	**33.56**	4.46	5.01	1.06	1.19
A62	11.55	14.04	1.72	2.10	0.41	0.50
A63	0.00	0.00	0.00	0.00	0.00	0.00
A64	6.34	9.47	0.95	1.41	0.23	0.34
A65	17.61	20.13	2.63	3.00	0.63	0.72
A66	**25.89**	**28.22**	3.87	4.21	0.92	1.00
A67	**33.01**	**35.12**	4.93	5.24	1.17	1.25
A68	13.22	16.79	1.97	2.51	0.47	0.60
A69	3.98	6.16	0.59	0.92	0.14	0.22
A70	0.23	1.58	0.03	0.24	0.01	0.06
A71	**38.31**	**40.48**	5.72	6.04	1.36	1.44
A72	**36.64**	**38.93**	5.47	5.81	1.30	1.38
A73	16.14	19.10	2.41	2.85	0.57	0.68
A74	19.05	21.66	2.84	3.23	0.68	0.77
A75	**31.82**	**35.75**	4.75	5.34	1.13	1.27
A76	11.58	13.68	1.73	2.04	0.41	0.49
A77	0.00	0.00	0.00	0.00	0.00	0.00
A78	0.00	0.00	0.00	0.00	0.00	0.00
A79	13.53	17.09	2.02	2.55	0.48	0.61
A80	15.43	17.75	2.30	2.65	0.55	0.63
A81	10.82	13.73	1.62	2.05	0.38	0.49

Table 2-1
Baneberry TEDs at Sample Locations
(Page 4 of 4)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A82	12.37	17.31	1.85	2.58	0.44	0.62
A83	0.00	0.00	0.00	0.00	0.00	0.00
A84	0.67	3.12	0.10	0.47	0.02	0.11
A85	3.37	5.39	0.50	0.81	0.12	0.19
A86	4.17	6.13	0.62	0.92	0.15	0.22
A87	2.58	4.55	0.39	0.68	0.09	0.16
A88	2.35	5.41	0.35	0.81	0.08	0.19
A89	0.00	0.00	0.00	0.00	0.00	0.00
A90	4.71	8.71	0.70	1.30	0.17	0.31
A91	2.10	6.47	0.31	0.97	0.07	0.23
A92	1.96	4.11	0.29	0.61	0.07	0.15
A93	0.00	0.00	0.00	0.00	0.00	0.00
A94	0.00	0.00	0.00	0.00	0.00	0.00
A95	0.15	3.45	0.02	0.51	0.01	0.12
A96	0.00	0.00	0.00	0.00	0.00	0.00
A98	**1,319.72**	**1,431.53**	**197.03**	**213.72**	**46.91**	**50.88**
A99	**715.79**	**743.71**	**106.86**	**111.03**	**25.44**	**26.43**
A100	**776.83**	**811.47**	**115.98**	**121.14**	**27.61**	**28.84**
A101	**34.14**	**41.20**	5.10	6.15	1.21	1.46
A102	**43.00**	**47.83**	6.42	7.14	1.53	1.70
A103	**45.59**	**51.57**	6.81	7.70	1.62	1.83
A106	7.81	8.11	1.16	1.21	0.28	0.29
A107	10.47	11.25	1.56	1.68	0.37	0.40
A108	0.00	0.00	0.00	0.00	0.00	0.00
A109	16.17	18.04	2.41	2.69	0.57	0.64
A110	4.22	6.54	0.63	0.98	0.15	0.23

Bold indicates the values exceeding the FAL.

TED at each sample location for the Remote Work Area and Industrial Area exposure scenarios, respectively.

The TEDs for surface soils exceeded the FAL of 25 mrem/RW-yr at sample locations A34, A98, A99, and A100, which are located directly to the southwest of the default contamination boundary (see Figure A.3-5). The default contamination boundary was defined in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) as the crater and surface expression of the fissure assuming that contamination within this boundary exceeds the FAL. This assumption was based on the knowledge of the test which suggests that much of the radioactivity associated with the test was captured within the crater.

Other Releases

Drainages potentially impacted by the Baneberry test were identified to the south and north of GZ. Three drainages were identified for evaluation based upon drainage assessments (Miller, 2010) and GWSs (Figure 2-1). Visual inspections and GWSs were conducted to evaluate the central drainage located directly north and adjacent to the crater, and the drainage south of the crater. No elevated readings were observed in either drainage, and further study was not warranted.

The northernmost drainage exhibited areas with elevated activity as identified by the GWSs. Seven sediment areas downstream from the area of highest activity were identified for placement of TLDs, and three areas were identified for soil sampling (see Figure A.3-6). Sediment accumulation areas with elevated radiological readings were identified where an abandoned road transected the wash in multiple locations. Sediment areas were identified directly upstream from where the road crossed the channel, forming a small impoundment that collected sediment. Surface and depth soil samples were collected at three locations within this drainage.

Subsurface samples were collected at two locations where field-screening results (FSRs) for samples at depth exceeded the FSL. At location A101, FSRs for the sample collected at a depth of 5 to 10 cm bgs exceeded the FSL. The FSL was also exceeded at location A102 at a depth of 25 to 30 cm. For these two locations, samples were collected at the surface and at the depth interval with the highest FSR. The 95 percent UCLs of the TEDs at these two locations (A101 and A102) and the next downstream sediment location (A103) ranged from 41.2 to 51.6 mrem/IA-yr, exceeding the PAL of 25 mrem/IA-yr. The TEDs at the two sediment locations farther downstream (A106 and A107) were

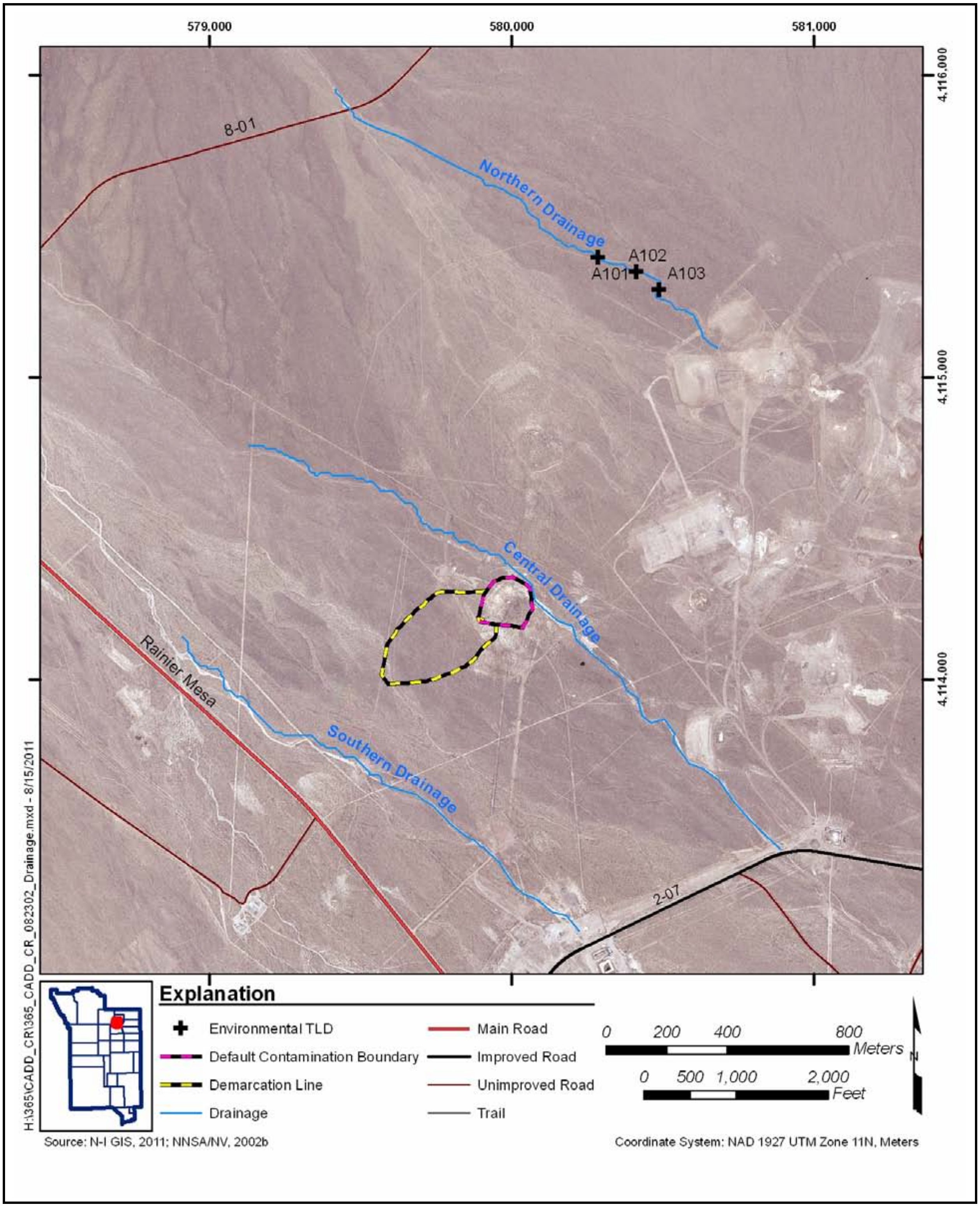

Figure 2-1
Evaluated Drainages at Baneberry

below the 25-mrem/IA-yr PAL, ranging from 8.1 to 11.3 mrem/IA-yr. The 95 percent UCLs of the TEDs ranged from 6.2 to 7.7 mrem/RW-yr at locations A101 through A103 and did not exceed the FAL of 25 mrem/RW-yr. Other biasing factors (e.g., staining) that would indicate the potential for other releases were not identified at this or other drainages within the study group.

Due to the nature of the primary release and based upon the CSM, radionuclides were deposited upon surface soils (0 to 5 cm bgs) in a consistent annular pattern around the GZ. This is supported by the correlation of GWS data and TED determinations as discussed in Section A.3.3. Both sets of data support the uniform annular distribution of contamination in the plume without revealing anomalous or scattered areas of contamination. If radiological contaminants were associated with excavation, clearing, or mounding activities, they would be observed on the surface of mounds or berms and detected by the radiological surveys. Mixing of soils from the physical movement of the surface soil material would also result in a decrease in contamination concentrations. No anomalies were identified in radiological surveys or visual inspections that indicated the presence of buried contamination. Therefore, it was determined that buried contamination is not present at Baneberry that would affect corrective action decisions.

One empty drum was identified in a cellar structure (location A104) at Baneberry. Soil beneath the empty drum was sampled, and concentrations of contaminants found in the sampled soil were below PALs for all radiological, volatile organic compound (VOC), semivolatile organic compound (SVOC), and metal constituents. This drum was removed and disposed of as a BMP. In addition, one area of deteriorated dry-cell batteries (location A105) was identified, and samples were collected for chemical and radiological constituents. The results of environmental sampling indicated that COCs were below the PALs for all constituents. The batteries and associated soil were collected, drummed, and properly disposed of as a BMP.

Summary of Investigation Results at Baneberry

Based on analytical results for surface soil (0 to 5 cm bgs) samples and TLD data collected at Baneberry, surface radiological contamination exceeds the FAL (25 mrem/RW-yr) at four locations (Table 2-1) outside the default contamination boundary (see Figure A.3-5). A corrective action of closure in place (based on the corrective action evaluation presented in Appendix E) with a UR was selected. A UR was established around the area that exceeds a net effective dose of 25 mrem/RW-yr above naturally occurring background levels to include the default contamination boundary as discussed in Section A.3.3 and Attachment D-1.

Although radiological surveys indicated elevated readings in the northern drainage, no TED values exceeded the FAL. As a BMP, the empty drum at location A104, and the dry-cell batteries and soil affected by the batteries at location A105 were removed.

2.2.2 Data Assessment Summary

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

The DQA process as presented in Appendix B consists of the following steps:

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

The results of the DQI evaluation show that the criteria for some parameters were not met. Three parameters—lead, silver, and cadmium—did not meet the 80 percent criteria for precision.
In addition to these three parameters not meeting the precision criteria, three constituents—pentachlorophenol, barium, and selenium—did not meet the 80 percent accuracy criteria. As presented in Appendix B, there was a negligible potential for these deficiencies to result in a false negative decision. For completeness, 1,4-Dioxane fell below the completeness criteria of 80 percent. Because this constituent has not historically been detected at the NNSS, there is no reason to suspect its presence or preclude the resolution of the DQO decisions.

The DQA process determined that information generated during the investigation supports the CSM assumptions and that the data collected support their intended use in the decision-making process. Based on the results of the DQA, the DQO requirements have been met.

2.3 Justification for No Further Action

No further corrective action is needed for Baneberry based on implementation of the corrective action of closure in place with a UR. The UR encompasses the crater and the area where surface soil contamination exceeds the FAL of 25 mrem/RW-yr (southwest of the crater). This corrective action was selected to ensure protection of the public and the environment in accordance with Chapter 445A of the *Nevada Administrative Code* (NAC) (NAC, 2008) based on an evaluation of risk, feasibility, and cost effectiveness (the evaluation of CAAs is presented in Appendix E).

2.3.1 Final Action Levels

The establishment of the FALs (presented in Appendix C) was based on risk to receptors.
The radiological risk to receptors from contaminants at Baneberry is due to chronic exposure to radionuclides (i.e., receiving a dose over time). Therefore, the risk to a receptor is directly related to the amount of time a receptor is exposed to the contaminants. A review of the current and projected use of the site determined that workers may be present for only a limited number of hours per year, and it is not reasonable to assume that any worker would be present at this site on a full-time basis (DOE/NV, 1996) as defined by the Industrial Area scenario. In the Baneberry DQOs, it was determined that the Occasional Use Area exposure scenario would be appropriate in calculating receptor exposure time based on current land use. In order to quantify the maximum number of hours a site worker may be present at Baneberry, current and anticipated future site activities were evaluated as part of the CAI (see Section C.1.10). This evaluation concluded that the most exposed worker under current land usage is an inspection and maintenance worker who has the potential to be present at the site for up to 10 hr/yr. As a result, the most exposed worker would not be exposed to site contamination for more time than is assumed under the Occasional Use Area exposure scenario (80 hr/yr).

Using the 95 percent UCL of the maximum dose measured outside the crater and fissure areas at Baneberry (213.7 mrem/RW-yr), a receptor would be exposed to a dose of 25 mrem after 39 hours. Although the most exposed worker under current land usage (10 hr/yr) will not be exposed to site contamination longer than the time assumed for the Remote Work Area scenario (336 hr/yr), it was decided to base the FALs on the Remote Work Area exposure scenario (see Section C.1.10).

3.0 Recommendation

Corrective actions for Baneberry were based on the risk assessment presented in Appendix C and the corrective action evaluation presented in Appendix E. It was decided to use in the risk assessment the Remote Work Area exposure scenario (with a duration of 336 hr/yr of site worker exposure) for the radiological FAL.

Baneberry radiological contamination exceeds the FAL of 25 mrem/RW-yr at four sample locations outside the default contamination boundary. It is assumed that radioactivity within the default contamination boundary shown on Figure A.3-1 exceeded the FAL. Therefore, corrective action is required. The selected corrective action (based on the evaluation presented in Appendix E) is closure in place with a UR. The FFACO UR boundary was established to encompass the GWS isopleth corresponding to a dose of 25 mrem/RW-yr (see Section A.3.3 and Attachment D-1) and the default contamination boundary (i.e., the crater and fissure).

To determine the extent of the UR, a correlation of radiation survey values to the 95 percent UCLs of Remote Work Area TED values was conducted for 1994 gross count, 1994 man-made, and 2009 aerial radiation surveys, and the site-specific GWS.

Each of these survey correlations was determined by converting point data into a continuous dataset (surface) by using an inverse distance weighted interpolation method. The continuous dataset was then used to determine values at each TLD location. The relationship between the surface value and the 95 percent UCL of the TED for the Remote Work Area exposure scenario was determined by statistical correlation for each type of radiation survey performed. The radiation survey method with the best fit to TED results was then used to determine the corrective action boundary. At Baneberry, the GWS method had the best correlation to the TED results. The corrective action boundary is presented in Figure A.3-4.

As a BMP, any area at Baneberry where an industrial land use of the area could cause a future site worker to receive a dose exceeding 25 mrem/IA-yr (assuming the worker would be exposed to site contamination for a period of 2,250 hr/yr) was identified and administratively use restricted (administrative UR). At Baneberry, the TED from surface soils exceeded a dose of 25 mrem under the Industrial Area scenario (25 mrem/IA-yr) at 21 locations (Table 2-1). The administrative

UR boundary was established to encompass the GWS value corresponding to 25 mrem/IA-yr (see Section A.3.3). The administrative UR is presented in Attachment D-1. To determine the extent of this area, a correlation of radiation survey values to the 95 percent UCLs of Industrial Area TED values was conducted for the 1994 aerial radiation surveys and the site-specific GWS. The radiation survey with the best correlation was the GWS. The GWS values were then interpolated using a kriging technique and isopleths established over the entire area of the GWS. The administrative UR boundary was established to encompass the GWS isopleth corresponding to a dose of 25 mrem/IA-yr. This would restrict any future industrial land use activities that would result in a site worker exceeding the exposure time assumed under the current land use scenario (336 hr/yr under the Remote Work Area exposure scenario).

The URs are recorded in the FFACO database; the DOE, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) Facility Information Management System; and the NNSA/NSO CAU/CAS files.

No further corrective action is required at Baneberry based upon the implementation of the corrective action of closure in place with a UR. Corrective action alternatives are evaluated in Appendix E based on technical merits focusing on reduction of toxicity, mobility, and/or volume; reliability; short- and long-term feasibility; and cost. The FFACO UR implemented at Baneberry will protect site workers from inadvertent exposure. The FFACO UR requires annual inspections to certify that postings are in place, intact, and readable. The corrective actions for Baneberry are based on the assumption that activities on the NNSS will be limited to those that are industrial in nature and that the NNSS will maintain controlled access (i.e., restrict public access and residential use). Should the future land use of the NNSS change such that these assumptions are no longer valid, additional evaluation may be necessary.

The administrative UR at Baneberry is not part of the corrective action but was implemented as a BMP. The administrative UR will be recorded and controlled in the same manner as the FFACO UR but does not require postings or inspections. The administrative UR is discussed and shown in Attachment D-1.

The NNSA/NSO requests that NDEP issue a Notice of Completion for Baneberry and approve transferring CAU 365 from Appendix III to Appendix IV of the FFACO.

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Appendix A

Corrective Action Investigation Results

A.1.0 Introduction

This appendix presents the CAI activities and analytical results for CAU 365, Baneberry Contamination Area. Corrective Action Unit 365 comprises one CAS, CAS 08-23-02, U-8d Contamination Area, shown on Figure A.1-1. This CAS is referred to in this document as Baneberry. The site is located in the southern portion of Area 8 of the NNSS. A release of radioactive material to the soil surface occurred as a result of the accidental venting of radioactive gases from a fissure formed during the Baneberry weapons-effects test.

Additional information regarding the history of this site, planning, and the scope of the investigation is presented in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a).

A.1.1 Project Objectives

The objective of the investigation was to provide sufficient information to complete corrective actions and support the recommendation for closure of the Baneberry site. This objective was achieved by identifying the nature and extent of COCs and by evaluating, selecting, and implementing acceptable CAAs.

For radiological contamination, a COC is defined as the presence of radionuclides that jointly present a dose to a receptor exceeding the FAL of 25 mrem/yr. For other types of contamination, a COC is defined as the presence of a contaminant at a concentration exceeding its corresponding FAL concentration (see Section C.1.4).

A.1.2 Contents

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

- Section A.1.0 describes the investigation background, objectives, and contents.
- Section A.2.0 provides an investigation overview.
- Section A.3.0 provides specific information regarding the CAI to include field activities, sampling methods, and laboratory analytical results from investigation sampling.

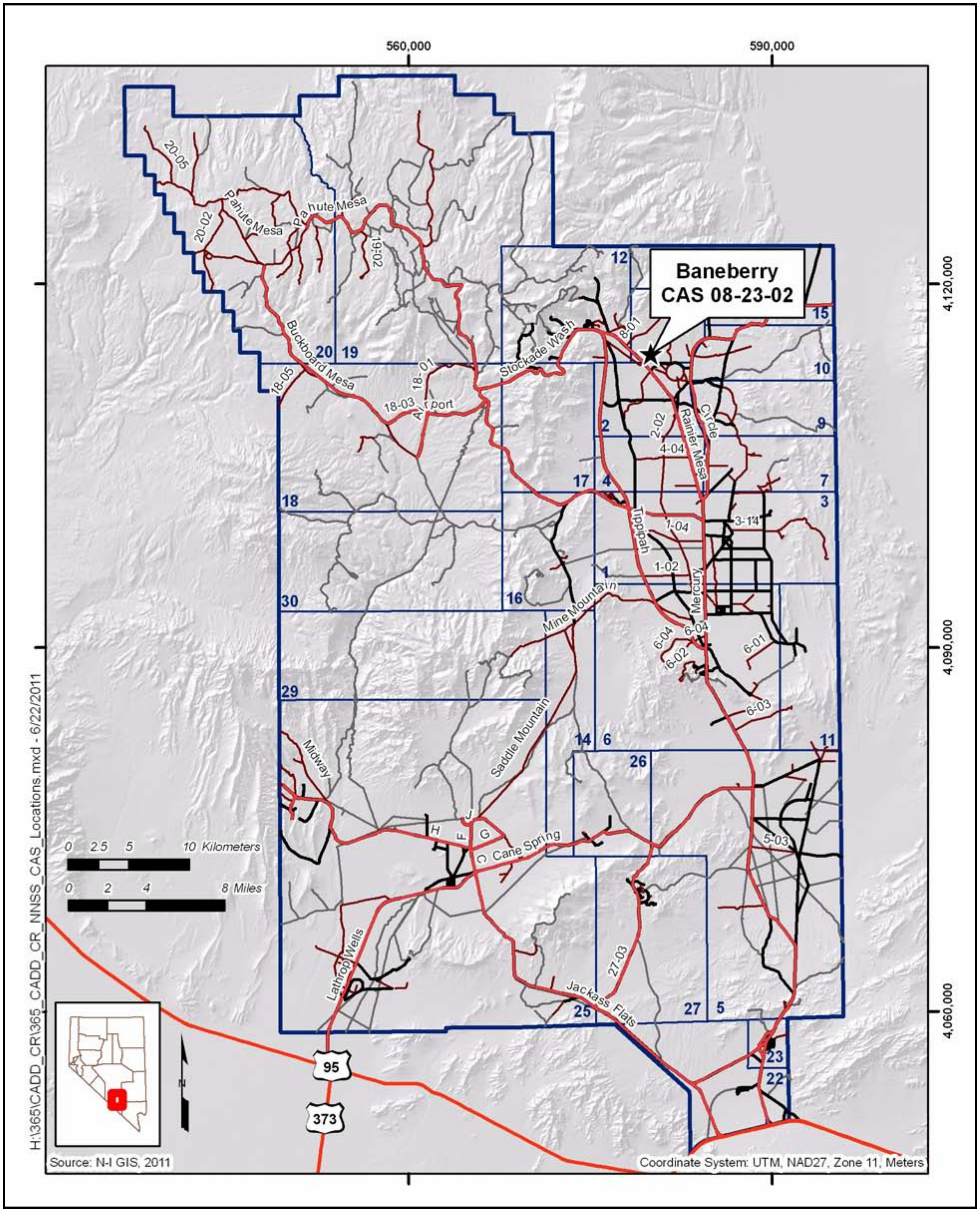

Figure A.1-1
CAU 365, CAS Location Map

- Section A.4.0 summarizes waste management activities.
- Section A.5.0 discusses the QA and QC processes followed and the results of QA/QC activities.
- Section A.6.0 provides a summary of the investigation results.
- Section A.7.0 lists the cited references.

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

A.2.0 Investigation Overview

The following CAI activities were conducted from January 18, 2011, through August 2, 2011:

- Inspected and verified the site components identified in the CAIP (NNSA/NSO, 2010a).
- Performed site walkovers to identify biased sample locations.
- Conducted GWSs.
- Established sample plots and composite sample aliquot locations.
- Staged TLDs at soil sample plots, background locations, and additional locations of interest.
- Collected and submitted TLDs for analysis.
- Collected soil samples at sample plots and biased sample locations.
- Submitted soil samples for offsite laboratory analysis.
- Collected GPS coordinates of sample locations, TLD locations, and points of interest.

The investigation and sampling program adhered to the requirements set forth in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a) to include sample collection, documentation, and analysis. Quality control samples (e.g., duplicate samples) were collected as required by the Industrial Sites QAPP (NNSA/NV, 2002a) and the CAIP.

To facilitate site investigation and the evaluation of DQO decisions for different CSM components, the releases at Baneberry were classified into one of the following two categories:

- **Primary releases—**This release scenario is specific to the atmospheric deposition of radionuclide contamination onto the soil surface that has not been displaced through excavation or migration. The contamination associated with the primary releases is limited to the top 5 cm of soil. Surface deposition of radionuclides that have been distributed at the NNSS from atmospheric nuclear releases has been found to be concentrated in the upper 5 cm of undisturbed soil (McArthur and Kordas, 1983, 1985; Gilbert et al., 1977; Tamura, 1977). Therefore, for the purposes of the CAIP, surface was defined as the upper 5 cm of soil.

- **Other releases—**This release scenario includes any contamination from site activities not specific to the atmospheric deposition of radionuclides. This includes radionuclide contaminants that were initially deposited onto the soil surface (as in the primary release category) but have subsequently been displaced through excavation or migration within washes or drainages. This category also includes radionuclides that were deposited under mechanisms other than atmospheric deposition. Included in this category are the injection of radionuclides into native material throughout the fissure during the venting of the Baneberry test and the placement of deposited contamination into soil piles due to surface scraping or exploratory excavations following the test. Chemical or radiological contamination discovered during the investigation through the identification of biasing factors that are not a part of a previously identified release also is included as a release under this scenario. The depth of radiological contamination from other releases is dependent upon the nature of the release or subsequent movement through excavation or migration. Investigation of other releases is accomplished through measurements of soil radioactivity using a judgmental sampling scheme at depths dependent upon the nature of the release, or by conservative assumptions that radioactivity is present at depth based on process knowledge.

Baneberry was investigated by collecting TLD samples for external radiological dose measurements, collecting soil samples for the calculation of internal radiological dose, and collecting samples to determine whether potential source material (PSM) was present. The field investigation was completed as specified in the CAIP, with minor deviations described in Section A.3.0.

Sections A.2.1 through A.2.5 provide the general investigation and evaluation methodologies used at Baneberry.

A.2.1 Sample Locations

Sample locations were selected based on interpretation of site-specific GWSs, historical investigations (1994 aerial radiological survey [BN, 1999], and Radionuclide Inventory and Distribution Program [RIDP] data [McArthur and Kordas, 1985; Gray et al., 2007]). Information obtained during site visits and site conditions as provided in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a) also were used in this determination. The center of each sample plot, judgmental sample locations, TLD locations, and points of interest were surveyed with a GPS instrument. Appendix G presents the sample location GPS coordinates in tabular format. Soil and TLD sample locations are presented in Tables A.3-1 and A.3-2, and are graphically presented in Figure A.3-1.

For the primary release, TLD sampling locations were selected using a combination of grid and vector patterns. The TLDs were placed in a grid pattern around the GZ to investigate contamination in the area surrounding GZ and the fissure. Vectors aligned and perpendicular to the plume also were established for TLD placement based on aerial radiation surveys and GWSs. Five TLDs were placed to measure background doses at locations determined to be outside the influence of the Baneberry release. The background locations were selected based on the NNSS-wide background aerial surveys (Hendricks, 2011). Soil sampling for the primary release at the Baneberry site consisted of the collection of surface soil samples (as defined in Section A.3.0) within sample plots. Four composite samples were collected within each sample plot, and TLDs were located close to the center of each sample plot. The randomly located aliquot locations were identified using a predetermined random-start, triangular grid pattern.

Sample locations for other releases were selected based on biasing factors such as visual identification of sedimentation areas in drainages, elevated radiological readings, locations of PSM, and soil staining.

A.2.2 Investigation Activities

The investigation activities performed at Baneberry were consistent with the field investigation activities specified in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a). The investigation strategy provided the necessary information to establish the nature and extent of contamination associated with this site. The following sections describe the specific investigation activities completed at Baneberry.

A.2.2.1 Radiological Surveys

An aerial radiological survey was performed at Baneberry in 1994 at an altitude of 200 ft with 500-ft flight-line spacing (BN, 1999).

Ground-level radiological surveys conducted at Baneberry included both walkover and drive-over surveys. Ground-level GWSs were performed to identify specific locations for sample locations. Count-rate data were collected with a TSA Systems PRM-470 model plastic scintillator. Count-rate and position data were collected and recorded at 1-second intervals via a Trimble Systems GeoXT GPS unit. The walkover speed was approximately 0.5 meter per second (m/s) with the radiation detector held at a height of approximately 18 inches (in.) above the ground surface. Drive-over surveys were performed at approximately 1.0 m/s with the detector at a height of approximately 36 in. above the ground surface.

A.2.2.2 Soil Sampling

Soil sampling for the primary release at Baneberry consisted of the collection of surface soil samples within two 100-m^2 sample plots. Within each sample plot, four composite samples were collected.

Each composite sample consisted of 9 randomly located aliquots, resulting in a total of 36 randomly located aliquots collected from each plot. The aliquot locations were identified using a predetermined random-start, triangular grid pattern. Sample aliquots were collected using a “vertical-slice cylinder and bottom-trowel” method, which allowed capture of a 5-cm-thick cylinder-shaped column of soil. All nine aliquots were combined atop a sieve (#4 mesh) fitted into a bottom pan with a plastic liner. The sample was slowly sieved to minimize dust hazards, and oversized material left atop the sieve was returned to the sample location. The sample was first field screened for radiological readings, and then transferred to a metal can and shaken for 3 minutes using a paint shaker to homogenize the soil.

At the other release location within the drainage feature at the site, samples were collected at 5-cm intervals vertically from the surface to a maximum depth of 30 cm. These grab samples were radiologically field screened, and the surface sample and any interval samples that exceeded the FSL were sent to the laboratory for analysis. Samples from the drainage were collected and prepared using the same sample collection and sieving methods described above. Samples of PSM solids and soil were collected from under a drum located in a cellar (location A104) and from deteriorated dry-cell batteries (location A105) using a grab sample method.

A.2.2.3 Internal Dose Estimates

Internal dose estimates were obtained using the radionuclide analytical results from soil samples and the corresponding RRMGs (see Attachment C-1). The internal dose RRMG concentration for a particular radionuclide is the concentration in surface soil that would cause an internal dose to a receptor of 25 mrem/yr (under the appropriate exposure scenario) independent of any other radionuclide (assuming that no other radionuclides contribute to the dose). The internal dose RRMG for each detected radionuclide (in picocuries per gram [pCi/g] of soil) was derived using the RESRAD computer code (Yu et al., 2001) under the appropriate exposure scenario (see Attachment C-1).

The total internal dose corresponding to each surface soil sample was calculated by adding the dose contribution from each radionuclide. For each sample, the radionuclide-specific analytical result was divided by its corresponding internal RRMG (see Attachment C-1) to yield a fraction of the 25-mrem/yr dose. The fractions for all radionuclides detected in a soil sample were summed to yield a total fraction for that sample. The total fraction was then multiplied by 25 to yield an internal dose estimate (in mrem/yr) at that sample location. For primary release samples, a 95 percent UCL was calculated for the internal dose in a sample plot using the results of all soil samples collected in that plot (see Attachment C-1). For other release sample locations where only one sample was collected, statistical inferences could not be calculated, and the single analytical result was used to calculate the internal dose.

For TLD locations where soil samples were not collected, the internal dose was estimated using the external dose measurement from the TLD and the ratio of internal dose to external dose from the sample plot with the maximum internal dose. This ratio was then multiplied by the external dose measured at each TLD location where soil samples were not collected to estimate the internal dose.

A.2.2.4 External Dose Measurements

Panasonic UD-814 TLDs were staged at Baneberry with the objective of collecting *in situ* measurements to determine the external radiological dose. The TLDs were placed at the approximate center of each sample plot, at selected locations, and in background areas (i.e., beyond the influence of the Baneberry release). Each TLD was placed at a height of 1 m above the ground surface, which is consistent with TLD placement in the NNSS routine environmental monitoring program (see Section 6.0 of the CAU 365, Baneberry Contamination Area, CAIP). Once retrieved from the field locations, the TLDs were analyzed with automated TLD readers that were calibrated and maintained by the NNSS management and operating (M&O) contractor. The TLD results are discussed in Section A.3.2.1.

This approach allowed for the use of existing QC procedures for TLD processing. Details of the environmental monitoring TLD program and TLD QC are presented in Section 6.0 of the CAIP. All readings conformed to the approved QC program and are considered representative of the external radiological dose at each location.

As a TLD measures external dose from only surface contamination, it cannot be used to directly measure external dose for subsurface sample locations. Therefore, at other release locations where subsurface soil samples were collected, the external portion of TED was established using RESRAD. The ratio of the RESRAD-calculated subsurface to surface external doses was used to increase the

TLD-measured surface external dose to estimate a TLD-equivalent subsurface external dose for subsurface samples from locations A101 and A102.

The TLDs used at Baneberry contain four individual elements. External dose at each TLD location is determined using the readings from TLD elements 2, 3, and 4. Each of these elements is considered a separate, independent measurement of external dose. A 95 percent UCL of the average of these measurements was calculated for each TLD location. Element 1 is designed to measure dose to the skin and is not relevant to the determination of the external dose for the purpose of this investigation.

Estimates of external dose, in mrem/IA-yr, at the Baneberry site are presented as net values (i.e., the dose from the natural or "field" background has been subtracted from the raw result). The "field" background TLDs measured doses from natural sources in areas unaffected by the release of radionuclides from the site as described in Section A.3.2.1. Five "field" background TLDs (A200 through A204) were deployed during the investigation. One TLD (A200) was placed at a location initially labeled as a background location, but the location was later determined not to be representative of background conditions. Therefore, readings from the TLD placed at this location were not included in background dose calculations.

A.2.3 Total Effective Dose

The TED represents the sum of the internal dose (calculated from soil sample results) and the external dose (calculated from TLD measurements) for each sample location. The average TED calculated from sample results is an estimate of the true (unknown) TED. It is uncertain how well the average TED represents the true TED. If an average TED were directly compared to the FAL, any significant difference between the true TED and the sample TED could lead to decision errors. To reduce the probability of a false negative decision error, a conservative estimate of the true TED (i.e., the 95 percent UCL) is used to compare to the FAL. By definition, there will be a 95 percent probability that the true TED is less than the 95 percent UCL of the calculated TED. The probabilistic sampling design as described in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a) conservatively prescribes using the 95 percent UCL of the TED to estimate dose at each sample plot. The 95 percent UCL of the TED at each sample location was calculated as the sum of the 95 percent UCLs of the internal and external doses.

A.2.4 Laboratory Analytical Information

Radiological analyses of the collected soil samples were performed by General Engineering Laboratories, LLC, of Charleston, South Carolina. The analytical suites and laboratory analytical methods used to analyze investigation samples are listed in Table A.2-1. Analytical results are reported in this appendix if they were detected above the minimum detectable concentrations (MDCs). The complete laboratory data packages are available in the project files.

Table A.2-1
Laboratory Analyses and Methods, Baneberry Investigation Samples[a]

Analysis	Analytical Method[b]
Radiological	
Gamma Spectroscopy	Aqueous - EPA 901.1[c] Non-aqueous - DOE EML HASL-300[d] Ga-01-R
Sr-90	Aqueous - EPA 905.0[c] Non-aqueous - DOE EML HASL-300[d] Sr-02-RC
Chemical	
VOCs	SW-846 8260[e]
SVOCs	SW-846 8270[e]
Metals	SW-846 6010/6020[e]
TCLP Metals	SW-846 1311/6010/7470[e]

[a]Investigation samples include both environmental and associated QC samples.
[b]The most current accepted EPA, DOE, ASTM, NIOSH, or equivalent analytical method may be used, including approved Laboratory Standard Operating Procedures (NNES, 2009).
[c]*Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA, 1980).
[d]*The Procedures Manual of the Environmental Measurements Laboratory* (DOE, 1997).
[e]*SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2011).

ASTM = ASTM International
EML = Environmental Measurements Laboratory
EPA = U.S. Environmental Protection Agency
HASL = Health and Safety Laboratory
NIOSH = National Institute for Occupational Safety and Health
Sr = Strontium
TCLP = Toxicity Characteristic Leaching Procedure

Validated analytical data for Baneberry investigation samples have been compiled and evaluated to determine the presence of COCs and to define the extent of COC contamination if present. However, only the radiological results that contribute to the calculation of internal dose were used in the evaluation of internal dose (see Attachment C-1). The analytical results for Baneberry are presented in Section A.3.2.

The analytical parameters were selected through the application of site process knowledge as described in the CAIP (NNSA/NSO, 2010a).

A.2.5 Comparison to Action Levels

The radiological PALs and FALs are based on an annual dose limit of 25 mrem/yr. This dose limit is specific to the annual dose a receptor could potentially receive from a Baneberry release. As such, it is dependent upon the cumulative annual hours of exposure to site contamination. The PALs were established in the CAIP (NNSA/NSO, 2010a) based on a dose limit of 25 mrem/yr over an annual exposure time of 2,250 hours (i.e., the Industrial Area exposure scenario that a site worker would be exposed to site contamination for 10 hr/day, 225 day/yr). The FALs were established in Appendix C based on a dose limit of 25 mrem/yr over an annual exposure time of 336 hours (i.e., the Remote Work Area exposure scenario in which a site worker is exposed to site contamination for 8 hr/day, 42 day/yr).

Results for both the primary releases and other releases are presented in Section A.3.2. Radiological results are reported as doses that are comparable to the dose-based FAL as established in Appendix C. Chemical results are reported as individual concentrations that are comparable to the individual chemical action levels as established in Appendix C. Results that are equal to or greater than FALs are identified by bold text in the results tables (see Section A.3.0).

A COC is defined as any contaminant present in environmental media exceeding a FAL. A COC may also be defined as a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk to a receptor based on a multiple constituent analysis (NNSA/NSO, 2006). If COCs are present, corrective action must be considered for Baneberry.

A corrective action may also be required if a waste present within Baneberry 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 code (Murphy, 2004). If the resulting soil concentration exceeds the FAL, then the waste would be considered PSM.

  - For liquid wastes, the resulting concentrations of contaminants in the surrounding soil will be calculated based on the concentrations 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.

A.3.0 Corrective Action Investigation Activities

The Baneberry site is located in the southern portion of Area 8 of the NNSS. Baneberry consists of a release of radioactive material to the soil surface as a result of the accidental venting of radioactive gases from a fissure formed during the Baneberry weapons-effects test. Additional details on the history of Baneberry are provided in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a).

A.3.1 Corrective Action Investigation Activities

The specific CAI activities conducted to satisfy the CAIP requirements at Baneberry (NNSA/NSO, 2010a) are described in the following sections.

A.3.1.1 Visual Inspections

Visual inspections of Baneberry were conducted over the course of the field investigation and included site walks, sampling efforts, and radiological surveys. The presence of scattered debris was identified and noted. As a result of the visual inspections, biasing factors were identified and two locations selected for the collection of additional samples. One location (A104) consisted of an abandoned concrete cellar with an empty drum located in the soil-filled bottom. Rust staining was observed under the drum. Two samples, 365A004 and 365A005 (field duplicate [FD]), were collected at this location. Another location (A105) consisted of deteriorated dry-cell batteries with visible staining. Four samples were collected at this location: two debris and soil samples (365A010 and 365A011), and two samples for waste management purposes (365A501 and 365A502). The locations of these features are shown in Figure A.3-1.

In addition to the physical features, drainages are present flowing through and downgradient of the site that were identified as potential routes for migration of contaminated sediments. Six soil samples were collected at locations within the drainages: two samples at location A101 (365A008 and 365A009), two samples at location A102 (365A006 and 365A007), and two samples at location A103 (365A002 and 365A003 [FD]). Visual inspections of these drainage locations noted no biasing factors.

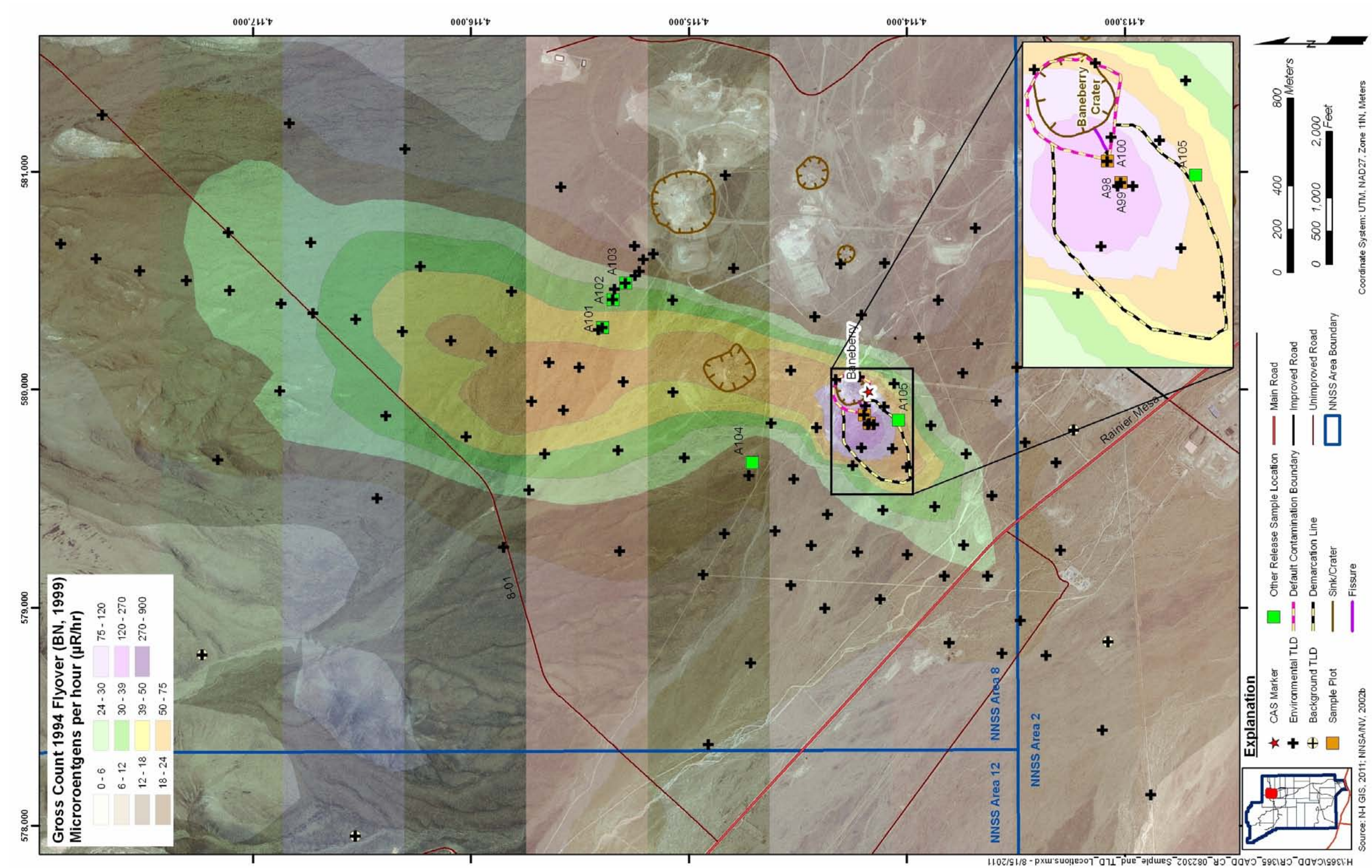

Figure A.3-1
Baneberry TLD and Sample Locations

A.3.1.2 Radiological Surveys

An aerial radiological survey was completed in 1994 (BN, 1999). The results of this survey were used to determine the basic distribution of radionuclides at Baneberry and proposed TLD locations (Figure A.3-1).

At Baneberry, GPS-assisted GWSs were performed during the CAI. The GWSs were conducted at the site to identify the spatial distribution of radiological readings, identify the location of the highest radiological readings, and verify the location of the plume as depicted in the 1994 aerial radiological survey (BN, 1999). Radiological measurements were collected with a TSA Systems PRM-470 model plastic scintillator. Data were logged, and GPS data were collected at 1-second intervals via a Trimble Systems GeoXT GPS unit. The walkover speed was approximately 0.5 m/s with the radiation detector held at a height of approximately 18 in. above the ground surface over a rough 100- and 200-m spacing. Data from the GWSs were post-processed, loaded into a geographical information system, color coded, and displayed on a map of Baneberry (Figure A.3-2).

The results of the GWSs were used in the determination of the locations of the soil sample plots and final TLD placement. The TLD sample locations were established in a grid and vector pattern within the plume (Figure A.3-1). Two locations of elevated radiological readings were identified outside and adjacent to the southwest side of the fenced area established as the default contamination boundary in the CAU 365, Baneberry Contamination Area, CAIP. These locations were established as sample plots A99 and A100.

A.3.1.3 Field Screening

Field screening was performed at sedimentation areas identified for soil sampling. These sedimentation areas were identified within the northernmost drainage exiting the Baneberry site and selected for further study (Figure A.3-2). Samples at this drainage were collected at 5-cm-depth intervals to a depth of 30 cm and screened with an alpha/beta contamination meter. Samples collected at two subsurface locations exceeded the FSL. Along with the surface sample, these subsurface samples were submitted to an offsite analytical laboratory for analysis. Samples 365A008 and 365A009 were collected at location A101 from 0 to 5 and 5 to 10 cm bgs, respectively.

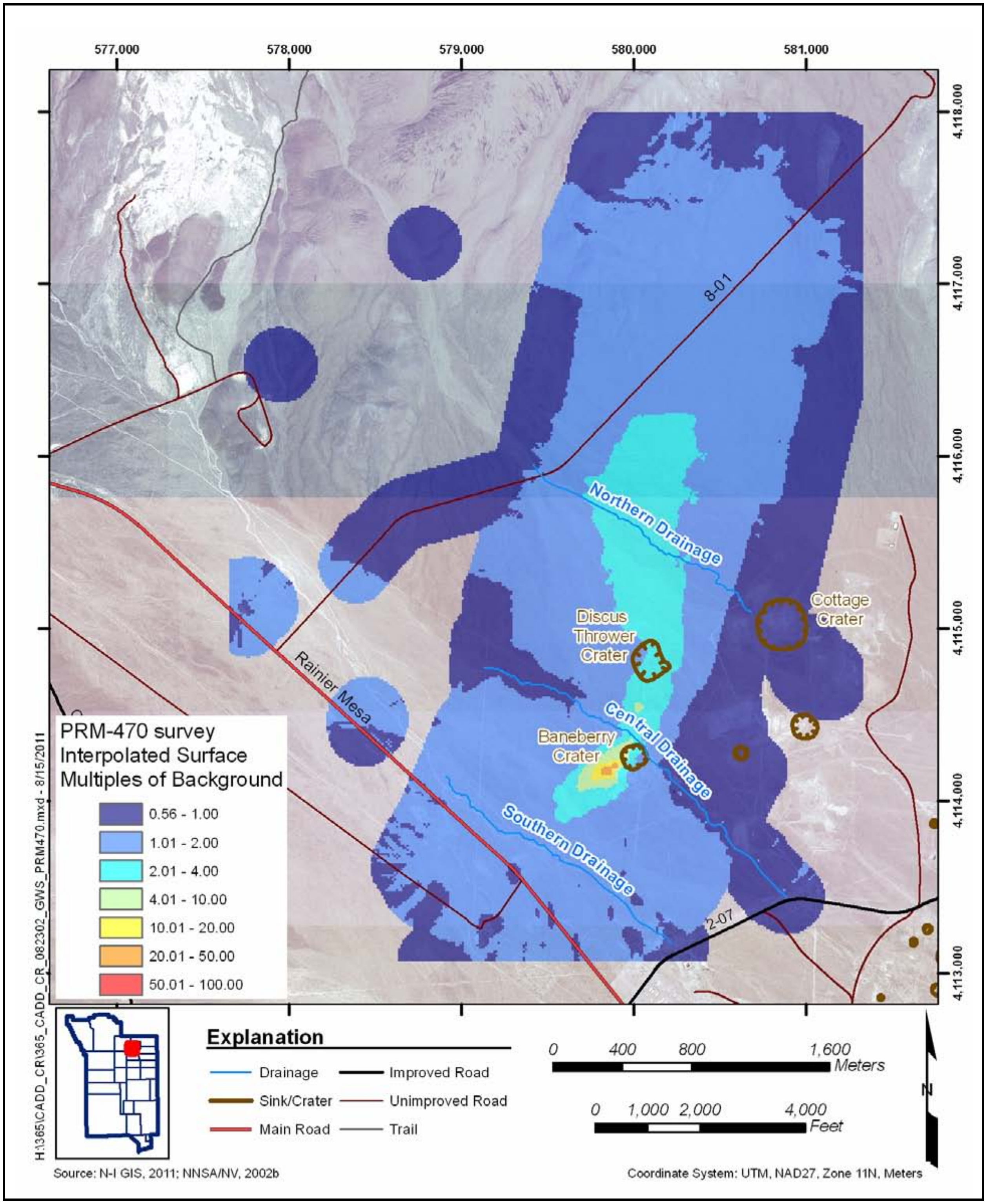

Figure A.3-2
Gamma Walkover Surveys at Baneberry

Samples 365A006 and 365A007 were collected at location A102 from 0 to 5 and 25 to 30 cm bgs, respectively. The FSRs were recorded on SCLs and are retained in project files.

A.3.1.4 Sample Collection

A.3.1.4.1 TLD Samples

A total of 132 TLDs were installed at 107 locations and 5 “field” background locations at Baneberry to measure external doses to site workers. The environmental TLDs (A01 through A103 and A106 through A110) were installed to measure external doses as depicted in Figure A.3-1. Five of these TLDs (A200 through A204) were placed to measure “field” background radiation levels. Based upon elevated radiological readings, two of these locations (A99 and A100) were selected as soil sampling plots.

Three major drainages were identified for examination based upon the drainage study discussed in the CAU 365, Baneberry Contamination Area, CAIP. These drainages were examined for evidence of contaminant migration, with one drainage exhibiting elevated radiological readings from the GWSs. The northernmost drainage was chosen for investigation based upon elevated radiological surveys. Eight TLDs were placed at the closest downgradient sedimentation locations (A101 through A103 and A106 through A110).

A.3.1.4.2 Soil Samples

A total of 22 samples were collected during investigation activities at Baneberry to include 17 environmental, 2 waste management, and 3 QC samples. Environmental soil samples included eight primary release samples from two plots, four grab samples from PSM, and five drainage samples from three sediment areas. All samples were analyzed for gamma spectroscopy and strontium (Sr)-90 in addition to any site-specific analysis. The soil sample locations, descriptions, and purposes are listed in Table A.3-1. Soil sample locations are presented in Figure A.3-1.

Soil sampling at Baneberry consisted of the collection of surface and subsurface soil samples. For the purpose of this investigation, surface soils are defined as soils at a depth of 0 to 5 cm bgs, and subsurface soils are defined as soils at a depth of 5 to 30 cm bgs.

Table A.3-1
Soil Samples Collected at Baneberry

Sample Location	Sample Description	Sample Number	Depth (cm bgs)	Matrix	Purpose	Gamma	Metals	Plutonium	Strontium	SVOCs	TCLP Metals	VOCs
A98	Grab	365A001	0–5	Soil	Environmental	X	--	--	X	--	--	--
A99 (Plot)	Plot B	365A605	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A606	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A607	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A608	0–5	Soil	Environmental	X	--	--	X	--	--	--
A100 (Plot)	Plot A	365A601	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A602	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A603	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A604	0–5	Soil	Environmental	X	--	--	X	--	--	--
A101	Biased Drainage	365A008	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A009	5–10	Soil	Environmental	X	--	--	X	--	--	--
A102		365A006	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A007	25–30	Soil	Environmental	X	--	--	X	--	--	--
A103		365A002	0–5	Soil	Environmental	X	--	--	X	--	--	--
		365A003	0–5	Soil	FD of #365A002	X	--	--	X	--	--	--
A104	Cellar Drum	365A004	0–5	Soil	Environmental	X	X	--	X	X	--	X
		365A005	0–5	Soil	FD of #365A004	X	X	--	X	X	--	X
A105	Dry-Cell Batteries	365A010	0–6 (in.)	Soil	Environmental	X	X	X	X	X	X	--
		365A011	0–6 (in.)	Soil	Environmental	X	X	--	X	X	--	--
	Waste Management	365A501	0–6 (in.)	Solid	Waste Management	X	X	--	X	--	X	--
		365A502	0–6 (in.)	Solid	Waste Management	--	--	--	--	--	X	--
N/A	QC	365A301	N/A	Water	Trip Blank	--	--	--	--	--	--	X

N/A = Not applicable
X = Analyzed
-- = Not required

For the primary release at Baneberry, four composite soil samples (defined in Section A.2.2.2) were collected at each of the two plot locations (A99 and A100) for the determination of internal doses at these plot locations. Samples collected at location A99 include 365A605 through 365A608 and at location A100 include 365A601 through 365A604. These plot locations were established in areas of elevated radiological readings as detected during the GWSs conducted at the site. Sample plot A100 was established directly outside the southwest side of the default contamination boundary (Figure A.3-1) in the area with high GWS values. Sample plot A99 was established southwest of the default contamination boundary in an area with elevated radiological readings. One grab sample (365A001) was collected at a separate location (A98) of elevated readings southwest of the default contamination boundary within a slight depression and corresponding mound. The sample was collected using hand-sampling methods. A scoop was used to collect a discrete volume of soil for the grab sample, which was then placed into a sample container. Although this grab sample location (A98) exhibited the highest radiological survey reading, it was not selected as a sample plot location because the depression and mound associated with it suggested that the location was not representative of the Baneberry area.

Sampling locations for other releases were determined based on the likelihood of a contaminant release at Baneberry. Locations were selected based on the identification of biasing factors to include visual identification, staining, and elevated radiological readings. Three environmental and two waste management samples were collected from areas identified during the site survey using grab-sampling methods. One environmental sample (365A004) and one FD (365A005) were collected from under an empty drum located within a concrete cellar structure with a soil floor (location A104). Two samples (365A010 and 365A011) were collected at the location of observed degraded dry-cell battery parts and associated soil (location A105). Sample 365A011 was a confirmation soil sample collected under the dry-cell battery parts after they had been removed. Visible staining was observed under the cellar drum and in the area around the degraded dry-cell batteries. Final sample locations (Table A.3-1) are shown in Figure A.3-1.

Of the three major drainages identified for examination based upon the drainage study discussed in the CAIP, one drainage was sampled. All three drainages were examined for evidence of contaminant migration, and the northern drainage was chosen for study (Figure 2-1).
Six environmental soil samples were collected at three downgradient sedimentation areas closest to the contamination plume (A101, A102, and A103). Two sedimentation areas (A101 and A102) showed higher radiological FSR values at depth; therefore, both the surface and depth samples were submitted to the laboratory for analysis. Samples 365A008 and 365A009 were collected at

location A101 from 0 to 5 and 5 to 10 cm bgs, respectively. Samples 365A006 and 365A007 were collected at location A102 from 0 to 5 and 25 to 30 cm bgs, respectively. Surface soil sample 365A002 and FD 365A003 were collected at location A103. The central and southern drainages identified for investigation in the CAIP showed no elevated GWS values and hence were not sampled. The "vertical-slice cylinder and bottom-trowel" method and sieving method discussed in Section A.2.2.2 were also used for the collection of samples within the drainage, except that these samples were grab samples collected from a single depth interval.

A.3.1.5 Deviations

Two deviations to the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a) were noted.

The CAIP stated that the background dose would be conservatively estimated by using the minimum value recorded on any TLD placed within the investigation area. A different approach, however, was taken in that five TLDs were placed in areas outside the Baneberry release area of influence to measure radioactivity in these "field" background areas. The background dose was determined by averaging the applicable TLDs placed to measure background dose. This method provides a more representative background dose as it uses an average of samples selected for the purpose of determining background dose as opposed to the minimum value of environmental samples used to determine external dose. This deviation does not have an adverse impact on the results of this CAI or the corrective action boundary determined based on the results of the CAI.

The CAIP stated that the maximum internal dose value from any sample plot will be conservatively applied as representative of the internal dose for all TLD locations. A different approach, however, was taken in that the internal dose was calculated using a scaling factor. The internal dose for all TLD locations was determined by multiplying the external (TLD) dose by the internal/external dose ratio calculated at the plot with the maximum internal dose (plot A100). Although this is a deviation to the method described in the CAIP, using a calculated ratio provides a more representative estimate of the internal dose contribution at the site. This deviation does not have an impact on the resulting corrective action boundary.

A.3.2 Investigation Results

The following sections present the analytical and computational results for soil and TLD samples. All sampling and analyses were conducted as specified in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a). The radiological results are reported as doses that are comparable to the dose-based FAL of 25 mrem/RW-yr. For chemical contaminants, the results are reported as individual concentrations that are comparable to their corresponding FALs. Results that are equal to or greater than FALs are identified by bold text in the results tables. The analytical parameters and laboratory methods used during this investigation are discussed in Section A.2.0 and listed in Table A.2-1.

A minimum number of samples is required to assure sufficient confidence in dose statistics such as the average and 95 percent UCL (EPA, 2006). As stated in the CAIP, if the minimum sample size criterion cannot be met, it must be assumed that contamination exceeds the FAL. The calculation of the minimum sample size is described in Section B.1.1.1.1.

The internal dose calculated from soil sample results and the external dose calculated from TLD measurements were combined to determine TED at each sample location. External doses for TLD locations are summarized in Section A.3.2.1. Internal doses for each sample plot are summarized in Section A.3.2.2. The TEDs for each sampled location are summarized in Section A.3.2.3. Radiological results for the other releases (i.e., drainage samples) are summarized in Section A.3.2.4.

A.3.2.1 External Dose Measurements

Measurements of the external dose were calculated for the Industrial Area exposure scenario and then scaled (based on exposure duration) to the Remote Work Area and Occasional Use Area exposure scenarios for each TLD location. The 95 percent UCL external dose values for each exposure scenario are presented in Table A.3-2. Statistical parameters were calculated for the external dose to include standard deviation and minimum sample size and are presented in Table B.1-2. As the minimum sample size criterion was not met at location A98, it was assumed that the TED at this location exceeds the FAL.

A background isopleth map generated from the 1994 aerial radiation survey (BN, 1999) was used to verify that background TLD measurements represent the background dose estimated at the Baneberry

Table A.3-2
Baneberry 95% UCL External Dose for Each Exposure Scenario
(Page 1 of 4)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A01	0.00	0.00	0.00
A02	0.00	0.00	0.00
A03	5.29	0.79	0.19
A04	7.69	1.15	0.27
A05	4.58	0.68	0.16
A06	4.53	0.68	0.16
A07	6.84	1.02	0.24
A08	12.28	1.83	0.44
A09	3.74	0.56	0.13
A10	7.43	1.11	0.26
A11	12.92	1.93	0.46
A12	8.49	1.27	0.30
A13	6.64	0.99	0.24
A14	4.56	0.68	0.16
A15	5.36	0.80	0.19
A16	6.08	0.91	0.22
A17	17.49	2.61	0.62
A18	10.36	1.55	0.37
A19	8.73	1.30	0.31
A20	6.41	0.96	0.23
A21	6.51	0.97	0.23
A22	5.77	0.86	0.21
A23	**38.33**	5.72	1.36
A24	**59.95**	8.95	2.13
A25	10.39	1.55	0.37
A26	5.41	0.81	0.19
A27	5.71	0.85	0.20
A28	5.44	0.81	0.19
A29	2.60	0.39	0.09

Table A.3-2
Baneberry 95% UCL External Dose for Each Exposure Scenario
(Page 2 of 4)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A30	6.89	1.03	0.25
A31	13.11	1.96	0.47
A32	**57.34**	8.56	2.04
A33	**41.68**	6.22	1.48
A34	**364.46**	**54.43**	12.96
A35	**70.32**	10.50	2.50
A36	13.58	2.03	0.48
A37	6.80	1.02	0.24
A38	6.34	0.95	0.23
A39	5.55	0.83	0.20
A40	8.44	1.26	0.30
A41	7.19	1.07	0.26
A42	6.68	1.00	0.24
A43	3.00	0.45	0.11
A44	6.31	0.94	0.22
A45	**33.78**	5.04	1.20
A46	9.11	1.36	0.32
A47	0.00	0.00	0.00
A48	0.00	0.00	0.00
A49	0.00	0.00	0.00
A50	0.00	0.00	0.00
A51	**60.26**	9.00	2.14
A52	6.61	0.99	0.24
A53	3.80	0.57	0.14
A54	0.00	0.00	0.00
A55	0.00	0.00	0.00
A56	5.74	0.86	0.20
A57	12.45	1.86	0.44
A58	**31.10**	4.64	1.11

Table A.3-2
Baneberry 95% UCL External Dose for Each Exposure Scenario
(Page 3 of 4)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A59	0.00	0.00	0.00
A60	12.04	1.80	0.43
A61	**33.53**	5.01	1.19
A62	14.03	2.09	0.50
A63	0.00	0.00	0.00
A64	9.46	1.41	0.34
A65	20.11	3.00	0.71
A66	**28.20**	4.21	1.00
A67	**35.09**	5.24	1.25
A68	16.77	2.50	0.60
A69	6.16	0.92	0.22
A70	1.58	0.24	0.06
A71	**40.45**	6.04	1.44
A72	**38.90**	5.81	1.38
A73	19.08	2.85	0.68
A74	21.64	3.23	0.77
A75	**35.72**	5.33	1.27
A76	13.66	2.04	0.49
A77	0.00	0.00	0.00
A78	0.00	0.00	0.00
A79	17.08	2.55	0.61
A80	17.74	2.65	0.63
A81	13.72	2.05	0.49
A82	17.29	2.58	0.61
A83	0.00	0.00	0.00
A84	3.12	0.47	0.11
A85	5.39	0.80	0.19
A86	6.13	0.92	0.22
A87	4.55	0.68	0.16

Table A.3-2
Baneberry 95% UCL External Dose for Each Exposure Scenario
(Page 4 of 4)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A88	5.40	0.81	0.19
A89	0.00	0.00	0.00
A90	8.70	1.30	0.31
A91	6.46	0.97	0.23
A92	4.11	0.61	0.15
A93	0.00	0.00	0.00
A94	0.00	0.00	0.00
A95	3.44	0.51	0.12
A96	0.00	0.00	0.00
A98	**1,430.26**	**213.58**	**50.85**
A99	**743.03**	**110.96**	**26.42**
A100	**810.61**	**121.05**	**28.82**
A101	**41.17**	6.15	1.46
A102	**47.78**	7.14	1.70
A103	**51.52**	7.69	1.83
A106	8.10	1.21	0.29
A107	11.24	1.68	0.40
A108	0.00	0.00	0.00
A109	18.02	2.69	0.64
A110	6.54	0.98	0.23

Bold indicates the values exceeding the FAL.

site (Figure A.3-3). The four background TLD measurements (A201 through A204) ranged from 28.5 to 34.6 mrem/IA-yr with an average of 31.66 mrem/IA-yr. The TLD at location A200 was initially labeled as a background TLD, but results were determined not to be representative of background conditions and therefore were not included in determining the average. The TLD at this location is in an area of lower natural background values relative to the Baneberry area. Therefore, this TLD location was excluded from background dose determinations.

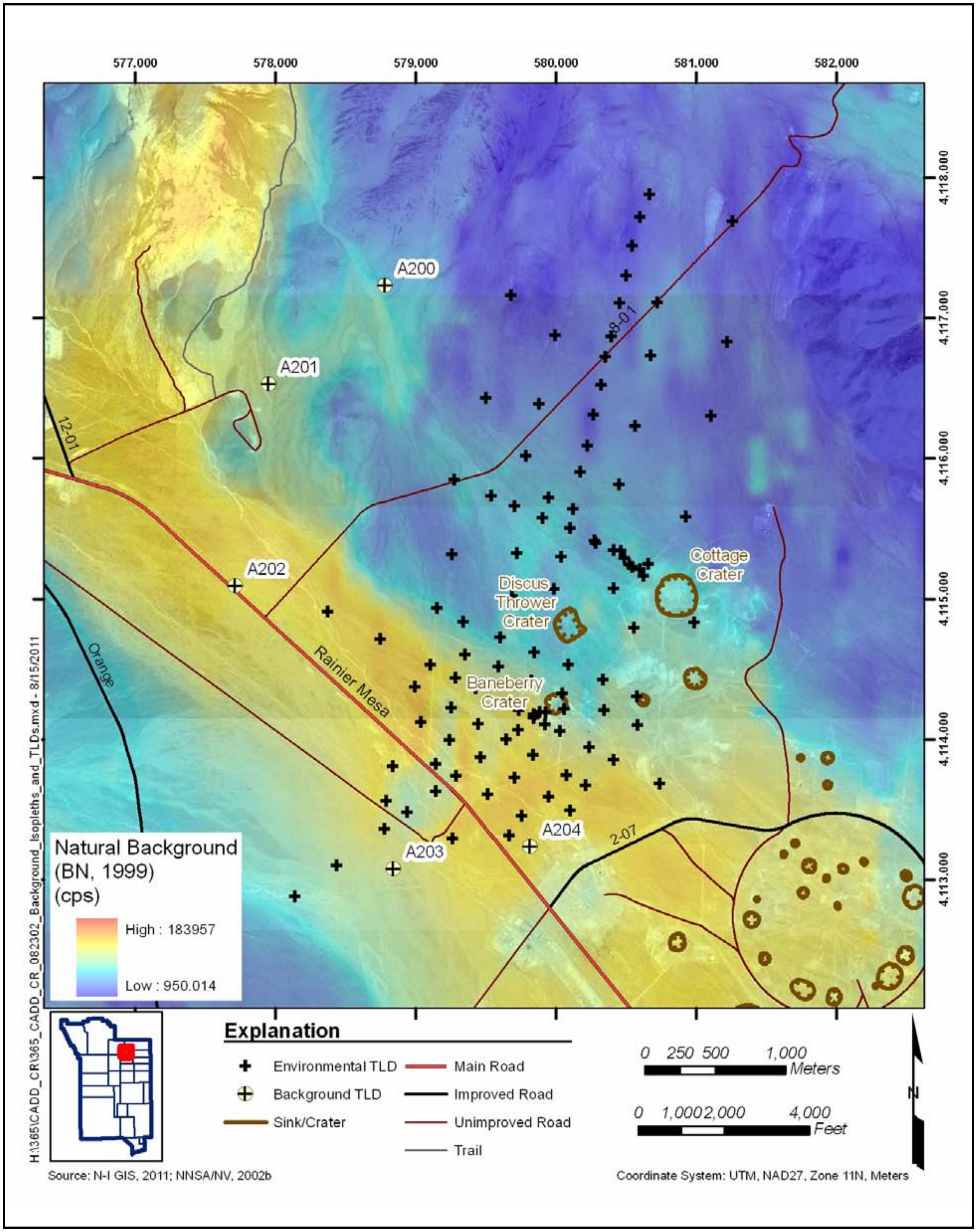

Figure A.3-3
TLD and Field Background TLD Locations and Natural Background Isopleths

A.3.2.2 Internal Dose Estimates

The potential internal dose that a receptor would receive at each TLD and sample location was estimated using the radionuclide analytical results from soil samples and the corresponding RRMGs. Estimates for the internal dose that a receptor would receive at each sample plot at Baneberry were determined as described in Section A.2.2.3. The calculated internal dose at each TLD location is presented in Table A.3-3 and provides evidence that the internal dose comprises a small percentage of the TED. For the Industrial Area scenario, the internal dose ranges from 0.0 to 1.27 mrem/IA-yr with a calculated internal/external dose ratio of 0.09 percent. For the Remote Work Area scenario, the internal dose ranges from 0.0 to 0.14 mrem/RW-yr with an internal/external dose ratio of 0.06 percent. The analytical results for the individual radionuclides in each composite sample are presented in Appendix F.

Table A.3-3
Baneberry 95% UCL Internal Dose for Each Exposure Scenario
(Page 1 of 5)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A01	0.00	0.00	0.00
A02	0.00	0.00	0.00
A03	0.00	0.00	0.00
A04	0.01	0.00	0.00
A05	0.00	0.00	0.00
A06	0.00	0.00	0.00
A07	0.01	0.00	0.00
A08	0.01	0.00	0.00
A09	0.00	0.00	0.00
A10	0.01	0.00	0.00
A11	0.01	0.00	0.00
A12	0.01	0.00	0.00
A13	0.01	0.00	0.00
A14	0.00	0.00	0.00
A15	0.00	0.00	0.00
A16	0.01	0.00	0.00

Table A.3-3
Baneberry 95% UCL Internal Dose for Each Exposure Scenario
(Page 2 of 5)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A17	0.02	0.00	0.00
A18	0.01	0.00	0.00
A19	0.01	0.00	0.00
A20	0.01	0.00	0.00
A21	0.01	0.00	0.00
A22	0.01	0.00	0.00
A23	0.03	0.00	0.00
A24	0.05	0.01	0.00
A25	0.01	0.00	0.00
A26	0.00	0.00	0.00
A27	0.01	0.00	0.00
A28	0.00	0.00	0.00
A29	0.00	0.00	0.00
A30	0.01	0.00	0.00
A31	0.01	0.00	0.00
A32	0.05	0.01	0.00
A33	0.04	0.00	0.00
A34	0.32	0.03	0.01
A35	0.06	0.01	0.00
A36	0.01	0.00	0.00
A37	0.01	0.00	0.00
A38	0.01	0.00	0.00
A39	0.00	0.00	0.00
A40	0.01	0.00	0.00
A41	0.01	0.00	0.00
A42	0.01	0.00	0.00
A43	0.00	0.00	0.00
A44	0.01	0.00	0.00
A45	0.03	0.00	0.00

Table A.3-3
Baneberry 95% UCL Internal Dose for Each Exposure Scenario
(Page 3 of 5)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A46	0.01	0.00	0.00
A47	0.00	0.00	0.00
A48	0.00	0.00	0.00
A49	0.00	0.00	0.00
A50	0.00	0.00	0.00
A51	0.05	0.01	0.00
A52	0.01	0.00	0.00
A53	0.00	0.00	0.00
A54	0.00	0.00	0.00
A55	0.00	0.00	0.00
A56	0.01	0.00	0.00
A57	0.01	0.00	0.00
A58	0.03	0.00	0.00
A59	0.00	0.00	0.00
A60	0.01	0.00	0.00
A61	0.03	0.00	0.00
A62	0.01	0.00	0.00
A63	0.00	0.00	0.00
A64	0.01	0.00	0.00
A65	0.02	0.00	0.00
A66	0.03	0.00	0.00
A67	0.03	0.00	0.00
A68	0.01	0.00	0.00
A69	0.01	0.00	0.00
A70	0.00	0.00	0.00
A71	0.04	0.00	0.00
A72	0.03	0.00	0.00
A73	0.02	0.00	0.00
A74	0.02	0.00	0.00

Table A.3-3
Baneberry 95% UCL Internal Dose for Each Exposure Scenario
(Page 4 of 5)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A75	0.03	0.00	0.00
A76	0.01	0.00	0.00
A77	0.00	0.00	0.00
A78	0.00	0.00	0.00
A79	0.02	0.00	0.00
A80	0.02	0.00	0.00
A81	0.01	0.00	0.00
A82	0.02	0.00	0.00
A83	0.00	0.00	0.00
A84	0.00	0.00	0.00
A85	0.00	0.00	0.00
A86	0.01	0.00	0.00
A87	0.00	0.00	0.00
A88	0.00	0.00	0.00
A89	0.00	0.00	0.00
A90	0.01	0.00	0.00
A91	0.01	0.00	0.00
A92	0.00	0.00	0.00
A93	0.00	0.00	0.00
A94	0.00	0.00	0.00
A95	0.00	0.00	0.00
A96	0.00	0.00	0.00
A98	1.27	0.14	0.03
A99	0.67	0.07	0.01
A100	0.86	0.09	0.02
A101	0.04	0.00	0.00
A102	0.04	0.00	0.00
A103	0.05	0.00	0.00
A106	0.01	0.00	0.00

Table A.3-3
Baneberry 95% UCL Internal Dose for Each Exposure Scenario
(Page 5 of 5)

Location	Industrial Area (mrem/IA-yr)	Remote Work Area (mrem/RW-yr)	Occasional Use Area (mrem/OU-yr)
A107	0.01	0.00	0.00
A108	0.00	0.00	0.00
A109	0.02	0.00	0.00
A110	0.01	0.00	0.00

A.3.2.3 Total Effective Dose

The TED for each sample plot or TLD location was calculated by adding the measured external dose values and the calculated internal dose values. Values for both the average TED and the 95 percent UCL of the TED for the Industrial Area, Remote Work Area, and Occasional Use Area exposure scenarios are presented in Table A.3-4.

Table A.3-4
Baneberry TEDs at Sample Locations
(Page 1 of 5)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A01	0.00	0.00	0.00	0.00	0.00	0.00
A02	0.00	0.00	0.00	0.00	0.00	0.00
A03	3.57	5.29	0.53	0.79	0.13	0.19
A04	4.37	7.70	0.65	1.15	0.16	0.27
A05	4.28	4.59	0.64	0.68	0.15	0.16
A06	2.93	4.54	0.44	0.68	0.10	0.16
A07	5.69	6.84	0.85	1.02	0.20	0.24
A08	9.18	12.29	1.37	1.83	0.33	0.44
A09	1.88	3.74	0.28	0.56	0.07	0.13
A10	6.02	7.44	0.90	1.11	0.21	0.26
A11	10.78	12.93	1.61	1.93	0.38	0.46

Table A.3-4
Baneberry TEDs at Sample Locations
(Page 2 of 5)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A12	4.63	8.50	0.69	1.27	0.16	0.30
A13	2.79	6.64	0.42	0.99	0.10	0.24
A14	2.40	4.56	0.36	0.68	0.09	0.16
A15	3.97	5.36	0.59	0.80	0.14	0.19
A16	3.69	6.09	0.55	0.91	0.13	0.22
A17	16.44	17.50	2.46	2.61	0.58	0.62
A18	7.62	10.37	1.14	1.55	0.27	0.37
A19	4.42	8.74	0.66	1.30	0.16	0.31
A20	3.36	6.42	0.50	0.96	0.12	0.23
A21	3.89	6.52	0.58	0.97	0.14	0.23
A22	4.99	5.77	0.74	0.86	0.18	0.21
A23	**36.11**	**38.36**	5.39	5.73	1.28	1.36
A24	**57.84**	**60.00**	8.64	8.96	2.06	2.13
A25	8.71	10.40	1.30	1.55	0.31	0.37
A26	3.32	5.42	0.50	0.81	0.12	0.19
A27	3.64	5.72	0.54	0.85	0.13	0.20
A28	3.43	5.45	0.51	0.81	0.12	0.19
A29	0.44	2.60	0.07	0.39	0.02	0.09
A30	1.97	6.90	0.29	1.03	0.07	0.25
A31	11.60	13.12	1.73	1.96	0.41	0.47
A32	**52.16**	**57.39**	7.79	8.57	1.85	2.04
A33	**39.41**	**41.71**	5.88	6.23	1.40	1.48
A34	**351.69**	**364.79**	**52.50**	**54.46**	12.50	12.97
A35	**66.76**	**70.38**	9.97	10.51	2.37	2.50
A36	10.80	13.59	1.61	2.03	0.38	0.48
A37	4.58	6.81	0.68	1.02	0.16	0.24
A38	5.26	6.35	0.79	0.95	0.19	0.23

Table A.3-4
Baneberry TEDs at Sample Locations
(Page 3 of 5)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A39	3.00	5.56	0.45	0.83	0.11	0.20
A40	3.21	8.44	0.48	1.26	0.11	0.30
A41	3.05	7.19	0.46	1.07	0.11	0.26
A42	3.35	6.68	0.50	1.00	0.12	0.24
A43	1.19	3.01	0.18	0.45	0.04	0.11
A44	3.80	6.32	0.57	0.94	0.14	0.22
A45	**32.27**	**33.81**	4.82	5.05	1.15	1.20
A46	8.03	9.12	1.20	1.36	0.29	0.32
A47	0.00	0.00	0.00	0.00	0.00	0.00
A48	0.00	0.00	0.00	0.00	0.00	0.00
A49	0.00	0.00	0.00	0.00	0.00	0.00
A50	0.00	0.00	0.00	0.00	0.00	0.00
A51	**51.78**	**60.32**	7.73	9.00	1.84	2.14
A52	2.84	6.62	0.42	0.99	0.10	0.24
A53	0.85	3.80	0.13	0.57	0.03	0.14
A54	0.00	0.00	0.00	0.00	0.00	0.00
A55	0.00	0.00	0.00	0.00	0.00	0.00
A56	0.99	5.75	0.15	0.86	0.04	0.20
A57	8.40	12.46	1.25	1.86	0.30	0.44
A58	**24.91**	**31.13**	3.72	4.65	0.89	1.11
A59	0.00	0.00	0.00	0.00	0.00	0.00
A60	8.63	12.05	1.29	1.80	0.31	0.43
A61	**29.87**	**33.56**	4.46	5.01	1.06	1.19
A62	11.55	14.04	1.72	2.10	0.41	0.50
A63	0.00	0.00	0.00	0.00	0.00	0.00
A64	6.34	9.47	0.95	1.41	0.23	0.34
A65	17.61	20.13	2.63	3.00	0.63	0.72

Table A.3-4
Baneberry TEDs at Sample Locations
(Page 4 of 5)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A66	**25.89**	**28.22**	3.87	4.21	0.92	1.00
A67	**33.01**	**35.12**	4.93	5.24	1.17	1.25
A68	13.22	16.79	1.97	2.51	0.47	0.60
A69	3.98	6.16	0.59	0.92	0.14	0.22
A70	0.23	1.58	0.03	0.24	0.01	0.06
A71	**38.31**	**40.48**	5.72	6.04	1.36	1.44
A72	**36.64**	**38.93**	5.47	5.81	1.30	1.38
A73	16.14	19.10	2.41	2.85	0.57	0.68
A74	19.05	21.66	2.84	3.23	0.68	0.77
A75	**31.82**	**35.75**	4.75	5.34	1.13	1.27
A76	11.58	13.68	1.73	2.04	0.41	0.49
A77	0.00	0.00	0.00	0.00	0.00	0.00
A78	0.00	0.00	0.00	0.00	0.00	0.00
A79	13.53	17.09	2.02	2.55	0.48	0.61
A80	15.43	17.75	2.30	2.65	0.55	0.63
A81	10.82	13.73	1.62	2.05	0.38	0.49
A82	12.37	17.31	1.85	2.58	0.44	0.62
A83	0.00	0.00	0.00	0.00	0.00	0.00
A84	0.67	3.12	0.10	0.47	0.02	0.11
A85	3.37	5.39	0.50	0.81	0.12	0.19
A86	4.17	6.13	0.62	0.92	0.15	0.22
A87	2.58	4.55	0.39	0.68	0.09	0.16
A88	2.35	5.41	0.35	0.81	0.08	0.19
A89	0.00	0.00	0.00	0.00	0.00	0.00
A90	4.71	8.71	0.70	1.30	0.17	0.31
A91	2.10	6.47	0.31	0.97	0.07	0.23
A92	1.96	4.11	0.29	0.61	0.07	0.15

Table A.3-4
Baneberry TEDs at Sample Locations
(Page 5 of 5)

Location	Industrial Area (mrem/IA-yr)		Remote Work Area (mrem/RW-yr)		Occasional Use Area (mrem/OU-yr)	
	Average TED	95% UCL of TED	Average TED	95% UCL of TED	Average TED	95% UCL of TED
A93	0.00	0.00	0.00	0.00	0.00	0.00
A94	0.00	0.00	0.00	0.00	0.00	0.00
A95	0.15	3.45	0.02	0.51	0.01	0.12
A96	0.00	0.00	0.00	0.00	0.00	0.00
A98	**1,319.72**	**1,431.53**	**197.03**	**213.72**	**46.91**	**50.88**
A99	**715.79**	**743.71**	**106.86**	**111.03**	**25.44**	**26.43**
A100	**776.83**	**811.47**	**115.98**	**121.14**	**27.61**	**28.84**
A101	**34.14**	**41.20**	5.10	6.15	1.21	1.46
A102	**43.00**	**47.83**	6.42	7.14	1.53	1.70
A103	**45.58**	**51.57**	6.80	7.70	1.62	1.83
A106	7.80	8.10	1.17	1.21	0.28	0.29
A107	10.47	11.25	1.56	1.68	0.37	0.40
A108	0.00	0.00	0.00	0.00	0.00	0.00
A109	16.17	18.04	2.41	2.69	0.57	0.64
A110	4.22	6.54	0.63	0.98	0.15	0.23

Bold indicates the values exceeding the FAL.

The 95 percent UCL values are also provided in Figure A.3-4, which provides an overview of the Baneberry area, and Figure A.3-5, which provides a closer look at the area adjacent to the crater and fissure. The 95 percent UCL of the average TED exceeds the 25-mrem/RW-yr FAL at locations A34, A98, A99, and A100, which are located outside the default contamination boundary. Sample location A98 was located in an area of anomalous readings identified during the GWSs as discussed in Section A.3.1.4.

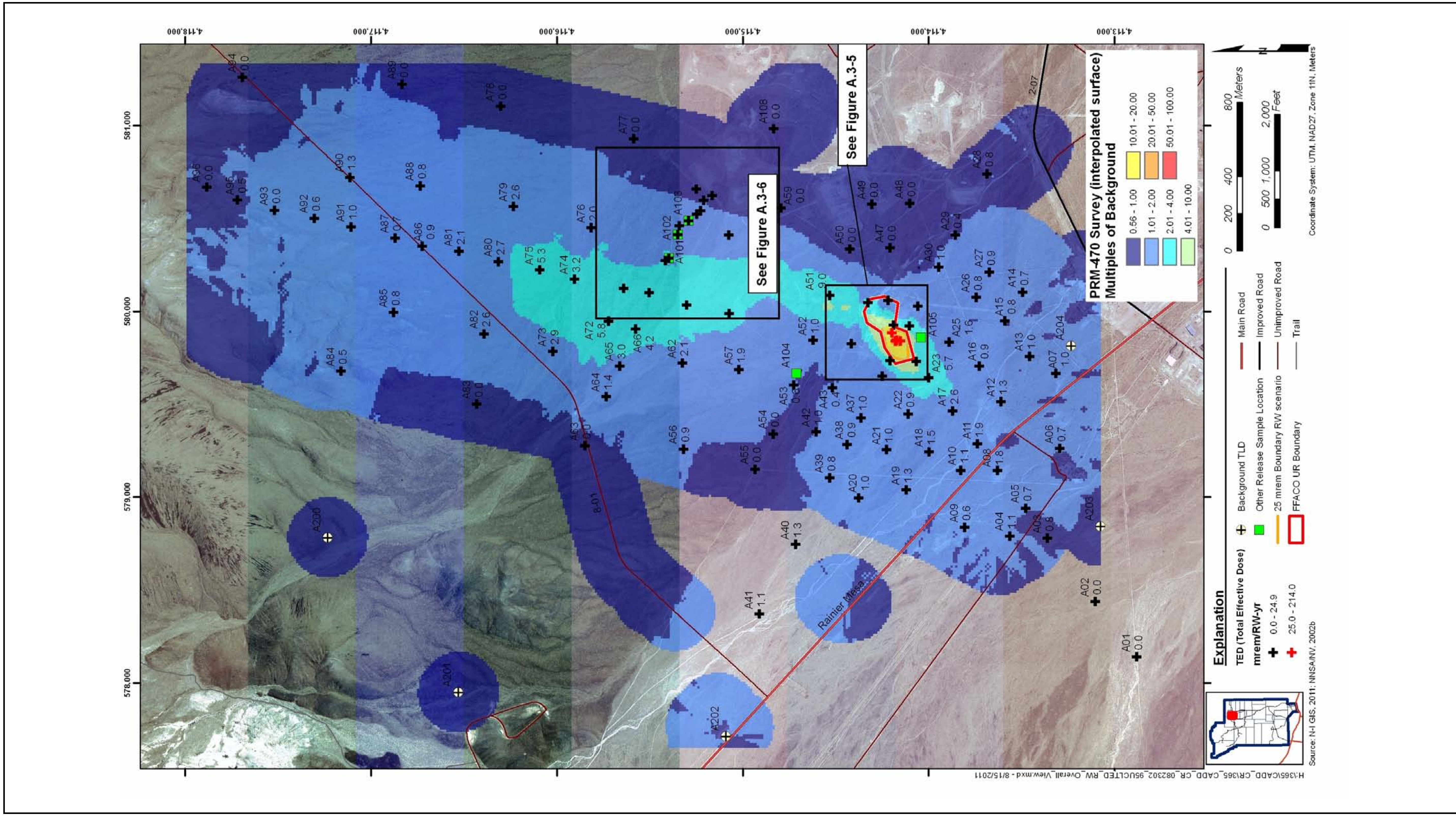

Figure A.3-4
95% UCL of the TED for the Remote Work Area Scenario—Overview

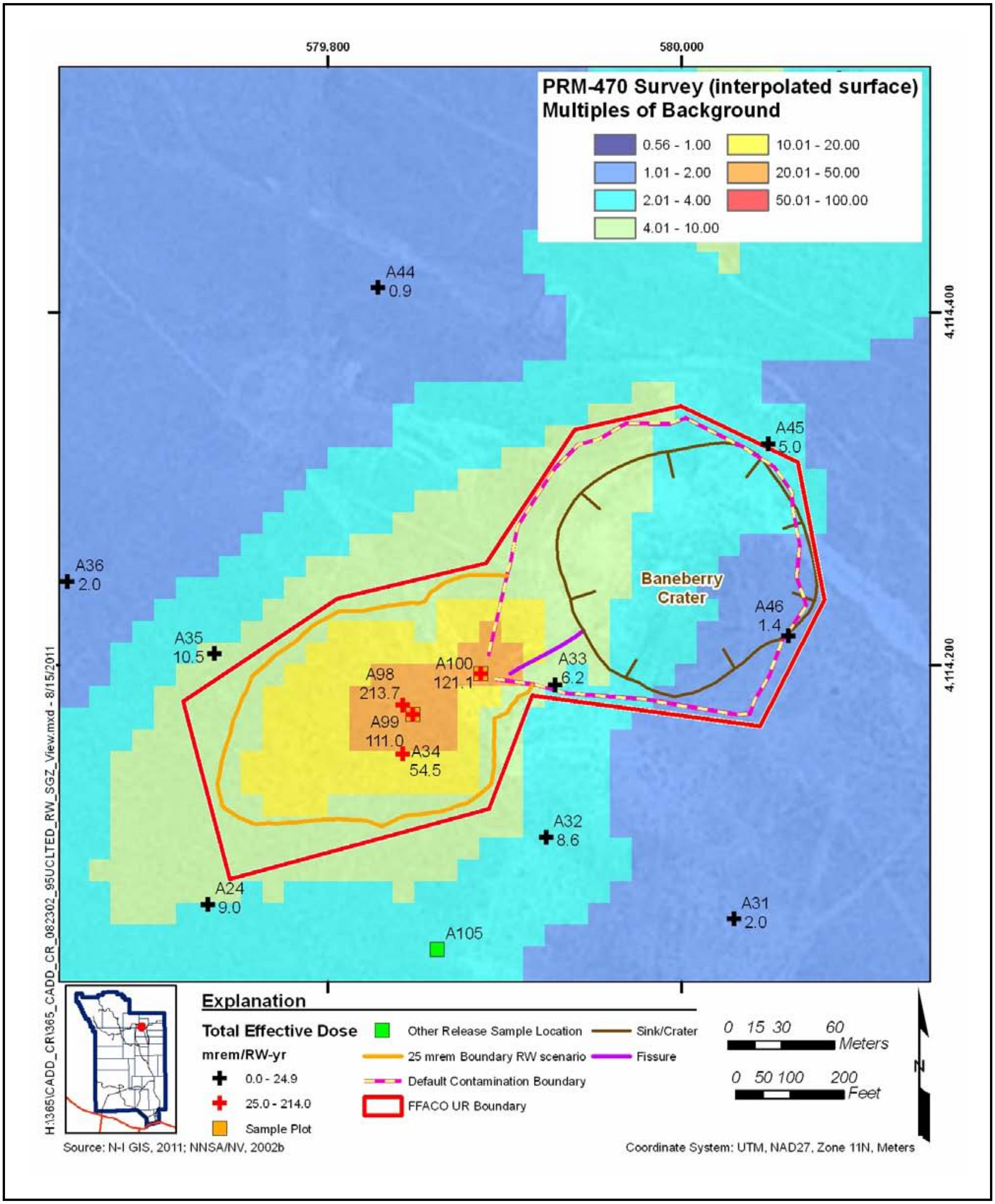

Figure A.3-5
95% UCL of the TED for the Remote Work Area Scenario—Default Contamination Boundary

Considering only radioactive decay mechanisms (ignoring contamination erosion and transport mechanisms), TED at the sample location with the maximum TED (A98) will take approximately 200 years to decay from current dose levels to 25 mrem/IA-yr. The effective half-life is about 28.1 years and is being driven by cesium (Cs)-137, which contributes about 95 percent of the TED at the site.

A.3.2.4 Results for Other Releases at Baneberry

The northernmost drainage at the Baneberry site was identified for further study based upon radiological surveys. Soil samples were collected at three sedimentation areas (A101, A102, and A103) within this drainage (Figure 2-1). The TED was determined based upon the external dose from the TLDs and the internal dose from analytical results from soil samples collected. Field screening was performed at 5-cm increments to a depth of 30 cm. At two locations (A101 and A102), samples at depth were determined to exceed the FSL and were submitted to an offsite analytical laboratory for analysis along with the surface samples. For these three locations, the 95 percent UCL of the TED was calculated at 6.2 mrem/RW-yr (A101), 7.1 mrem/RW-yr (A102), and 7.7 mrem/RW-yr (A103) (Figure A.3-6). Because these TED values are less than the FAL, a corrective action is not required for this drainage. For the Industrial Area use scenario, however, it was observed that the three drainage locations exhibited TED values of 41.2 mrem/IA-yr (A101), 47.8 mrem/IA-yr (A102), and 51.6 mrem/IA-yr (A103) (see Figure A.3-10). These three areas were included within the administrative UR as a BMP. The subsequent two downstream sediment locations (A106 and A107) exhibited TED values of 8.1 and 11.3 mrem/IA-yr, respectively; both were below the FAL of 25 mrem/IA-yr.

Soil beneath the empty drum within the cellar located to the northwest of the Baneberry crater was sampled. This location (A104) is identified in Figure A.3-1. Analytical results (Tables A.3-5 through A.3-7) revealed that results were below the FALs for all contaminants of potential concern (COPCs). The drum was removed for disposal at the Area 9, U10c Industrial Landfill, as a BMP.

Three deteriorated dry-cell batteries were identified in an area south-southwest of the Baneberry crater. This location (A105) is depicted in Figure A.3-1. The analytical results (Tables A.3-5 through A.3-7) for the sample of the potentially impacted soil are below the PALs for all COPCs. The battery

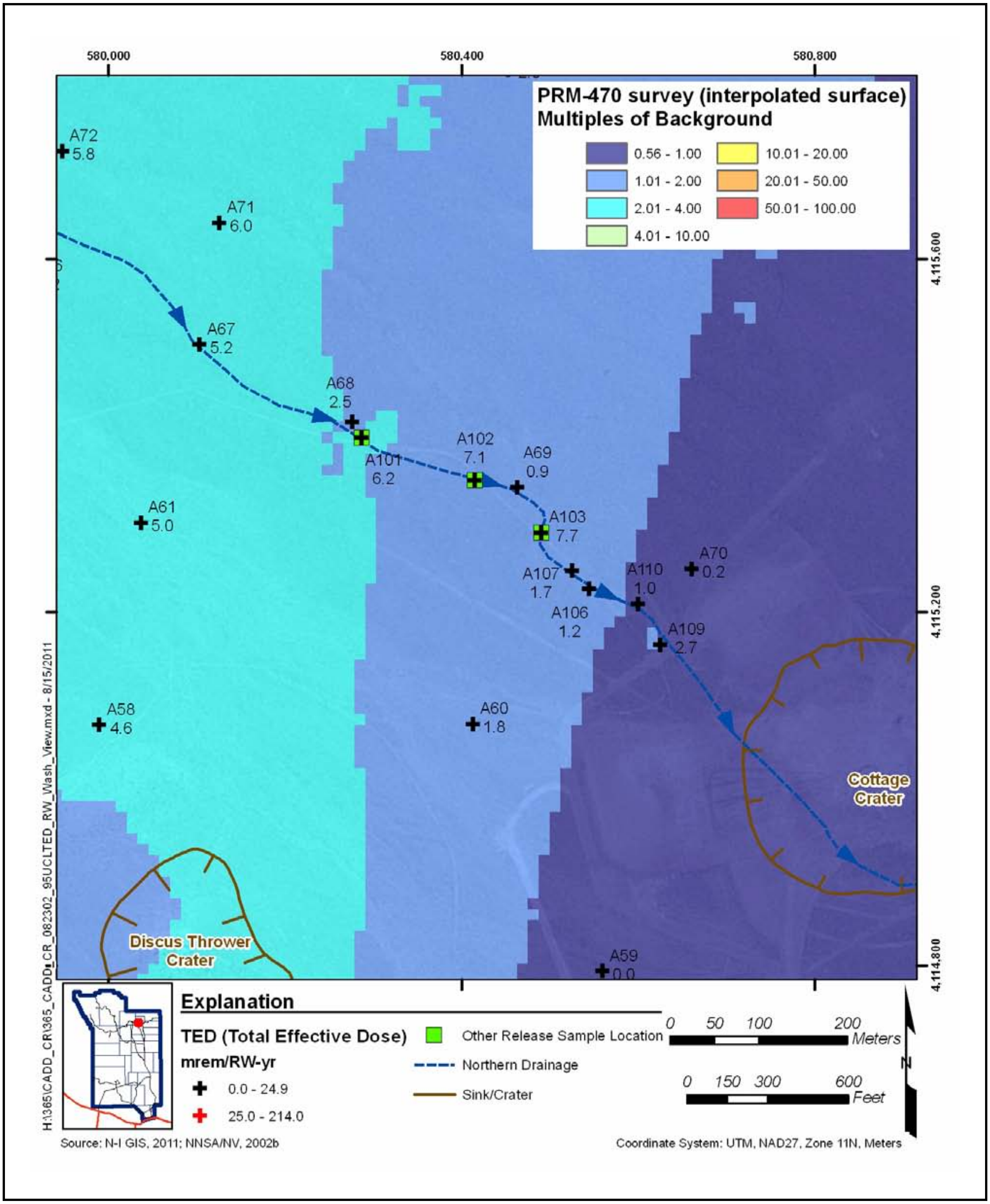

Figure A.3-6
95% UCL of the TED for the Remote Work Area Scenario—Northern Drainage

Table A.3-5
Sample Results Detected above MDCs at Baneberry—VOCs

Sample Location	Sample Number	Depth (cm bgs)	COPC (mg/kg)	
			Toluene	Trichloroethene
FALs			45,000	14
A104	365A004	0–5	--	0.00225
	365A005	0–5	0.000332 (J)	0.00347

mg/kg = Milligrams per kilogram

J = Estimated value
-- = Not detected above MDCs

Table A.3-6
Sample Results Detected above MDCs at Baneberry—SVOCs

Sample Location	Sample Number	Depth (cm bgs)	COPC (mg/kg)	
			Bis(2-ethylhexyl)phthalate	Di-n-butyl phthalate
FALs			120	62,000
A104	365A004	0–5	--	0.537
	365A005	0–5	0.107 (J)	0.165 (J)

J = Estimated value
-- = Not detected above MDCs

Table A.3-7
Sample Results Detected above MDCs at Baneberry—Metals

Sample Location	Sample Number	Depth (cm bgs)	COPC (mg/kg)							
			Arsenic	Barium	Cadmium	Chromium	Lead	Mercury	Selenium	Silver
FALs			23	190,000	800	39.2[a]	800	34	5,100	5,100
A104	365A004	0–5	3.58	149 (J)	0.686	18.8	22.3 (J)	0.0827	--	2.61 (J)
	365A005	0–5	7.53	124 (J)	0.671	17.5	27.1 (J)	0.0834	--	1.77 (J)
A105	365A010	0–6 (in.)	3.77	267	5.5 (J)	31.8	202 (J)	1.48	0.469 (J)	39.8
	365A011	0–6 (in.)	2.29	177	0.691 (J)	8.34	12.7 (J)	0.121	--	44.1

[a] Based on a 6:1 ratio of trivalent chromium to hexavalent chromium

J = Estimated value
-- = Not detected above MDCs

parts and associated soil were collected, placed within a drum, and disposed of as a BMP. No additional other releases were identified at Baneberry.

A.3.3 Nature and Extent of Contamination

An evaluation of dose using the Remote Work Area exposure scenario was performed by comparing the calculated TED values to the FAL of 25 mrem/RW-yr. Based upon the evaluation of the sampling results, four locations outside the default contamination boundary contained radionuclides that have a TED exceeding the FAL. As a result, these locations are considered to contain COCs and require a corrective action.

The FFACO UR was established to encompass the area exceeding the FAL to include the default contamination boundary and is represented by the red line on Figures A.3-4 and A.3-5. Due to the prompt injection of radionuclides into the subsurface soil from the Baneberry test, it was assumed that subsurface contamination exceeding the FAL is present within the crater and associated fissure area. The FFACO UR was established to include any area where a worker could receive a net effective dose exceeding 25 mrem/RW-yr above naturally occurring background levels.

To determine the extent of the area where the Remote Work Area scenario TED exceeds the FAL, a correlation of the 95 percent UCL of the Remote Work Area scenario TED was plotted against each of the following datasets:

- Ground-based radiological survey (GWS) obtained in 2011
- Aerial radiological surveys (gross count) obtained in 1994
- Aerial radiological surveys (man-made) obtained in 1994

Each of the datasets was converted from point data into a continuous dataset (surface) by using an inverse distance weighted interpolation method. The continuous dataset was then used to determine values at each TLD location. The relationship between the surface value and the 95 percent UCL of the TED for the Remote Work Area exposure scenario was determined by statistical correlation. The correlation coefficient (R^2 value) indicates the strength of the correlation. The R^2 values for the correlations were 0.84, 0.42, and 0.52, respectively. A graphical representation for each of these correlations is provided in Figure A.3-7. Generally, the closer the correlation coefficient is to 1.0, the stronger the correlation is between the datasets. The dataset with the best correlation was the GWS (Section 3.0).

Based on this correlation, the GWS value that corresponds to 25 mrem/RW-yr is 8.06 multiples of background. An isopleth that represents this value was generated using the continuous surface created from the GWS. This isopleth is represented by the solid orange line on Figure A.3-4 and A.3-5, and represents the estimated 25-mrem/RW-yr boundary within which a receptor can expect to receive a net effective dose increase of 25 mrem/yr above naturally occurring background levels. The FFACO UR boundary was established based upon this correlation to encompass all areas where the TED exceeds the 25-mrem/RW-yr FAL. This boundary is represented by the solid red line in Figures A.3-4 and A.3-5, and in Attachment D-1.

The calculated net TED values for the Baneberry site were also compared to the PAL of 25 mrem/IA-yr established in the CAU 365, Baneberry Contamination Area, CAIP as indicated in Figures A.3-8, A.3-9, and A.3-10. As a BMP, an administrative UR was established to include any areas where an industrial land use of the area (2,250 hours of exposure per year) could cause a future site worker to receive a net effective dose increase of 25 mrem/yr above naturally occurring background levels. To determine the extent of the area where the Industrial Area scenario TED exceeds the FAL, a correlation of the 95 percent UCL of the Industrial Area scenario TED was performed for the same three datasets and in the same manner as described for the Remote Work Area scenario. The R^2 values for the administrative UR correlations were 0.84, 0.42, and 0.52 for the respective datasets presented above. The dataset with the best correlation was the GWS (Section 3.0). Based on this correlation, the GWS value that corresponds to 25 mrem/IA-yr is 1.96 multiples of background. The isopleth that represents this value was generated using the continuous surface created from the GWS. This isopleth is represented by the solid blue line on Figure A.3-8. The administrative UR boundary was established to include all areas with a TED greater than 25 mrem/IA-yr above naturally occurring background levels and is presented in Figure A.3-8 and Attachment D-1 as the solid purple line.

The high values within the GWS dataset used for correlations were removed due to the effect on the linear solution of the action level. Locations A34, A98, A99, and A100 were eliminated because they were at the high response end and did not represent the distribution near the decision value.

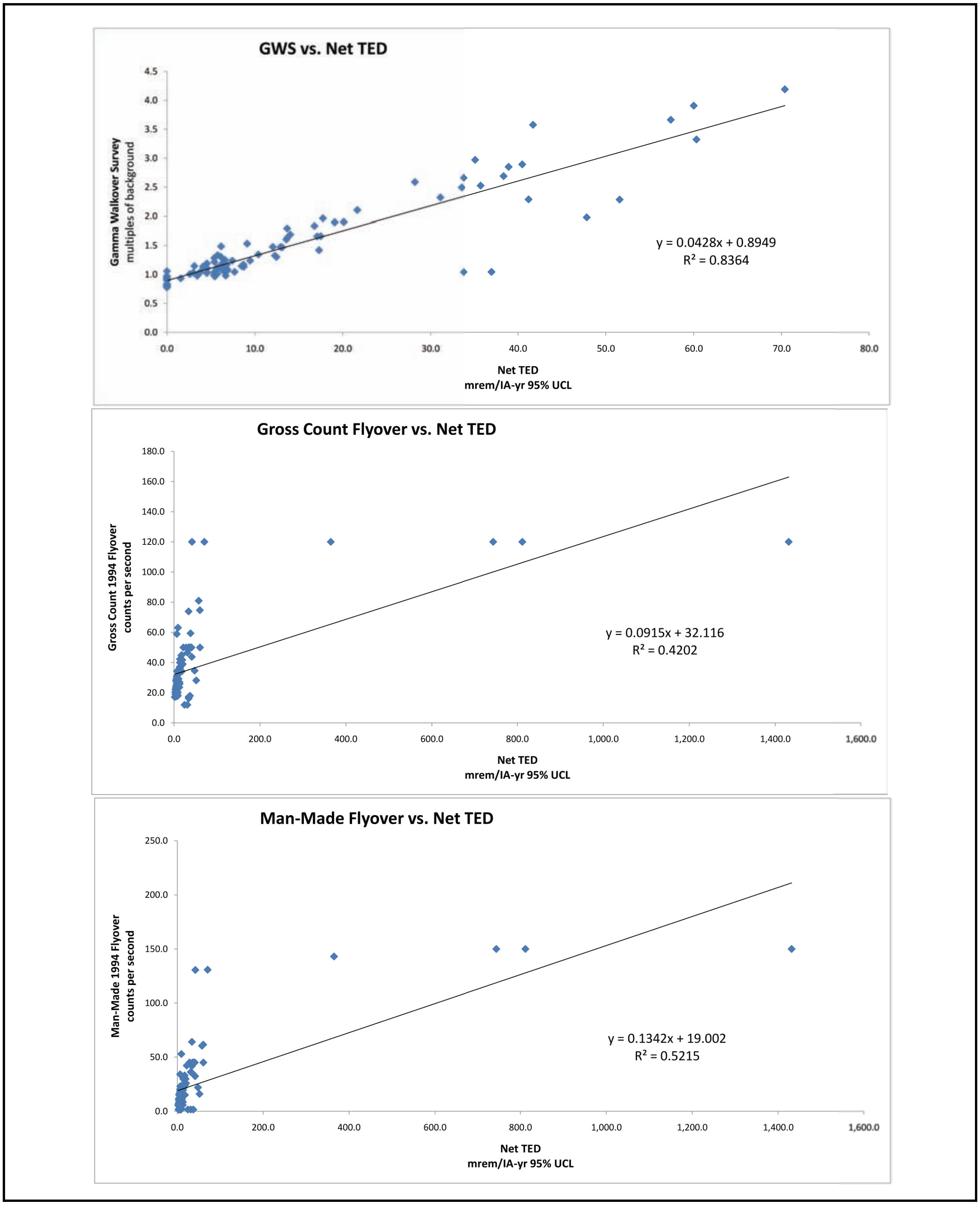

Figure A.3-7
Radiological Survey Correlations

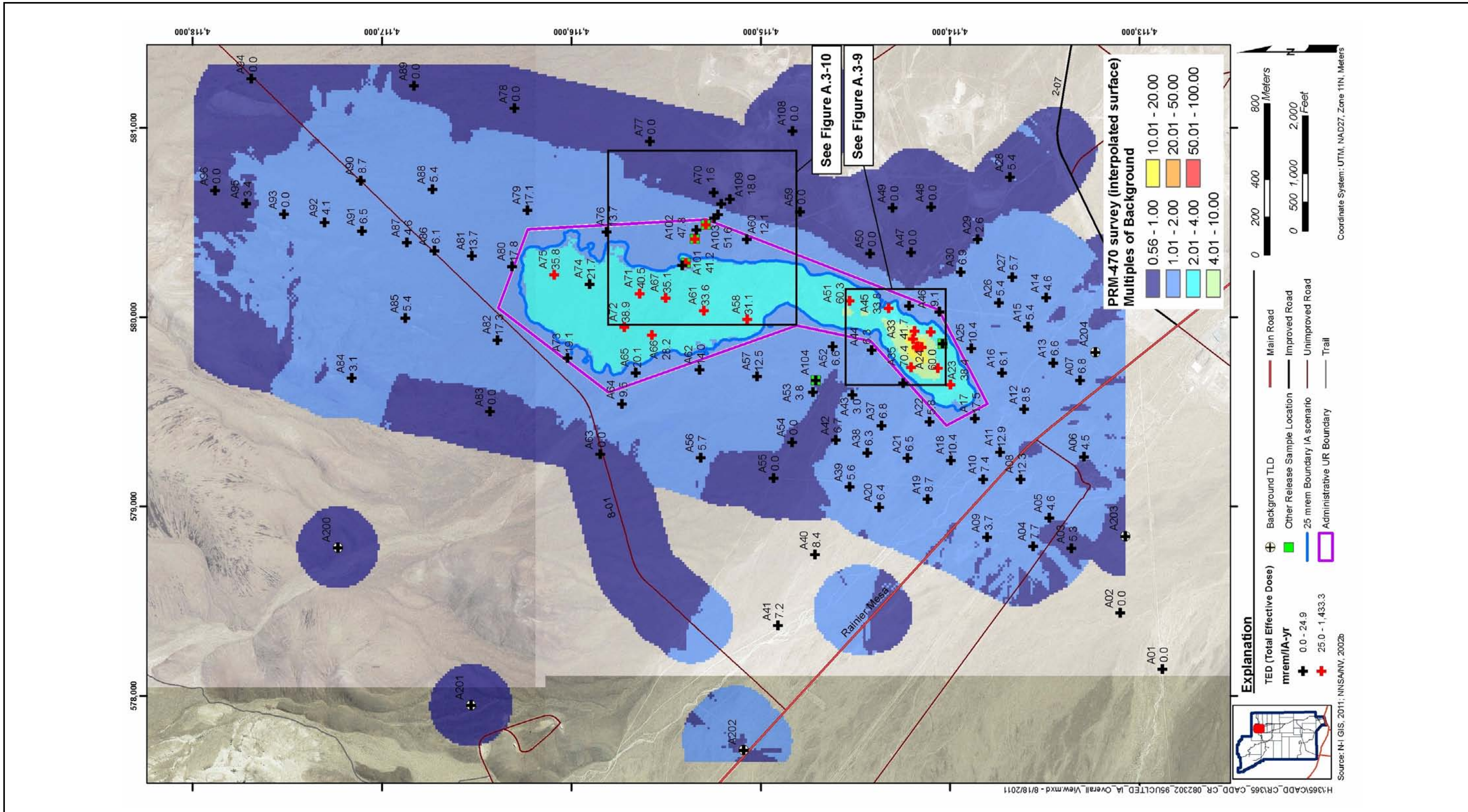

Figure A.3-8
95% UCL of the TED for the Industrial Area Scenario—Overview

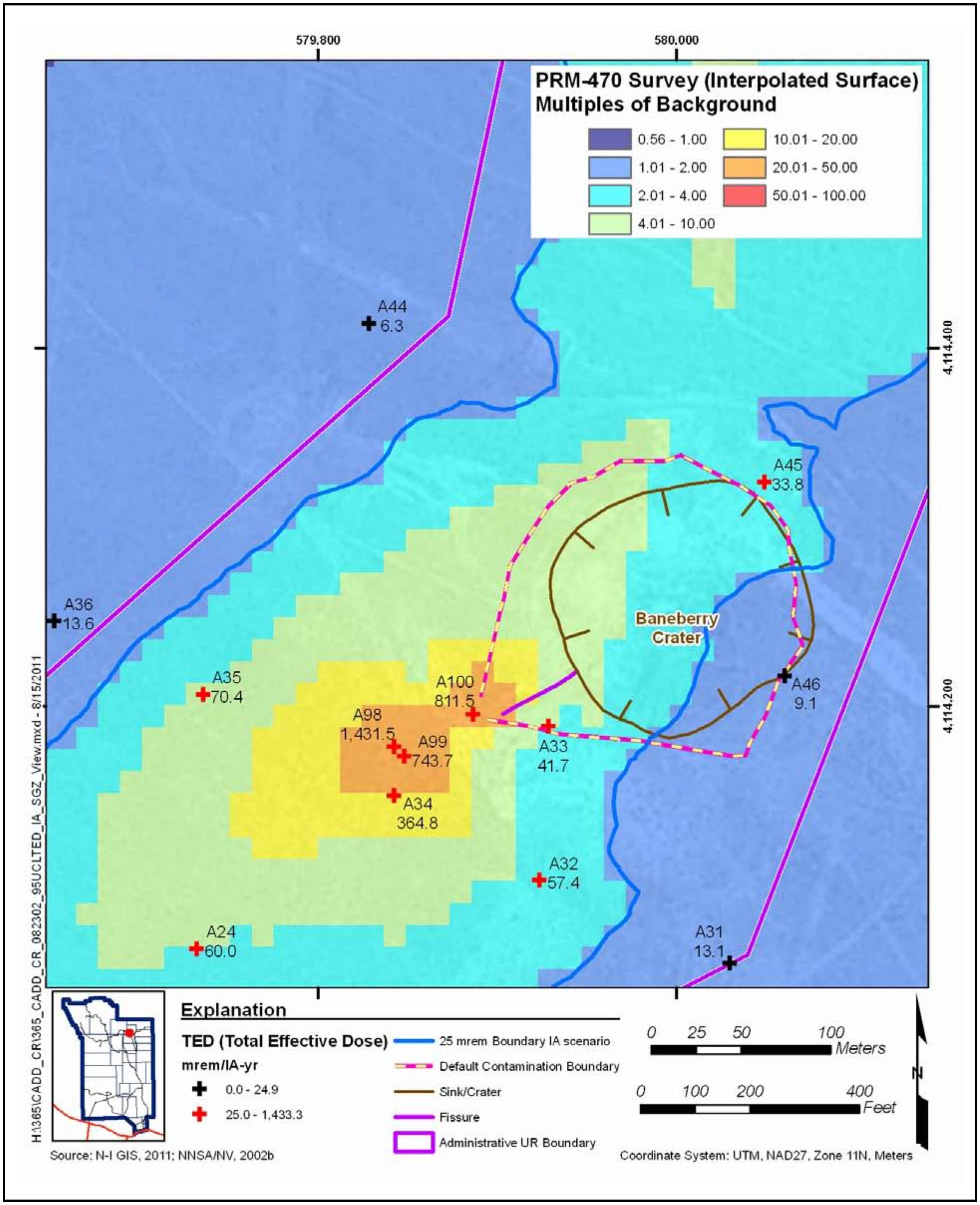

Figure A.3-9
95% UCL of the TED for the Industrial Area Scenario—Default Contamination Area

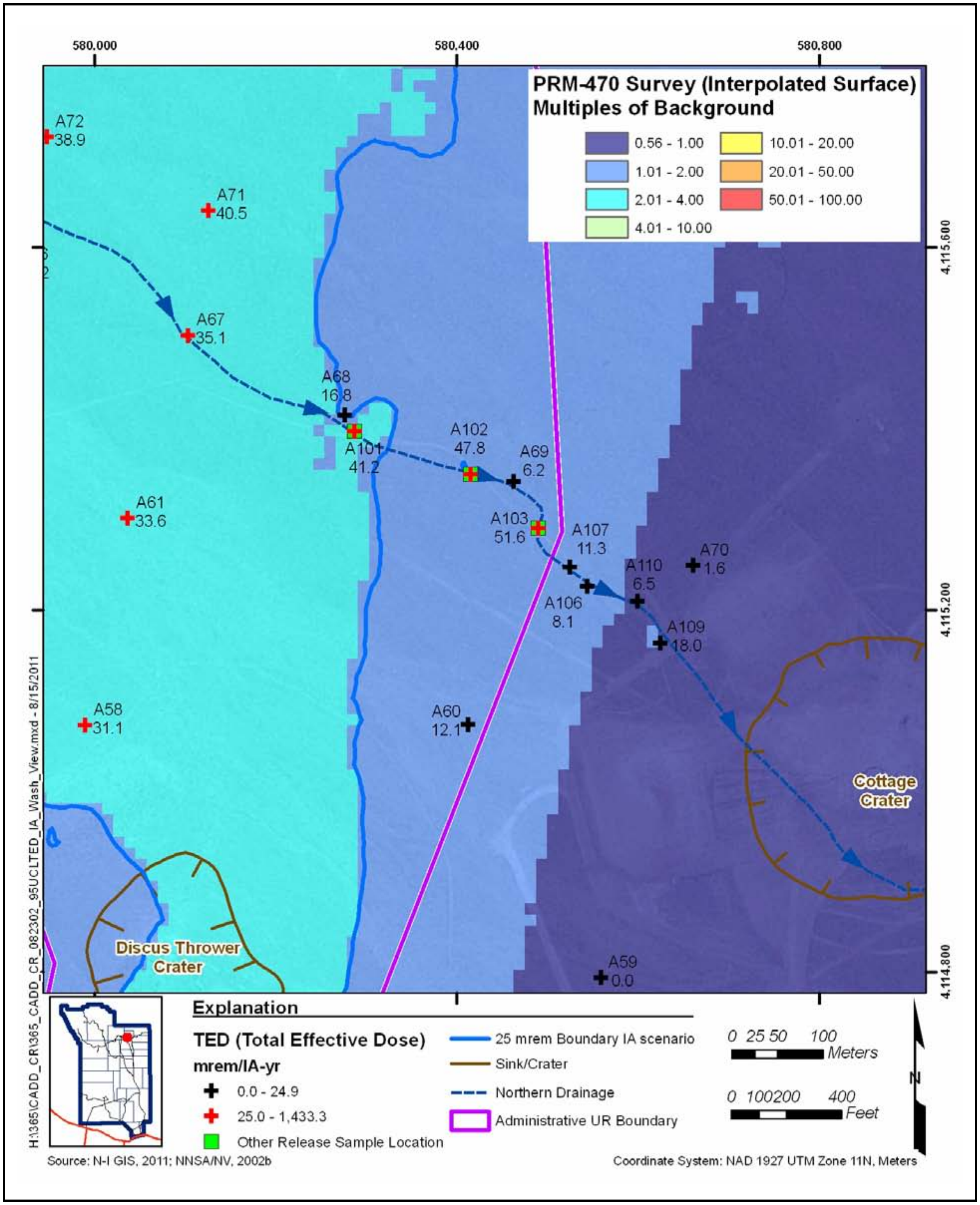

Figure A.3-10
95% UCL of the TED for the Industrial Area Scenario—Northern Drainage

Locations A01, A02, A03, A40, A41, A200, A201, and A203 (Figure A.3-8) were eliminated from the GWS correlation due to either lack of or sparsity of data in the vicinity of these data points.

Based on the data evaluated for the other release locations, no PSM was identified at the Baneberry site. Therefore, corrective actions for PSM were not required.

A.3.4 Revised Conceptual Site Model

The CAIP requirements (NNSA/NSO, 2010a) were met at Baneberry. The information gathered during the CAI supports the CSM as presented in the CAIP. Therefore, no revisions were necessary to the CSM.

A.4.0 Waste Management

Waste management activities were implemented and completed during the CAI and closure activities at Baneberry and the final disposition of the waste. All waste was managed in accordance with federal and state regulations, permit limitations, and disposal facility acceptance criteria. Waste management activities were conducted as specified in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010a). A summary of the waste streams generated, the waste type (i.e., characterization), and final waste disposition is provided in Table A.4-1.

A.4.1 Investigation-Derived Waste

The following waste streams were generated during the Baneberry field investigation:

- Disposable personal protective equipment (PPE) and sampling equipment
- Surface debris (deteriorated batteries and an empty metal drum)

All waste streams were field screened as generated to comply with the radiological release limits of Table 4-2 of the *Nevada Test Site Radiological Control Manual* (NNSA/NSO, 2010b).

A.4.2 Waste Characterization

The results of soil and potential PSM samples collected for waste characterization purposes and detected above MDCs are reported in Table A.4-2. The analytical suite was tailored to characterize the waste for disposal and to support recommended closure actions. Results were reviewed against federal regulations, state regulations, and DOE directives/policies/guidance, as well as waste disposal criteria for NNSS disposal facilities.

A.4.2.1 Industrial Waste

Industrial wastes were characterized based upon radiological surveys, analytical data, and process knowledge. Industrial solid waste generated at Baneberry consisted of disposable sampling equipment and PPE, an empty metal drum, and deteriorated dry-cell batteries.

Table A.4-1
Waste Summary

Waste Characterization						Waste Disposition			
Container ID	**Waste Item**	**Hazardous**	**Radioactive**	**Hydrocarbon**	**PCBs**	**Disposal Facility**	**Waste Volume**	**Disposal Date**	**Disposal Document**
365A01	Debris: batteries and soil	No	No	No	No	Area 9, U10c	0.2 yd^3	09/22/2011	LVF
N/A	Debris: empty metal drum	No	No	No	No	Area 9, U10c	0.3 yd^3	05/31/2011	LVF

LVF = Load Verification Form
N/A = Not applicable
PCB = Polychlorinated biphenyl
yd^3 = Cubic yard

Table A.4-2
Waste Characterization Sample Results

Sample Location	Sample Number	Depth (in. bgs)	Matrix	Parameter	Result	Criteria[a]	Units
A105	365A010	0–6	Soil	Barium	0.505 (J-)	100	mg/L
				Cadmium	0.0521	1	
				Chromium	0.0138 (J)	5	
				Lead	0.0754 (J)	5	
				Mercury	0.00124 (J)	0.2	
				Silver	0.0102 (J)	5	
				Am-241	0.52 (J)	10[b]	pCi/g
				Co-60	0.381	100[b]	
				Cs-137	29.4	100[b]	
				Pu-238	0.0596	10[b]	
				Pu-239/240	0.337	10[b]	
				Sr-90	0.473	100[b]	
	365A501	0–6	Solid	Barium	2.94 (J-)	100	mg/L
				Cadmium	0.0599	1	
				Lead	0.0688 (J)	5	
				Mercury	0.0129 (J)	0.2	
				Cs-137	6.3	100[b]	pCi/g
	365A502	0–6	Solid	Mercury	0.0015(J-)	0.2	mg/L

[a] TCLP limit unless otherwise noted.
[b] Radionuclide limits in NNSS U10c landfill permit.

Am = Americium
Co = Cobalt
mg/L = Milligrams per liter
Pu = Plutonium

J = Estimated value.
J- = Result is an estimated quantity, but may be biased low.

The disposable sampling equipment and PPE were collected daily and bagged, labeled, and placed in the roll-off container at Building 23-153 for ultimate disposal at Area 9 U10c Landfill. The metal drum was inspected and determined to meet the criteria of empty; and is not subject to RCRA regulation. The empty drum was placed in the roll-off container at Building 23-153 for disposal at the Area 9, U10c Landfill. The disposal document for this waste is presented in Attachment A-1.

One 55-gallon (gal) drum (container 365A01) containing approximately 40 gal of deteriorated battery parts and soil was generated during the investigation. A small area of discolored soil underlying and adjacent to the battery debris was identified during visual inspection of the area and therefore removed and packaged into the 55-gal drum. Samples 365A501 and 365A502 are direct samples of the battery debris, and Sample 365A010 is a direct sample of the underlying soil. Based on the analytical results (Table A.4-2), the material was characterized as non-hazardous, non-radioactive, non-hydrocarbon, non-PCB-contaminated debris that meets the chemical and radiological waste acceptance criteria of the Area 9, U10c Industrial Landfill. The disposal document for this waste consisting of deteriorated battery parts and soil is presented in Attachment A-1.

A.5.0 Quality Assurance

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

Laboratory analyses were conducted for samples used in the decision-making process to provide a quantitative measurement of any COPCs present. Rigorous QA/QC was implemented for all laboratory 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 Industrial Sites QAPP (NNSA/NV, 2002a).

A.5.1 Data Validation

Data validation was performed in accordance with the Industrial Sites QAPP (NNSA/NV, 2002a) and approved protocols and procedures. All laboratory data from samples collected and analyzed for Baneberry were evaluated for data quality in a tiered process. Data were reviewed to ensure that samples were appropriately processed and analyzed and that 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.

All 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.

A.5.1.1 Tier I Evaluation

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

- Sample count/type consistent with chain of custody.
- Analysis count/type consistent with chain of custody.
- Correct sample matrix.
- Significant problems and/or nonconformances stated in cover letter or case narrative.
- Completeness of certificates of analysis.

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

A.5.1.2 Tier II Evaluation

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

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

A.5.1.3 Tier III Evaluation

The Tier III review is an independent examination of the Tier II evaluation. A Tier III review of 6.5 percent of the sample radiological data was performed by TLI Solutions, Inc., in Golden, 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,
    - data package for completeness.
- Determine sample results qualifiers through the evaluation of (but not limited to)
    - tracers and QC sample results (e.g., duplicates, LCSs, blanks, matrix spikes) evaluated and used to determine sample results qualifiers,
    - sample preservation, sample preparation/extraction and run logs, sample storage, and holding time,
    - instrument and detector tuning,
    - initial and continuing calibrations,
    - calibration verification (initial, continuing, second source),
    - retention times,
    - second column and/or second detector confirmation,
    - mass spectra interpretation,

  - interference check samples and serial dilutions,
  - post-digestion spikes and method of standard additions,
  - breakdown evaluations.

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

A.5.2 Field QC Samples

Field QC samples consisted of two full laboratory QCs (365A004 and 365A006) collected and submitted for analysis by the laboratory analytical methods shown in Table A.2-1. The QC samples were assigned individual sample numbers and sent to the laboratory "blind." Full laboratory QC samples are used to measure accuracy and precision associated with the matrix (see Appendix B for further discussion).

During the CAI, two FDs also were sent as blind samples to the laboratory to be analyzed for the investigation parameters listed in Table A.2-1. For these samples, the duplicate results were evaluated for precision (i.e., relative percent differences [RPDs] between the environmental sample results and their corresponding FD sample results).

A.5.2.1 Laboratory QC Samples

Analysis of QC preparation blanks, LCSs, and laboratory duplicate samples was performed on each sample delivery group (SDG) for radionuclides. 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.

A.5.3 Field Nonconformances

There were no field nonconformances identified for the CAI.

A.5.4 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. A data review was conducted by reviewing QA reports and inspecting the data. There were 11 laboratory nonconformances. Nine nonconformances pertained to either matrix spike recovery failure or laboratory duplicate precision failure. These nonconformances were addressed during Tier II data validation, and data were qualified accordingly. One nonconformance pertained to a sample that was analyzed out of holding time. This sample was retaken and resubmitted to the laboratory within holding time. One nonconformance pertained to the laboratory's internal procedures for maintaining sample custody within the laboratory. However, the laboratory maintained physical custody of the samples at all times. Laboratory nonconformances were reviewed for relevance, and where appropriate, data were qualified.

A.5.5 TLD Data Validation

The use of a TLD to determine an individual's external exposure is the standard in radiation safety and serves as the "legal dose of record" when other measurements are not available. Specifically, 10 CFR Part 835.402 (CFR, 2011) stipulates that personal dosimeters shall be provided to monitor individual exposures and that the monitoring program that uses the dosimeters shall be accredited in accordance with a DOE Laboratory Accreditation Program, as was the case for the TLDs used at Baneberry.

The TLDs were exposed at the Baneberry sample locations for exposure durations ranging from 1,968 to 2,160 hours. The measured dose from each TLD was then scaled based on the exposure durations defined for the Industrial Area and Remote Work Area exposure scenarios.

A.6.0 Summary

Radionuclide contaminants detected in environmental samples during the CAI were evaluated against FALs to determine the nature and extent of COCs for Baneberry. Assessment of the data generated from surface soil samples indicates that surface radiological contamination at the site exceeds the PALs and the FALs (based on the Remote Work Area exposure scenario) at locations outside the default contamination boundary. Subsurface contamination is assumed to be present within the default contamination boundary that exceeds the FALs. Therefore, corrective action is required. The following summarizes the results for Baneberry.

Based on analytical results of soil samples, radiological contamination at the Baneberry site exceeds the FAL of 25 mrem/RW-yr at four sample locations. It is also assumed that radioactivity within the default contamination boundary exceeds the FAL and requires corrective action. For other releases, dry-cell batteries and a drum within a cellar discovered during the investigation were removed as a BMP because radiological and chemical analytical results did not exceed the FAL for any COC. No corrective action is required at the northernmost drainage identified for study as radiological results did not exceed the FAL at any sample location.

For the primary release, an FFACO UR was established to encompass the GWS isopleth corresponding to a net effective dose of 25 mrem/RW-yr (Section A.3.3) above naturally occurring background levels and the default contamination boundary as shown in Figure A.3-5 and Attachment D-1. To determine the extent of this area, a correlation of GWS values to the 95 percent UCL of the Remote Work Area scenario TED values was conducted. The GWS values were then interpolated using a kriging technique and isopleths established for the site. Based on this correlation, the radiation survey value that corresponds to 25 mrem/RW-yr is 8.06 multiples of background. Therefore, the UR boundary was established around the area exceeding this value.

As a BMP, an administrative UR was established to include the area beyond the FFACO UR where an industrial land use of the area (2,250 hours of exposure per year) could cause a site worker to receive a dose exceeding 25 mrem/yr. The extent of this area was determined as described above for the FFACO UR boundary. Based on this correlation, the radiation survey value that corresponds to

25 mrem/IA-yr is 1.96 multiples of background. Therefore, as a BMP, an administrative UR boundary was established around the area exceeding this value as shown in Figure A.3-8 and Attachment D-1.

A.7.0 References

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Attachment A-1

Waste Disposition Documentation

(2 Pages)

Sep-27-2011 09:03 From-SOLID WASTE WORK MANAGEMEMT +702 295 9673 T-509 P.001/001 F-549

NSTec Form FRM-0918

10/07/09 Rev. 01

NTS LANDFILL LOAD VERIFICATION

SWO USE (Select One) AREA ☐ 23 ☐ 6 ☒ 9/10C **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: Nicole Nastanski (NI, WO) (M/S - NSF167) (Fax 5-2025) Phone Number: (o)5-1839

Location / Origin: CAU 365, Baneberry (Area 8). Container # 365A01 - Industrial Waste 5-2025 FAX

Waste Category: (check one) ☐ Commercial ☒ Industrial

Waste Type: (check one) ☐ NTS ☐ Non-Putrescible ☐ Putrescible ☐ Asbestos Containing Material ☒ FFACO-onsite ☐ FFACO-offsite ☐ WAC Exception ☐ 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.) Dry-Cell Batteries

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 Area (CWMA) and to the best of my knowledge, does not contain radiological materials.

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

Print Name: Nicole Nastanski

Signature: /s/ Nicole Nastanski Date: 7/11/11

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

Radiological Survey Release for Waste Disposal
RCT Initials
JB 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:** 7-20-11
BN-0648 (10/05)

SWO USE ONLY

Load Weight (net from scale or estimate) 300 9/22/11 Signature of Certifier: /s/ Signature on File

UNCONTROLLED When Printed

NSTec Form FRM-0918

NTS LANDFILL LOAD VERIFICATION

2

08/23/06
Rev. 0

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 - NSF167) (Fax 5-2241) Phone Number: (o)5-2124; (c)496-0150

Location / Origin: CAU 102, WELLS ER-20-4; ER-EC-12, ER-EC-13 & ER-EC-15 - 33 MT drums; * 1 HC solid (6-909-HC-1)

Waste Category: (check one) ☐ Commercial ☒ Industrial

Waste Type: (check one) ☐ NTS ☐ Non-Putrescible ☐ Putrescible ☐ Asbestos Containing Material ☒ FFACO-onsite ☐ FFACO-offsite ☐ WAC Exception ☐ 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 Manageme knowledge, does not contain radiological materials.

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

Print Name: Mark Heser

Signature: /s/ Mark Heser Date: 4/26/11

Radiological Survey Release for Waste Disposal
RCT Initials
_____ **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.**
MW **This container/load is exempt from survey due to process knowledge and origin.**
SIGNATURE: /s/ Signature on File **DATE:** 4/19/11
BN-0646 (10/05)

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."

SWO USE ONLY

Load Weight (net from scale or estimate): 2,100 Signature of Certifier: /s/ Signature on File 5/31/11

* Includes one (55 gallon) RCRA Empty container removed from CAU 365 Baneberry - 5/4/11 Mark Heser

Appendix B

Data Assessment

B.1.0 Data Assessment

The DQA process is the scientific evaluation of the actual investigation results to determine whether the DQO criteria established in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) 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 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. The five steps are briefly summarized as follows:

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

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

Step 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.

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

Step 5: Draw Conclusions from the Data—Perform the calculations required for the test.

B.1.1 Review DQOs and Sampling Design

This section contains a review of the DQO process presented in Appendix A of the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010). 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 also are presented.

B.1.1.1 Decision I

The Decision I statement as presented in the CAIP is as follows:

> "Is any contaminant of concern (COC) associated with Baneberry present in environmental media?" For judgmental sampling decisions, any contaminant of potential concern (COPC) associated with a CAS that is present at concentrations exceeding its corresponding final action level (FAL) will be defined as a COC. For probabilistic sampling decisions, any COPC for which the 95 percent upper confidence limit (UCL) of the mean radioactivity exceeds its corresponding FAL will be defined as a COC. A COC may also be defined as a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk (NNSA/NSO, 2006).

Contamination is assumed to be present within the fissure and under the crater because of the injection of radionuclides from the test device and the venting of the nuclear test through the fissure. A default contamination boundary has been established to encompass this area.

<u>**Decision Rules**</u>

The decision rules for Decision I are as follows:

- If COC contamination is inconsistent with the CSM or extends beyond the spatial boundaries identified in Section A.5.2 of the CAIP, then work will be suspended and the investigation strategy will be reconsidered, else the decision will be to continue sampling.
- If the population parameter of any COPC in the Decision I population of interest exceeds the corresponding FAL, then that contaminant is identified as a COC, and Decision II samples will be collected, else no further investigation is needed for that COPC in that population.
- If a COC exists at any CAS, then a corrective action will be determined, else no further action will be necessary.

- 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.

B.1.1.1.1 DQO Provisions to Limit False Negative Decision Error

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

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

2. Maintaining a false negative decision error rate of 0.05 (probabilistic sampling).

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

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

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

Criterion 1a

To resolve Decision I for the primary release at Baneberry (as stipulated in the DQOs), sample plot locations were chosen based on the highest GWS values and TLD locations chosen based upon the radiological surveys at the Baneberry site. For the primary release scenario, the DQO process resulted in an assumption that the crater and fissure within the default contamination boundary require corrective action. Therefore, sample plots and TLD locations were established at locations outside the default contamination boundary to resolve Decision I (Section A.2.1).

The locations for sampling the drainage areas at Baneberry were selected at the northernmost drainage. This was based upon the GWS of the major drainages that showed elevated readings at this location. Elevated readings at the other drainages selected for study were not observed and hence were not sampled.

Criterion 1b

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

- The samples are collected from unbiased locations.
- A sufficient sample size was collected.
- A false rejection rate of 0.05 was used in calculating the 95 percent UCLs and minimum sample size for probabilistic sampling.

Selection of the sample aliquot locations within a sample plot was accomplished through the use of the Visual Sample Plan (VSP) software (PNNL, 2007). Each set of sample aliquot locations was derived using the random start, systematic triangular grid pattern for sample placement. Use of the VSP software permitted an unbiased, equal-weighted chance that any given location within the boundaries of the sample plot would be chosen. Although TLDs were not placed at random locations (i.e., they were placed at the center of the sample plot), they provided an integrated, unbiased measurement of dose from the plot area.

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

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

where

s = standard deviation,

$z_{.95}$ = z-score associated with the false negative rate of 5 percent,

$z_{.80}$ = z-score associated with the false positive rate of 20 percent,

μ = dose level where false positive decision is not acceptable (12.5 mrem/yr), and

C = FAL (25 mrem/yr).

The use of this formula requires the input of basic statistical values associated with the sample data. Data from a minimum of three samples are required to calculate these statistical values and as such, the least possible number of samples required to apply the formula is three. Therefore, in instances where the formula resulted in a value less than three, three is adopted as the minimum number of samples required. The results of the minimum sample size calculations and the number of samples collected are presented in Tables B.1-1 and B.1-2. As shown in these tables, the minimum number of sample plot and TLD samples was met or exceeded for areas outside the established UR boundaries. One sample location (A98) did not meet the minimum sample size but was included within the UR. The minimum sample size calculations were conducted as stipulated in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) based on the following parameters:

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

Table B.1-1
Input Values and Minimum Number of Soil Samples Required for the Remote Work Area Exposure Scenario

Sample Plot	Standard Deviation	Minimum Number of Samples Required	Actual Number of Samples Collected
A	6.26	3	4
B	5.05	3	4

Table B.1-2
Input Values and Minimum Number of TLD Samples Required for the Remote Work Area Exposure Scenario
(Page 1 of 5)

TLD Location	Standard Deviation	Minimum Number of Samples Required	Actual Number of Samples Collected
A01	0.22	3	3
A02	0.22	3	3
A03	0.15	3	3
A04	0.29	3	3
A05	0.03	3	3
A06	0.14	3	3
A07	0.10	3	3
A08	0.28	3	3
A09	0.16	3	3

Table B.1-2
Input Values and Minimum Number of TLD Samples Required for the Remote Work Area Exposure Scenario
(Page 2 of 5)

TLD Location	Standard Deviation	Minimum Number of Samples Required	Actual Number of Samples Collected
A10	0.13	3	3
A11	0.19	3	3
A12	0.34	3	3
A13	0.34	3	3
A14	0.19	3	3
A15	0.12	3	3
A16	0.21	3	3
A17	0.09	3	3
A18	0.24	3	3
A19	0.38	3	3
A20	0.27	3	3
A21	0.23	3	3
A22	0.07	3	3
A23	0.41	3	6
A24	0.39	3	6
A25	0.15	3	3
A26	0.19	3	3
A27	0.18	3	3
A28	0.18	3	3
A29	0.19	3	3
A30	0.44	3	3
A31	0.28	3	6
A32	0.95	3	6
A33	0.42	3	6
A34	2.38	3	6
A35	0.66	3	6
A36	0.25	3	3
A37	0.20	3	3

Table B.1-2
Input Values and Minimum Number of TLD Samples Required for the Remote Work Area Exposure Scenario
(Page 3 of 5)

TLD Location	Standard Deviation	Minimum Number of Samples Required	Actual Number of Samples Collected
A38	0.10	3	3
A39	0.23	3	3
A40	0.46	3	3
A41	0.37	3	3
A42	0.30	3	3
A43	0.16	3	3
A44	0.22	3	3
A45	0.28	3	6
A46	0.20	3	6
A47	0.11	3	3
A48	0.03	3	3
A49	0.07	3	3
A50	0.17	3	3
A51	1.55	3	6
A52	0.33	3	3
A53	0.26	3	3
A54	0.04	3	3
A55	0.22	3	3
A56	0.42	3	3
A57	0.98	3	9
A58	0.55	3	3
A59	0.08	3	3
A60	0.30	3	3
A61	0.33	3	3
A62	0.22	3	3
A63	0.16	3	3
A64	0.28	3	3
A65	0.22	3	3

Table B.1-2
Input Values and Minimum Number of TLD Samples Required for the Remote Work Area Exposure Scenario
(Page 4 of 5)

TLD Location	Standard Deviation	Minimum Number of Samples Required	Actual Number of Samples Collected
A66	0.42	3	6
A67	0.38	3	6
A68	0.32	3	3
A69	0.19	3	3
A70	0.12	3	3
A71	0.39	3	6
A72	0.42	3	6
A73	0.26	3	3
A74	0.23	3	3
A75	0.35	3	3
A76	0.19	3	3
A77	0.13	3	3
A78	0.28	3	3
A79	0.32	3	3
A80	0.21	3	3
A81	0.26	3	3
A82	0.44	3	3
A83	0.05	3	3
A84	0.22	3	3
A85	0.18	3	3
A86	0.17	3	3
A87	0.17	3	3
A88	0.27	3	3
A89	0.27	3	3
A90	0.35	3	3
A91	0.39	3	3
A92	0.19	3	3
A93	0.13	3	3

Table B.1-2
Input Values and Minimum Number of TLD Samples Required for the Remote Work Area Exposure Scenario
(Page 5 of 5)

TLD Location	Standard Deviation	Minimum Number of Samples Required	Actual Number of Samples Collected
A94	0.17	3	3
A95	0.29	3	3
A96	0.12	3	3
A98	20.28	**18**	**6**
A99	5.05	3	6
A100	6.26	3	6
A101	0.37	3	3
A102	0.19	3	3
A103	1.09	3	6
A106	0.03	3	3
A107	0.07	3	3
A108	0.35	3	3
A109	0.17	3	3
A110	0.21	3	3

Bolded values indicate that the actual number of samples collected is less than the number of samples required.

Criterion 2

All samples were analyzed using the analytical methods listed in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) to include gamma spectroscopy and Sr-90. Specific analyses for other samples were based on the nature of the potential release as specified in the CAIP. Soil samples collected under the drum in the cellar and associated with the dry-cell batteries were analyzed for VOCs, SVOCs, and *Resource Conservation and Recovery Act* (RCRA) metals. Waste management samples for the dry-cell batteries were also analyzed for Toxicity Characteristic Leaching Procedure (TCLP) metals.

Sample results were assessed against the acceptance criterion for the DQI of sensitivity as defined in the Industrial Sites QAPP (NNSA/NV, 2002). The sensitivity acceptance criterion defined in the CAIP (NNSA/NSO, 2010) is that analytical detection limits will be less than the corresponding FAL.

All detection limits were less than the FALs except for n-Nitrosodi-n-propylamine. This parameter was not detected in any sample analyzed for this parameter and is not suspected to be present at this site as it is not produced for commercial purposes (NLM, 2011). The inability to detect this constituent at a level below the FAL is not considered to affect the DQO decisions.

Criterion 3

To satisfy the third criterion, the entire dataset, as well as individual sample results, was assessed against the acceptance criteria for the DQIs of precision, accuracy, comparability, completeness, and representativeness, as defined in the Industrial Sites QAPP (NNSA/NV, 2002). The DQI acceptance criteria are presented in Table 6-1 of the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010). The individual DQI results are presented in the following subsections.

Precision

Precision was evaluated as described in Section 6.2.3 of the CAIP (NNSA/NSO, 2010). Table B.1-3 provides the results for all constituents that were qualified for precision.

Table B.1-3
Precision Measurements[a]

Parameter	Analyses	Number of Measurements Qualified	Number of Measurements Performed	Percent within Criteria
Cadmium	Metals	2	4	50
Lead	Metals	2	4	50
Silver	Metals	2	4	50

[a]*SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2011)

The precision rate for the three parameters—cadmium, lead, and silver—did not meet the criteria of 80 percent specified in the CAIP (NNSA/NSO, 2010). The precision evaluations were based on differences in laboratory duplicate sample results (RPDs). The precision rate for these metals can be attributed to the nature of the nonhomogeneous distribution of contaminants within soil and measurement error. The estimated results for these parameters were detected at lower concentration levels as discussed below where it is observed that errors are proportionally greater.

There is a negligible potential for a false negative DQO decision error because the highest reported activities for cadmium, lead, and silver that were qualified for precision are relatively small in comparison to the FALs. The highest cadmium concentration of 5.5 mg/kg is approximately 0.69 percent of the FAL of 800 mg/kg. The highest lead concentration of 202 mg/kg is approximately 25.3 percent of the FAL of 800 mg/kg. The highest reported silver concentration of 44.1 mg/kg is approximately 0.86 percent of the FAL of 5,100 mg/kg. At the lower levels, it is also observed that percentage differences are proportionally greater, contributing to the number of measurements qualified. Because of the low reported values, the cadmium, lead, and silver results that were qualified for precision can be confidently used to support the DQO decision. As the precision rates for all other constituents meet the acceptance criteria for precision, the dataset is determined to be acceptable for the DQI of precision.

Accuracy

Accuracy was evaluated as described in Section 6.2.4 of the CAIP (NNSA/NSO, 2010). There were no radiological data qualified for accuracy. Therefore, the CAIP criterion of 80 percent accuracy was met for radiological constituents.

As shown in Table B.1-4, the accuracy rate for three parameters—pentachlorophenol, barium, and selenium—did not meet the criteria of 80 percent specified in the CAIP (NNSA/NSO, 2010). This is probably due to sample matrix interferences. The estimated results for these parameters were detected at lower concentration levels as discussed below where it is observed that errors are proportionally greater.

Table B.1-4
Accuracy Measurements[a]

Parameter	Analyses	Number of Measurements Qualified	Number of Measurements Performed	Percent within Criteria
Pentachlorophenol	SVOC	1	4	75
Barium	Metals	2	4	50
Selenium	Metals	2	4	50

[a]*SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2011)

The barium and selenium results qualified for accuracy were from samples collected under a rusted metal drum. These soil samples contained flecks of rust that probably resulted in a matrix interference in the failed matrix spike. The highest qualified barium concentration was estimated at 149 mg/kg and is approximately 0.08 percent of the FAL of 190,000 mg/kg. The highest qualified selenium concentration of 1.07 mg/kg is approximately 0.02 percent of the FAL of 5,100 mg/kg. All qualified results for selenium were considered estimated nondetects.

Pentachlorophenol results were reported as estimated nondetect data. The compound is not suspected to be present at this site as it is not produced for commercial purposes (NLM, 2011) and is used in processes not suspected to have been performed at the Baneberry site. The highest concentration of 3.4 mg/kg is approximately 37.7 percent of the FAL of 9 mg/kg. As a result, the dataset is determined to be acceptable for the DQI of accuracy.

Representativeness

The DQO process as identified in Appendix A of the CAIP (NNSA/NSO, 2010) was used to address sampling and analytical requirements. During this process, appropriate locations were selected that enabled the samples collected to be representative of the population parameters identified in the DQO (the most likely locations to contain contamination [judgmental sampling] or that represent contamination of the sample plot [probabilistic sampling] and locations that bound COCs) (Section A.2.1). The sampling locations identified in the Criterion 1 discussion meet this criterion. Therefore, the analytical data acquired during the CAI are considered representative of the population parameters.

Comparability

Field sampling, as described in the CAIP (NNSA/NSO, 2010), was performed and documented in accordance with approved procedures that are comparable to standard industry practices. Approved analytical methods and procedures per DOE were used to analyze, report, and validate the data. These are comparable to not only other methods used in industry and government practices, but most importantly other investigations conducted for the NNSS. Therefore, project datasets are considered comparable to other datasets generated using these same standardized DOE procedures, thereby meeting DQO requirements.

Also, standard, approved field and analytical methods ensured that data were appropriate for comparison to the investigation action levels specified in the CAIP.

Completeness

The CAIP (NNSA/NSO, 2010) defines acceptable criteria for completeness to be that the dataset is sufficiently complete to be able to make the DQO decisions. This is initially evaluated as 80 percent of CAS-specific analytes identified in the CAIP having valid results.

The analyte 1,4-Dioxane fell below the completeness criteria of 80 percent. This analyte is classified as an ether and is mainly used as a stabilizer for the solvent trichloroethane. Neither this constituent nor its associated solvent has been detected in this area of the NNSS; as a result, there is no reason to suspect the presence of 1,4-Dioxane at Baneberry. Although the detection limit for this parameter was above the FAL, 1,4-Dioxane was not detected in any other sample and is not suspected to be present at the site because of its noncommercial use (NLM, 2011).

Rejected data were not used in the resolution of DQO decisions and are not counted toward meeting the completeness acceptance criterion. Therefore, the absence of a usable result for 1,4-Dioxane does not preclude the resolution of the DQO decisions. Table B.1-5 provides the rejected data for the site.

Table B.1-5
Rejected Measurements[a]

Parameter	Chemical Abstracts Service Number	Analyses	Number of Measurements Qualified	Number of Measurements Performed	Percent within Criteria
1,4-Dioxane	123-91-1	VOCs	2	2	0

[a]*SW-846, Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2011)

B.1.1.1.2 DQO Provisions to Limit False Positive Decision Error

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

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

B.1.1.2 Decision II

Decision II as presented in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) is as follows:

> "If a COC is present, is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include the following:
>
> - The lateral and vertical extent of COC contamination
> - The information needed to determine potential remediation waste types and volumes
> - Any other information needed to evaluate the feasibility of remediation alternatives

As COCs were detected outside the default contamination boundary at Baneberry, Decision II sampling was necessary.

Decision II was resolved for the subsurface contamination within the fissure and crater by including the area in the default contamination boundary where it was assumed that COCs were present in amounts exceeding the FAL.

Decision II was resolved for the areas outside the default contamination boundary by the placement of TLDs and collection of samples. Samples were also collected from waste materials identified during the visual surveys that were determined not to be PSM. These sample results were evaluated using the PSM criteria listed in Section 3.4 of the CAIP to provide sufficient information to determine the PSM status of the wastes and to characterize the wastes for disposal.

<u>Decision Rules</u>

The decision rule for Decision II are as follows:

- If COC contamination is inconsistent with the CSM or extends beyond the spatial boundaries identified in Section A.5.2 of the CAIP (NNSA/NSO, 2010), then work will be suspended, and the investigation strategy will be reconsidered, else the decision will be to continue sampling.

- If the population parameter of any COPC in the Decision I population of interest exceeds the corresponding FAL, then that contaminant is identified as a COC, and Decision II samples will be collected, else no further investigation is needed for that COPC in that population.

- If valid analytical results are available for the waste characterization samples defined in Section A.8.0 of the CAIP (NNSA/NSO, 2010), then the decision will be that sufficient information exists to determine potential remediation waste types and evaluate the feasibility of remediation alternatives, else additional waste characterization samples will be collected.

B.1.1.3 Sampling Design

The CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) stipulated that the following sampling processes would be implemented:

1. Judgmental sampling will be conducted at other releases and at locations of potential contamination identified during the CAI.

   Result: Judgmental sampling was conducted in three sedimentation areas within a drainage north of the default contamination boundary to determine whether migration from the site has occurred. A judgmental sample was collected under an empty drum located within a cellar structure. Other judgmental samples were collected in an area of deteriorated dry-cell batteries.

2. Sampling of the primary release will be conducted by a combination of judgmental and probabilistic sampling approaches.

   Result: A judgmental sampling approach was utilized for the two selected soil sample plots. Soil sample aliquots were collected within each plot probabilistically as described in Section A.2.0. In addition, a judgmental soil sample was collected in an area of elevated radiological readings southwest of the default contamination boundary.

B.1.2 Conduct a Preliminary Data Review

A preliminary data review was conducted by reviewing QA reports and inspecting the data. The contract analytical laboratories generate a QA nonconformance report when data quality does not meet contractual requirements. All data received from the analytical laboratories met contractual requirements, and laboratory nonconformance reports were reviewed for relevance and, where appropriate, data were qualified. 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.

B.1.3 Select the Test and Identify Key Assumptions

The test for making DQO decisions for radiological contamination was the comparison of the TED to the FAL of 25 mrem/RW-yr. For other types of contamination, the test for making DQO decisions was the comparison of the maximum analyte result to the corresponding FAL. All FALs were based on an exposure duration to a site worker using the Remote Work Area exposure scenario.

The key assumptions that could impact a DQO decision are listed in Table B.1-6.

Table B.1-6
Key Assumptions

Exposure Scenario	The potential for contamination exposure is limited to inspection and maintenance, demarcation, and utility workers. These human receptors may be exposed to COCs through oral ingestion or inhalation of soil and/or debris due to inadvertent disturbance of these materials or irradiation by radioactive materials.
Affected Media	Surface and shallow subsurface soil, debris such as metal and concrete.
Location of Contamination/Release Points	Surface soil (to 5 cm depth). Refer to Section 2.1.
Transport Mechanisms	Surface water runoff may provide for the transportation of some contaminants within or outside the boundaries of the Baneberry site. Percolation of precipitation through subsurface media serves as a minor driving force for vertical migration of contaminants. Wind may serve as a means for migration of contaminants.
Preferential Pathways	Drainages. Lateral transport is expected to be more important than vertical transport because of limited infiltration.
Lateral and Vertical Extent of Contamination	Contamination is expected to be contiguous to the release points. Concentrations are expected to decrease with distance and depth from the release. Groundwater contamination is not expected. Lateral and vertical extent of surface COC contamination is assumed to be within the spatial boundaries of Baneberry.
Groundwater Impacts	None.
Future Land Use	Nuclear Test Zone.
Other DQO Assumptions	Subsurface contamination is present at the crater and fissure because of the subsurface detonation from the nuclear test device. Surface contamination is present because of atmospheric deposition from material that vented. The CSM includes the potential for subsurface contamination from excavated areas. The DQIs were satisfactorily met as discussed in Section B.1.1.1.1. The rejected data discussed in this section are not considered to adversely impact the ability for the data to support the DQO decisions. The data collected during the CAI are considered to support the CSM and the DQO decision; therefore, no revisions to the CSM were necessary.

B.1.4 Verify the Assumptions

The results of the investigation support the key assumptions identified in the DQOs and Table B.1-6. All data collected during the CAI supported the CSM with the exceptions noted in this section. These exceptions did not invalidate the CSM presented in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010), nor did they necessitate revisions to the CSM.

B.1.4.1 Other DQO Commitments

The CAIP (NNSA/NSO, 2010) made the following commitments:

1. For Baneberry, Decision I for the primary release scenario outside the default contamination boundary will be resolved. Decision II must be resolved if contamination above FALs is present outside the default contamination boundary.

   Result: Decision I was resolved by the placement of TLDs and collection of environmental samples. Decision I sample locations outside the default contamination boundary yield a 95 percent UCL of the average TED that exceeds the FAL. Decision II was resolved by the collection and analysis of samples and placement of TLDs.

2. For Baneberry, a grid and vector sampling pattern will be established such that they are approximately normal to the gamma radiation survey isopleths. The grid and vectors will be established with the constraint that at least one location will present a TED less than the FAL.

   Result: A sampling pattern was established in a grid and vector pattern normal to the gamma radiation surveys as illustrated in Figure A.3-1. The TLD sampling pattern met these requirements as a decreasing trend of TED rates from more than 25 mrem/yr to less than 25 mrem/yr has been observed to adequately bracket the Industrial Work Area and Remote Work Area decision boundaries.

3. The Task Manager or Site Supervisor may modify the number, location, and spacing of the grid or vectors as warranted by site conditions to achieve DQO criteria stipulated in Appendix A.

   Result: Any necessary modifications of aliquot locations from planned positions by the Site Supervisor were due to field conditions and observations resulting from vegetation obstruction. The distances of the new aliquot locations from planned locations that needed to be changed ranged from approximately 5 in. to approximately 12 in. to meet conditions that are representative of the area. These changes from the planned locations did not impact the DQO decisions because the samples were collected from the nearest possible locations and were not subject to judgment or biasing factors. Therefore, these samples are considered randomly located.

4. The internal dose rate at Baneberry is expected to contribute little to the TED.

   Result: Based upon validated analytical data, the internal dose rate at Baneberry was determined to contribute little to the TED. Calculation of the internal dose indicates that it contributes less than 1 percent of the TED.

B.1.5 Draw Conclusions from the Data

This section resolves the two DQO decisions for Baneberry.

B.1.5.1 Decision Rule Applicable to Both Decision I and Decision II

Decision Rule: If COC contamination is inconsistent with the CSM or extends beyond the spatial boundaries identified in Section A.5.2 of the CAIP (NNSA/NSO, 2010), then work will be suspended, and the investigation strategy will be reconsidered, else the decision will be to continue sampling.

Results: The COC contamination was found to be consistent with the CSM and to not extend beyond the spatial boundaries; therefore, work was not suspended.

B.1.5.2 Decision Rules for Decision I

Decision Rule: If the population parameter of any COPC in the Decision I population of interest exceeds the corresponding FAL, then that contaminant is identified as a COC, and Decision II samples will be collected, else no further investigation is needed for that COPC in that population.

Result: Decision I determined that COCs were identified at the Baneberry site as TED results exceeded the 25-mrem/RW-yr FAL at four locations. Therefore, Decision I was resolved that COCs exist and Decision II was required to determine the extent of contamination. As a decreasing trend of TED rates from more than 25 mrem/RW-yr to less than 25 mrem/RW-yr was determined, Decision II was resolved.

Decision Rule: If a COC is determined to exist at Baneberry, then a corrective action will be determined, else no further action will be necessary.

Result: Because COCs were identified at Baneberry, corrective actions are required.

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

Result: Although potential releases were identified in the form of a drum within a cellar structure and deteriorating dry-cell batteries, radiological and chemical parameters were determined to be below the FAL. No corrective actions were performed at locations A201 through A204.

B.1.5.3 Decision Rules for Decision II

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

Result: Decision II samples were collected to determined the extent of contamination. For the primary release, additional sample plots were not needed.

Decision Rule: If valid analytical results are available for the waste characterization samples defined in Section A.8.0 of the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010), then the decision will be that sufficient information exists to determine potential remediation waste types and evaluate the feasibility of remediation alternatives, else additional waste characterization samples will be collected.

Result: Valid analytical data were obtained to adequately characterize the material associated with the cellar drum and dry-cell batteries for disposal. Data were determined to be adequate to determine waste types and evaluate alternatives.

B.2.0 References

EPA, see U.S. Environmental Protection Agency.

NLM, see U.S. National Library of Medicine.

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

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Appendix C

Risk Assessment

C.1.0 Risk Assessment

The risk-based corrective action (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 (NAC, 2008a), which lists the requirements for sites with soil contamination. 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 necessary remediation standards.

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 365, Baneberry Contamination Area, CAIP [NNSA/NSO, 2010]). 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.
- 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 *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006) is summarized in Figure C.1-1.

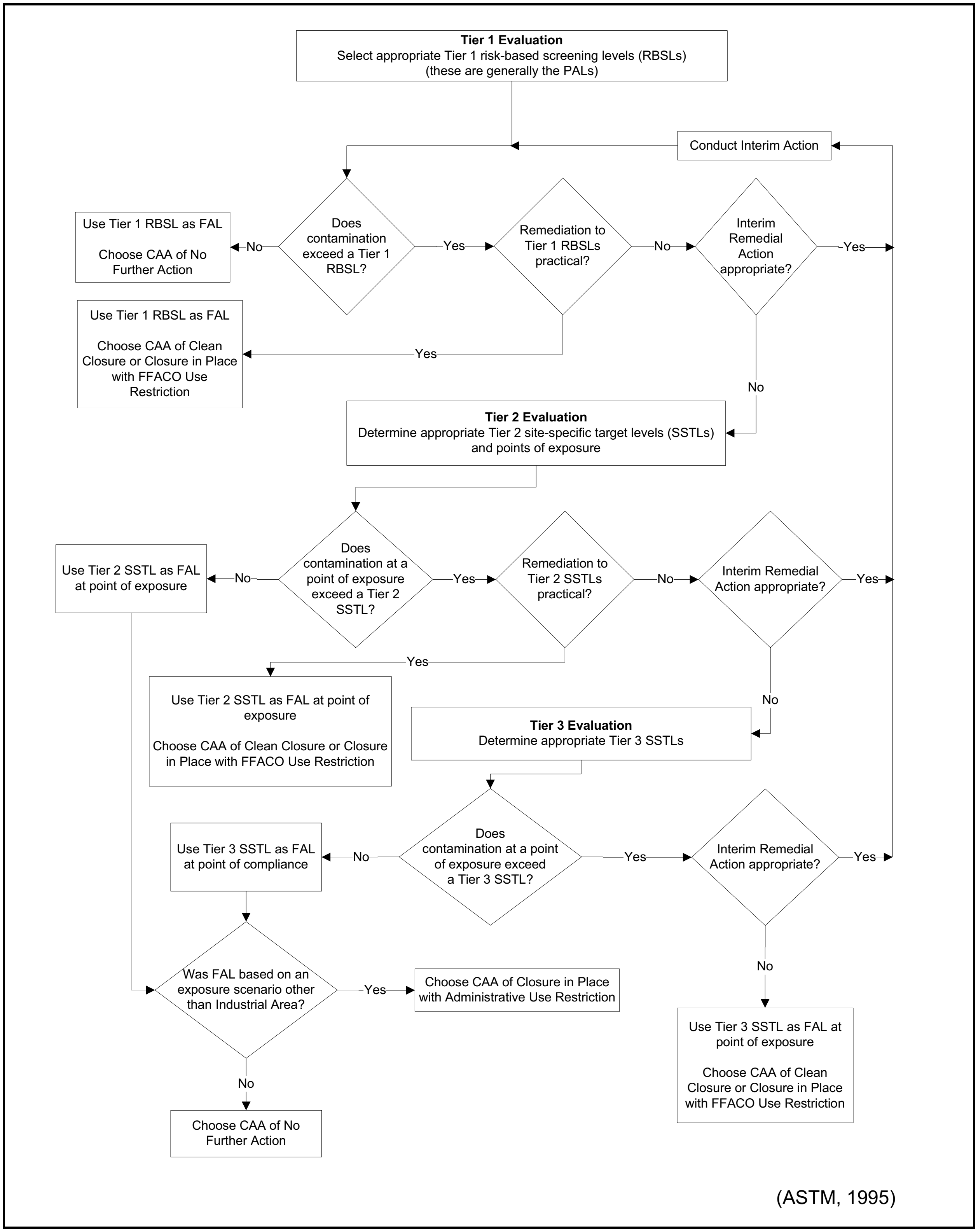

Figure C.1-1
Risk-Based Corrective Action Decision Process

C.1.1 A. Scenario

Baneberry is an inactive site located in the southern section of Area 8 of the NNSS. The Baneberry weapons-related test resulted in a release of radionuclides to the surrounding soil surface as a result of unintentional venting. The Baneberry test was conducted on December 18, 1970, at a depth of 912 ft bgs. A subsidence crater measuring 455 ft in diameter and 78 ft deep (AEC, 1971) resulted from the test.

C.1.2 B. Site Assessment

The Baneberry site includes the area affected by the surface release of radioactivity associated with unintentional venting from the subsurface Baneberry nuclear test. A subsidence crater and the surface expression of the fissure where the vent occurred are present at the site and have been included within the default contamination boundary. Scattered testing-related debris is present throughout the area. No removable contamination was identified on the debris. Staged TLDs and soil samples collected at various locations were used to calculate TED to workers as discussed in Section A.3.2.3. The TEDs from TLD and surface soil plot locations exceeded the FAL established in this appendix based on the Remote Work Area exposure scenario (25 mrem/RW-yr) at four locations to the southwest of the default contamination boundary. The maximum calculated TED (based on the Remote Work Area scenario) was 213.7 mrem/RW-yr.

C.1.3 C. 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, Baneberry does not present an immediate threat to human health, safety, and the environment; therefore, no interim response actions are necessary at this site. However, corrective actions are required because of the presence of contamination exceeding 25 mrem/RW-yr that could pose a short- and long-term threat to human health, safety, or the environment. Thus, Baneberry has been determined to be a Classification 2 site as defined by ASTM Method E1739.

C.1.4 D. Development of Tier 1 Lookup Table of RBSLs

Tier 1 RBSLs are defined as the PALs listed in the CAU 365, Baneberry Contamination Area, CAIP (NNSA/NSO, 2010) 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 RBSL (i.e., PAL) value if implementing a corrective action based on the Tier 1 RBSL would be appropriate.

The PALs for radionuclides are based on a dose of 25 mrem/yr using the Industrial Area exposure scenario. The Industrial Area scenario assumes that a full-time industrial worker is present at a particular location for his entire career (10 hr/day, 225 day/yr for a duration of 25 years). The 25-mrem/yr dose-based Tier 1 RBSL for the primary release is implemented by calculating the dose a site worker would receive if exposed to the site contaminants over an annual exposure period of 2,250 hours.

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

- *Region 9: Superfund, Regional Screening Table (Formerly PRGs* [Preliminary Remediation Goals]*), Screening Levels for Chemical Contaminants* (EPA, 2010).
- 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 *Mineral and Energy Resource Assessment of the Nellis Air Force Range* (NBMG, 1998; Moore, 1999).
- For COPCs without established screening levels, a protocol similar to EPA Region 9 will be used to establish an action level; otherwise, an established screening level from another EPA region may be chosen.

These chemical PALs are based on the Industrial Area exposure scenario. Because there are no assigned work stations near the Baneberry site, and it is considered to be in a remote area, the use of PALs based on the Industrial Area exposure scenario is conservative.

C.1.5 E. Exposure Pathway Evaluation

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

C.1.6 F. Comparison of Site Conditions with Tier 1 RBSLs

The crater and associated fissure areas at Baneberry are assumed to contain contamination at concentrations exceeding the FALs and require corrective action. Therefore, these areas are not included in the RBCA evaluations. Rather, this evaluation was limited to the areas outside the default contamination boundary. An exposure time based on the Industrial Area scenario (2,250 hr/yr) was used to calculate site radiological doses (TED). These values were compared to the Tier 1 RBSL (25-mrem/IA-yr dose) that is also based on an exposure time of 2,250 hr/yr.

The TEDs for all sampled locations at Baneberry that exceed the Tier 1 RBSL (i.e., PAL) based on the Industrial Area exposure scenario are listed in Table C.1-1. Based on the conservative assumption that a site worker would be exposed to the maximum dose measured at any sampled location outside the default contamination boundary (A98), this site worker would receive a 25-mrem dose at this location in approximately 39 hours.

C.1.7 G. Evaluation of Tier 1 Results

The risk to receptors from contaminants at Baneberry is due to chronic exposure to radionuclides (i.e., receiving a dose over time). Therefore, the risk to a receptor is directly related to the amount of time a receptor is exposed to the contaminants. A review of the current and projected use of this site determined that workers may be present for only a few hours per year (see Section C.1.10), and it is not reasonable to assume that any worker would be present at this site for 2,250 hr/yr (DOE/NV, 1996). Therefore, NNSA/NSO determined that remediation to the RBSL is not appropriate.

Table C.1-1
Locations Where TED Exceeds the Tier 1 RBSL at Baneberry

Location	Average TED (mrem/IA-yr)	95% UCL of TED (mrem/IA-yr)
A23	36.11	38.36
A24	57.84	60.00
A32	52.16	57.39
A33	39.41	41.71
A34	351.69	364.79
A35	66.76	70.38
A45	32.27	33.81
A51	51.78	60.32
A58	24.91	31.13
A61	29.87	33.56
A66	25.89	28.22
A67	33.01	35.12
A71	38.31	40.48
A72	36.64	38.93
A75	31.82	35.75
A98	1,319.72	1,431.53
A99	715.79	743.71
A100	776.83	811.47
A101	34.12	41.20
A102	42.99	47.82
A103	40.45	47.02

C.1.8 H. Tier 1 Remedial Action Evaluation

No remedial actions are proposed based on Tier 1 RBSLs.

C.1.9 I. Tier 2 Evaluation

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

C.1.10 J. Development of Tier 2 SSTLs

The Tier 2 action levels are typically compared to contaminant values that are representative of areas in which an individual or population may come in contact with a COC originating from the site. This concept is illustrated in the EPA's Human Health Evaluation Manual (EPA, 1989). This document states that "the area over which the activity is expected to occur should be considered when averaging the monitoring data for a hot spot. For example, averaging soil data over an area the size of a residential backyard (e.g., an eighth of an acre) may be most appropriate for evaluating residential soil pathways." When evaluating industrial receptors, the area over which an industrial worker is exposed to contaminated soil may be much larger than for residential receptors. For a site that is limited to industrial uses, the receptor would be a site worker, and patterns of employee activity would be used to estimate the area over which the receptor is exposed to contaminated soil. This can be very complicated to calculate, as industrial workers may perform routine activities at many locations where only a portion of these locations may be contaminated. A more practical measure of integrated risk to radiological dose for an industrial worker is to calculate the portion of total work time that the worker is in proximity to elevated radioactivity and therefore could receive a dose. For example, site workers may have routine activities that require them to be at a radioactive location for 225 hr/yr. If the worker's industrial work schedule was 10 hr/day for 225 day/yr—or 2,250 hr/yr (as is used for the Industrial Area exposure scenario)—the site worker would receive 10 percent of the potential annual dose that they would otherwise receive if exposed to the radioactive location for the entire work year.

For the development of radiological Tier 2 SSTLs, the annual dose limit for a site worker is 25 mrem/yr (the same as was used for the Tier 1 evaluation). The Tier 2 evaluation is based on a receptor exposure time that is more specific to actual site conditions. The maximum potential exposure time for the most exposed worker at Baneberry was determined based on an evaluation of current and reasonable future activities that may be conducted at the site. Activities on the NNSS are strictly controlled through a formal work control process. This process requires facility managers to authorize all work activities that take place on the land or at the facilities within their purview. Therefore, these facility managers are aware of all activities conducted at the site. The facility managers responsible for the Baneberry area identified the general types of work activities that are currently conducted at the site to include fencing/posting inspection and maintenance, and utility maintenance and repair. Site activities that may occur in the future were identified by assessing tasks related to maintenance of existing infrastructure and long-term stewardship of the site (e.g., inspection and maintenance of UR signs, trespasser). In order to estimate the amount of time a site worker might spend conducting current or future activities, the NNSA/NSO and/or M&O contractor departments responsible for these activities were consulted. Under the current land use at Baneberry, the following workers were identified as being potentially exposed to site contamination:

- **Inspection and Maintenance Worker.** Inspection and maintenance workers conduct the annual inspection of the postings and fencing around the site and perform maintenance. The UR requires periodic inspection and maintenance of fencing and postings to ensure that the fencing is intact and the signs are legible. Inspections will require 2 people to spend up to 5 hr/yr on the site. A separate maintenance effort is estimated to take 5 hr/yr for 6 people. This results in a total of 10 hr/yr to conduct both activities.

- **Demarcation Worker**. A Contamination Area, Radioactive Materials Area, and Radiation Area are posted at the Baneberry site. Radiological readings are collected at Baneberry on a periodic basis to confirm the existing postings. It was conservatively estimated that such readings would be required every other year and that a site worker involved in collecting the readings could potentially spend up to 5 hours in the vicinity of this fenced area.

- **Utility Worker.** Electrical power utility lines are present at the site and cross the site north of the default contamination boundary. The maintenance of utility lines is established on a 5-year basis and is estimated to require 2 days (10-hour days) to complete 1 mi. This 800-ft (0.15-mi) section of line would conservatively require 5 hours of work over 5 years, or 1 hour every 1 year.

- **Trespasser**. This would include workers or individuals who do not have a specific work assignment at Baneberry, but may inadvertently walk across the site and come in contact with site contamination. This is assumed to be an infrequent occurrence, so a potential exposure of less than 1 day per year per person is assumed. Thus, the maximum number of hours a trespasser would spend at Baneberry is 8 hr/yr.

Under the current land use at Baneberry, the most exposed worker would be the inspection and maintenance worker who would not be exposed to site contamination for more than 10 hr/yr. Based on the conservative assumption that the most exposed worker would be exposed annually to the maximum dose measured at any sampled location outside the default contamination boundary (A98) for the entire 10 hours, this worker would receive a maximum potential additional dose of approximately 6 mrem.

In the DQOs, it was conservatively determined that the Occasional Use Area exposure scenario (as listed in Section 3.1.1 of the CAU 365, Baneberry Contamination Area, CAIP [NNSA/NSO, 2010]) would be appropriate in calculating receptor exposure time based on current land use at the Baneberry site. 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 hr/yr. However, as the corrective action requirements at Baneberry would not be significantly different if based on the Remote Work Area exposure scenario, it was determined to base the Tier 2 SSTL on the more conservative Remote Work Area exposure scenario. This exposure scenario assumes a site worker will be exposed to the maximum site contamination for 336 hr/yr.

C.1.11 K. Comparison of Site Conditions with Tier 2 Table SSTLs

The 25-mrem/yr dose-based Tier 2 SSTL for the primary release based on the Remote Work Area exposure scenario was accomplished by calculating dose (i.e., TED) at the site over an exposure period of 336 hr/yr (8 hr/day, 42 day/yr). The TEDs calculated using the Remote Work Area exposure scenario were then compared to the 25-mrem/RW-yr Tier 2 SSTL. As shown in Table C.1-2, the 95 percent UCLs of TED values exceeded the 25-mrem/RW-yr Tier 2 SSTL at four locations to include the two sample plots.

Table C.1-2
Remote Work Area Scenario TED Exceeding the Tier 2 SSTL

Location	Average TED (mrem/RW-yr)	95% UCL of TED (mrem/RW-yr)
A34	52.50	54.46
A98	197.03	213.72
A100 (Plot A)	115.98	121.14
A99 (Plot B)	106.86	111.03

C.1.12 L. Tier 2 Remedial Action Evaluation

Based on the Tier 2 evaluation, the surface and subsurface soils at Baneberry pose an unacceptable risk to human health and the environment at locations outside the default contamination boundary. Surface soils exceed the Tier 2 SSTL of 25 mrem/RW-yr at four locations. It was assumed that subsurface contamination exists at Baneberry because of the direct injection of radioactivity within the fissure and under the crater from the nuclear test and that the subsurface contamination exceeds the Tier 2 SSTL of 25 mrem/RW-yr.

Any corrective action at Baneberry would also need to address the contamination in the crater and fissure areas that were assumed to exceed FALs. A corrective action of clean closure at Baneberry would require extensive excavations of up to 25 ft in depth. Based on the extent of the corrective action boundaries, the infeasibility of removing deep contamination in the craters, and the high physical hazards of working in a subsidence crater, a corrective action of closure in place with URs for the areas encompassed by the Tier 2 SSTL corrective action boundary was used for the Tier 2 remedial action evaluation. As this corrective action is practical and appropriate for the contamination at Baneberry, the Tier 2 SSTL was established as the FAL for radiological releases, and a corrective action will be implemented.

As the radiological FAL was established as the Tier 2 SSTL, a Tier 3 evaluation was not necessary.

C.2.0 Recommendations

Because TED values for surface soils at Baneberry exceeded the corresponding FALs at four locations (using the Remote Work Area exposure scenario), it was determined that corrective actions were warranted. It is also assumed that subsurface contamination within the default contamination boundary exceeds the FAL based on the Remote Work Area exposure scenario (i.e., 25 mrem/RW-yr). Therefore, the corrective action boundary includes the areas identified as exceeding the 25-mrem/RW-yr FAL as well as the crater and fissure areas (default contamination boundary) at Baneberry.

It is recommended that a corrective action of closure in place with a UR be implemented for the area within the corrective action boundary. The FFACO UR area around the corrective action boundary will be posted with signs to warn worker of the hazards.

The FAL was based on an exposure time of 336 hr/yr of site worker exposure to surface soils at the site. Should the land use change such that industrial land use activities are proposed to be conducted, a site worker could be potentially exposed to a dose exceeding 25 mrem/yr. Therefore, an administrative UR was implemented as a BMP that would restrict future industrial land use without NDEP notification.

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

The FFACO UR and the administrative UR for Baneberry are recorded in the FFACO database, NNSA/NSO Facility Information Management System, and the NNSA/NSO CAU/CAS files. These URs are included in Appendix D.

C.3.0 References

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Attachment C-1

Derivation of Residual Radioactive Material Guidelines for Radionuclides in Soil at Corrective Action Unit (CAU) 365 Baneberry Contamination Area Nevada National Security Site, Nevada

(10 Pages)

Introduction

This appendix promulgates tables of Residual Radioactive Material Guidelines (RRMGs) for the Industrial Area, Remote Work Area, and Occasional Use Area exposure scenarios for use in the evaluation of Soils Project sites. These exposure scenarios are described in the document *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). Two sets of RRMGs were calculated for each of the three exposure scenarios: one set using only the inhalation and ingestion pathways (e.g., internal dose), and one set that added the external gamma pathway (e.g., internal and external dose). The second set is needed to evaluate "other release" soil samples where thermoluminescent dosimeters (TLDs) were not emplaced to measure the external dose.

Background

The *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006) provides a Nevada Division of Environmental Protection (NDEP)-approved process for the derivation of soil sampling final action levels that are congruent with the risk-based corrective action process. This document is used by the Navarro-Intera, LLC, Soils Project as well.

The Residual Radioactive (RESRAD) computer code, version 6.5 (Yu et al., 2001), and the guidance provided in NNSA/NSO (2006) were used to derive RRMGs for use in the Soils Project. The RRMGs are radionuclide-specific values for radioactivity in surface soils, expressed in units of picocuries per gram (pCi/g). A soil sample with a radionuclide concentration that is equal to the RRMG value for that radionuclide would present a potential dose of 25 millirem per year (mrem/yr) to a receptor under the conditions described in the exposure scenario. When more than one radionuclide is present, the potential dose must be evaluated by summing the fractions for each radionuclide (i.e., the measured concentration divided by the RRMG for the radionuclide). The resultant sum of the fractions value is then multiplied by 25.0 to obtain an estimate of the dose.

The RRMGs are specific to a particular exposure scenario. The dose estimates obtained from the use of RRMGs are valid only when the assumptions provided in the exposure scenario for the intended land-use hold true. In most cases at the Nevada National Security Site (NNSS), the Industrial Area exposure scenario is quite conservative and is bounding for most anticipated future land uses.

A recent revision to Title 10 of the *Code of Federal Regulations* (CFR), Part 835 (CFR, 2011), had adopted new, more sophisticated, dosimetric models and new dosimetric terms. Internal dose is now to be expressed in terms of the Committed Effective Dose (CED), and International Commission on Radiological Protection (ICRP) 72 dose conversion factors are to be used.

Methods

Calculations were performed using the RESRAD code, version 6.5 (Yu et al., 2001). The ICRP 72 dose conversion factors were used. The RESRAD input parameters were verified and checkprinted.

The radionuclide niobium (Nb)-94 was previously added to the RRMGs to accommodate work in Area 25 that is related to the Nuclear Rocket Development Station (NRDS). The radionuclides silver (Ag)-108m, curium (Cm)-243, and Cm-244 were recently detected on one or more Soils Project sites, and RRMGs were calculated to demonstrate that their contribution to the total effective dose (TED) is negligible.

The RESRAD calculations have identified that for all radionuclides evaluated, with one exception: The maximum potential dose occurs at time-zero. The RRMGs provided in this memorandum do reflect those for time-zero. The exception previously mentioned is the radionuclide thorium (Th)-232, which has several daughters with short half-lives. Because the daughter activity "grows in," and because RRMGs include the contributions from daughters, the maximum potential dose for Th-232 actually occurs at 10.21 years. A RRMG for Th-232 at 10.21 years was not selected, and the RRMG for time-zero was used, for the following reasons:

- RESRAD suggests a set of RRMGs for use when the overall total dose is at its maximum. Considering the contributions from all radionuclide contaminants of potential concern (COPCs), this would be at time-zero.
- The additional dose from the in-growth of Th-232 daughters is offset by the radioactive decay of other radionuclides that would be present (e.g., cesium [Cs]-137).
- The additional dose from the in-growth of Th-232 daughters is very small when compared to the basic dose limit of 25 mrem/yr. For example, if Th-232 were found at a concentration of 100 pCi/g, the increase in potential dose from time-zero to 10.21 years would only be 0.52 millirem (mrem). To date, Th-232 has only been seen on Soils Project sites at environmental levels of about 1.5 to 3 pCi/g.

Assumptions and Default Parameters

Appendix B to DOE/NV--1107 (NNSA/NSO, 2006) lists the RESRAD code variables (i.e., input parameters) for the three exposure scenarios. These pre-determined values were used to calculate the RRMGs, with a few exceptions as described in Table 1.

Results

The RRMGs are presented in Tables 2 to 7. The abbreviation "RRMG" in each of the six tables includes a subscript to indicate the scenario and the exposure pathways that are activated. When referencing a set of RRMGs, the subscripts should be included to avoid confusion and a potential misapplication of the RRMGs.

Table 1: RESRAD Input Parameters

Item #	RESRAD Parameter	Industrial Area	Remote Work Area	Occasional Use Area	Explanation
1	Area of CZ (m^2)	1,000			Appendix B states “Site Specific.” Previously, 100 m^2 was selected to conform to the maximum area of contamination limitation in DOE Order 458.1 (DOE, 2011). Going forward, 1,000 m^2 has been selected to add conservatism and realism to the RRMGs. The 1,000 m^2 RRMGs will be applied to 100-m^2 evaluation areas.
2	Thickness of CZ (m)	0.05			Appendix B states “Site Specific.” This depth encompasses the bulk of the potential contamination and includes the maximum concentration.
3	Cover Depth	0.00			Appendix B states “Site Specific.” Cover depth only affects the time delay before contamination becomes available for erosion and airborne suspension. Increasing the cover depth, in some cases, may lead to lower dose estimates.
4	Precipitation (m/yr)	0.144			Appendix B states “Site Specific.” The selected value is the average annual rainfall as recorded at Camp Desert Rock.
5	Indoor Time Fraction	**[0.1712]**	**[0.0256]**	0	The stated value was 0, conservatively assuming no time is spent indoors. The new value more accurately reflects the Industrial Area scenario in which 66% of the time is spent indoors. $\left(\frac{2{,}250 \text{ hours on site}}{8{,}760 \text{ hours in a year}}\right) 0.6666 \text{ indoors} = 0.1712$ The same correction was made for the Remote Work Area scenario.
6	Soil Ingestion Rate (g/yr)	**[43.43]**	20.2	4.8	The stated value was 108, assuming that all time is spent outdoors under a 480-mg/day soil ingestion rate. The new value more accurately reflects the soil ingestion rate of 193 mg/day when both indoor and outdoor time fractions are considered. Refer to page 14 of DOE/NV--1107 (NNSA/NSO, 2006).
7	Indoor Dust Filtration Factor	**[0.4]**	**[0.4]**	1	This is the RESRAD default value and is appropriate as, under the Industrial Area and Remote Work Area scenarios, 66% of the time is spent indoors.
8	Shielding Factor External Gamma	**[0.7]**	**[0.7]**	1	This is the RESRAD default value and is appropriate as, under the Industrial Area and Remote Work Area scenarios, 66% of the time is spent indoors.
9	Pathway 1 – External Gamma	Suppressed	Suppressed	Suppressed	In general, external dose at Soils Projects will be evaluated via TLDs or direct measurement with a dose-rate meter. Soil samples and RRMGs are used to determine the internal dose component only. The pathway was activated for the second set of RRMGs for each scenario to allow the evaluation of biased sample locations where TLDs were not emplaced.

Note 1: Items 1–4 above are site-specific default values that were selected for the Soils Project.
Note 2: Table B.1-1 in Appendix B contains several errors. The bold and bracketed values are corrections to those values.

CZ = Contamination zone
g/yr = Grams per year
m = Meter
m^2 = Square meter
m/yr = Meters per year
mg/day = Milligrams per day

Table 2: Soils Project – Industrial Area Exposure Scenario – Internal Dose Only

Radionuclide	**RRMG$_{(IA-I)}$** (pCi/g)
Ag-108m	2.737E+06
Am-241	2.816E+03
Cm-243	3.852E+03
Cm-244	4.735E+03
Co-60	5.513E+05
Cs-137	1.409E+05
Eu-152	1.177E+06
Eu-154	8.469E+05
Eu-155	5.588E+06
Nb-94	3.499E+06
Pu-238	2.423E+03
Pu-239/240	2.215E+03
Sr-90	5.947E+04
Th-232	2.274E+03
U-234	1.960E+04
U-235	2.089E+04
U-238	2.120E+04

A soil sample at this RRMG value would present an internal dose potential of 25 mrem under the Industrial Area exposure scenario.

Table 3: Soils Project – Industrial Area Exposure Scenario – Internal & External Dose

Radionuclide	**RRMG$_{(IA-IE)}$** (pCi/g)
Ag-108m	9.281E+01
Am-241	1.503E+03
Cm-243	3.155E+02
Cm-244	4.713E+03
Co-60	1.833E+01
Cs-137	7.290E+01
Eu-152	3.826E+01
Eu-154	3.571E+01
Eu-155	9.583E+02
Nb-94	9.653E+01
Pu-238	2.416E+03
Pu-239/240	2.207E+03
Sr-90	7.714E+03
Th-232	5.067E+02
U-234	1.865E+04
U-235	2.555E+02
U-238	1.423E+03

A soil sample at this RRMG value would present a TED potential of 25 mrem under the Industrial Area exposure scenario.

Table 4: Soils Project – Remote Work Area Exposure Scenario – Internal Dose Only

Radionuclide	**RRMG$_{(RWA\text{-}I)}$** (pCi/g)
Ag-108m	3.389E+07
Am-241	1.612E+04
Cm-243	2.223E+04
Cm-244	2.716E+04
Co-60	7.229E+06
Cs-137	1.955E+06
Eu-152	1.324E+07
Eu-154	9.741E+06
Eu-155	6.645E+07
Nb-94	3.966E+07
Pu-238	1.388E+04
Pu-239/240	1.268E+04
Sr-90	8.075E+05
Th-232	1.341E+04
U-234	1.379E+05
U-235	1.496E+05
U-238	1.554E+05

A soil sample at this RRMG value would present an internal dose potential of 25 mrem under the Remote Work Area exposure scenario.

Table 5: Soils Project – Remote Work Area Exposure Scenario – Internal & External Dose

Radionuclide	**RRMG$_{(RWA-IE)}$** (pCi/g)
Ag-108m	6.204E+02
Am-241	9.239E+03
Cm-243	2.083E+03
Cm-244	2.715E+04
Co-60	1.225E+02
Cs-137	4.874E+02
Eu-152	2.557E+02
Eu-154	2.387E+02
Eu-155	6.406E+03
Nb-94	6.452E+02
Pu-238	1.390E+04
Pu-239/240	1.269E+04
Sr-90	5.522E+04
Th-232	3.292E+03
U-234	1.314E+05
U-235	1.709E+03
U-238	9.572E+03

A soil sample at this RRMG value would present a TED potential of 25 mrem under the Remote Work Area exposure scenario.

Table 6: Soils Project – Occasional Use Area Exposure Scenario – Internal Dose Only

Radionuclide	**RRMG$_{(OUA-I)}$** (pCi/g)
Ag-108m	2.762E+08
Am-241	4.555E+04
Cm-243	6.307E+04
Cm-244	7.68E+04
Co-60	7.421E+07
Cs-137	2.756E+07
Eu-152	8.174E+07
Eu-154	6.353E+07
Eu-155	4.751E+08
Nb-94	2.492E+08
Pu-238	3.922E+04
Pu-239/240	3.582E+04
Sr-90	9.949E+06
Th-232	3.852E+04
U-234	4.470E+05
U-235	4.922E+05
U-238	3.361E+05

A soil sample at this RRMG value would present an internal dose potential of 25 mrem under the Occasional Use Area exposure scenario.

Table 7: Soils Project – Occasional Use Area Exposure Scenario - Internal & External Dose

Radionuclide	**RRMG$_{(OUA-IE)}$** (pCi/g)
Ag-108m	2.087E+03
Am-241	2.797E+04
Cm-243	6.886E+03
Cm-244	7.653E+04
Co-60	4.122E+02
Cs-137	1.640E+03
Eu-152	8.604E+02
Eu-154	8.031E+02
Eu-155	2.156E+04
Nb-94	2.171E+03
Pu-238	3.915E+04
Pu-239/240	3.573E+04
Sr-90	1.955E+05
Th-232	1.062E+04
U-234	4.252E+05
U-235	5.749E+03
U-238	3.219E+04

A soil sample at this RRMG value would present a TED potential of 25 mrem under the Occasional Use Area exposure scenario.

References

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Appendix D

Closure Activity Summary

D.1.0 Closure Activity Summary

The following sections document closure activities completed for Baneberry. Surface soil samples, TLD measurements, and GWS measurements were collected to characterize the presence and lateral extent of radiological contamination at Baneberry.

D.1.1 Baneberry Closure Activities

Based on the results of this investigation, a corrective action of closure in place with a UR was implemented to encompass the area exceeding a dose of 25 mrem/RW-yr. The area includes the default contamination boundary (Figure A.3-5), which encompasses the crater and fissure.

The established FFACO UR for Baneberry is defined by the coordinates listed in the FFACO UR form and as illustrated in Attachment D-1. Additionally, an administrative UR was established around the area containing radioactivity at levels that can result in a dose exceeding the FAL based on the Industrial Area scenario to prevent more intensive use of the site in the future as discussed and illustrated in Attachment D-1 and Figure A.3-8. Both URs are recorded in the FFACO database, NNSA/NSO Facility Information Management System, and the NNSA/NSO CAU/CAS files. Permission to conduct the following restricted activities within the administrative UR area requires prior approval from NDEP:

- Full-time work assignments to the site
- Construction of facilities at the site
- Any activity that would result in a worker being assigned to a regular work station within the UR area

Attachment D-1

Use Restrictions

(4 Pages)

Use Restriction Information

CAU Number/Description: CAU 365, Baneberry Contamination Area

Applicable CAS Number/Description: 08-23-02, U-8d Contamination Area

Contact (Federal Sub-Project Director/Sub-Project): Kevin Cabble

FFACO Use Restriction Physical Description:

Surveyed Area (UTM, Zone 11, NAD 27, meters):

UR Points	Northing	Easting
Southeast	4,114,165.7	580,044.3
South	4,114,183.2	579,915.6
South	4,114,118.9	579,891.0
Southwest	4,114,079.1	579,744.6
West	4,114,179.7	579,718.2
Northwest	4,114,238.0	579,805.3
Northwest	4,114,257.9	579,889.4
North	4,114,333.3	579,939.4
North	4,114,346.8	579,999.8
Northeast	4,114,315.0	580,065.7
East	4,114,237.2	580,080.8

Depth: No depth limitation _

Survey Source (GPS, GIS, etc.): Heads-up digitizing

Basis for FFACO UR(s):

Summary Statement: This FFACO use restriction is to protect site workers from inadvertent exposure. Data from surface sampling indicate that a worker could potentially receive a 25-mrem dose in approximately 39 hours of exposure to the surface location with the maximum detected radioactivity. Also, radioactivity is assumed to be present at similar or higher levels within the crater and fissure. The analytical results and locations of all samples collected are presented in the CADD/CR for CAU 365.

Personnel are restricted from performing work in this area that would require personnel to be present for other than short-term activities. The permissible short-term activities include site visits, maintenance of the use restriction postings, maintenance of demarcation areas, and work on utilities. Any activities to be conducted within this area that are not consistent with these defined short-term activities require the prior notification to and approval of the NDEP.

Contaminants Table:

Maximum Concentration of Contaminants for CAU 365 CAS 08-23-02, U-8d Contamination Area			
Constituent	**Maximum Concentration**	**Action Level**	**Units**
TED	213.72	25	mrem/336 hours

Site Controls: The use restricted area encompasses the area where surface soil contamination exceeds the final action level. It is established at the boundary identified by the coordinates listed above and depicted in the attached figure. Site controls include warning signs placed on the use restriction boundary.

Administrative Use Restriction Physical Description*:

Surveyed Area (UTM, Zone 11, NAD 27, meters):

UR Points	Northing	Easting
Southeast	4,114,061.5	580,039.8
South	4,113,802.6	579,541.4
Southwest	4,114,019.7	579,427.3
West	4,114,417.8	579,872.7
West	4,114,810.4	579,956.2
Northwest	4,115,804.3	579,602.7
North	4,116,386.1	580,048.1
Northeast	4,116,230.2	580,462.9
East	4,115,286.5	580,515.8

Depth: No depth limitation

Survey Source (GPS, GIS, etc.): Heads-up digitizing

*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. Data from surface sampling indicate that a worker could potentially receive a 25-mrem dose in approximately 800 hours of exposure to the surface location with the maximum detected radioactivity. Current land use at this site does not require site workers to be present for this amount of exposure time. However, as a best management practice, this administrative use restriction will prevent a future (more intensive) use of the area. The analytical results and locations of all samples collected are presented in the CADD/CR for CAU 365.

Personnel are restricted from performing work in this location that would require any use of the area within the use restriction for activities that would result in a more intensive use of the site than the current land use. Activities included in the current land use would include short-duration activities such as site visits, maintenance of the use restriction postings, maintenance of demarcation areas, and work on utilities. Any activities to be conducted within this area that are not consistent with this defined current land use require the prior notification to and approval of the NDEP.

Contaminants Table:

Maximum Concentration of Contaminants for CAU 365 CAS 08-23-02, U-8d Contamination Area			
Constituent	**Maximum Concentration**	**Action Level**	**Units**
TED	70.4	25	mrem/2250 hours

Site Controls: This administrative use restriction area is established at the boundary identified by the coordinates listed above and depicted in the attached figure, but does not include the FFACO use restriction at this site.

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

Description: This administrative use restriction area is established at the boundary identified by the coordinates listed above and depicted in the attached figure but does not include the FFACO use restriction at this site. No site controls are required for this administrative use restriction other than the administrative controls for land use at the NNSS.

Inspection/Maintenance Frequency: Annual post-closure inspections will be conducted to ensure that postings are in place, intact, and legible.

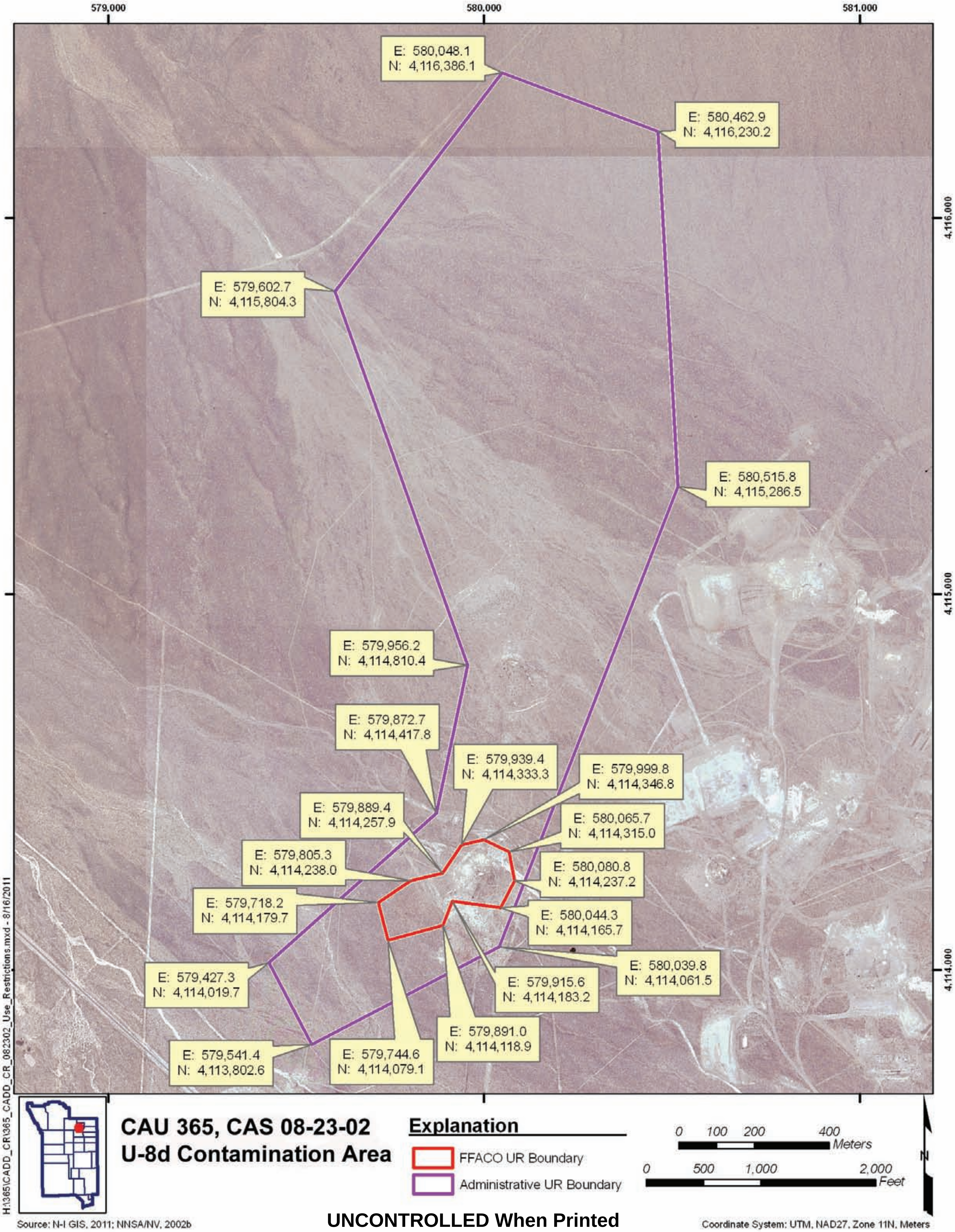
Use Restriction Information

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: Personnel are restricted from performing work in this location that would require any use of the area within the use restriction for activities that would result in a more intensive use of the site than the current land use (i.e., activities consistent with the Remote Work Area exposure scenario). Activities included in the current land use would include short duration activities such as site visits, maintenance of the use restriction postings, maintenance of demarcation areas, and work on utilities. Permission to conduct any restricted activities within this area requires notification to the NDEP.

Submitted By: /s/ Kevin Cabble **Date:** 9-26-11

Note: Effective upon acceptance of closure documents by NDEP.



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Appendix E

Corrective Action Alternatives

E.1.0 Corrective Action Alternatives

This appendix presents the corrective action objectives for Baneberry, describes the general standards and decision factors used to screen the various CAAs, and develops and evaluates a set of selected CAAs that will meet the corrective action objectives.

All CAAs for Baneberry are based on the presumption that all areas within the current NNSS boundary will be controlled in perpetuity and restricted from public release. As such, only industrial activities are permitted, and risks to receptors under residential scenarios will not be considered. Should the control of the NNSS change in the future to include public access or residential use, the selected CAAs may need to be reconsidered.

E.1.1 Corrective Action Objectives

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

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

- Treatment should be used to address principal threats wherever practicable and cost effective.
- Engineering controls, such as containment, should be used where wastes and contaminated media can be reliably contained, pose relatively low long-term threats, or for which treatment is impracticable.
- A combination of methods (e.g., treatment, engineering, and institutional controls) should be used, as appropriate, to protect human health and the environment.
- Institutional controls should be used primarily to supplement engineering controls as appropriate for short- or long-term management to prevent or limit exposure.

- Innovative technologies should be considered where such technologies offer potential for comparable or superior performance or implementability, less adverse impacts, or lower costs.

- Usable groundwater should be returned to maximum beneficial use wherever practicable.

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

Implementation of the corrective action will ensure that contaminants remaining at Baneberry will not pose an unacceptable risk to human health and the environment and that site conditions are in compliance with all applicable laws and regulations.

E.1.2 Screening Criteria

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

Corrective action alternatives are evaluated based on four general corrective action standards and five remedy selection decision factors. All CAAs must meet the four general standards to be selected for evaluation using the remedy selection decision factors.

The general corrective action standards are as follows:

- Protection of human health and the environment
- Compliance with media cleanup standards
- Control the source(s) of the release
- Comply with applicable federal, state, and local standards for waste management

The remedy selection decision factors are as follows:

- Short-term reliability and effectiveness
- Reduction of toxicity, mobility, and/or volume
- Long-term reliability and effectiveness
- Feasibility
- Cost

E.1.3 Corrective Action Standards

The following subsections describe the corrective action standards used to evaluate the CAAs.

Protection of Human Health and the Environment

Protection of human health and the environment is a general mandate of the RCRA statute (EPA, 1994). This mandate requires that the corrective action include any protective measures necessary to ensure the requirements are met. These measures may or may not be directly related to media cleanup, source control, or management of wastes.

Compliance with Media Cleanup Standards

The CAAs are evaluated for the ability to meet the proposed media cleanup standards. The media cleanup standards are the FALs.

Control the Source(s) of the Release

The CAAs are evaluated for the ability to stop further environmental degradation by controlling or eliminating additional releases that may pose a threat to human health and the environment. Unless source control measures are taken, efforts to clean up releases may be ineffective or, at best, will involve a perpetual cleanup. Therefore, each CAA must provide effective source control to ensure the long-term effectiveness and protectiveness of the corrective action.

Comply with Applicable Federal, State, and Local Standards for Waste Management

The CAAs are evaluated for the ability to be conducted in accordance with applicable federal and state regulations (e.g., 40 CFR 260 to 282, "Hazardous Waste Management" [CFR, 2011a]; 40 CFR 761, "Polychlorinated Biphenyls" [CFR, 2011b]; and NAC 444, "Sanitation" [NAC, 2011]).

E.1.3.1 Remedy Selection Decision Factors

The following text describes the remedy selection decision factors used to evaluate the CAAs.

Short-Term Reliability and Effectiveness

Each CAA must be evaluated with respect to its effects on human health and the environment during implementation of the selected corrective action. The following factors will be addressed for each alternative:

- Protection of the community from potential risks associated with implementation, (e.g., fugitive dusts, transportation of hazardous materials, and explosion)
- Protection of workers during implementation
- Adverse environmental impacts that may result from implementation
- The amount of time until the corrective action objectives are achieved

Reduction of Toxicity, Mobility, and/or Volume

Each CAA must be evaluated for its ability to reduce the toxicity, mobility, and/or volume of the contaminated media. Reduction in toxicity, mobility, and/or volume refers to changes in one or more characteristics of the contaminated media by using corrective measures that decrease the inherent threats associated with that media.

Long-Term Reliability and Effectiveness

Each CAA must be evaluated in terms of risk remaining at the site after the CAA has been implemented. The primary focus of this evaluation is on the extent and effectiveness of the control that may be required to manage the risk posed by treatment of residuals and/or untreated wastes.

Feasibility

The feasibility criterion addresses the technical and administrative feasibility of implementing a CAA and the availability of services and materials needed during implementation. Each CAA must be evaluated for the following criteria:

- Construction and Operation—The feasibility of implementing a CAA given the existing set of waste and site-specific conditions.
- Administrative Feasibility—The administrative activities needed to implement the CAA (e.g., permits, URs, public acceptance, rights of way, offsite approval).

- Availability of Services and Materials—The availability of adequate offsite and onsite treatment, storage capacity, disposal services, necessary technical services and materials, and prospective technologies for each CAA.

Cost

Costs for each alternative are estimated for comparison purposes only. The cost estimate for each CAA includes both capital, and operation and maintenance costs, as applicable, and is provided in Section E.3.0. The following is a brief description of each component:

- Capital Costs—Costs that include direct costs that may consist of materials, labor, construction materials, equipment purchase and rental, excavation and backfilling, sampling and analysis, waste disposal, demobilization, and health and safety measures. Indirect costs are separate and not included in the estimates.

- Operation and Maintenance—Separate costs that include labor, training, sampling and analysis, maintenance materials, utilities, and health and safety measures. These costs are not included in the estimates.

E.1.4 Development of CAAs

This section identifies and briefly describes the viable corrective action technologies and the CAAs considered for Baneberry. Contamination providing a dose exceeding the FAL of 25 mrem/RW-yr is present in surface soils and is assumed to be present in subsurface soils in the Baneberry crater and fissure.

Based on the review of existing data, future use, and current operations at the NNSS, the following alternatives have been developed for consideration at Baneberry:

- Alternative 1—No Further Action
- Alternative 2—Clean Closure
- Alternative 3—Closure in Place

E.1.4.1 Alternative 1—No Further Action

Under the no further action alternative, no corrective action activities will be implemented. This alternative is a baseline case with which to compare and assess the other CAAs and their ability to meet the corrective action standards.

E.1.4.2 Alternative 2—Clean Closure

Alternative 2 includes excavating and disposing of impacted soil and debris presenting a dose exceeding the 25-mrem/RW-yr FAL to a depth of 25 ft bgs (the maximum depth to which a construction activity might excavate for a building foundation or basement). A visual inspection will be conducted to ensure that contaminated surface debris has been removed before the completion of the corrective action. Verification soil samples will also be collected and analyzed for the presence of a dose exceeding the 25-mrem/RW-yr FAL following removal of contaminated soil. Contaminated materials removed will be disposed of at appropriate disposal facilities. Excavated areas will be returned to surface conditions compatible with the intended future use of the site.

E.1.4.3 Alternative 3—Closure in Place

For radiological contamination, Alternative 3 includes the implementation of a UR in an area where a radiological dose is present at levels that exceed the 25-mrem/RW-yr FAL to include the default contamination boundary. This UR will restrict inadvertent contact with contaminated media by prohibiting any activity that would cause a site worker to be exposed to a dose exceeding 25 mrem/yr. This alternative does not include the removal of soil within the 25-mrem/RW-yr FAL area.

E.1.5 Evaluation and Comparison of Alternatives

Each CAA presented in Section E.1.4 was evaluated based on the general corrective action standards listed in Section E.1.2. This evaluation is presented in Table E.1-1. Any CAA that does not meet the general corrective action standards will be removed from consideration.

Only CAAs 2 and 3 met the corrective action standards and will be further evaluated based on the remedy selection decision factors described in Section E.1.2. This evaluation is presented in Table E.1-2. For each remedy selection decision factor, the CAAs are ranked relative to one another. The CAA with the least desirable impact on the remedy selection decision factor will be given a ranking of 1. The CAAs with increasingly desirable impacts on the remedy selection decision factor will receive increasing rank numbers. The CAAs that will have an equal impact on the remedy selection decision factor will receive an equal ranking number. The scoring listed in this table represents the sum of the remedy selection decision factor rankings for each CAA.

Table E.1-1
Evaluation of General Corrective Action Standards

CAU 365, Baneberry Contamination Area		
CAA 1, No Further Action		
Standard	Comply?	Explanation
Protection of Human Health and the Environment	No	Contamination is present within the 25-mrem/RW-yr FAL boundary that could provide workers with a dose exceeding the 25-mrem/RW-yr FAL.
Compliance with Media Cleanup Standards	No	Contamination is present that could provide workers with a dose exceeding the 25-mrem/RW-yr FAL.
Control the Source(s) of the Release	Yes	Source is a one-time unique event.
Comply with Applicable Federal, State, and Local Standards for Waste Management	Yes	This alternative will not generate waste.
CAA 2, Clean Closure		
Standard	Comply?	Explanation
Protection of Human Health and the Environment	Yes	Contamination exceeding the risk-based action levels will be removed.
Compliance with Media Cleanup Standards	Yes	Contamination exceeding the risk-based action levels will be removed.
Control the Source(s) of the Release	Yes	Source is a one-time unique event.
Comply with Applicable Federal, State, and Local Standards for Waste Management	Yes	Excavated waste can be managed in compliance with all standards.
CAA 3, Closure in Place with Administrative Controls		
Standard	Comply?	Explanation
Protection of Human Health and the Environment	Yes	A UR will be implemented to warn workers about an inadvertant dose.
Compliance with Media Cleanup Standards	Yes	Although COCs will not be removed, site will be controlled to prevent workers from receiving a dose exceeding the 25-mrem/RW-yr FAL.
Control the Source(s) of the Release	Yes	Source is a one-time unique event.
Comply with Applicable Federal, State, and Local Standards for Waste Management	Yes	This alternative will not generate waste.

Table E.1-2
Evaluation of Remedy Selection Decision Factors

CAU 365, Baneberry Contamination Area		
CAA 1, No Further Action		
Factor	Rank	Explanation
Not evaluated, as this CAA did not meet the General Corrective Action Standards		
CAA 2, Clean Closure		
Standard	Rank	Explanation
Short-Term Reliability and Effectiveness	1	This alternative is reliable and effective, but involves increased short-term exposure of site workers to COCs during soil removal operations within the 25-mrem/RW-yr FAL boundary.
Reduction of Toxicity, Mobility, and/or Volume	2	This alternative will result in a decrease of toxicity and mobility, but will generate significant waste volumes.
Long-Term Reliability and Effectiveness	2	This alternative is reliable and effective at protecting human health and the environment because removal of the contaminated media will eliminate future exposure of site workers to COCs. However, the short-term exposure to site workers would increase.
Feasibility	1	Involves the removal of large quantities of soil. Stability of crater is unknown.
Cost	1	Cost to remove and dispose of contaminated soil and to place clean fill is estimated at $130 million.
Score	7	
CAA 3, Closure in Place with Administrative Controls		
Standard	Rank	Explanation
Short-Term Reliability and Effectiveness	2	This alternative is reliable and effective in providing increased protection of human health by preventing contact with COCs.
Reduction of Toxicity, Mobility, and/or Volume	1	This alternative will not reduce toxicity or mobility of the COCs that are present, but will not generate excavation waste volumes.
Long-Term Reliability and Effectiveness	1	This alternative is reliable in the long term with ongoing maintenance. It is effective in providing protection of human health by preventing inadvertent contact with COCs.
Feasibility	2	This alternative requires maintenance and long-term monitoring because no soil is removed.
Cost	2	The installation costs are estimated at $45,000. Ongoing maintenance costs for this alternative are estimated at $4,000 annually.
Score	8	

The five EPA remedy selection decision factors are short-term reliability and effectiveness; reduction of toxicity, mobility, and/or volume; long-term reliability and effectiveness; feasibility; and cost. These factors are provided in Table E.1-2.

The first remedy selection decision factor—short-term reliability and effectiveness—is a qualitative measure of the impacts on human health and the environment during implementation of the CAA. While clean closure is both reliable and effective in the long term, this alternative involves increased short-term exposure of, and increased risk to, site workers during radiologically contaminated soil and debris removal. In contrast, closure in place does not require removal of soil, and there is no short-term exposure of site workers; signs are posted, and disturbance of contaminated soil and debris is not necessary.

The second remedy selection decision factor—reduction of toxicity, mobility, and/or volume—is a qualitative measure of changes in characteristics of contaminated media that result from implementation of the CAA. Under clean closure, contaminated media that exceed FALs (to a depth of 25 ft bgs) would be removed from the area, thereby eliminating both mobility and the onsite volume of contaminated media. In contrast, closure in place does not reduce toxicity, mobility, or volume.

The third remedy selection decision factor—long-term reliability and effectiveness—is a qualitative evaluation of performance following site closure, and into the future. Removal of contaminated media for clean closure provides long-term reliability and effectiveness, whereas closure in place does not.

The fourth remedy selection decision factor—feasibility—includes an evaluation of the requirements for construction and operation as well as administrative constraints. For the closure in place alternative, no construction is required other than the installation of postings. Some maintenance, inspection, and administrative requirements would be onging. For the clean closure alternative, substantial construction, operation, and administrative actions consistent with soil removal and management of generated wastes are needed.

The fifth remedy selection decision factor—cost—includes assessment of both capital (direct) costs of implementation and costs for operation and maintenance of the corrective action. As shown in

Table E.1-2, the estimated cost for clean closure would exceed $130 million because of extensive soil removal, placement, and disposal operations. The costs for closure in place include the costs from acquiring, hanging, inspecting, and occasionally replacing UR signs. These activities are estimated to be $45,000 for the first year and $4,000 for each year thereafter for maintenance.

E.2.0 Recommended Alternative

Three CAAs were evaluated for Baneberry: no further action (CAA 1), clean closure (CAA 2), and closure in place (CAA 3). Only CAA 2 and CAA 3 met all requirements for general corrective action standards (Section E.1.2). In general, for the clean closure alternative, near-surface soils would be removed from the site to a depth of 25 ft bgs. For the closure in place alternative, potential worker exposure to radiological contamination would be controlled through the implementation of URs. Both CAAs would, therefore, be protective of human health and the environment, comply with media cleanup standards, and control the source of release. As supported by the following discussion, further examination of the two CAAs by the five EPA remedy selection decision factors resulted in the selection of closure in place as the preferred CAA for Baneberry.

Based upon the five remedy selection decision factors, clean closure received an overall score of 7 (less desirable), whereas closure in place received an overall score of 8 (more desirable). This result was the product of not only an examination of the two CAAs by the five remedy selection decision factors, but also consideration of the current NNSS administrative controls (e.g., NNSS access restrictions and control of site activities), the remoteness of the site, no nearby structures or activities, no current or planned use of the site, the present-day stability of the contaminated soil at the site through the evolution of a mature plant community, and the development of soil surface durability (i.e., soil crust). Also, the clean closure alternative is not feasible at this site. The subsurface contamination at Baneberry is located within a fissure and subsidence crater area. As this area is still subject to potential future subsidence, excavation workers removing the contaminated subsurface material would be subject to unacceptable risk. The subsurface contamination at Baneberry is located underneath the surface expression of the fissure and a 78-ft-deep crater. To excavate this contaminated material would require the removal of approximately 487,227 yd^3 of contaminated material. Currently, this contaminated material beneath the Baneberry crater is covered by clean eroded material and is not accessible to workers or the public. Therefore, the removal of this material would pose a greater risk to human health than restricting access through postings and a UR. In addition, the cost of the removal effort effectively makes the clean closure alternative infeasible because cleaning to 25 ft would not remove all contamination.

Therefore, selection of the CAA of closure in place for Baneberry is consistent with past practices for CASs that contain similar radiological COCs and where there would be significant costs and short-term health risks to workers involved in cleanup activities. However, if the control of the NNSS should change in the future to include public access or residential use, the selected CAA may need to be reconsidered.

E.3.0 Cost Estimates

The cost estimate for clean closure is estimated to exceed $130 million to conduct the following activities:

- Preparation and procurement
- Grub surface contamination
- Excavate, load, and dispose of contaminated soil (approximately 487,227 yd^3)
- Dispose of debris
- Backfill with clean soil
- Equipment decontamination

The estimated costs for clean closure of Baneberry was based on removing contaminated soil within the 25 mrem/RW-yr boundary and replacing with clean backfill. Specifically, soil within the corrective action boundary that includes the default contamination boundary (posted fissure and crater) area at Baneberry would be removed. The cost for clean closure of Baneberry was estimated to be more than $130 million.

The costs for closure in place, however, are limited to those derived from acquiring, hanging, inspecting, and occasionally replacing UR signs, and are estimated to be approximately $45,000 for the first year and $4,000 for each year thereafter.

E.4.0 References

CFR, see *Code of Federal Regulations*.

Code of Federal Regulations. 2011a. Title 40 CFR, Parts 260 to 282, “Hazardous Waste Management.” Washington, DC: U.S. Government Printing Office.

Code of Federal Regulations. 2011b. Title 40 CFR 761, “Polychlorinated Biphenyls (PCBs) Manufacturing, Processing, Distribution in Commerce, and Use Prohibitions.” Washington, DC: U.S. Government Printing Office.

EPA, see U.S. Environmental Protection Agency.

Laws, E.P., and S.A. Herman, U.S. Environmental Protection Agency. 1997. Memorandum to RCRA/CERCLA Senior Policy Managers Region I–X titled “Use of the Corrective Action Advance Notice of Proposed Rulemaking as Guidance,” 17 January. Washington, DC: Offices of Solid Waste and Emergency Response, and Enforcement and Compliance Assurance.

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Nevada Administrative Code. 2011. NAC 444, “Sanitation.” Carson City, NV. As accessed at http://www.leg.state.nv.us/nac on 22 July.

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U.S. Environmental Protection Agency. 1994. *Final RCRA Corrective Action Plan,* EPA/520-R-94-004. Washington, DC: Office of Solid Waste and Emergency Response.

U.S. Environmental Protection Agency. 1996. “Corrective Action for Releases from Solid Waste Management Units at Hazardous Waste Management Facilities,” 1 May. In *Federal Register,* Vol. 61, No. 85.

Appendix F

Sample Analytical Data

F.1.0 Sample Analytical Data

Analytical results for radionuclide and chemical environmental samples collected at Baneberry that were detected above MDCs are presented in the following tables. Included are the results from radionuclide environmental samples collected at the sample plots that were detected above MDCs. Because individual radionuclide results were not used for decisions, these results are presented in this appendix for completeness.

Soil samples were collected from eight locations at the Baneberry site. Radiological analysis was completed at all locations selected for soil sampling to investigate the primary and other releases with the following results:

- Sample results for gamma-emitting radionuclides detected at Baneberry are presented in Table F.1-1.
- Results for detected isotopic analysis are provided in Table F.1-2.

Chemical analysis was performed at two locations to support the investigation of other releases with the following results:

- Sample results for VOCs detected are provided in Table A.3-5.
- Results for detected SVOCs are provided in Table A.3-6.
- Results for detected metals are provided in Table A.3-7.

Results for TLDs staged at Baneberry soil sample plots are presented in Table F.1-3. Results for TLDs staged at Baneberry field background locations are presented in Table F.1-4.

Table F.1-1
Sample Results for Gamma-Emitting Radionuclides Detected above MDCs at Baneberry (pCi/g)

Sample Location	Sample Number	Depth (cm bgs)	Ac-228	Am-241	Co-60	Cs-137	Nb-94
A98	365A001	0–5	--	101	110	9,330	12
A99	365A605	0–5	--	14.8 (J)	15.5	1,340	1.78
	365A606	0–5	--	16.4	16.5	1,400	2.01
	365A607	0–5	--	16.9	16.4	1,460	2.01
	365A608	0–5	--	21.6	21.8	1,930	2.87
A100	365A601	0–5	--	22.4 (J)	21.7	1,720	2.77
	365A602	0–5	--	35 (J)	33.8	2,170	4.17
	365A603	0–5	--	22 (J)	20.3	1,510	2.53
	365A604	0–5	3.1	19 (J)	17.7	1,340	2.18
A101	365A008	0–5	1.57	3.87 (J)	1.92	94	0.271
	365A009	5–10	1.38	4.22 (J)	3.26	157	0.336
A102	365A006	0–5	1.46	1.2 (J)	1.01	47.9	0.158
	365A007	25–30	1.82	3.46 (J)	1.68	108	0.187
A103	365A002	0–5	1.52	3.59 (J)	2.86	199	0.38
	365A003	0–5	1.8	4.19 (J)	3.49	241	0.459
A104	365A004	0–5	1.44	--	--	1.81	--
	365A005	0–5	1.81	--	--	1.98	--
A105	365A010	0–6 (in.)	2.13	0.52 (J)	0.381	29.4	--
	365A011	0–6 (in.)	2.78	--	--	1.69	--

Nb = Niobium

J = Estimated value
-- = Not detected above MDCs

Table F.1-2
Sample Results for Isotopes Detected above MDCs at Baneberry (pCi/g)

Sample Location	Sample Number	Depth (cm bgs)	Pu-238	Pu-239/240	Sr-90
A98	365A001	0–5	--	--	136
A99	365A605	0–5	--	--	262
	365A606	0–5	--	--	319
	365A607	0–5	--	--	315
	365A608	0–5	--	--	384
A100	365A601	0–5	--	--	654
	365A602	0–5	--	--	354
	365A603	0–5	--	--	261
	365A604	0–5	--	--	300
A101	365A008	0–5	--	--	0.965
	365A009	5–10	--	--	2.88
A102	365A006	0–5	--	--	0.954
	365A007	25–30	--	--	1.56
A103	365A002	0–5	--	--	2.94
	365A003	0–5	--	--	1.91
A105	365A010	0–6 (in.)	0.0596	0.337	0.473

-- = Not detected above MDCs

Table F.1-3
TLD Results for Soil Sample Plots at Baneberry (mrem/IA-yr)

Sample Plot (Location)	Element 1	Element 2	Element 3	Element 4	Element 5	Element 6
Plot A (A100)	788	733	694	731	728	680
Plot B (A99)	707	676	624	698	669	653

Table F.1-4
Background TLD Results for Baneberry (mrem/IA-yr)

Location	Element 1	Element 2	Element 3
A201	26.9	29.2	27.2
A202	31.6	30.9	29.3
A203	32.2	32.0	30.1
A204	35.6	33.8	33.0

Appendix G

Sample Location Coordinates

G.1.0 Sample Location Coordinates

The coordinates for sample plots, TLDs, judgmental samples, and background locations were collected. The center of each sample plot, and the locations of TLDs and individual (judgmental) sample locations for Baneberry were surveyed using a GPS instrument. Survey coordinates for sample plot and TLD locations are listed in Table G.1-1.

Nine aliquot sample locations were established at each plot for each composite sample (4 composite samples, 36 aliquot sample locations). A systematic triangular grid pattern was used based on a randomly generated origin or starting point. In some cases, aliquot locations were moved due to surface/subsurface obstructions or conditions (e.g., rocks, vegetation, and animal burrows). These offsets (distance and direction) of each aliquot location were recorded in the project files.

The GPS coordinates for the background TLD locations are presented in Table G.1-2. The GPS coordinates for judgemental sample locations investigated as part of other releases are listed in Table G.1-3.

Table G.1-1
Sample Plot and TLD Locations for the Primary Release at Baneberry
(Page 1 of 5)

Sample Plot/Location	Easting[a]	Northing[a]
Sample Plot Locations[b]		
Sample Plot B/A99	579,848.3	4,114,171.9
Sample Plot A/A100	579,886.9	4,114,195.2
TLD Locations		
A01	578,142.8	4,112,879.1
A02	578,440.4	4,113,101.6
A03	578,781.6	4,113,358.5
A04	578,793.2	4,113,561.2
A05	578,942.6	4,113,477.0
A06	579,264.4	4,113,292.8
A07	579,668.6	4,113,313.1
A08	579,146.7	4,113,627.7

Table G.1-1
Sample Plot and TLD Locations for the Primary Release at Baneberry
(Page 2 of 5)

Sample Plot/Location	Easting[a]	Northing[a]
A09	578,840.4	4,113,804.4
A10	579,146.7	4,113,825.1
A11	579,288.9	4,113,737.0
A12	579,516.1	4,113,608.5
A13	579,760.6	4,113,454.9
A14	580,105.4	4,113,493.7
A15	579,951.3	4,113,587.4
A16	579,708.5	4,113,726.4
A17	579,466.2	4,113,869.7
A18	579,245.6	4,113,995.8
A19	579,041.5	4,114,119.7
A20	578,998.8	4,114,374.5
A21	579,258.2	4,114,224.4
A22	579,449.4	4,114,108.0
A23	579,646.5	4,113,998.6
A24	579,732.5	4,114,064.5
A25	579,837.7	4,113,888.3
A26	580,078.4	4,113,742.5
A27	580,213.7	4,113,672.1
A28	580,742.6	4,113,683.6
A29	580,412.3	4,113,853.9
A30	580,241.0	4,113,943.2
A31	580,030.0	4,114,056.4
A32	579,923.8	4,114,102.8
A33	579,928.8	4,114,188.6
A34	579,842.6	4,114,149.9
A35	579,736.1	4,114,206.4
A36	579,653.1	4,114,247.3
A37	579,429.8	4,114,362.4

Table G.1-1
Sample Plot and TLD Locations for the Primary Release at Baneberry
(Page 3 of 5)

Sample Plot/Location	Easting[a]	Northing[a]
A38	579,286.3	4,114,437.7
A39	579,105.7	4,114,531.0
A40	578,748.9	4,114,714.4
A41	578,374.2	4,114,909.6
A42	579,353.8	4,114,603.2
A43	579,592.0	4,114,516.7
A44	579,828.8	4,114,413.4
A45	580,049.3	4,114,325.1
A46	580,060.9	4,114,216.7
A47	580,345.6	4,114,206.1
A48	580,583.4	4,114,100.8
A49	580,579.4	4,114,303.3
A50	580,337.6	4,114,421.8
A51	580,089.6	4,114,531.9
A52	579,847.5	4,114,621.0
A53	579,606.9	4,114,724.0
A54	579,342.1	4,114,835.0
A55	579,153.4	4,114,933.2
A56	579,260.9	4,115,317.2
A57	579,690.5	4,115,020.6
A58	579,990.3	4,115,072.0
A59	580,559.8	4,114,793.3
A60	580,413.2	4,115,073.1
A61	580,037.5	4,115,300.8
A62	579,724.0	4,115,324.1
A63	579,279.2	4,115,848.8
A64	579,542.7	4,115,733.3
A65	579,709.0	4,115,660.8
A66	579,908.4	4,115,574.5

Table G.1-1
Sample Plot and TLD Locations for the Primary Release at Baneberry
(Page 4 of 5)

Sample Plot/Location	Easting[a]	Northing[a]
A67	580,103.8	4,115,502.5
A68	580,276.8	4,115,414.7
A69	580,463.3	4,115,341.2
A70	580,661.1	4,115,248.4
A71	580,126.3	4,115,640.0
A72	579,948.3	4,115,721.4
A73	579,787.0	4,116,020.9
A74	580,175.8	4,115,905.1
A75	580,226.0	4,116,092.2
A76	580,452.9	4,115,813.7
A77	580,930.9	4,115,586.4
A78	581,105.8	4,116,302.1
A79	580,566.5	4,116,232.3
A80	580,269.0	4,116,313.4
A81	580,325.4	4,116,527.2
A82	579,881.50	4,116,390.0
A83	579,503.9	4,116,429.9
A84	579,680.7	4,117,161.6
A85	579,996.5	4,116,877.4
A86	580,353.1	4,116,723.7
A87	580,397.4	4,116,869.8
A88	580,677.9	4,116,734.1
A89	581,224.5	4,116,831.6
A90	580,724.0	4,117,113.9
A91	580,457.8	4,117,107.7
A92	580,503.7	4,117,304.8
A93	580,546.6	4,117,518.7
A94	581,261.8	4,117,690.9
A95	580,602.5	4,117,719.5

Table G.1-1
Sample Plot and TLD Locations for the Primary Release at Baneberry
(Page 5 of 5)

Sample Plot/Location	Easting[a]	Northing[a]
A96	580,671.2	4,117,882.6
A98	579,842.7	4,114,177.3
A99	579,848.3	4,114,171.9
A100	579,886.9	4,114,195.2

[a]UTM Zone 11, NAD 1927 (U.S. Western) in meters.
[b]Coordinates for the sample plots listed are from the southwest corner.

Table G.1-2
Background TLD Location Coordinates for Baneberry

Background Location	Easting[a]	Northing[a]
A200	578,784.6	4,117,232.9
A201	577,952.6	4,116,530.9
A202	577,715.2	4,115,091.0
A203	578,844.6	4,113,075.5
A204	579,816.9	4,113,232.7

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

Table G.1-3
Other Release Sample Location Coordinates for Baneberry

Sample Location	Easting[a]	Northing[a]
A98 (Grab Sample)	579,842.7	4,114,177.3
A101, Drainage	580,287.5	4,115,396.7
A102, Drainage	580,415.5	4,115,348.8
A103, Drainage	580,490.0	4,115,289.8
A104, Cellar Structure	579,668.2	4,114,709.1
A105, Dry-Cell Batteries	579,862.2	4,114,039.1
A106, Drainage	580,544.7	4,115,225.8
A107, Drainage	580,525.4	4,115,246.6
A108, Drainage	580,986.3	4,114,832.0
A109, Drainage	580,625.1	4,115,162.9
A110, Drainage	580,599.9	4,115,209.1

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

Appendix H

Nevada Division of Environmental Protection Comments

(1 Page)

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Decision Document/Closure Report for Corrective Action Unit 365: Baneberry Contamination Area, Nevada National Security Site, Nevada	**2. Document Date:**	8/18/2011
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	9/19/2011
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850 ext. 233	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
1.) General	Mandatory	The closure alternative selected for CAS 08-23-02 is closure in place with Land Use Restriction, due to radiological doses exceeding the FAL outside (southwest) and inside the crater (presumed). In the final document, add language to the Executive Summary as well as to Sections 2.3 and 3.0 which clearly states this and is consistent with the closure alternative. These sections currently indicate that no further corrective action is necessary and are without reference to closure in place with UR.	Changes to the document were made to clarify that the reason no further corrective action is required is because the corrective action of closure in place with use restrictions was implemented. We include the statement that no further corrective action is required in order to comply with the FFACO outline instructions and note that there may be some confusion between the term “no further corrective action” and the corrective action of “no further action.” Revisions were made to clarify the following cited sections: **Executive Summary:** Replace "administrative controls" with "a use restriction (UR)" in the first sentence of the second paragraph. Replace the last sentence of the fourth paragraph with "Corrective actions were undertaken that consisted of establishing a UR and posting warning signs for the crater, fissure, and the area located to the southwest of the crater where soil concentrations exceeded the FAL." **Section 2.3** Insert the following sentence between the first and second sentences "The UR encompasses the crater and the area where surface soil contamination exceeds the FAL of 25 mrem/RW-yr (southwest of the crater)." **Section 3.0** Eight paragraph, first sentence: Add to the end, "...of closure in place with a UR."	

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