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DOE/NV--1474

National Nuclear Security Administration

Corrective Action Investigation Plan for Corrective Action Unit 569: Area 3 Yucca Flat Atmospheric Test Sites Nevada National Security Site, Nevada

Controlled Copy No.: ___
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Environmental Restoration
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CORRECTIVE ACTION INVESTIGATION PLAN FOR CORRECTIVE ACTION UNIT 569: AREA 3 YUCCA FLAT ATMOSPHERIC TEST SITES NEVADA NATIONAL SECURITY SITE, NEVADA

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

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Derivative Classifier: Joseph P. Johnston/N-I CO
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Signature: /s/ Joseph P. Johnston
Date: 02/13/2012

CORRECTIVE ACTION INVESTIGATION PLAN FOR
CORRECTIVE ACTION UNIT 569:
AREA 3 YUCCA FLAT ATMOSPHERIC TEST SITES
NEVADA NATIONAL SECURITY SITE, NEVADA

Approved by: /s/ Kevin J. Cabble Date: 2/13/12
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Approved by: /s/ Robert F. Boehlecke Date: 2/13/12
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Federal Project Director
Environmental Restoration Project

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List of Acronyms and Abbreviations

Ac	Actinium
Ag	Silver
Am	Americium
ASTM	ASTM International
bgs	Below ground surface
BJY	Buster Jangle Y
CA	Contamination area
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
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
cm	Centimeter
cm^3	Cubic centimeter
Cm	Curium
Co	Cobalt
COC	Contaminant of concern
COPC	Contaminant of potential concern
cps	Counts per second
Cs	Cesium
CSM	Conceptual site model

List of Acronyms and Abbreviations *(Continued)*

CZ	Contamination zone
DCB	Default contamination boundary
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQI	Data quality indicator
DQO	Data quality objective
EPA	U.S. Environmental Protection Agency
Eu	Europium
FAL	Final action level
FFACO	*Federal Facility Agreement and Consent Order*
FIDLER	Field instrument for the detection of low-energy radiation
FSL	Field-screening level
FSR	Field-screening result
ft	Foot
GPS	Global Positioning System
g/yr	Grams per year
GZ	Ground zero
HWAA	Hazardous waste accumulation area
ICRP	International Commission on Radiological Protection
IDW	Investigation-derived waste
in.	Inch
in./yr	Inches per year
K	Potassium
keV	Kiloelectron volt
kt	Kiloton
LCS	Laboratory control sample

List of Acronyms and Abbreviations *(Continued)*

m	Meter
m^2	Square meter
m/yr	Meters per year
MDC	Minimum detectable concentration
mg/day	Milligrams per day
mi	Mile
mm/yr	Millimeters per year
mrem	Millirem
mrem/IA-yr	Millirem per Industrial Area year
mrem/OA-yr	Millirem per Occasional Use Area year
mrem/RW-yr	Millirem per Remote Work Area year
mrem/yr	Millirem per year
MS	Matrix spike
MSD	Matrix spike duplicate
N/A	Not applicable
NAC	*Nevada Administrative Code*
NAD	North American Datum
NAEG	Nevada Applied Ecology Group
Nb	Niobium
ND	Normalized difference
NDEP	Nevada Division of Environmental Protection
NEPA	*National Environmental Policy Act*
N-I	Navarro-Intera, LLC
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
NTS	Nevada Test Site
PAL	Preliminary action level
Pb	Lead
PCB	Polychlorinated biphenyl
pCi/g	Picocuries per gram
PET	Potential evapotranspiration
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
RBCA	Risk-based corrective action
RBSL	Risk-based screening level
RCRA	*Resource Conservation and Recovery Act*
REOP	Real Estate/Operations Permit
RESRAD	Residual Radioactive
RIDP	Radionuclide Inventory and Distribution Program
RL	Reporting limit
RMA	Radioactive material area
RPD	Relative percent difference
RRMG	Residual radioactive material guideline
RWMS	Radioactive waste management site
Sr	Strontium

List of Acronyms and Abbreviations *(Continued)*

SSTL	Site-specific target level
SVOC	Semivolatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
TED	Total effective dose
Th	Thorium
Tl	Thallium
TLD	Thermoluminescent dosimeter
TPH	Total petroleum hydrocarbons
TSCA	*Toxic Substances Control Act*
U	Uranium
UCL	Upper confidence limit
UGTA	Underground Test Area
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
WAC	Waste Acceptance Criteria
yd^3	Cubic yard
%R	Percent recovery

Executive Summary

Corrective Action Unit (CAU) 569 is located in Area 3 of the Nevada National Security Site, which is approximately 65 miles northwest of Las Vegas, Nevada. Corrective Action Unit 569 comprises the nine numbered corrective action sites (CASs) and one newly identified site listed below:

- 03-23-09, T-3 Contamination Area (hereafter referred to as Annie, Franklin, George, and Moth)
- 03-23-10, T-3A Contamination Area (hereafter referred to as Harry and Hornet)
- 03-23-11, T-3B Contamination Area (hereafter referred to as Fizeau)
- 03-23-12, T-3S Contamination Area (hereafter referred to as Rio Arriba)
- 03-23-13, T-3T Contamination Area (hereafter referred to as Catron)
- 03-23-14, T-3V Contamination Area (hereafter referred to as Humboldt)
- 03-23-15, S-3G Contamination Area (hereafter referred to as Coulomb-B)
- 03-23-16, S-3H Contamination Area (hereafter referred to as Coulomb-A)
- 03-23-21, Pike Contamination Area (hereafter referred to as Pike)
- Waste Consolidation Site 3A

Because CAU 569 is a complicated site containing many types of releases, it was agreed during the data quality objectives (DQO) process that these sites will be grouped into the following seven study groups based on geographic proximity to simplify the investigation of these sites:

Study Group	Site	CAS	Type
1	Catron, Coulomb-B	03-23-13, 03-23-15	Atmospheric Safety Experiments
2	Pike	03-23-21	Weapons-Related Underground Test (which vented)
3	Annie, Franklin, George, Moth	03-23-09	Weapons-Related Tower Tests
4	Humboldt	03-23-14	Weapons-Related Tower Test
5	Harry, Hornet, Rio Arriba	03-23-10, 03-23-12	Weapons-Related Tower Tests
	Coulomb-A	03-23-16	Atmospheric Safety Experiment
6	Fizeau	03-23-11	Weapons-Related Tower Test
7	Waste Consolidation Site 3A	N/A	Associated with Atmospheric Testing Operations

N/A = Not applicable

These sites are being investigated because existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend corrective action alternatives (CAAs). Additional information will be obtained by conducting a corrective action investigation before

evaluating CAAs and selecting the appropriate corrective action for each study group. The results of the field investigation will support a defensible evaluation of viable CAAs that will be presented in the Corrective Action Decision Document.

The sites will be investigated based on the DQOs developed on September 26, 2011, by representatives of the Nevada Division of Environmental Protection and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office. The DQO process was used to identify and define the type, amount, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 569.

The presence and nature of contamination at CAU 569 will be evaluated based on information collected from a field investigation. Radiological contamination will be evaluated based on a comparison of the total effective dose (TED) at sample locations to the dose-based final action level (FAL). The TED will be calculated as the total of separate estimates of internal and external dose. Results from the analysis of soil samples will be used to calculate internal radiological dose. Thermoluminescent dosimeters placed at the center of each sample location will be used to measure external radiological dose.

A field investigation will be performed to define any areas where TED exceeds the FAL and to determine whether contaminants of concern are present at the site from other potential releases.

The presence and nature of contamination from other types of releases (e.g., excavation, migration, and any potential releases discovered during the investigation) will be evaluated using soil samples collected from biased locations indicating the highest levels of contamination.

Appendix A provides a detailed discussion of the DQO methodology and the objectives specific to each study group.

This Corrective Action Investigation Plan has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) that was agreed to by the State of Nevada; DOE, Environmental Management; U.S. Department of Defense; and DOE, Legacy Management. Under the FFACO, this Corrective Action Investigation Plan will be submitted to the Nevada Division of Environmental Protection for approval. Fieldwork will be conducted after the plan is approved by NDEP.

1.0 Introduction

This Corrective Action Investigation Plan (CAIP) contains project-specific information, including facility descriptions, environmental sample collection objectives, and criteria for conducting site investigation activities at Corrective Action Unit (CAU) 569: Area 3 Yucca Flat Atmospheric Test Sites, Nevada National Security Site (NNSS), Nevada.

This CAIP has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management.

Corrective Action Unit 569 is located in Area 3 of the NNSS (formerly the Nevada Test Site [NTS]), which is approximately 65 miles (mi) northwest of Las Vegas, Nevada. Corrective Action Unit 569 comprises the nine numbered corrective action sites (CASs) and one newly identified site listed below:

- 03-23-09, T-3 Contamination Area (hereafter referred to as Annie, Franklin, George, and Moth)
- 03-23-10, T-3A Contamination Area (hereafter referred to as Harry and Hornet)
- 03-23-11, T-3B Contamination Area (hereafter referred to as Fizeau)
- 03-23-12, T-3S Contamination Area (hereafter referred to as Rio Arriba)
- 03-23-13, T-3T Contamination Area (hereafter referred to as Catron)
- 03-23-14, T-3V Contamination Area (hereafter referred to as Humboldt)
- 03-23-15, S-3G Contamination Area (hereafter referred to as Coulomb-B)
- 03-23-16, S-3H Contamination Area (hereafter referred to as Coulomb-A)
- 03-23-21, Pike Contamination Area (hereafter referred to as Pike)
- Waste Consolidation Site 3A

Corrective Action Unit 569 is a complicated site containing many types of releases. The nine CASs and one waste consolidation site were grouped into seven study groups based on geographic proximity to simplify the investigation. The study groups are listed in Table 1-1 and shown on Figure 1-1.

The corrective action investigation (CAI) will include field inspections, radiological surveys, geophysical surveys, sampling of environmental media, analysis of samples, and assessment of

Table 1-1
Study Groups

Study Group	Site	CAS	Type
1	Catron, Coulomb-B	03-23-13, 03-23-15	Atmospheric Safety Experiments
2	Pike	03-23-21	Weapons-Related Underground Test (which vented)
3	Annie, Franklin, George, Moth	03-23-09	Weapons-Related Tower Tests
4	Humboldt	03-23-14	Weapons-Related Tower Test
5	Harry, Hornet, Rio Arriba	03-23-10, 03-23-12	Weapons-Related Tower Tests
	Coulomb-A	03-23-16	Atmospheric Safety Experiment
6	Fizeau	03-23-11	Weapons-Related Tower Test
7	Waste Consolidation Site 3A	N/A	Associated with Atmospheric Testing Operations

N/A = Not applicable

investigation results. Data will be obtained to support corrective action alternative (CAA) evaluations and waste management decisions.

1.1 Purpose

The study groups in CAU 569 are being investigated because hazardous and/or radioactive contaminants may be present in concentrations that exceed risk-based corrective action (RBCA) levels. Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the study groups. Additional information will be generated by conducting a CAI before evaluating and selecting CAAs.

1.1.1 CAU 569 History and Description

Corrective Action Unit 569, Area 3 Yucca Flat Atmospheric Test Sites, is located in the western portion of Area 3. This CAU consists of 7 study groups comprising 9 CASs and 1 inactive waste consolidation site. At these 9 CASs, at total of 13 tests were conducted. These 13 tests include 1 underground test, 9 weapons-related tower tests, 1 tower safety experiment, and 2 surface safety experiments. The CAU 569 sites were used to support nuclear testing conducted in the Yucca Flat

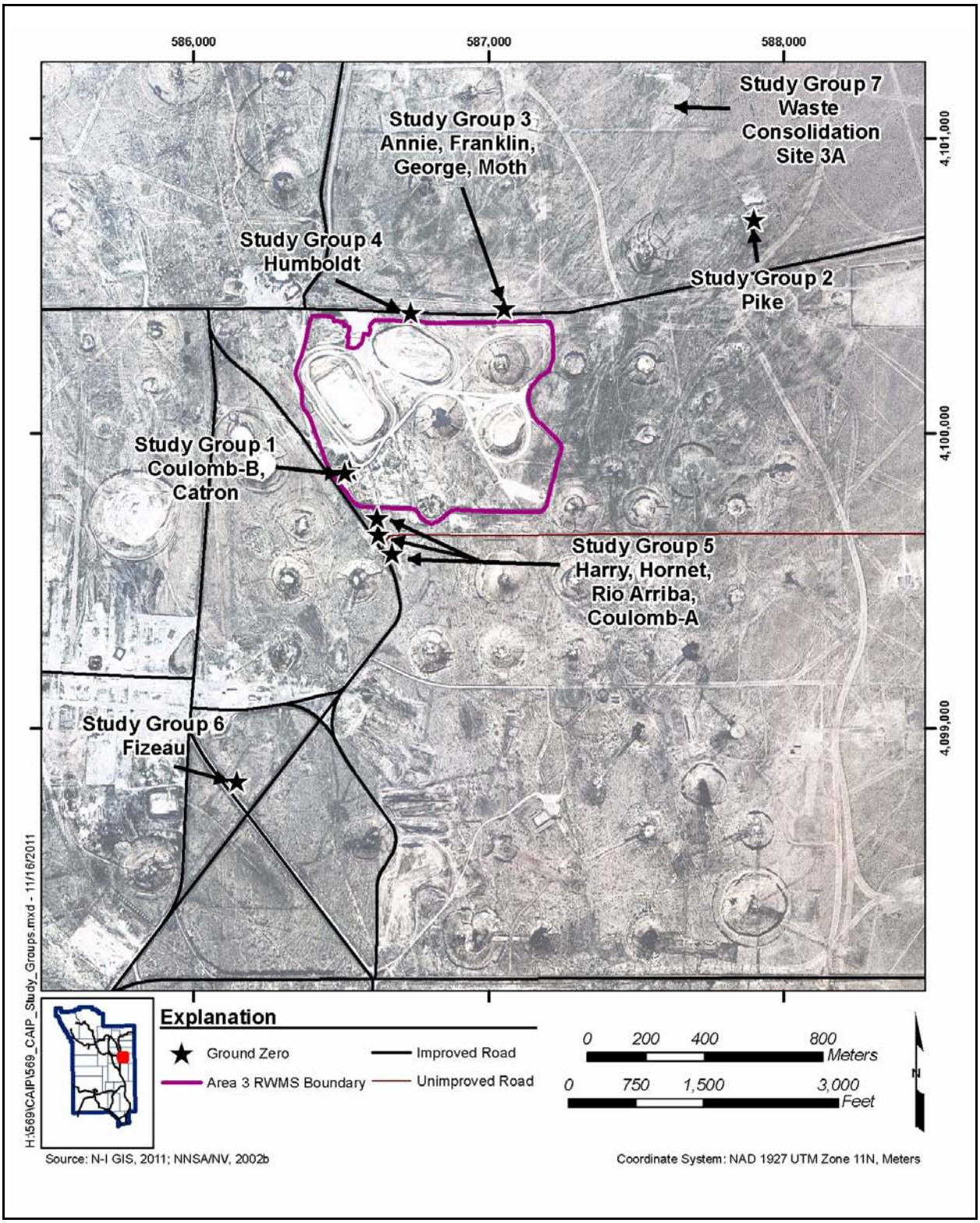

Figure 1-1
CAU 569 Study Group Location Map

area from the 1950s through the 1960s. Operational histories for each CAU 569 study group are detailed in Section 2.2.

1.1.2 Data Quality Objective Summary

The study groups will be investigated based on data quality objectives (DQOs) developed by representatives of the Nevada Division of Environmental Protection (NDEP) and the DOE, National Nuclear Security Administration Nevada Site Office (NNSA/NSO). The DQOs are used to identify and define the type, amount, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 569. This CAIP describes the investigative approach developed to collect the necessary data identified in the DQO process. Discussions of the DQO methodology and the DQOs specific to each CAS are presented in Appendix A. A summary of the DQO process is provided below.

The DQO problem statement for CAU 569 is as follows: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the study groups in CAU 569." To address this problem, resolution of the following decision statements is required:

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

- **Decision II.** "Is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include the following:
  - The lateral and vertical extent of COC contamination
  - The information needed to predict potential remediation waste types and volumes
  - Any other information needed to evaluate the feasibility of remediation alternatives

A corrective action will be determined for any site containing a COC. The evaluation of the need for corrective action will include the potential for wastes that are present at the site to cause the future contamination of site environmental media if the wastes were to be released (see Section 3.4).

The informational inputs and data needs to resolve the problem statement and the decision statements were generated as part of the DQO process for this CAU and are documented in Appendix A. The information necessary to resolve the DQO decisions will be generated for each CAU 569 study group by collecting and analyzing samples generated during a field investigation. The presence of a COC will be determined by collecting and analyzing samples following these two criteria:

- To make a judgmental sampling decision, samples must be collected in areas most likely to contain a COC.
- To make a probabilistic sampling decision, samples must be collected from unbiased locations that represent contamination within the sampling unit (see Section A.5.4).

The DQOs for CAU 569 defined the following release scenarios to appropriately address the different types of releases that may be present at the study groups:

- **Primary releases.** This release category 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. Atmospheric releases of radionuclides that have been distributed at the NNSS from nuclear testing have been found to be concentrated in the upper 5 cm of undisturbed soil (McArthur and Kordas, 1983 and 1985; Gilbert et al., 1977; Tamura, 1977). Therefore, for the purposes of this CAIP, surface is defined as the upper 5 cm of soil.
- **Other releases.** This release category includes any radionuclide contamination from test activities that is not atmospheric deposition of radionuclides. This includes radionuclide contaminants that were initially deposited onto the soil surface (as in the primary release category) but have been displaced through subsequent activities. This category also includes radionuclides that were deposited under mechanisms other than atmospheric deposition (such as radionuclides being driven into the soil by high explosives at each of the ground zero [GZ] areas). This category includes any other chemical or radiological contamination that may be discovered during the investigation through the identification of biasing factors that are not a part of a previously identified release.

As shown in the conceptual site model (CSM) in Section 3.1, it is assumed that contamination exceeding the FAL is present within the crater and soil berm north of the crater within Study Group 2 (Pike) that requires corrective action (see Section A.2.2.1). This collective area will be defined as a default contamination boundary (DCB) (see Section 3.4) and require corrective action.

At Study Group 2, DQO decisions will be resolved only for the areas outside the DCB. Investigation of primary releases will be accomplished through measurements of surface soil radioactivity using a

combination of judgmental and probabilistic sampling schemes. Investigation of other releases will be accomplished using a judgmental sampling scheme at depths dependent upon the nature of the release.

1.2 Scope

To generate information needed to resolve the decision statements identified in the DQO process, the scope of the CAI for CAU 569 may include the following activities:

- Move surface debris and/or materials, as needed, to facilitate sampling.
- Conduct radiological surveys.
- Conduct geophysical surveys.
- Perform field screening.
- Measure *in situ* external dose rates using thermoluminescent dosimeters (TLDs) or other dose-measurement devices.
- Collect and submit environmental samples for laboratory analysis to determine whether any COC is present.
- Collect and submit environmental samples for laboratory analysis to determine the nature and extent of any COCs that are present.
- Collect samples of waste material, if present, to determine the potential for a release to result in contamination exceeding FALs.
- Collect samples of potential remediation wastes, if present.
- Collect quality control (QC) samples.

Contamination of environmental media originating from activities not identified in the CSM of any study group will not be considered as part of this CAU unless the CSM and the DQOs are modified to include the release. If contamination is present that is not included in this CAU, the contamination will be identified as part of another CAS (either new or existing).

1.3 Corrective Action Investigation Plan Contents

Section 1.0 presents the purpose and scope of this CAIP, while Section 2.0 provides background information about CAU 569. Objectives of the investigation, including the CSM, are presented in Section 3.0. Field investigation and sampling activities are discussed in Section 4.0, and waste management issues for this project are discussed in Section 5.0. General field and laboratory quality assurance (QA) (including collection of QA samples) is presented in Section 6.0 and in the Industrial Sites Quality Assurance Project Plan (QAPP) (NNSA/NV, 2002a). The project schedule and records availability are discussed in Section 7.0. Section 8.0 provides a list of references.

Appendix A provides a detailed discussion of the DQO methodology and the DQOs specific to each study group, while Appendix B contains information on the project organization.

2.0 Facility Description

Corrective Action Unit 569 comprises nine CASs that were grouped together based on their location within or near the Area 3 Radioactive Waste Management Site (RWMS). In order to simplify the investigation of CAU 569, these nine CASs and one recently identified waste consolidation site were grouped into seven study groups based on geographic proximity (Section 1.0).

2.1 Physical Setting

The following sections describe the general physical setting of Area 3 of the NNSS. Additional background information pertaining to topography, geology, hydrogeology, and climatology is provided for this specific area of the NNSS region in the *Geologic Map of the Nevada Test Site, Southern Nevada* (Frizzell and Shulters, 1990); *CERCLA Preliminary Assessment of DOE's Nevada Operations Office Nuclear Weapons Testing Areas* (DRI, 1988); *Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada* (ERDA, 1977); and the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996).

The seven study groups in CAU 569 are located within the Yucca Flat Hydrographic Area of the NNSS. Yucca Flat is a closed basin, which is slowly being filled with alluvial deposits eroding from the surrounding mountains (Laczniak et al., 1996).

Local topography within the area is relatively flat and slopes gently to the south. Much of the area has been disturbed due to road construction, Area 3 RWMS construction and activities, underground testing that was conducted subsequent to the atmospheric testing in the area, and cleanup operations at the sites. Precipitation runoff from CAU 569 flows generally to the south, into the Yucca Flat dry lake. Several craters present within the area have disturbed the ground surface and may affect drainage.

Groundwater flow in Yucca Flat is generally northeast to southwest. Within the overlying alluvial and volcanic aquifers, lateral groundwater flow occurs from the margins to the center of the basin and downward into the carbonate aquifer (Laczniak et al., 1996). The average annual precipitation at the nearest rain gauge station to CAU 569 (Buster Jangle Y [BJY]) is 15.9 cm (6.25 inches [in.])

(ARL/SORD, 2011). Average annual potential evapotranspiration (PET) has been estimated for the Area 3 RWMS as 156.7 cm (61.7 in.). Rainfall and PET data are presented in Table 2-1.

Table 2-1
Rainfall and PET Information for Yucca Flat

	Area 3 PET (cm)	BJY Precipitation (cm)
Minimum	150.2	3.8
Maximum	160.8	37.4
Mean	156.7	15.9
95% UCL	159.6	18.8

Source: ARL/SORD, 2011; Yucel, 2009

The nearest groundwater well to CAU 569 is U.S. Geological Survey (USGS) Water Well WW-A, an active well located approximately 0.65 mi southwest of Study Group 5 (USGS/DOE, 2011). The thickness of the unsaturated zone extends to more than 600 feet (ft) below ground surface (bgs) (Hevesi et al., 2003), while the most recent recorded depth to the water table (at Water Well WW-A) is approximately 1,600 ft bgs. Therefore, it is expected that vertical migration of contaminants would be very limited.

2.2 Operational History

The following subsections provide a description of the use and history of each study group in CAU 569 that may have resulted in releases of contaminants to the environment. The study group-specific summaries are designed to define each study group and document all relevant, known activities.

2.2.1 Study Group 1: Coulomb-B, Catron

Study Group 1 is defined as the release of contaminants associated with the Coulomb-B and Catron safety experiments. Coulomb-B was conducted as part of Operation Plumbbob on September 6, 1957. The test was detonated at a height of 3 ft above ground surface at location S-3G and had a yield of 300 tons (DOE/NV, 2000; GE, 1979). Catron was conducted as part of Operation Hardtack II on October 24, 1958. The device was detonated on a tower at 72.5 ft above ground surface at location

T-3T and had a yield of 21 tons (DOE/NV, 2000; GE, 1979). The GZs for Catron and Coulomb-B are located within the boundary of the Area 3 RWMS. Waste disposal operations at the Area 3 RWMS began in the late 1960s. The RWMS consists of seven subsidence craters configured into five disposal cells, three of which were used for disposal of bulk low-level waste. In July 2006, the site was placed into inactive status (NSTec, 2011). The RWMS is posted with radioactive material area (RMA) signs and requires an escort to enter the area.

According to historical documentation, debris at Catron was collected and disposed of in a radioactive waste dump (presumably Waste Consolidation Site 3B [CAU 545, CAS 03-17-01] based on the location of the dump on a drawing in the document) (REECo, 1959). Extensive reworking has occurred in this area due to RWMS construction and activities, road construction, nearby underground testing, and site cleanup operations. As a result, soil contamination from the Study Group 1 tests may be buried below the ground surface. See Figure 2-1 for an overview of the Study Group 1 area within the Area 3 RWMS.

2.2.2 Study Group 2: Pike

Study Group 2 is defined as the release of contaminants associated with the Pike weapons-related shaft test. Pike was conducted in borehole U-3cy as part of Operation Niblick on March 13, 1964. The test was detonated at 374 ft bgs and had a yield of less than 20 kilotons (kt) (Schoengold et al., 1996; DOE/NV, 2000). According to historical documentation, within 10 to 15 seconds after detonation of the Pike device, a dense black cloud began to develop above the detonation point. The cloud continued to form until some 69 seconds after the detonation, when the cavity collapsed and a crater was formed at the surface. Subsequent analysis of the site showed an 8- to 10-ft-long surface crack (i.e., fissure) located northeast of the crater about 30 ft beyond the crater lip. Near the midpoint of this crack was an irregular hole approximately 4 to 6 in. in width at its widest point (AEC, 1964). A berm of soil is present at the north edge of the crater at Pike, which covers the surface expression of the fissure. Documentation states that the berm was placed after the test as radiation shielding between the crater and the drill rig work areas (REECo, 1964). The Pike crater and fissure are currently located within a posted contamination area (CA), and the Pike post-test area is posted as an RMA. Due to the inaccessibility to sample within the crater and the soil berm at Study Group 2, it is

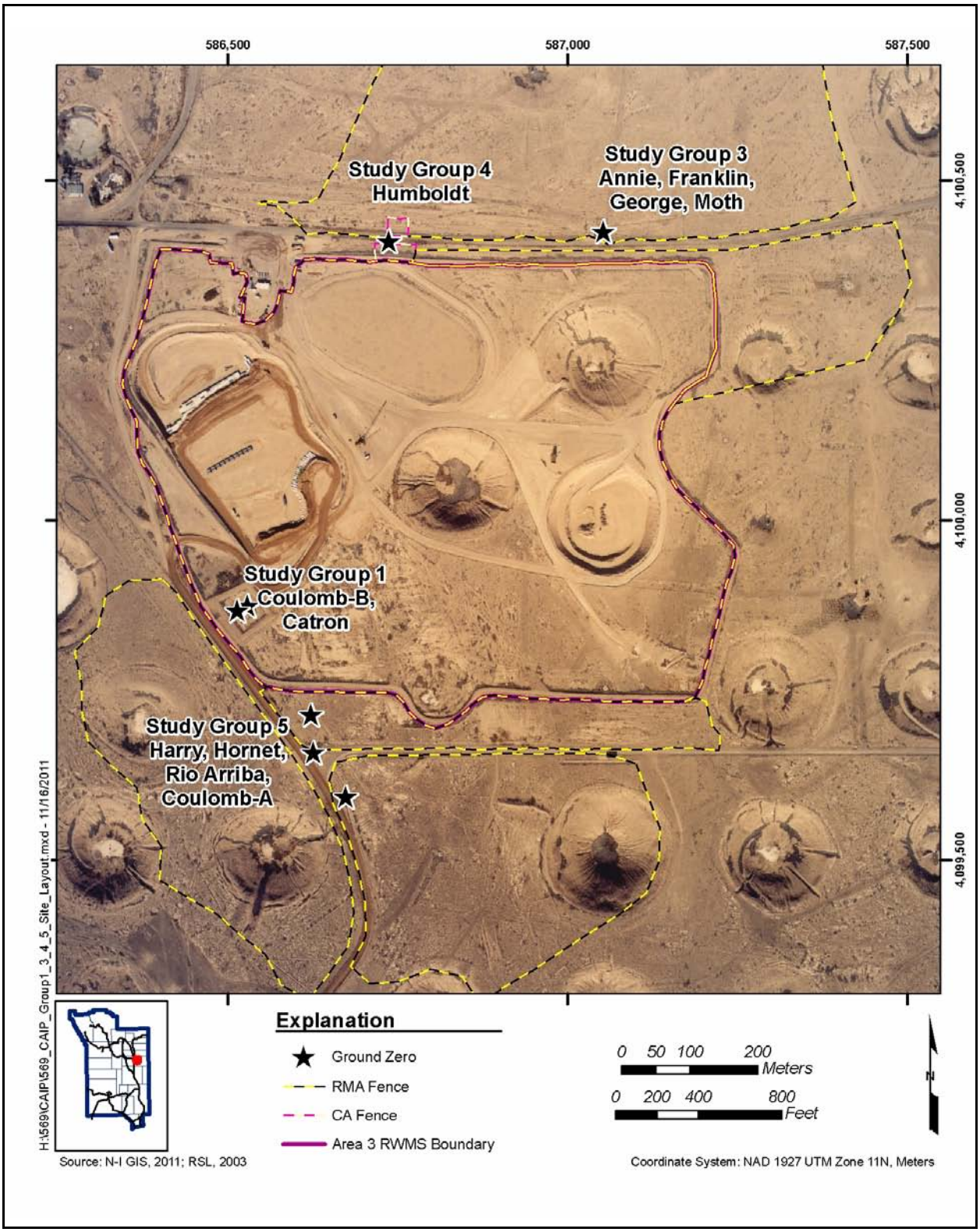

Figure 2-1
Study Groups 1, 3, 4, and 5 Site Layout

proposed that a DCB be established that includes the crater and the soil berm. See Figure 2-2 for an overview of the Study Group 2 area, including the DCB.

2.2.3 Study Group 3: Annie, Franklin, George, Moth

Study Group 3 is defined as the release of contaminants associated with the Annie, Franklin, George, and Moth weapons-related tower tests. All four tests were conducted at tower T-3 at a height of 300 ft above ground surface. George was a 15-kt-yield test conducted as a part of Operation Tumbler-Snapper on June 1, 1952. Annie was a 16-kt-yield test conducted as part of Operation Upshot-Knothole on March 17, 1953. Moth was a 2-kt-yield test conducted as part of Operation Teapot on February 22, 1955. Franklin was a 140-ton-yield test conducted as part of Operation Plumbbob on June 2, 1957 (DOE/NV, 2000; GE, 1979). An RMA fence is present in the area. See Figure 2-1 for an overview of the Study Group 3 area located within and north of the Area 3 RWMS.

2.2.4 Study Group 4: Humboldt

Study Group 4 is defined as the release of contaminants associated with the Humboldt weapons-related tower test. Humboldt was conducted as part of Operation Hardtack II on October 29, 1958. The test was detonated at a height of 25 ft above ground surface at location T-3V and had a yield of 7.8 tons (DOE/NV, 2000; GE, 1979). The GZ for Humboldt is located just north of the Area 3 RWMS, on 3-03 Road. According to historical documentation, debris at Humboldt was collected and disposed of in a radioactive waste dump (presumably Waste Consolidation Site 3B) (REECo, 1959). A CA fence is present in the area on the north and south side of 3-03 Road. See Figure 2-1 for an overview of the Study Group 4 area north of the Area 3 RWMS.

2.2.5 Study Group 5: Harry, Hornet, Rio Arriba, Coulomb-A

Study Group 5 is defined as the release of contaminants associated with the Harry, Hornet, Rio Arriba, and Coulomb-A tests. The Harry and Hornet tests were weapons-related tower tests conducted at tower T-3A at a height of 300 ft above ground surface. Harry, a 32-kt-yield test, was conducted as part of Upshot-Knothole on May 19, 1953. Hornet, a 4-kt-yield test, was conducted as part of Operation Teapot on March 12, 1955. Rio Arriba was a weapons-related tower test conducted north of Harry and Hornet on tower T-3S at a height of 72.5 ft. Rio Arriba was a 90-ton-yield test conducted as part of Operation Hardtack II on October 18, 1958. According to historical

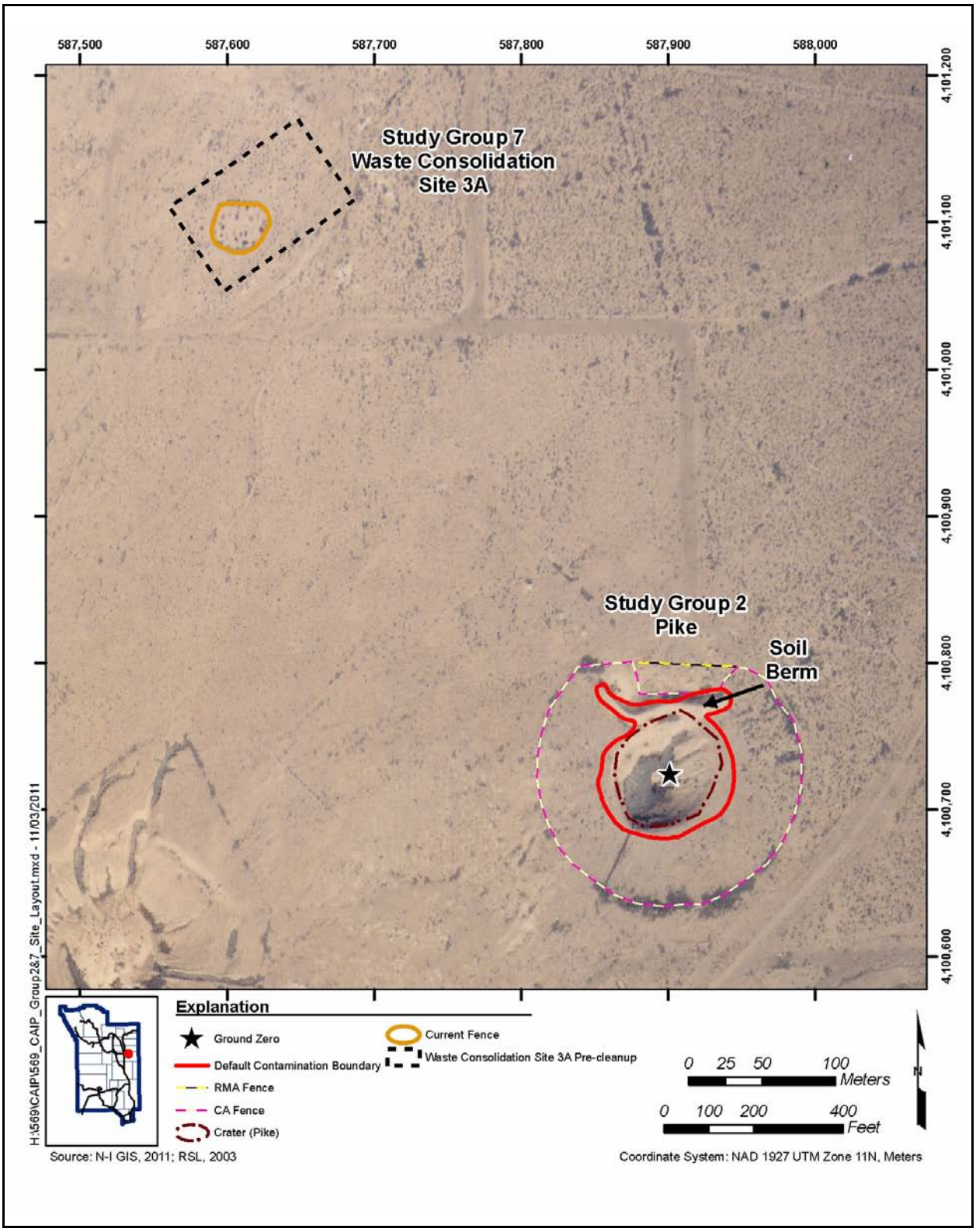

Figure 2-2
Study Groups 2 and 7 Site Layout

documentation, debris at Rio Arriba was collected and disposed of in a radioactive waste dump (presumably Waste Consolidation Site 3B) (REECo, 1959). Coulomb-A was a surface safety experiment with zero yield conducted east of Rio Arriba at location S-3H. Coulomb-A was conducted as part of Operation Plumbbob on July 1, 1957 (DOE/NV, 2000; GE, 1979). An RMA fence is present in the area. See Figure 2-1 for an overview of the Study Group 5 area located adjacent to the southwest border of the Area 3 RWMS.

2.2.6 Study Group 6: Fizeau

Study Group 6 is defined as the release of contaminants associated with the Fizeau weapons-related tower test. Fizeau was conducted as part of Operation Plumbbob on September 14, 1957. The test was detonated at a height of 500 ft above ground surface at location T-3B and had a yield of 11 kt (DOE/NV, 2000; GE, 1979). An underground bunker located at the Fizeau GZ was constructed in 1957 as a multipurpose underground concrete structure that served as a base detector station and footing for the tower and a vertical detector pipe (DRI, 2002). The bunker is still present at the site, and access into the bunker is restricted by a large bell hatch. The Fizeau area is segmented by 3-12 Road and Angle Road, and an RMA fence is present in the area. See Figure 2-3 for an overview of the Study Group 6 area.

2.2.7 Study Group 7: Waste Consolidation Site 3A

Study Group 7 is defined as the potential release of contaminants associated with the consolidation of soil and potentially debris from atmospheric testing operations. According to historical documentation, weapons-testing activities conducted at the NNSS resulted in widely distributed areas containing radioactively contaminated debris. Study Group 7 has been identified as one such location, known as Waste Consolidation Site 3A. The waste consolidation site historically measured 210 by 340 ft. Cleanup operations were conducted at the waste consolidation sites beginning in 1980. Approximately 8,000 cubic yards (yd^3) of dirt mounds were removed from Study Group 7 in 1980 and 1981 and disposed of in the U3axbl landfill (REECo, 1983). Currently, a fence with t-posts and barbed wire is present at the site that measures approximately 110 by 120 ft. See Figure 2-2 for an overview of the Study Group 7 area.

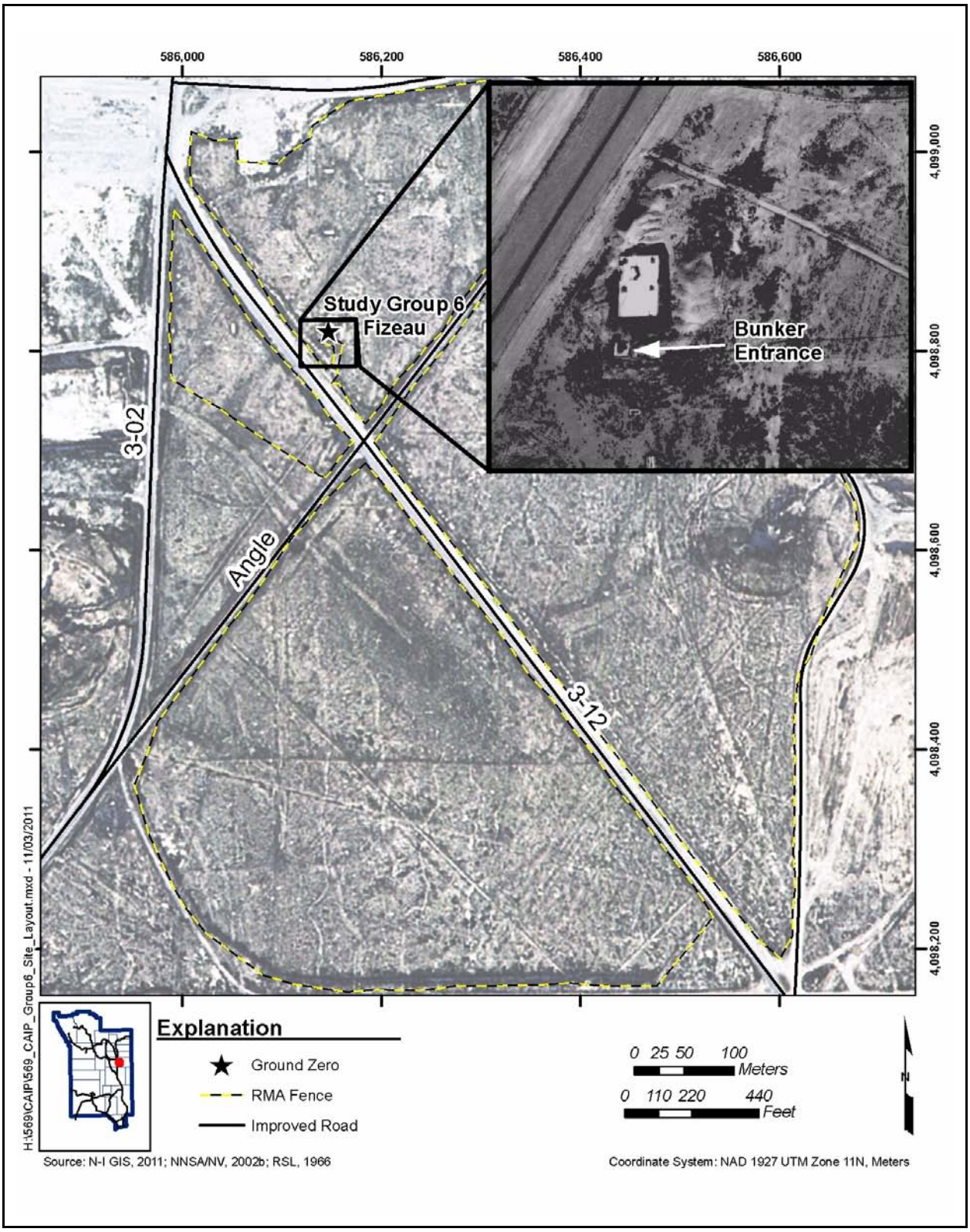

Figure 2-3
Study Group 6 Site Layout

2.3 Waste Inventory

Available documentation, process knowledge, general historical NNSS practices, and visual surveys were used to identify wastes that may be present. The potential wastes that were identified at the seven study groups include metal, cables, wood, a lead brick, batteries, drums, filters, cans, asphalt piles, and other various debris associated with atmospheric and underground nuclear testing.

Additional wastes generated during the investigation may include investigation-derived waste (IDW), decontamination liquids, and soils. Potential waste types include sanitary waste, hydrocarbon waste, *Resource Conservation and Recovery Act* (RCRA) hazardous waste, radioactive waste, and mixed waste.

2.4 Release Information

The releases of contamination to the Study Groups 1 through 6 are directly or indirectly associated with the nuclear testing activities conducted in the area. The releases of contamination to Study Group 7 are associated with atmospheric testing operations conducted in Area 3. The investigation of specific releases at CAU 569 will depend upon the nature of these releases. Therefore, the releases have been categorized into one of the two release scenarios defined in Section 1.1.2.

Exposure routes to receptors include ingestion and inhalation of radionuclides in surface soil (internal exposure). Site workers may also be exposed to direct radiation by performing activities in proximity to radiologically contaminated materials (i.e., external dose).

The following subsections contain study group-specific descriptions of known or suspected releases associated with CAU 569.

2.4.1 Study Groups 1, 3, 4, 5, and 6

The primary release at Study Groups 1, 3, 4, 5, and 6 includes the atmospheric deposition of radioactive contamination onto the surface soils from the atmospheric nuclear tests conducted within these study groups. The initial release of radionuclides from the tests was distributed in roughly concentric patterns on the ground surface, exhibiting a pattern of surface contamination that is generally decreasing in concentration with increasing distance from the release locations, as

illustrated in the 1996 aerial radiological survey (Figures 2-4 and 2-5). Cleanup operations were conducted in 1959 to remove debris from some of the areas within these study groups. Additionally, subsequent underground testing, road construction operation, and Area 3 RWMS construction/operation operations may have moved surface contaminants from the original atmospheric deposition location. Therefore, there is the potential for surface soil contamination from the atmospheric testing to be mixed in with or covered by clean soil.

In addition, other releases at Study Groups 1, 3, 4, 5, and 6 include potential soil contamination from batteries, lead bricks, drums, former transformer areas, asphalt piles, and any additional spills or debris that may also be present within the study groups.

2.4.2 Study Group 2

The primary release at Study Group 2 includes the atmospheric deposition of radioactive contamination onto surface soils from the venting of radioactive gases through a fissure during the Pike underground test. The surface expression of the fissure was covered by a soil berm shortly after the test was conducted. As illustrated in the 1996 aerial radiological survey of the area (Figure 2-4), the initial release of radionuclides was distributed in a roughly annular pattern located at the southwest edge of the Pike crater. Other releases include the prompt injection of radionuclides and activated material into the geological formation around the test device (covered under the scope of Underground Test Area [UGTA] CAU 97, CAS 03-57-066) and within the fissure after detonation. Lead from a battery identified near the main road to Pike may have released contaminants to the surface soil, and additional spills or debris may also be present within this study group.

2.4.3 Study Group 7

The release of contamination at Study Group 7 is from contaminated soil and possibly debris that were consolidated at this location during atmospheric testing operations in the area. This release includes the potential subsurface (buried) soil contamination due to the reworking of soil from waste consolidation and removal operations.

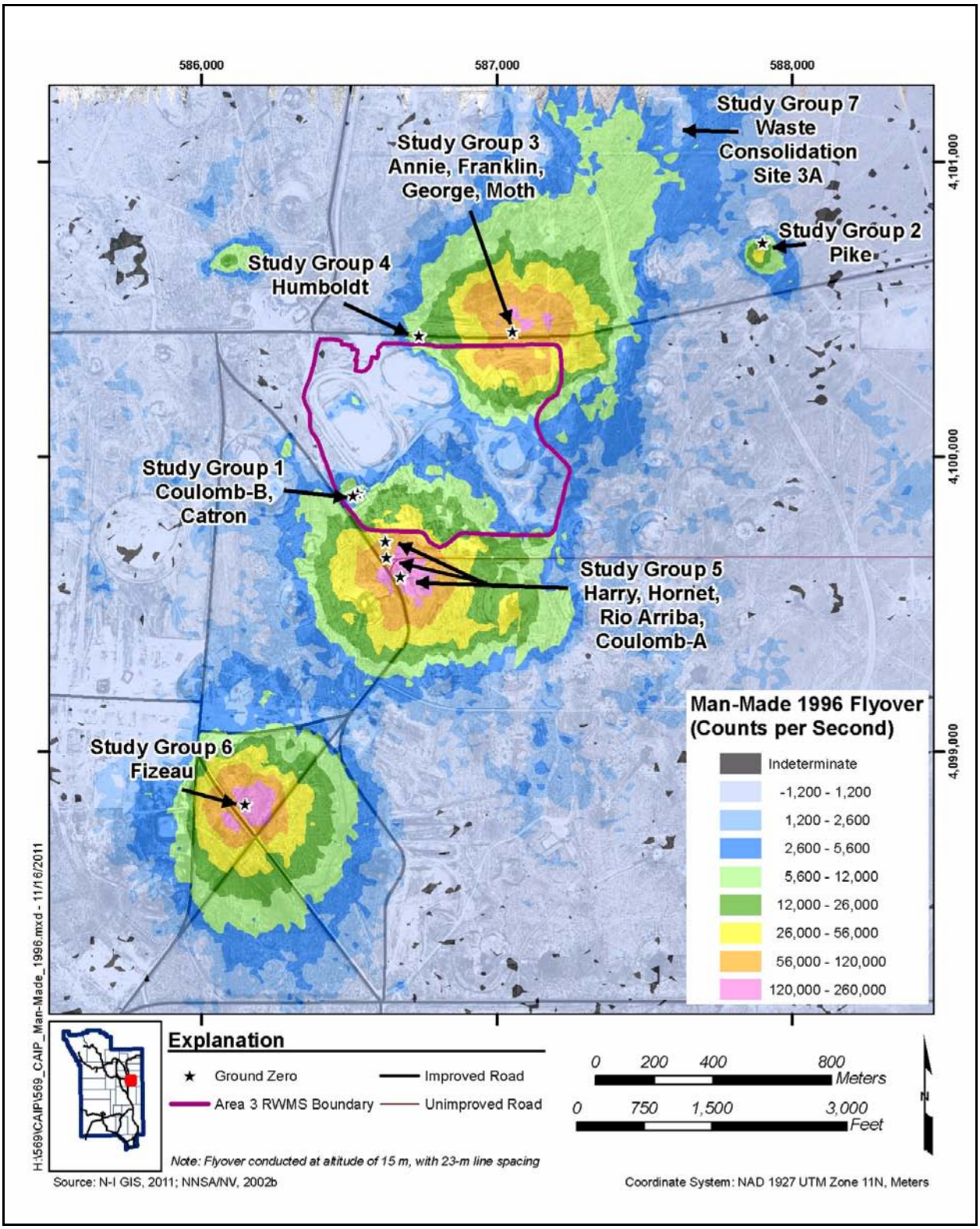

Figure 2-4
Area 3 Low-Altitude Aerial Man-Made Radiation Survey

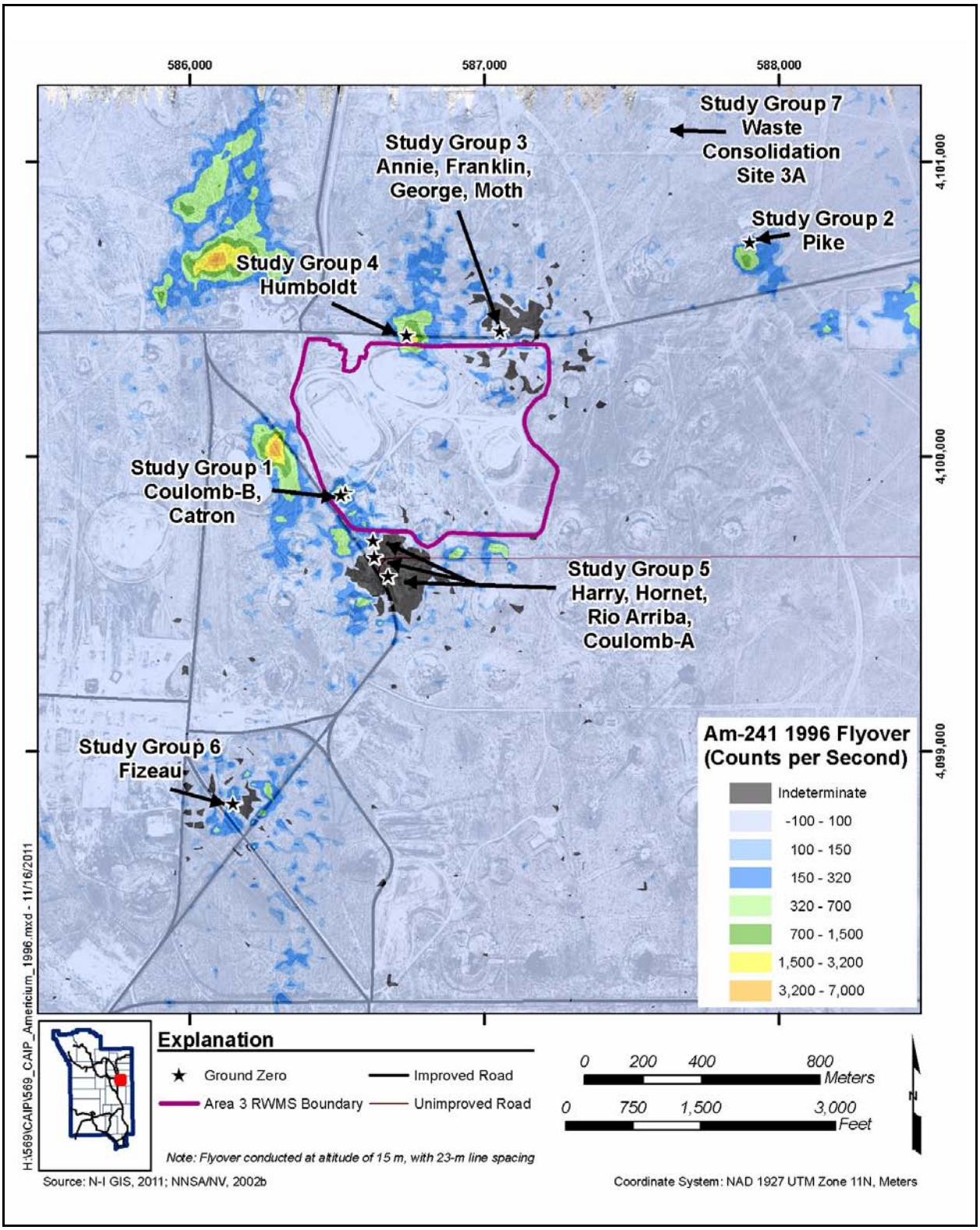

Figure 2-5
Area 3 Low-Altitude Aerial Am-241 Survey

2.5 Investigative Background

All previous investigation data are assessed in the planning phase as biasing information for selecting appropriate sampling locations. A variety of different radiation surveys were conducted in the CAU 569 area. These include aerial and ground-based surveys. Table 2-2 lists the method descriptions for the different radiation surveys conducted within the area of CAU 569, advantages, limitations, spatial and spectral resolutions, measurement dates, and applied use as a comparison of the radiation survey methods. Details of the surveys are also discussed in Sections 2.5.1, 2.5.3, and 2.5.4.

These data are not considered to be decision quality and are not used in making corrective action decisions. However, the radiation surveys will be evaluated for use in defining corrective action boundaries in the investigation report. For defining corrective action boundaries, the radiation surveys will be used only in terms of defining a relative spatial distribution of contamination. This relative spatial distribution will be correlated to measured dose (decision quality) to define the shape of the areas that require corrective action.

The aerial radiation surveys provided spectral information that was used to differentiate specific isotopic signatures. This allowed the separate mapping of americium (Am)-241 contamination, man-made gamma activity, and gross gamma activity within the surveyed areas. The Am-241 distribution map is used as an indicator of the locations of potential plutonium contamination.

The radionuclide activity in this area is due to a combination of fission products (primarily high-energy gamma radiation) and unfissioned nuclear material (primarily low-energy gamma, beta, and alpha radiation). The sources of these radiation types are not necessarily co-located.

The Radionuclide Inventory and Distribution Program (RIDP) conducted an investigation from 1981 through 1986 that estimated the inventory of man-made radionuclides at the NNSS through *in situ* gamma spectroscopy (McArthur and Mead, 1987). These RIDP data were extrapolated to estimate levels of plutonium across CAU 569 as shown on Figure 2-6 and discussed in Section 2.5.2. More detailed discussions of these investigations are found in Appendix A.

Table 2-2
Comparison of Radiation Survey Methods

	KIWI	FIDLER	PRM-470	Aerial Radiological Survey
Method Description Summary	Ground-based, sodium iodide gamma spectroscopy unit	Ground-based instrument that detects low-energy gamma emissions	Ground-based organic plastic scintillator instrument that detects gamma emissions	Helicopter-mounted thallium-activated sodium iodide, gamma-ray scintillation detectors
Advantages and Limitations	Advantages: Can post-process data to identify specific gamma-emitting radionuclides of interest Limitations: Detector mounted on a vehicle, may have issues with terrain and a higher potential for contamination	Advantages: Lightweight hand-held instrument designed to see low-energy gamma emissions Limitations: Does not discriminate between low energy gamma emissions from different isotopes	Advantages: Lightweight hand-held instrument that detects gamma emissions Limitations: Does not distinguish between the radionuclides emitting the gamma emissions	Advantages: Gives a wide area of view (as opposed to ground-based surveys); can survey large areas quickly Limitations: Because it is elevated and moving at a fast rate, does not distinguish small localized areas of contamination or materials that are contaminated
Spatial Resolution	Mounted ~2.5 ft above ground surface; stationary KIWI has an Am-241 footprint of ~3 m wide and 1.2 m long; travelling at 5 miles per hour, the footprint for each 1-second measurement is ~3 m wide by 3.4 m long	Held at approx. 6 in. above ground surface, has a small field of view	Held at approx. 1 m above ground surface, has a small field of view	Altitude: 15 m Line Spacing: 23 m 30-m diameter window
Spectral Resolution	28 to 4,000 keV	10 to 100 keV	All gamma emitters	38 to 3,026 keV
Measurement Date	1996	08/2011 and 09/2011	08/2011 and 09/2011	12/1996
Applied Use	Processed for energies in the 57- to 70-keV range (Am-241) relative to the 38- to 50-keV and 70- to 82-keV background windows; used to identify Am-241 contamination as an indicator of plutonium contamination	Energies in the 59-keV range, which are indicative of Am-241 or other higher-energy emitters; used to identify Am-241 contamination as an indicator of plutonium contamination	Nondiscriminatory gamma count used to identify contamination from nuclear testing	For Am-241: Processed for energies in the 57- to 70-keV range (Am-241) relative to the 38- to 50-keV and 70- to 82-keV background windows. Used to identify Am-241 contamination as an indicator of plutonium contamination. For man-made: Processed for energies in the 38- to 1,294-keV window relative to the 1,394- to 3,026-keV background window. Used to identify contamination from nuclear testing.

FIDLER = Field instrument for the detection of low-energy radiation
keV = Kiloelectron volt
m = Meter

Source: N-I GIS, 2011; BN, 1999b; Hendricks, 2011; Riedhauser, 1999; Buchheit and Marianno, 2005; TSA Systems, 2005

2.5.1 Aerial Radiological Surveys

Aerial radiological surveys were conducted at the NNSS in 1978, 1992, 1994, and 1996 to characterize the radiation exposure (Fritzche, 1981; BN, 1997; BN, 1999a and b). The overall pattern of the radiological distribution has not changed significantly from the initial 1978 survey to the 1996 survey. However, the 1996 aerial survey was conducted at a lower altitude (15 m) above ground surface with tighter line spacings (23 m) than the previous surveys (which were predominantly conducted at an altitude of 150 m). Thus, the more recent survey provides a more precise representation of site contamination. As a result, the data from the 1996 aerial survey are referenced throughout the document. This survey shows that the study groups with the highest levels of gamma radioactivity (up to 260,000 counts per second [cps]) are Study Groups 3, 5, and 6. Lower levels of gamma radioactivity were detected at Study Groups 1, 2, and 4. No elevated gamma levels were detected at Study Group 7. Americium-241 levels measuring 1,500 to 3,200 cps were detected at Study Group 4, and lower levels were detected at Groups 1 and 2. No elevated Am-241 levels were detected at Study Group 7. No usable Am-241 data are available for Study Groups 3, 5, and 6 due to the high levels of gamma radioactivity that rendered the Am-241 results indeterminate. Results for the gamma and Am-241 aerial surveys covering the seven study groups are shown in Figures 2-4 and 2-5.

2.5.2 RIDP and NAEG

As part of an effort to assess the implications of contamination on future uses of the NNSS, the RIDP was established in 1981 to make a comprehensive survey of the important man-made radionuclides of NNSS origin in the surface soil at the site (McArthur and Mead, 1987). Data collected for the RIDP and by the Nevada Applied Ecology Group (NAEG) in the 1980s allowed for estimates of surface soil inventories throughout the NNSS. The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy and limited confirmatory soil sampling (McArthur and Mead, 1987; Gray et al., 2007). Desert Research Institute reported *in situ* gamma spectroscopy measurements for Area 3, which included the CAU 569 area (McArthur and Mead, 1987). Although the RIDP data present a general distribution of contamination, there is not sufficient resolution for biasing sample locations with CAU 569. The RIDP *in situ* measurements for plutonium (Pu)-239 within the boundaries of CAU 569 are shown in Figure 2-6.

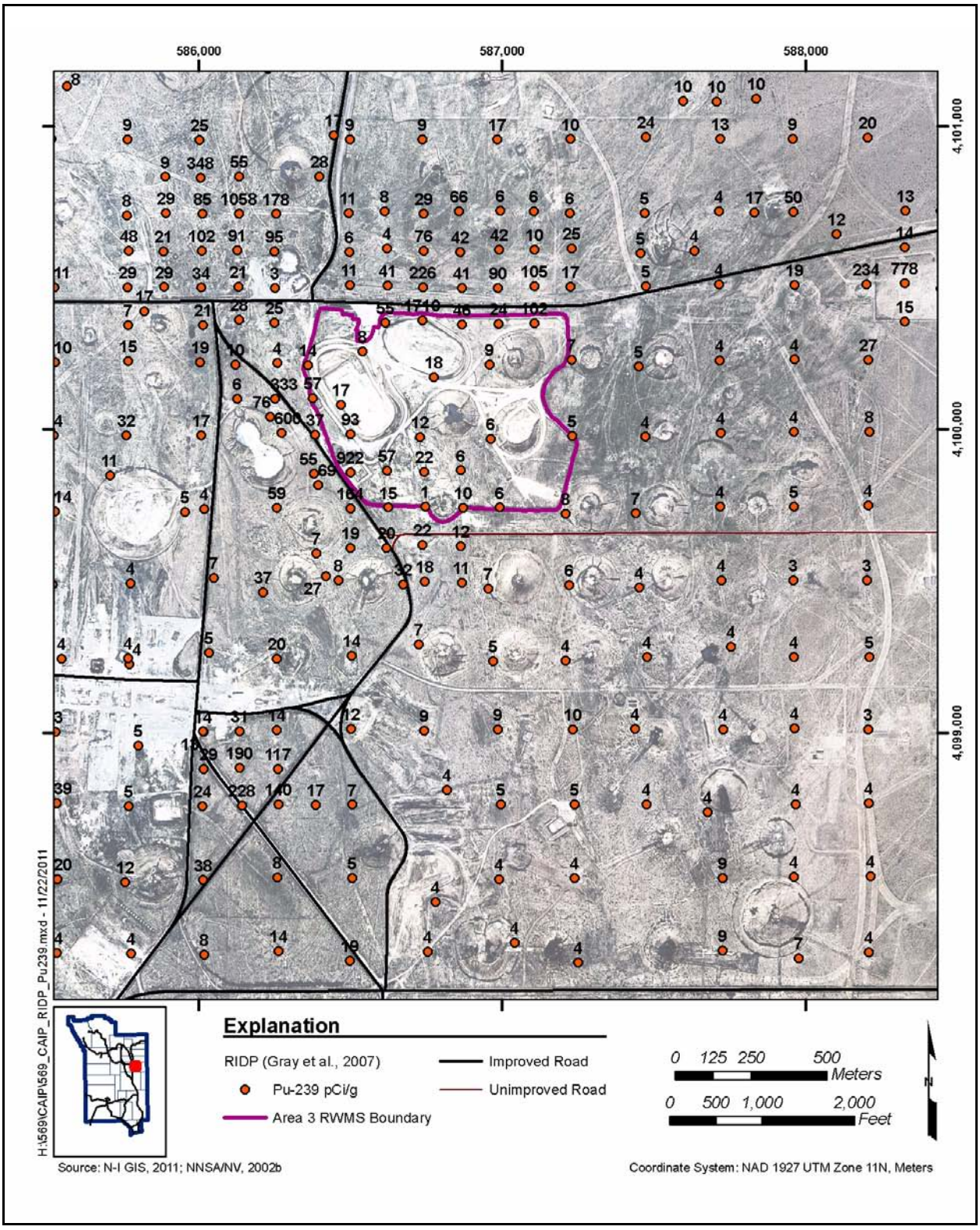

Figure 2-6
CAU 569 RIDP *In Situ* Data

2.5.3 KIWI Survey

In 1996, a ground-based KIWI survey was conducted in Area 3 to measure gamma radiation within the area. The KIWI is an array of sodium-iodide detectors mounted on a vehicle approximately 2.5 ft above the ground surface with line spacings of approximately 2 m. The data from the KIWI survey were post-processed in October 2011 to extract the Am-241 component in the data. Data from this survey are available for Study Groups 1, 3, 4, 5, and 6 (Hendricks, 2011). Americium-241 results from the post-processing of the 1996 KIWI survey are shown in Figure 2-7.

2.5.4 CAU 569 Preliminary Investigation

In 2011, a preliminary field investigation was completed in the CAU 569 area. This effort included visual surveys and ground-based radiological surveys. During the visual survey, which included walking the area of Study Groups 1 through 6, photographs were taken and site conditions were noted. The visual survey was conducted with approximate 10-m line spacing, and scattered metal, batteries, drums, a lead brick, stained soil, and other debris were identified.

Radiological surveys were also completed within Study Groups 1 through 6. The FIDLER was used at the study groups where plutonium was identified as a potential contaminant. The PRM-470 instrument was used at all study groups (1 through 6). Figures 2-8 and 2-9 show the results of the ground-based radiological survey from the PRM-470 and FIDLER radiological instruments, respectively.

2.5.5 National Environmental Policy Act

The *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996) includes site investigation activities such as those proposed for CAU 569. In accordance with the NNSA/NSO *National Environmental Policy Act* (NEPA) Compliance Program, a NEPA checklist will be completed before beginning site investigation activities at CAU 569. This checklist requires NNSA/NSO project personnel to evaluate their proposed project activities against a list of potential impacts that include, but are not limited to, air quality, chemical use, waste generation, noise level, and land use. Completion of the checklist results in a determination of the appropriate level of NEPA documentation by the NNSA/NSO NEPA Compliance Officer. This will be accomplished before mobilization for the field investigation.

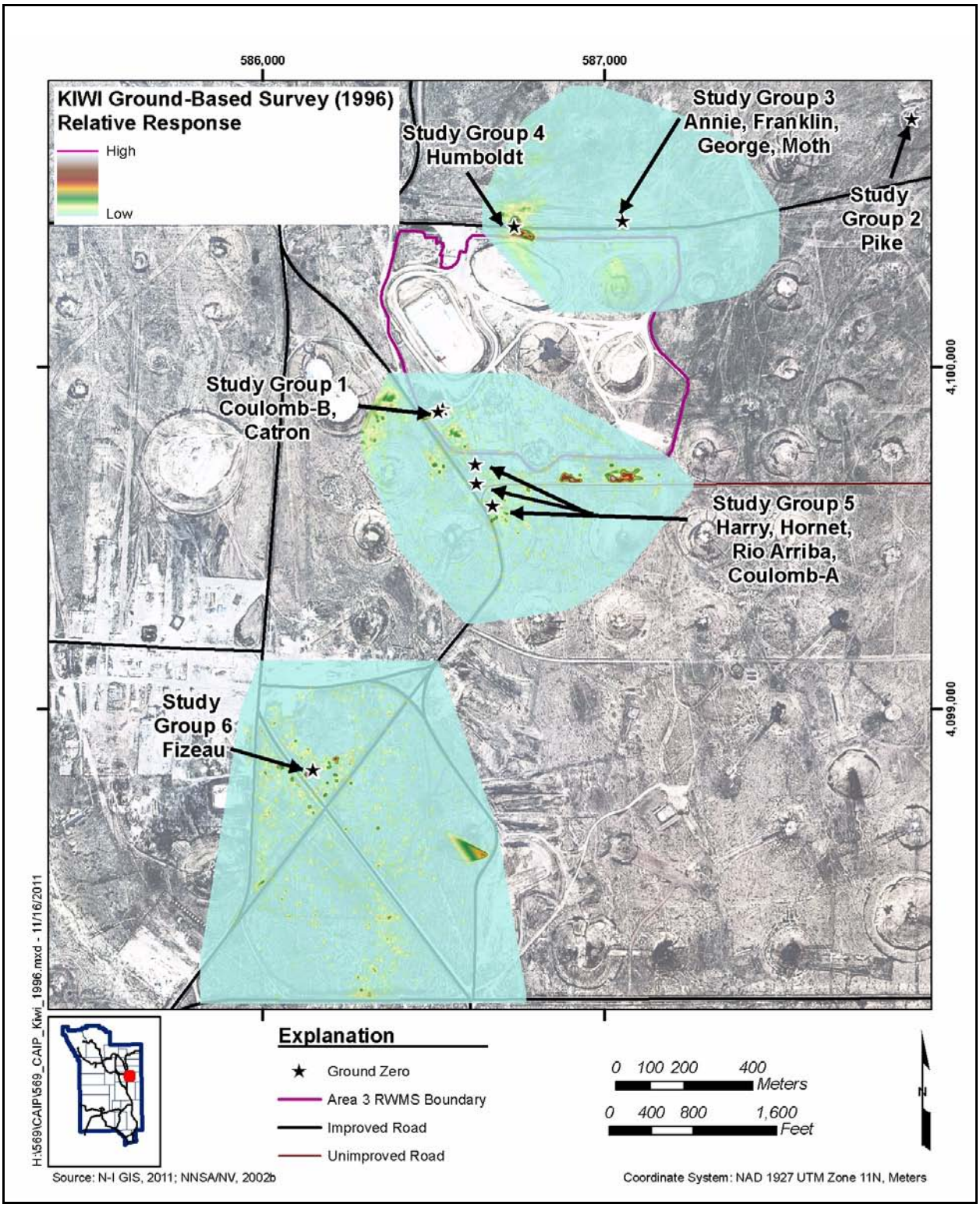

Figure 2-7
Area 3 KIWI Survey

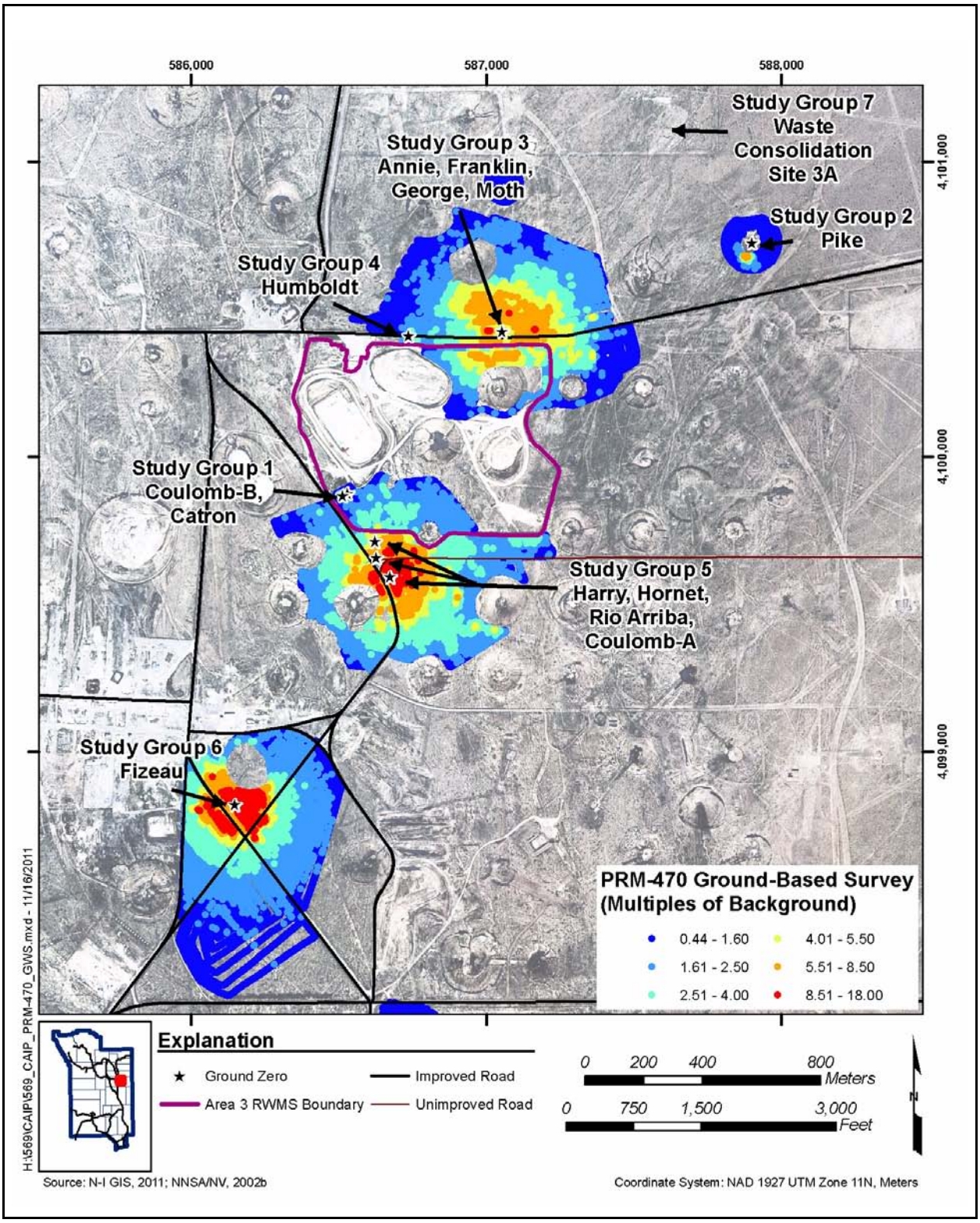

Figure 2-8
Ground-Based PRM-470 Survey

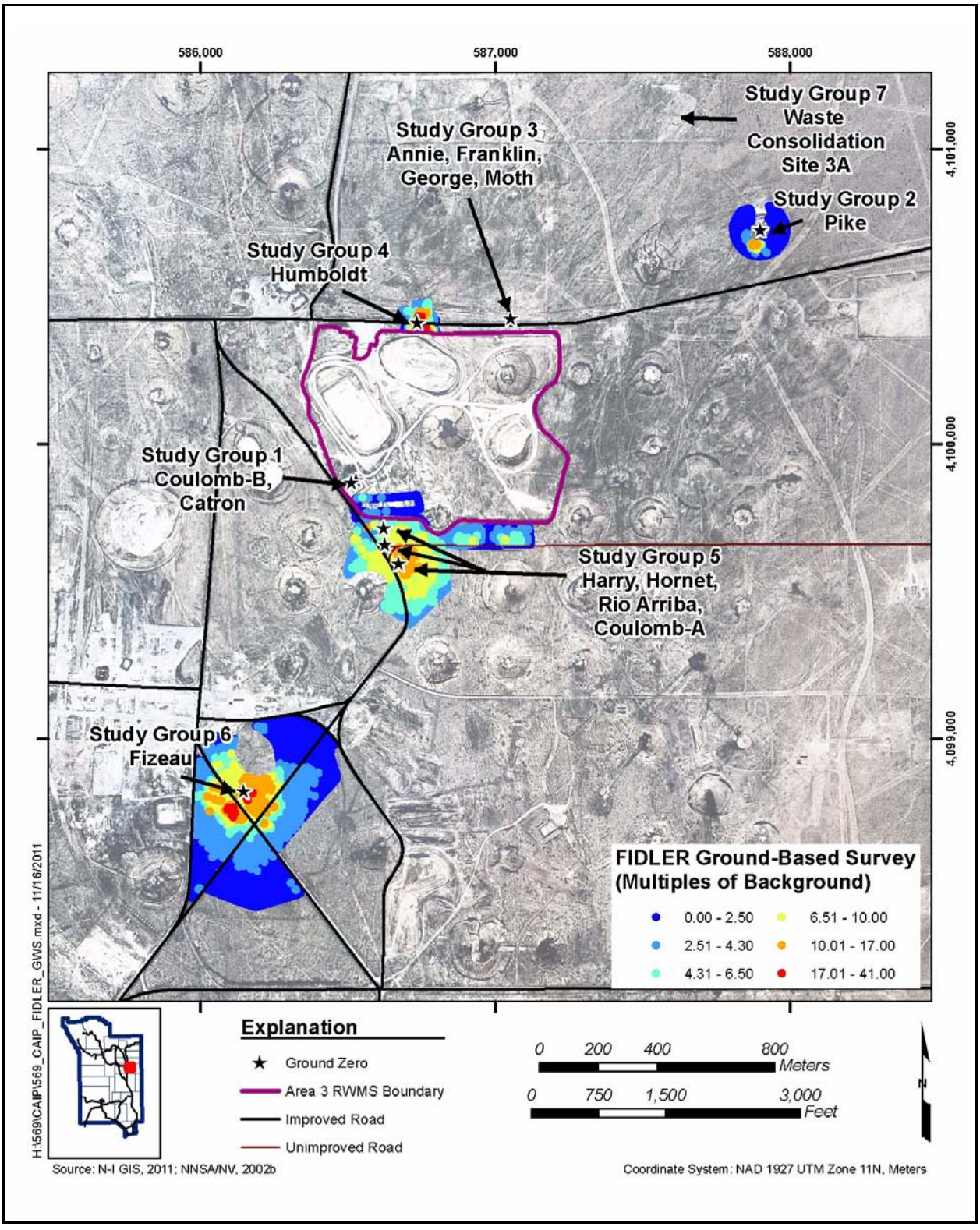

Figure 2-9
Ground-Based FIDLER Survey

3.0 Objectives

This section presents an overview of the DQOs for CAU 569 and formulation of the CSM. Also presented is a summary listing of the contaminants of potential concern (COPCs), the preliminary action levels (PALs), and the process used to establish FALs. Additional details and figures depicting the CSM are located in Appendix A.

3.1 Conceptual Site Model

The CSM describes the most probable scenario for current conditions at each site and defines the assumptions that are the basis for identifying the future land use, contaminant sources, release mechanisms, migration pathways, exposure points, and exposure routes. The CSM was used to develop appropriate sampling strategies and data collection methods. The CSM was developed for CAU 569 using information from the physical setting, potential contaminant sources, release information, historical background information, knowledge from similar sites, and physical and chemical properties of the potentially affected media and COPCs. Figure 3-1 depicts a representation of the conceptual pathways to receptors from CAU 569 sources. Figure 3-2 depicts a graphical representation of the CSM. If evidence of contamination that is not consistent with the presented CSM is identified during investigation activities, the situation will be reviewed, the CSM will be revised, the DQOs will be reassessed, and a recommendation will be made as to how best to proceed. In such cases, decision-makers listed in Section A.2.1 will be notified and given the opportunity to comment on and/or concur with the recommendation.

The following sections discuss future land use and the identification of exposure pathways (i.e., combination of source, release, migration, exposure point, and receptor exposure route) for CAU 569.

3.1.1 Land-Use and Exposure Scenarios

Land-use zones where the CAU 569 study groups are located dictate future land use, and restrict current and future land use to nonresidential (i.e., industrial) activities. The CAU 569 site is located in the land-use zone described as “Nuclear and High Explosive Test Zone” within the NNSS. This area is designated within the Nuclear Test Zone for additional underground nuclear weapons tests and

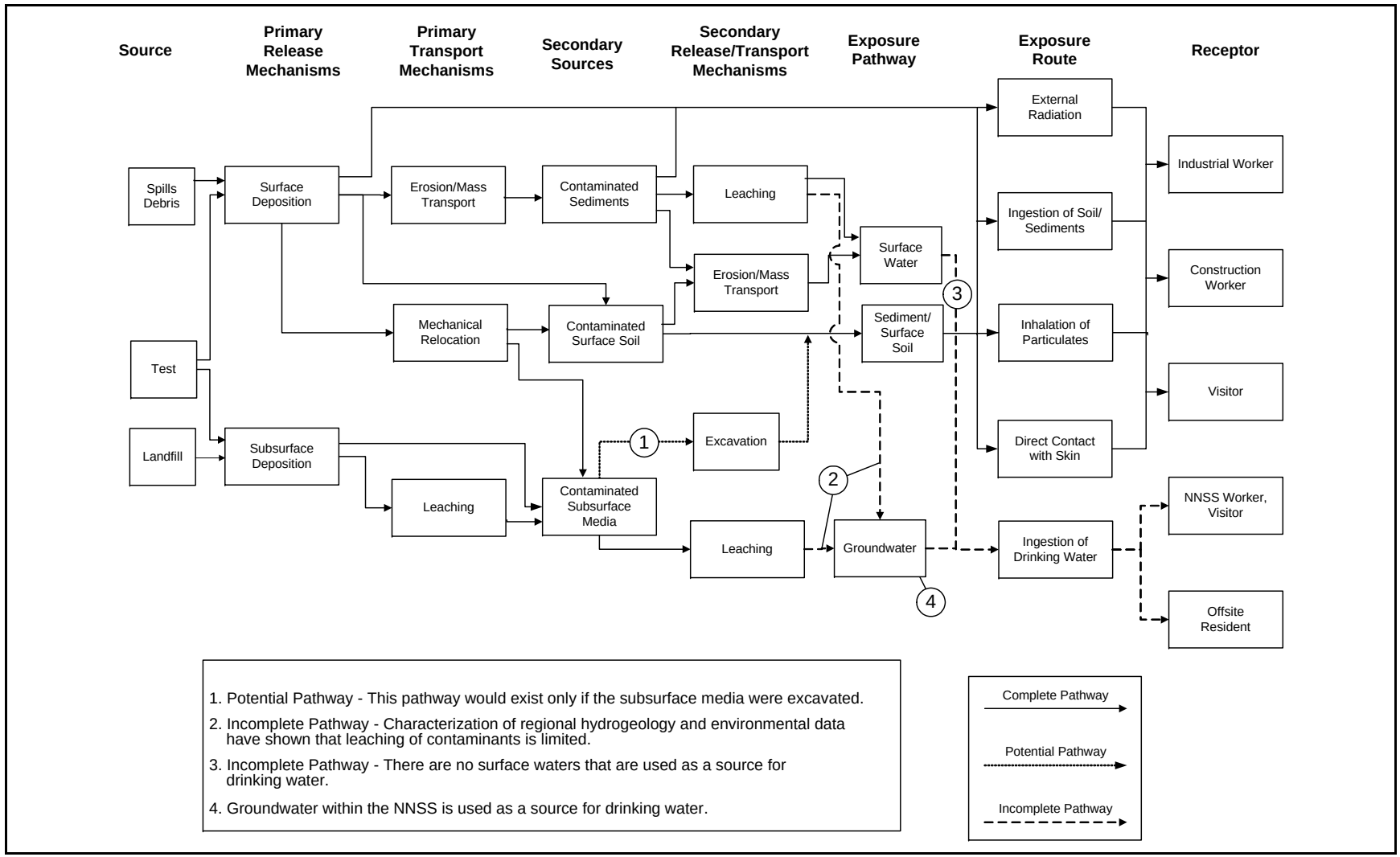

Figure 3-1
Conceptual Site Model Diagram

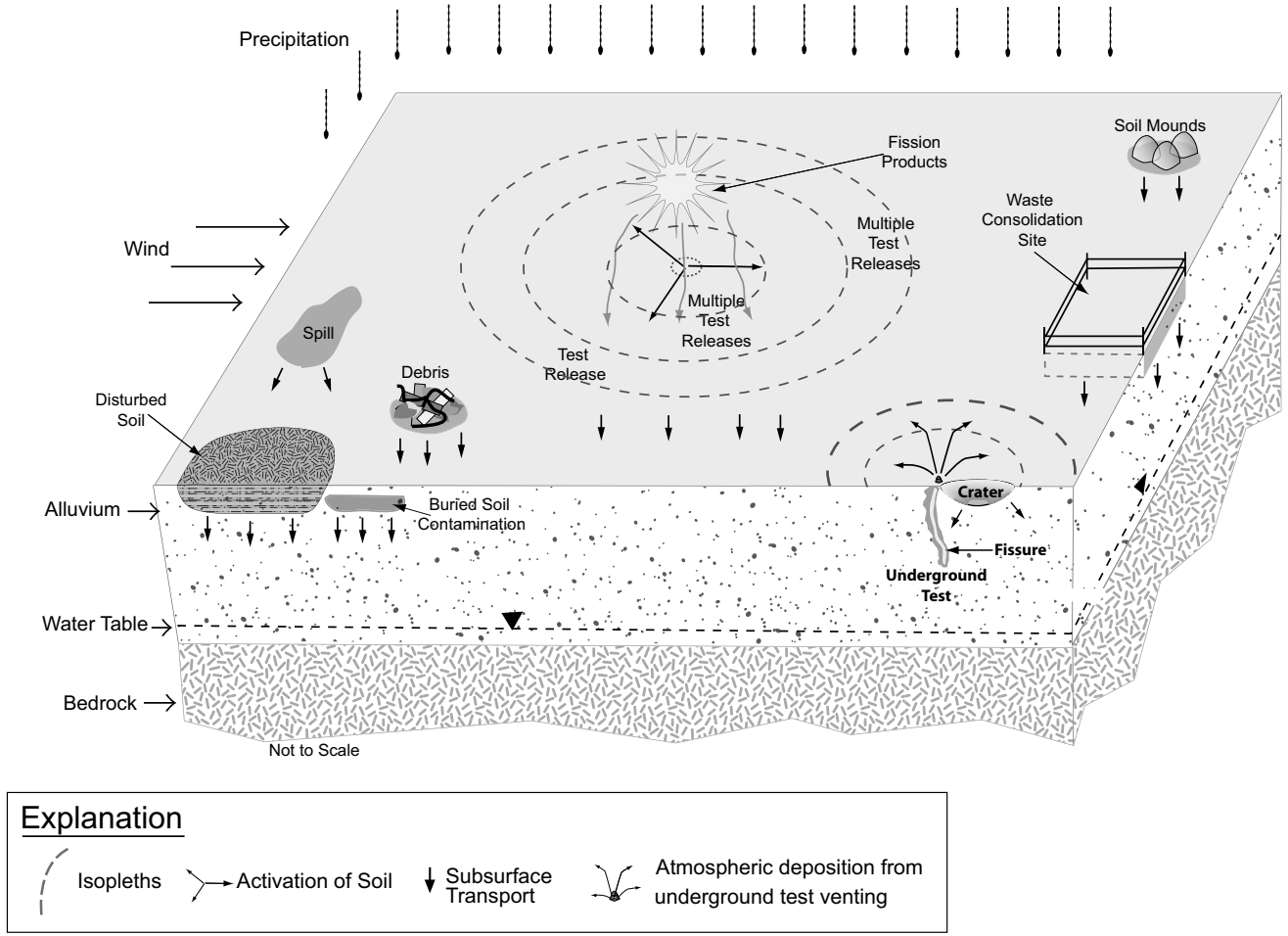

Figure 3-2
CAU 569 Conceptual Site Model

outdoor high-explosive tests. This zone includes compatible defense and nondefense research, development, and testing activities (DOE/NV, 1998).

Exposure scenarios for the CAU 569 study groups have been categorized into the following three types based on current and projected future land uses:

- **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 (225 days per year, 10 hours per day, for 25 years). The total effective dose (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 exposure 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 hours (or 42 days) per year 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 hours (or 10 days) per year for 5 years. The TED calculated using this exposure scenario is the TED an occasional use area 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).

The CAU 569 land-use zone and exposure scenario are based on NNSS current and future land use. The majority of CAU 569 (except for Study Group 1) is a remote location without any site improvements and where no regular work is performed. There is still the possibility, however, that site workers could occupy these locations on an occasional and temporary basis such as a military exercise. Therefore, the Occasional Use Area is the exposure scenario most representative of Study Groups 2 through 7. Study Group 1 is located within the boundary of the Area 3 RWMS, where waste disposal operations were conducted and regular work may be performed. Therefore, the Industrial Area is the exposure scenario most representative of Study Group 1.

3.1.2 Contaminant Sources

The contamination sources for CAU 569 study groups are from releases of radiological contamination to the atmosphere and soil as a result of nuclear tests (safety experiments and weapons-related tests). The atmospheric detonations irradiated the surrounding soil with neutrons, causing the activation of some elements in the soil (primarily europium [Eu]-152 and -154). Fission fragments were released in an annular pattern around GZ. Radionuclides with a low melting point (e.g., iodine) traveled significant distances before condensing and falling out of the plume, while those with higher melting points (e.g., cesium) condensed earlier and were deposited closer to GZ. The nuclear fuel that did not fission (e.g., uranium [U]-235) has a very high melting point and is generally found very near to GZ. Different mixtures of radionuclides may be present at these release sites based on the varying composition of the nuclear source material used in the test devices and the type of test (underground, safety, weapons related). Contamination on the soil surface may be sources for future migration.

Other sources of contamination include spills and debris. During preliminary investigations at the CAU, batteries, a lead brick, former transformer areas, and asphalt piles were identified. The batteries and lead brick may release lead to the soil; the transformers may have released polychlorinated biphenyls (PCBs) to the soil; and the asphalt may release semivolatile organic compounds (SVOCs) to the soil. Additionally, two locations of stained soil were identified. It is unknown what was spilled on the ground surface to cause the stains. Additional stained soil and debris may be identified during site characterization activities, and will be investigated as appropriate.

3.1.3 Release Mechanisms

Release mechanisms for the primary releases at Study Groups 1, 3, 4, 5, and 6 include the release of fission products, and release of unfissioned nuclear fuel from the detonation of nuclear devices as well as neutron activation of soil and debris. At Study Group 2, the release mechanism for the primary release was the venting of radioactive gases into the atmosphere through a fissure north of GZ shortly after test detonation. The release consisted of gaseous fission products.

The release mechanisms for the other release from Study Group 1 is similar to that of the primary release at Study Groups 1, 3, 4, 5, and 6; however, as discussed in Section 2.4, the location of this

study group within the Area 3 RWMS and the reworking operations that have occurred create the possibility that surface contamination from the two tests within Study Group 1 have been disturbed and may be buried under the current surface soil. Also, similar to the other release for Study Group 1, due to reworking operations that occurred adjacent to the southeast boundary of the Area 3 RWMS (within the boundary of Study Group 5) and the presence of the two areas of elevated Am-241 levels detected during the KIWI survey, there is the potential for buried soil contamination to be present within this portion of Study Group 5. A geophysical survey will be conducted within this area of Study Group 5 to verify that no debris is buried within this location.

The release mechanisms for Study Group 7 are from the consolidation of contaminated soil on the ground surface in piles. This contaminated soil was removed from the site; however, there is the potential for residual contamination to be present at this study group. A geophysical survey will be conducted within Study Group 7 to verify that no debris is buried within the waste consolidation site.

For all study groups, release mechanisms from other releases include potential spills and leaks onto surface soils from materials such as batteries, transformers, and drums.

3.1.4 Migration Pathways

Migration pathways for CAU 569 include the lateral migration of potential contaminants across surface soils and accumulation in craters within the site, and vertical migration of potential contaminants into the subsurface soils. No major washes were identified at CAU 569. Drainage from the CAU 569 area flows toward Yucca Flat dry lake. Other migration pathways for contamination from the site include the potential for wind-borne material. Contaminants may also have been disturbed through mechanical means due to maintenance or construction activities at the site. Specifically, this can include activities such as construction, maintenance, or waste disposal operations at the Area 3 RWMS; construction and maintenance of roadways such as Angle or 3-03 Road; and cleanup operations conducted at the waste consolidation site.

Migration is influenced by physical and chemical characteristics of the contaminants and media. Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. Media characteristics include permeability, porosity, water-holding capacity, sorting, chemical composition, and organic content. In general, contaminants with low solubility, high affinity

for media, and high density (e.g., plutonium and americium) can be expected to be found relatively close to release points. Contaminants with high solubility, low affinity for media, and low density can be expected to be found further from release points. These factors affect the migration pathways and potential exposure points for the contaminants in the various media under consideration. Based on the COPCs for CAU 569 (Section 3.2), it is anticipated that they will not have migrated very far from their release point. See Section A.2.2.3 for additional details.

Infiltration and percolation of precipitation serve as driving forces for downward migration of contaminants. However, due to high PET (annual PET at the Area 3 RWMS has been estimated at 61.7 in. [Yucel, 2009]) and limited precipitation for this region (6.34 inches per year [in./yr] at Station BJY [ARL/SORD, 2011]), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Subsurface migration pathways at CAU 569 are expected to be predominately vertical, although spills or leaks at the ground surface may also have limited lateral migration before infiltration. The depth of infiltration (shape of the subsurface contaminant plume) will be dependent upon the type, volume, and duration of the discharge as well as the presence of relatively impermeable layers that could modify vertical or lateral transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., caliche layers). For surface contamination to reach the water table, the contaminants would have to be transported by infiltrating precipitation through the vadose alluvium that extends the entire unsaturated thickness of 488 m at ER-3-2.

The vertical penetration distance of infiltrating precipitation in 1,000 years would be the groundwater recharge rate (in millimeters per year [mm/yr]) divided by the volumetric moisture content (cm^3/cm^3) of the subsurface vadose alluvium times 1,000 years. The groundwater recharge rate in the vicinity of CAU 569 has been estimated to range from less than 0.1 mm/yr to 2.5 mm/yr based on regional infiltration studies (SNJV, 2006). The moisture content observed in the subsurface alluvium in shallow boreholes near the Area 3 RWMS indicates moisture contents in the range of 0.05 to 0.1 (Kwicklis et al., 2006). Based on these observations, penetration distances of infiltrating precipitation may be as much as 50 m in 1,000 years (using the maximum groundwater recharge rate of 2.5 mm/yr and the minimum moisture content of 0.05).

3.1.5 Exposure Points

Exposure points, as identified in the CSM, are expected to be areas of surface contamination where visitors and site workers may come in contact with contaminated surface soil. Subsurface exposure points may exist if construction workers come in contact with contaminated media during excavation activities.

3.1.6 Exposure Routes

Exposure routes for site workers include ingestion and inhalation from disturbance of, or direct contact with, contaminated media. Site workers may also be exposed to direct ionizing radiation by performing activities in proximity to radioactive materials.

3.1.7 Additional Information

Information concerning topography, geology, climatic conditions, hydrogeology, floodplains, and infrastructure at the CAU 569 study groups is presented in Section 2.1 as it pertains to the investigation. This information has been addressed in the CSM and will be considered during the evaluation of CAAs, as applicable. Climatic and site conditions (e.g., surface and subsurface soil descriptions) as well as specific structure descriptions will be recorded during the CAI. If encountered, areas of erosion and deposition within washes will be qualitatively evaluated to provide additional information on potential offsite migration of contamination.

3.2 Contaminants of Potential Concern

The COPCs at the Study Groups 1, 2, 4, 5, and 6 include U-234, -235, -238; Pu-238, 239/240; Eu-152, -154, -155; thorium (Th)-232; cesium (Cs)-137; and Am-241. Contaminants of potential concern for Study Group 3 consist of the aforementioned COPCs, with the exception of Pu-238 and Pu-239/-240 (see Table A.2-2). These COPCs will be reported by the analytical methods identified in Table A.2-3 for Decision I environmental samples taken at each of the study groups. The analytes reported for each analytical method are listed in Table A.2-4. For Study Group 7, COPCs include the same radionuclide COPCs identified for Study Groups 1 through 6, based on the fact that contaminated soil from atmospheric testing operations was consolidated at Study Group 7.

The list of COPCs is intended to encompass all contaminants reasonably expected at each site that could contribute to a dose or risk exceeding action levels. These COPCs were identified during the planning process through the review of site history, process knowledge, personal interviews, past investigation efforts (where available), and inferred activities associated with the study groups and other releases (including those that may be discovered during the investigation). Specific COPCs (and subsequently the analyses requested) will be determined for potential releases discovered during the CAI based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks).

3.3 Preliminary Action Levels

The PALs presented in this section are to be used for site screening purposes. They are not necessarily intended to be used as cleanup action levels or FALs. However, the PALs are useful in screening out contaminants that are not present in sufficient concentrations to warrant further evaluation, thereby streamlining the consideration of remedial alternatives. The RBCA process used to establish FALs is described in the *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). This process conforms with *Nevada Administrative Code* (NAC) Section 445A.227, which lists the requirements for sites with soil contamination (NAC, 2008a). For the evaluation of corrective actions, NAC Section 445A.22705 (NAC, 2008b) requires the use of ASTM International (ASTM) Method E1739 (ASTM, 1995) to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary." For the evaluation of corrective actions, the FALs are established as the necessary remedial standard.

This RBCA process, summarized in Figure 3-3, defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses:

- **Tier 1 evaluation.** Sample results from source locations (highest concentrations) are compared to action levels based on generic (non-site-specific) conditions (i.e., the PALs established in the CAIP). The FALs may then be established as the Tier 1 action levels, or the FALs may be calculated using a Tier 2 evaluation.

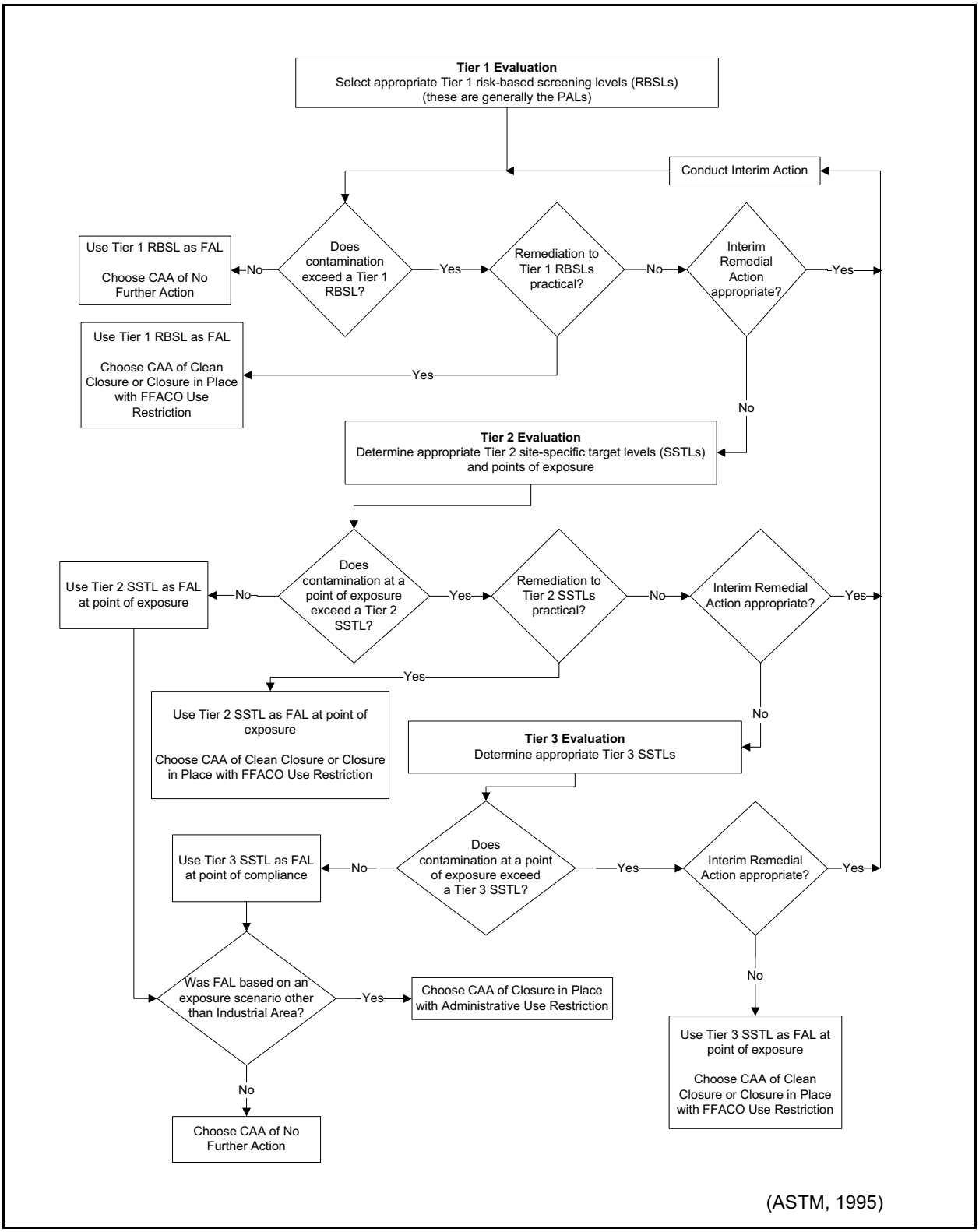

Figure 3-3
Risk-Based Corrective Action Decision Process

- **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 exposure areas (as opposed to the source locations as is done in Tier 1).

- **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.

This RBCA process includes a provision for conducting an interim remedial action if necessary and appropriate. The decision to conduct an interim action may be made at any time during the investigation and at any level (tier) of analysis. Concurrence of the decision-makers listed in Section A.2.1 will be obtained before any interim action is implemented. Evaluation of DQO decisions will be based on conditions at the site after any interim actions are completed. Any interim actions conducted will be reported in the Corrective Action Decision Document (CADD).

If, after implementation of corrective actions, contamination remains in place that is less than the site-specific exposure scenario based FAL but exceeds 25 millirem per year (mrem/yr) based on the Industrial Area exposure scenario, an administrative use restriction will be implemented to prevent future industrial use of the area. For this reason, contamination at all sites will be evaluated against the Industrial Area exposure scenario based PALs and site-specific exposure scenario based FALs. The FALs (along with the basis for their selection) will be proposed in the CADD, where they will be compared to laboratory results in the evaluation of potential corrective actions.

3.3.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the U.S. Environmental Protection Agency (EPA) *Pacific Southwest, Region 9: Regional Screening Levels (Formerly PRGs), Screening Levels for Chemical Contaminants* in industrial soils (EPA, 2011a). Background concentrations for RCRA metals will be used instead of screening levels when natural background concentrations exceed the screening level, as is often the case with arsenic on the NNSS. Background is considered the mean plus two standard deviations of the mean for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening

levels, the protocol used by EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the CADD.

3.3.2 Radionuclide PALs

The PAL for radioactive contaminants is 25-mrem/yr TED, based upon the Industrial Area exposure scenario. The Industrial Area exposure scenario is described in *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). For primary releases, the TED is calculated as the sum of external dose and internal dose. External dose is determined directly from TLD measurements. Internal dose is determined by comparing analytical results from soil samples to residual radioactive material guidelines (RRMGs) that were established using the Residual Radioactive (RESRAD) computer code (Yu et al., 2001). The RRMGs presented in Table 3-1 are radionuclide-specific values for radioactivity in surface soils. The RRMG is the value, in picocuries per gram (pCi/g) of surface soil, for a particular radionuclide that would result in an internal dose of 25 mrem/yr to a receptor (under the appropriate exposure scenario) independent of any other radionuclide (assumes that no other radionuclides contribute dose). The internal dose associated with any specific radionuclide is established using the following equation:

$$\text{Internal dose (mrem/yr)} = [\text{Analytical result (pCi/g)} / \text{RRMG}] \times 25 \text{ mrem/yr}$$

When more than one radionuclide is present, the internal dose will be calculated as the sum of the internal doses for each radionuclide. In the RESRAD calculation, several input parameters are not specified so that site-specific information can be used. The default and site-specific input parameters used in the RESRAD calculation of RRMGs for each exposure scenario are listed in Attachment A-1 of Appendix A.

3.4 Data Quality Objective Process Discussion

This section contains a summary of the DQO process that is presented in Appendix A. The DQO process is a strategic planning approach based on the scientific method that is designed to ensure that the data collected will provide sufficient and reliable information to identify, evaluate, and technically defend the recommendation of viable corrective actions (e.g., no further action, clean closure, or closure in place).

Table 3-1
Residual Radioactive Material Guideline Values

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

Co = Cobalt
Nb = Niobium
Sr = Strontium

As presented in Section 4.1, it is assumed that TED within the DCB of Study Group 2 (i.e., crater and soil berm covering the fissure) exceeds the FAL. Figure A.8-2 shows the DCB associated with Study Group 2. For this area, the DQO decisions are resolved and corrective action is required. The DQO decisions will be resolved for the areas outside the DCB for Study Group 2 and for all of the areas affected by releases from the other study groups.

As presented in Section 1.1.2, the DQOs address two types of potential contaminant release scenarios. The primary releases will be investigated through a combination of probabilistic and judgmental sampling, and the other releases will be investigated based on site-specific strategies. Therefore, discussions related to these two release scenarios are presented separately.

The DQO strategy for CAU 569 was developed at a meeting on September 26, 2011. The DQOs were developed to identify data needs, clearly define the intended use of the environmental data, and to design a data collection program that will satisfy these purposes. During the DQO discussions for this CAU, the informational inputs or data needs to resolve problem statements and decision statements were documented.

The problem statement for CAU 569 is as follows: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the study groups in CAU 569." To address this problem statement, resolution of the following decision statements is required:

- **Decision I.** "Is any COC present in environmental media within the study group?" If a COC is detected, then Decision II must be resolved.
- **Decision II.** "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
    - The information needed to evaluate the feasibility of remediation alternatives

The presence of a COC would require a corrective action. A corrective action may also be necessary if there is a potential for wastes (i.e., potential source material [PSM]) that are present at a site to introduce COCs into site environmental media. Several conservative assumptions were made to evaluate the potential for wastes to introduce a COC to the surrounding environmental media. These assumptions are detailed in Section A.3.1.

For the primary release scenario, it is unknown whether COCs are present (outside the DCB at Study Group 2) and Decision I sampling for the primary release scenario will be conducted. If COCs are identified, Decision II must be resolved for the primary releases at CAU 569.

For the other release scenario, Decision I samples will be submitted to analytical laboratories to determine the presence of COCs. The specific analyses for samples from other releases will be selected dependent upon the type and nature of the identified release. Decision II samples for both release scenarios will be submitted as necessary to define the extent of unbounded COCs. In addition,

samples will be submitted for analyses, as needed, to support waste management or health and safety decisions.

For the laboratory data, the data quality indicators (DQIs) of precision, accuracy, representativeness, completeness, comparability, and sensitivity needed to satisfy DQO requirements are discussed in Section 6.2. Laboratory data will be assessed in the CADD to confirm or refute the CSM and determine whether the DQO data needs were met.

Analytical methods and target minimum detectable concentrations (MDCs) for each CAU 569 COPC are provided in Tables 3-2 and 3-3. The criteria for precision and accuracy listed in Tables 3-2 and 3-3 may vary from information in the Industrial Sites QAPP as a result of the laboratory used or updated/new analytical methods (NNSA/NV, 2002a).

Table 3-2
Analytical Requirements for Radionuclides for CAU 569

Analysis[a]	Medium or Matrix	Analytical Method	MDC[b]	Laboratory Precision	Laboratory Accuracy
Gamma-Emitting Radionuclides					
Gamma Spectroscopy	Aqueous	EPA 901.1[c]	10% of RRMGs[d]	RPD 35% (non-aqueous)[e] 20% (aqueous)[e] ND -2<ND<2[f]	LCS Recovery (%R) 80-120[g]
	Non-aqueous	GA-01-R[h]			
Other Radionuclides					
Isotopic U	All	U-02-RC[h]	10% of RRMGs[d]	RPD 35% (non-aqueous)[e] 20% (aqueous)[e] ND -2<ND<2[f]	Chemical Yield Recovery (%R) 30-105[i] LCS Recovery (%R) 80-120[i]
Isotopic Pu	Aqueous	Pu-10-RC[h]			
	Non-aqueous	Pu-02-RC[h]			
Isotopic Am	Aqueous	Am-03-RC[h]			
	Non-aqueous	Am-01-RC[h]			
Gross Alpha/Beta	Aqueous	EPA 900.0[c]			MS Recovery (%R) Lab-specific[j] LCS Recovery (%R) 80-120[i]
	Non-aqueous	SM 7110 B[k]			

[a]A list of constituents reported for each method is provided in Table A.2-4.
[b]The MDC is the minimum concentration of a constituent in accordance with Standard Methods[k].
[c]*Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA, 1980).
[d]The RRMG is the value, in picocuries per gram of surface soil, for a particular radionuclide that would result in a dose of 25 mrem/IA-yr (e.g., the PAL).
[e]*Sampling and Analysis Plan Guidance and Template* (EPA, 2000).
[f]*Evaluation of Radiochemical Data Usability* (Paar and Porterfield, 1997).
[g]*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2011b).
[h]*The Procedures Manual of the Environmental Measurements Laboratory* (DOE, 1997).
[i]Professional judgment and other industry acceptance criteria are used.
[j]Accuracy criteria are developed in-house using approved laboratory standard operating procedures in accordance with industry standards and the N-I Statement of Work requirements (NNES, 2009).
[k]*Standard Methods for the Examination of Water and Wastewater* (Clesceri et al., 1998).

LCS = Laboratory control sample
MS = Matrix spike
ND = Normalized difference
N-I = Navarro-Intera, LLC
RPD = Relative percent difference
%R = Percent recovery

Table 3-3
Analytical Requirements for Chemicals for CAU 569

Analysis[a]	Medium or Matrix	Analytical Method	MDC[b]	Laboratory Precision	Laboratory Accuracy
Organics					
VOCs	All	8260[c]	< FALs	Lab-specific[d]	Lab-specific[d]
TCLP VOCs	Leachate	1311/8260[c]	< Regulatory Levels	Lab-specific[d]	Lab-specific[d]
SVOCs	All	8270[c]	< FALs	Lab-specific[d]	Lab-specific[d]
TCLP SVOCs	Leachate	1311/8270[c]	< Regulatory Levels	Lab-specific[d]	Lab-specific[d]
PCBs	All	8082[c]	< FALs	Lab-specific[d]	Lab-specific[d]
Inorganics					
RCRA Metals	All	6010/6020[c]	< FALs	RPD 35% (non-aqueous) 20% (aqueous)[e] Absolute Difference ±2x RL (non-aqueous)[f] ±1x RL (aqueous)[f]	MS Recovery (%R) 75-125[c] LCS Recovery (%R) 80-120[c]
TCLP Metals	Leachate	1311/6010/7470[c]	< Regulatory Levels		

[a]A list of constituents reported for each method is provided in Table 3-2.
[b]The MDC is the minimum concentration of a constituent in accordance with SW-846[c].
[c]*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2011b).
[d]Precision and accuracy criteria are developed in-house using approved laboratory standard operating procedures in accordance with industry standards and the N-I Statement of Work requirements (NNES, 2009).
[e]*Sampling and Analysis Plan Guidance and Template* (EPA, 2000).
[f]*USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2004).

RL = Reporting limit
TCLP = Toxicity Characteristic Leaching Procedure
VOC = Volatile organic compound

4.0 Field Investigation

This section contains a description of the activities to be conducted to gather and document information from the CAU 569 field investigation.

4.1 Technical Approach

The information necessary to satisfy the DQO data needs will be generated for CAU 569 by collecting and analyzing samples generated during a field investigation. However, the investigation will not include the Study Group 2 (Pike) subsidence crater area or soil berm north of the crater (see Section A.2.2.1), as contamination exceeding FALs is assumed to be present within these areas. For the soil berm, this assumption is based on the documented venting through a fissure 30 ft northeast of the crater. The surface expression of the fissure is situated beneath the soil berm. This assumption is based on the assumption of subsurface contamination. This contamination is currently effectively contained in near-surface unsaturated media and, in its current state, is sufficiently isolated so there is limited potential exposure to site workers and the public. A DCB has been established that comprises the crater and the soil berm covering the fissure; therefore, a corrective action is required. For the area outside the DCB, information will be generated during a site investigation to resolve DQO decisions.

The presence and nature of contamination for primary releases will be evaluated using a combination of judgmental and probabilistic approaches. The location of the sample plots will be selected judgmentally, and the samples collected within the sample plots will be collected and evaluated probablistically. Other release samples will be located and sample results evaluated based on site-specific criteria.

If it is determined that a COC is present at any CAS, that CAS will be further investigated to determine the extent of contamination before evaluating CAAs.

For probabilistic sampling of radiological contamination, DQO decisions will be based on the 95 percent UCL of the average TED for each sample location. For judgmental sampling, DQO decisions will be based a direct comparison of sample results to the FAL.

The TED will be determined by summing internal and external dose measurements at each sample location. Sample results for individual radionuclides will be used to calculate internal dose using RESRAD computer code (Yu et al., 2001). External dose will be determined by collecting *in situ* measurements using a TLD. The TLD will be installed at the approximate center of the sample plot or at grab sample locations, at a height of 1 m and be left in place for approximately 2,250 hours (equivalent to an annual industrial worker exposure). The project-specific TLDs are subjected to the same QA checks as the routine NNSS environmental monitoring TLDs, as described in Section 6.0. The Panasonic UD-814 TLD used in the NNSS environmental monitoring program contains four individual elements. The readings from each element are compared as part of the routine QA checks during the TLD processing. External dose at each TLD location is then determined using the readings from TLD elements 2, 3, and 4. Element 1 is designed to measure dose to the skin and is not relevant to the determination of the external dose. Where sufficient data are available, the 95 percent UCL of the average TED will be the sum of the 95 percent UCL of the TLD element results for external dose and the 95 percent UCL of the internal dose based on each soil sample. For grab sample locations where TED is calculated, the 95 percent UCL of the average TED will be the sum of the 95 percent UCL of the TLD element results for external dose and the internal dose from the single sample.

Modifications to the investigative strategy may be required should unexpected field conditions be encountered at any study group. Significant modifications shall be justified and documented before implementation. If an unexpected condition indicates that conditions are significantly different from the CSM, the activity will be rescoped and the identified decision-makers will be notified.

4.2 Field Activities

Field activities at CAU 569 include site preparation, sample location selection, sample collection, and demobilization.

4.2.1 Site Preparation Activities

Site preparation activities to be conducted before the start of environmental sampling may include relocating or removing surface debris, equipment, and structures; constructing hazardous waste accumulation areas (HWAAs) and site exclusion zones; providing sanitary facilities; constructing decontamination facilities; and moving staged equipment.

Before mobilization for collecting investigation samples, the following preparatory activities will also be conducted:

- Perform radiological surveys within Study Group 7.
- Perform geophysical surveys within Study Groups 5 and 7.
- Install project-specific environmental monitoring TLDs (see Section 4.2.3 for additional information).
- Perform visual surveys within Study Group 7 to identify any staining, discoloration, disturbance of native soils, or any other indication of potential contamination.

4.2.2 Sample Location Selection

Rationale for selecting areas for sampling is discussed in the following sections.

4.2.2.1 Primary Releases

Decision I will be evaluated by measuring TED within sample plots. The sample plots are planned for the collection of soil samples to determine internal dose. Sample plots will be established within the areas of the highest values from the applicable ground-based radiological surveys. At CAU 569, the radiological instruments used during the preliminary investigation to survey the area outside the DCB were the PRM-470 and FIDLER. A ground-based KIWI survey was also conducted in 1996 in the areas of Study Groups 1, 3, 4, 5, and 6. Based on the results of these surveys, Decision I sample plots at Study Groups 1, 3, 4, 5, and 6 are planned at the locations of the highest readings from the PRM-470 and KIWI surveys. However, for Study Group 2, because a KIWI survey was not conducted, Decision I sample plots are planned at the locations of the highest readings from the PRM-470 and FIDLER surveys. See Section A.8.1.1 for additional detail on the selection of sample plot locations. The Decision I sample plot locations are depicted on Figures A.8-1 through A.8-6, and coordinates for the Decision I sample plots are presented in Table A.8-1.

The establishing of sample plots at the highest radiological survey values will be done in an effort to find the location within each study group where the internal dose contributes the greatest amount to TED. A TLD will be placed in the approximate center of each sample plot to determine the external dose. If the 95 percent UCL of the TED at the Decision I sample plots associated with Study Groups

5 and 6 exceeds 25 mrem/IA-yr, three Decision II sample plot locations will be established judgmentally along a vector that is approximately normal to the gamma radiation survey isopleths.

In addition to the TLDs placed within each sample plot, TLDs will also be installed within Study Groups 2, 3, 5, and 6 using a random start with a triangular grid pattern to measure external dose. No additional TLDs are planned to be placed as part of the primary release investigation at Study Groups 1 or 4. Therefore, if the results of the Decision I samples at Study Groups 1 or 4 indicate contamination present that exceeds the FALs, then a Decision II sampling strategy will be presented to and agreed upon by the stakeholders. The known Decision II sample plot locations and additional TLD locations are depicted on Figures A.8-2, A.8-3, A.8-5, and A.8-6, and coordinates for these sample locations are listed in Table A.8-1.

The TED rates at each TLD location where soil samples are not collected will be estimated by adding an estimate of internal dose of the respective study group to the TLD results. The conservative estimate of internal dose for each of these locations will be calculated based on a ratio of internal dose to external dose. This ratio will be conservatively established from the measured internal and external doses at the sample plot within each study group with the maximum internal dose rate (see equation below). Use of this ratio will overestimate internal dose (and therefore TED) at all locations with lower dose rates. The TED for each of these TLD locations will be calculated as the total of the external dose measured by the TLD and the internal dose estimated using internal/external dose ratio from the selected sample plot.

$$INT_{inferred\ at\ location\ x} = \frac{Int_{location\ of\ \max internal\ dose}}{TLD_{location\ of\ \max internal\ dose}} \times TLD_{location\ x}$$

All soil samples collected at each sample plot and all TLDs placed at each sample location will be sampled as described in Section 4.2.3.

Study Group 7 is considered an other release and is discussed in the following subsection.

4.2.2.2 Other Releases

For other releases at CAU 569, a judgmental sampling approach will be used to investigate the likelihood of the soil containing a COC. Biasing factors such as stains, radiological survey results, and wastes suspected of containing hazardous or radiological components will be used to select the most appropriate samples from a particular location for collection and analysis.

Within Study Group 1, there is the potential for subsurface (buried) contamination to be present. To determine whether subsurface contamination is present at Study Group 1, 10 subsurface samples will be collected based on a probabilistic sampling scheme. At each of the 10 randomly selected locations, a TLD will be placed and a sample will be collected from each 5-cm depth interval from the ground surface down to a maximum depth of 30 cm. Each sample will be screened with an alpha/beta contamination meter. If the field-screening level (FSL) for any depth sample exceeds the FSL of the surface sample by at least 20 percent, as agreed to in the DQOs, the depth sample with the greatest exceedance, along with the surface soil sample, will be submitted for analysis. If the FSL is not exceeded in any depth sample, only the surface sample will be submitted for analysis.

For Study Group 7, a ground-based radiological survey will be conducted to identify any elevated levels of radioactivity. If levels are greater than two times background levels, a judgmentally located sample plot to sample the surface contamination will be established within the area of the highest values from the ground-based radiological survey. In addition to the surface sample plot, four areas within the plot will be screened to determine whether buried contamination exists. If buried contamination is present, sampling will be conducted within the sample plot in accordance with Section A.8.3.1.2. In addition to soil sampling within Study Group 7, a geophysical survey will be conducted to verify the CSM that this area was used to consolidate contaminated soil from atmospheric testing operations. The geophysical survey will be conducted because insufficient documentation has been identified to prove that no waste disposal operations occurred at Study Group 7. If buried material is identified, then it will be assumed that contamination exists above FALs, and a strategy for addressing Decision II for the buried waste will be presented to and agreed upon by the stakeholders. No samples will be collected based on the geophysical survey results.

Within Study Group 5, KIWI survey results show that two distinct elevated Am-241 areas are present south of the RWMS boundary. These areas will be investigated and sampled identical to Study Group 7 (see previous paragraph).

If a COC is present at any other release scenario sample location, Decision II sampling will be conducted to define the extent of contamination where COCs have been confirmed. Extent (Decision II) sampling locations at each study group will be selected based on the CSM, biasing factors, field-survey results, existing data, and the outer boundary sample locations where COCs are detected. If COCs extend beyond extent locations, additional Decision II samples will be collected from locations further from the source.

If a spatial boundary is reached, the CSM is shown to be inadequate, or the Site Supervisor determines that extent sampling needs to be reevaluated, then work will be temporarily suspended, NDEP will be notified, and the investigation strategy will be reevaluated. A minimum of one analytical result less than the action level from each lateral and vertical direction will be required to define the extent of COC contamination. The lateral and vertical extent of COCs will only be established based on validated laboratory analytical results (i.e., not field screening).

The sampling strategy and the estimated locations of biased samples are presented in Appendix A. The Task Manager or Site Supervisor may modify the number, location, and spacing of step-outs as warranted by site conditions to achieve DQO criteria stipulated in Appendix A. Where sampling locations are modified, the justification for these modifications will be documented in the CADD.

4.2.3 Sample Collection

The CAU 569 sampling program will consist of the following activities:

- Collect and analyze samples from locations as described in Section 4.2.2.
- Collect required QC samples.
- Collect waste management samples as necessary.
- Collect external dose measurements by hanging TLDs at the sample locations, or collect instrument dose readings at extent locations.

- Collect soil samples from locations outside the influence of releases from the study groups, if necessary.
- Perform radiological characterization surveys of construction materials and debris as necessary for disposal purposes.
- Record Global Positioning System (GPS) coordinates for each environmental sample location.

To determine internal dose for the primary release scenario and the other release locations for determination of buried contamination (Study Groups 5 and 7), a probabilistic sampling approach will be implemented for collecting composite samples within the sample plots. Each composite sample will consist of soil collected from nine randomly located subsample locations within the plot. For each composite sample, the first location will be selected randomly; the remaining eight subsample locations will be established on a systematic triangular grid (see Section A.8.0). External dose will be sampled from a TLD installed at the approximate center of the sample plot at a height of 1 m and be left in place for approximately 2,250 hours (equivalent to an annual industrial worker exposure).

Decision I other release samples will be collected from the locations described in Section 4.2.2.2. If biasing factors are present in soils below locations where Decision I samples were collected, subsurface soil samples will also be collected by augering, backhoe excavation, direct-push, or drilling techniques, as appropriate. Subsurface soil samples will be collected at depth intervals selected by the Site Supervisor based on biasing factors to a depth where the biasing factors are no longer present.

4.2.4 Sample Management

The laboratory requirements (i.e., MDCs, precision, and accuracy) to be used when analyzing the COPCs are presented in Tables 3-2 and 3-3. The analytical program is presented in Tables A.2-2 through A.2-4. All sampling activities and QC requirements for field and laboratory environmental sampling will be conducted in compliance with the Industrial Sites QAPP (NNSA/NV, 2002a) and other applicable, approved procedures.

4.3 Site Restoration

Upon completion of CAI and waste management activities, the following actions will be implemented before closure of the site Real Estate/Operations Permit (REOP):

- All equipment, wastes, debris, and materials associated with the CAI will be removed from the site.
- All CAI-related signage and fencing (unless part of a corrective action) will be removed from the site.
- Site will be inspected to ensure restoration activities have been completed.

5.0 Waste Management

Waste generated during the CAU 569 field investigation will be managed in accordance with all applicable DOE orders, federal and state regulations, and agreements and permits between DOE and NDEP. Wastes will be characterized based on these regulations using process knowledge, field-screening results (FSRs), and analytical results from investigation and waste samples. Waste types that may be generated during the CAI include industrial, low-level radioactive, hazardous, hydrocarbon, *Toxic Substances Control Act* (TSCA) regulated, or mixed wastes.

Disposable sampling equipment, personal protective equipment (PPE), and rinsate are considered potentially contaminated waste only by virtue of contact with potentially contaminated media (e.g., soil) or potentially contaminated debris (e.g., lead bricks). These wastes may be characterized based on CAI sample results of associated samples, process knowledge, or directly sampled. Chemicals were not known to be used or present at this CAU in a manner that would generate listed hazardous waste; therefore, wastes will be characterized based on their chemical characteristics. The waste will be managed and disposed of accordingly.

Conservative estimates of total waste contaminant concentrations may be made based on the mass of the waste, the amount of contaminated media contained in the waste, and the maximum concentration of contamination found in the media.

The following sections discuss how the field investigation will be conducted to minimize the generation of waste, the waste streams that are expected to be generated, and the management of IDW.

5.1 Waste Minimization

The CAI will be conducted in a manner that will minimize the generation of wastes using process knowledge, segregation, visual examination, and/or field screening (e.g., radiological survey and swipe results) to avoid cross-contaminating uncontaminated media or IDW that would otherwise be characterized and disposed of as industrial waste. As appropriate, media and debris will be returned to their original location. To limit unnecessary generation of hazardous or mixed waste, hazardous materials will not be used during the CAI unless required and approved by Environmental

Compliance and Safety and Health. Other waste minimization practices will include, as appropriate, avoiding contact with contaminated materials, performing dry or wet decontamination over source locations, and carefully segregating waste streams.

5.2 Potential Waste Streams

The expected waste types to be generated during the CAU 569 field investigation include industrial and low-level radioactive IDW from the sampling activities. However, because of the uncertainty about what wastes are present within the study group boundaries (e.g., lead, batteries, spills), the following waste streams have been included as potential waste streams that may require management and disposal:

- Disposable sampling equipment and/or PPE
- Environmental media (e.g., soil)
- Surface debris in investigation area (e.g., metal, concrete, batteries)
- Decontamination rinsate

5.3 Investigation-Derived Waste Management

The onsite management of IDW will be determined based on regulations associated with the particular waste type (e.g., industrial, hydrocarbon, low-level, hazardous, mixed), or the combination of waste types. The following subsections describe how specific waste types will be managed.

5.3.1 Industrial Waste

Industrial IDW, if generated, will be collected, managed, and disposed of in accordance with the solid waste regulations and the permits for operation of the NNSS Solid Waste Disposal Sites.

5.3.2 Hydrocarbon Waste

Hydrocarbon soil wastes, if generated, will be managed on site in a drum or other appropriate container until fully characterized. Hydrocarbon waste may be disposed of at a designated hydrocarbon landfill, an appropriate hydrocarbon waste management facility (e.g., recycling facility), or other method in accordance with the State of Nevada regulations (NDEP, 2006).

5.3.3 Low-Level Waste

Low-level radioactive wastes, if generated, will be managed in accordance with the contractor-specific waste certification program plan, DOE orders, and the requirements of the current version of the NNSS Waste Acceptance Criteria (WAC) (NNSA/NSO, 2011). Potential radioactive waste may be staged and managed at a designated RMA.

5.3.4 Hazardous Waste

Suspected hazardous wastes, if generated, will be placed in U.S. Department of Transportation (DOT)-compliant containers. All containerized hazardous waste will be managed in accordance with Title 40 *Code of Federal Regulations* (CFR) 262.34 (CFR, 2011b).

5.3.5 Mixed Low-Level Waste

Mixed waste, if generated, shall be managed and dispositioned in accordance with the requirements of RCRA (CFR, 2011b), agreements between NNSA/NSO and the State of Nevada, and DOE requirements for radioactive waste. Waste characterized as mixed will not be stored for a period of time that exceeds the requirements of RCRA unless subject to agreements between NNSA/NSO and the State of Nevada. Mixed waste with hazardous waste constituent concentrations below Land Disposal Restrictions may be disposed of at the NNSS Area 5 RWMS if the waste meets the requirements of the NNSS WAC (NNSA/NSO, 2011) and the NNSS NDEP permit for a Hazardous Waste Management Facility (NEV HW0101 [NDEP, 2011]). Mixed waste constituent concentrations exceeding Land Disposal Restrictions will be transferred to the management and operating contractor for treatment and disposal.

5.3.6 Polychlorinated Biphenyls

The management of PCBs is governed by TSCA (USC, 2009) and its implementing regulations at 40 CFR 761 (CFR, 2011c), and agreements between EPA and NDEP. If any detected PCB waste is generated, it will be managed in accordance with 40 CFR 761 (CFR, 2011c) as well as State of Nevada requirements (NAC, 2008b), guidance, and agreements with NNSA/NSO.

6.0 Quality Assurance/Quality Control

The overall objective of the characterization activities described in this CAIP is to collect accurate and defensible data to support the selection and implementation of a closure alternative for the study groups in CAU 569. The data from the TLD measurements will meet rigorous data quality requirements. The TLDs will be obtained from, and measured by, the Environmental Technical Services group at the NNSS. This group is responsible for a routine environmental monitoring program at the NNSS. The program includes a campaign of TLDs that are emplaced at pre-established locations across the NNSS for the monitoring of external dose. The TLDs are replaced and read quarterly. Details of this campaign can be found in the *Nevada Test Site Environmental Report 2006* (Wills, 2007). The TLDs placed at CAU 569 locations will be submitted to the Environmental Technical Services group for inclusion in their routine quarterly read of the NNSS environmental monitoring TLDs. The TLDs will be analyzed using automated TLD readers that are calibrated and maintained by the National Security Technologies, LLC, Radiological Control Department in accordance with existing QC procedures for TLD processing. A summary of the routine environmental monitoring TLD QC efforts and results can be found in Section 5.2.1 of the *Nevada Test Site Environmental Report 2006*. Certification is maintained through the DOE Laboratory Accreditation Program for dosimetry.

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

1. The TLDs will be exposed at the sample locations for the 2,250 hours of exposure time used for the Industrial Area exposure scenario. This eliminates errors in reading dose-rate meter scale graduations and needle fluctuations that would be magnified when as-read meter values are multiplied from units of “per-hour” to 2,250 hours.

2. The use of a TLD to determine an individual’s external dose is the standard in radiation safety and serves as the “legal dose of record” when other measurements are available. Specifically, 10 CFR Part 835.402 (CFR, 2011a) indicates 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.

Sections 6.1 and 6.2 discuss the collection of required QC samples in the field and QA requirements for soil samples.

6.1 Quality Control Sampling Activities

Field QC samples will be collected in accordance with established procedures. Field QC samples are collected and analyzed to aid in determining the validity of environmental sample results. The number of required QC samples depends on the types and number of environmental samples collected. As determined in the DQO process, the minimum frequency of collecting and analyzing QC samples for this investigation is as follows:

- **For radiological samples**
  - Field duplicates (1 per 20 environmental samples, or 1 per study group per matrix if less than 20 collected), and
  - Laboratory QC samples (1 per 20 environmental samples, or 1 per study group per matrix if less than 20 collected).
- **For chemical samples (if collected)**
  - Trip blanks (1 per sample cooler containing VOC environmental samples),
  - Equipment rinsate blanks (1 per sampling event for each type of decontamination procedure),
  - Source blanks (1 per lot of uncharacterized source material that contacts sampled media),
  - Field duplicates (1 per 20 environmental samples, or 1 per study group per matrix if less than 20 collected),
  - Field blanks (1 per study group depending on site conditions), and
  - Laboratory QC samples (1 per 20 environmental samples, or 1 per study group per matrix if less than 20 collected).

Additional QC samples may be submitted based on site conditions at the discretion of the Task Manager or Site Supervisor. Field QC samples shall be analyzed using the same analytical procedures implemented for associated environmental samples. Additional details regarding field QC samples are available in the Industrial Sites QAPP (NNSA/NV, 2002a).

6.2 Laboratory/Analytical Quality Assurance

As stated in the DQOs (see Appendix A), and except where noted, laboratory analytical quality data will be used for making DQO decisions. Rigorous QA/QC will be implemented for all laboratory samples, including documentation, data verification and validation of analytical results, and an assessment of DQIs as they relate to laboratory analysis.

6.2.1 Data Validation

Data verification and validation will be performed in accordance with the Industrial Sites QAPP (NNSA/NV, 2002a), except where otherwise stipulated in this CAIP. All chemical and radiological laboratory data from samples that are collected and analyzed will be evaluated for data quality in accordance with company-specific procedures. The data will be reviewed to ensure that all required samples were appropriately collected and analyzed, and that the results met data validation criteria. Validated data, including estimated data (i.e., J-qualified), will be assessed to determine whether the data meet the DQO requirements of the investigation and the performance criteria for the DQIs. The results of this assessment will be documented in the CADD. If the DQOs were not met, corrective actions will be evaluated, selected, and implemented (e.g., refine CSM or resample to fill data gaps).

6.2.2 Data Quality Indicators

The DQIs are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data. Data quality indicators are used to evaluate the entire measurement system and laboratory measurement processes (i.e., analytical method performance) as well as to evaluate individual analytical results (i.e., parameter performance). The quality and usability of data used to make DQO decisions will be assessed based on the following DQIs:

- Precision
- Accuracy/bias
- Representativeness
- Completeness
- Comparability
- Sensitivity

Table 6-1 provides the established analytical method/measurement system performance criteria for each of the DQIs and the potential impacts to the decision if the criteria are not met. The following

Table 6-1
Laboratory and Analytical Performance Criteria for CAU 569 DQIs

DQI	Performance Metric	Potential Impact on Decision If Performance Metric Not Met
Precision	At least 80% of the sample results for each measured contaminant are not qualified for precision based on the criteria for each analytical method-specific and laboratory-specific criteria presented in Section 6.2.3.	The affected analytical results from each affected study group will be assessed to determine whether there is sufficient confidence in analytical results to use the data in making DQO decisions.
Accuracy	At least 80% of the sample results for each measured contaminant are not qualified for accuracy based on the method-specific and laboratory-specific criteria presented in Section 6.2.4.	The affected analytical results from each affected study group will be assessed to determine whether there is sufficient confidence in analytical results to use the data in making DQO decisions.
Representativeness	Samples contain contaminants at concentrations present in the environmental media from which they were collected.	Analytical results will not represent true site conditions. Inability to make appropriate DQO decisions.
Decision I Completeness	80% of the study group-specific COPCs have valid results.	Cannot support/defend decision on whether COCs are present.
Decision II Completeness	100% of COCs used to define extent have valid results.	Extent of contamination cannot be accurately determined.
Comparability	Sampling, handling, preparation, analysis, reporting, and data validation are performed using standard methods and procedures.	Inability to combine data with data obtained from other sources and/or inability to compare data to regulatory action levels.
Sensitivity	Minimum detectable concentrations are less than or equal to respective FALs.	Cannot determine whether COCs are present or migrating at levels of concern.

subsections discuss each of the DQIs that will be used to assess the quality of laboratory data. The criteria for precision and accuracy in Tables 3-2 and 3-3 may vary from corresponding information in the Industrial Sites QAPP as a result of changes in analytical methodology and laboratory contracts (NNSA/NV, 2002a).

The TLDs will be analyzed using automated TLD readers that are calibrated and maintained in accordance with existing QC procedures for TLD processing (Section 6.0) by a laboratory that is certified through the DOE Laboratory Accreditation Program for dosimetry. The data from this system meet rigorous data quality requirements and will be assessed for the listed DQIs before inclusion in the CAU 569 datset. Therefore, a separate evaluation of the TLD data against the DQIs will not be conducted.

6.2.3 Precision

Precision is a measure of the repeatability of the analysis process from sample collection through analysis results and is used to assess the variability between two equal samples.

Determinations of precision will be made for field duplicate samples and laboratory duplicate samples. Field duplicate samples will be collected simultaneously with samples from the same source under similar conditions in separate containers. The duplicate sample will be treated independently of the original sample in order to assess field impacts and laboratory performance on precision through a comparison of results. Laboratory precision is evaluated as part of the required laboratory internal QC program to assess performance of analytical procedures. The laboratory sample duplicates are an aliquot, or subset, of a field sample generated in the laboratory. They are not a separate sample but a split, or portion, of an existing sample. Typically, laboratory duplicate QC samples may include matrix spike duplicate (MSD) and LCS duplicate samples for organic, inorganic, and radiological analyses.

Precision is a quantitative measure used to assess overall analytical method and field-sampling performance as well as the need to “flag” (qualify) individual parameter results when corresponding QC sample results are not within established control limits.

The criteria used for the assessment of inorganic chemical precision when both results are greater than or equal to 5x reporting limit (RL) are 20 and 35 percent for aqueous and soil samples, respectively. When either result is less than 5x RL, a control limit of ±1x RL and ±2x RL for aqueous and soil samples, respectively, is applied to the absolute difference. The criteria used for the assessment of organic chemical precision are based on professional judgment using laboratory-defined control limits. The criteria used for the assessment of radiological precision when both results are greater than or equal to 5x MDC are 20 and 35 percent for aqueous and soil samples, respectively. When either result is less than 5x MDC, the ND should be between -2 and +2 for aqueous and soil samples. The parameters to be used for assessment of precision for duplicates are listed in Table 3-3.

Any values outside the specified criteria do not necessarily result in the qualification of analytical data. It is only one factor in making an overall judgment about the quality of the reported analytical

results. The performance metric for assessing the DQI of precision on DQO decisions (Table 6-1) is that at least 80 percent of sample results for each measured contaminant are not qualified due to duplicates exceeding the criteria. If this performance criterion is not met, an assessment will be conducted in the CADD on the impacts to DQO decisions specific to affected contaminants at specific CASs.

6.2.4 Accuracy

Accuracy is a measure of the closeness of an individual measurement to the true value. It is used to assess the performance of laboratory measurement processes.

Accuracy is determined by analyzing a reference material of known parameter concentration or by reanalyzing a sample to which a material of known concentration or amount of parameter has been added (spiked). Accuracy will be evaluated based on results from three types of spiked samples: MS, LCS, and surrogates (organics). The LCS sample is analyzed with the field samples using the same sample preparation, reagents, and analytical methods used for the samples. One LCS will be prepared with each batch of samples for analysis by a specific measurement.

The criteria used for the assessment of inorganic chemical accuracy are 75 to 125 percent for MS recoveries and 80 to 120 percent for LCS recoveries. For organic chemical accuracy, MS and LCS laboratory-specific percent recovery criteria developed and generated in-house by the laboratory in accordance with approved laboratory procedures are applied. The criteria used for the assessment of radiochemical accuracy are 80 to 120 percent for LCS and MS recoveries.

Any values outside the specified criteria do not necessarily result in the qualification of analytical data. It is only one factor in making an overall judgment about the quality of the reported analytical results. Factors beyond laboratory control, such as sample matrix effects, can cause the measured values to be outside the established criteria. Therefore, the entire sampling and analytical process may be evaluated when determining the usability of the affected data.

The performance metric for assessing the DQI of accuracy on DQO decisions (Table 6-1) is that at least 80 percent of the sample results for each measured contaminant are not qualified for accuracy. If

this performance criterion is not met, an assessment will be conducted in the CADD on the impacts to DQO decisions specific to affected contaminants and study groups.

6.2.5 Representativeness

Representativeness is the degree to which sample characteristics accurately and precisely represent characteristics of a population or an environmental condition (EPA, 2002). Representativeness is ensured by carefully developing the CAI sampling strategy during the DQO process such that false negative and false positive decision errors are minimized. The criteria listed in DQO Step 6 (Specify Performance or Acceptance Criteria) are as follows:

- For Decision I judgmental sampling, having a high degree of confidence that the sample locations selected will identify COCs if present anywhere within the study group.
- For Decision I probabilistic sampling, having a high degree of confidence that the sample locations selected will represent contamination of the study group.
- Having a high degree of confidence that analyses conducted will be sufficient to detect any COCs if present in the samples.
- For Decision II, having a high degree of confidence that the sample locations selected will identify the extent of COCs.

These are qualitative measures that will be used to assess measurement system performance for representativeness. The assessment of this qualitative criterion will be presented in the CADD.

6.2.6 Completeness

Completeness is defined as generating sufficient data of the appropriate quality to satisfy the data needs identified in the DQOs. For judgmental sampling, completeness will be evaluated using both a quantitative measure and a qualitative assessment. The quantitative measurement to be used to evaluate completeness is presented in Table 6-1 and is based on the percentage of measurements made that are judged to be valid.

For the judgmental sampling approach, the completeness goal is 80 percent. If this goal is not achieved, the dataset will be assessed for potential impacts on making DQO decisions. For the

probabilistic sampling approach, the completeness goal is a calculated minimum sample size required to produce a valid statistical comparison of the sample mean to the FAL.

The qualitative assessment of completeness is an evaluation of the sufficiency of information available to make DQO decisions. This assessment will be based on meeting the data needs identified in the DQOs and will be presented in the CADD. Additional samples will be collected if it is determined that the available information is not sufficient to resolve DQO decisions.

6.2.7 Comparability

Comparability is a qualitative parameter expressing the confidence with which one dataset can be compared to another (EPA, 2002). The criteria for the evaluation of comparability will be that all sampling, handling, preparation, analysis, reporting, and data validation were performed and documented in accordance with approved procedures that are in conformance with standard industry practices. Analytical methods and procedures approved by DOE will be used to analyze, report, and validate the data. These methods and procedures are in conformance with applicable methods used in industry and government practices. An evaluation of comparability will be presented in the CADD.

6.2.8 Sensitivity

Sensitivity is the capability of a method or instrument to discriminate between measurement responses representing different levels of the variable of interest (EPA, 2002). If this criterion is not achieved, the affected data will be assessed for usability and potential impacts on meeting site characterization objectives. This assessment will be presented in the CADD.

As presented in Section 3.4, the evaluation criterion for this parameter will be that the analytical methods must be sufficient to detect contamination that is present in the samples at concentrations less than or equal to the corresponding FALs. The target MDCs for each COPC are provided in Tables 3-2 and 3-3.

Although the data quality for TLD measurements is assessed via the routine environmental monitoring program (Section 6.0), the sensitivity evaluation criterion for TLD measurements is 50 percent of the FAL (i.e., 12.5 net mrem/yr).

7.0 Duration and Records Availability

7.1 Duration

Field and analytical activities will require approximately 160 days to complete.

7.2 Records Availability

Historical information and documents referenced in this plan are retained in the NNSA/NSO project files in Las Vegas, Nevada, and can be obtained through written request to the NNSA/NSO Federal Sub-Project Director. This document is available in the DOE public reading rooms located in Las Vegas and Carson City, Nevada, or by contacting the appropriate DOE Federal Sub-Project Director.

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Appendix A

Data Quality Objectives

A.1.0 Introduction

The DQO process described in this appendix is a seven-step strategic systematic planning method used to plan data collection activities and define performance criteria for the CAU 569, Area 3 Yucca Flat Atmospheric Test Sites, field investigation. The DQOs are designed to ensure that the data collected will provide sufficient and reliable information to identify, evaluate, and technically defend recommended corrective actions (i.e., no further action, closure in place, or clean closure). Existing information about the nature and extent of contamination at the study groups in CAU 569 is insufficient to evaluate and select preferred corrective actions; therefore, a CAI will be conducted.

The CAU 569 CAI will be based on the DQOs presented in this appendix as developed by NDEP and NNSA/NSO representatives. The seven steps of the DQO process presented in Sections A.2.0 through A.8.0 were developed in accordance with *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

The DQO process presents a combination of probabilistic and judgmental sampling approaches. In general, the procedures used in the DQO process provide the following:

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

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

A.2.0 Step 1 - State the Problem

Step 1 of the DQO process defines the problem that requires study, identifies the planning team, and develops a conceptual model of the environmental hazard to be investigated.

The problem statement for CAU 569 is as follows: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the study groups in CAU 569."

A.2.1 Planning Team Members

The DQO planning team consists of representatives from NDEP and NNSA/NSO. The DQO planning team met on September 26, 2011, for the DQO meeting.

A.2.2 Conceptual Site Model

The CSM is used to organize and communicate information about site characteristics. It reflects the best interpretation of available information at a point in time. The CSM is a primary vehicle for communicating assumptions about release mechanisms, potential migration pathways, or specific constraints. It provides a summary of how and where contaminants are expected to move and what impacts such movement may have. It is the basis for assessing how contaminants could reach receptors both in the present and future. The CSM describes the most probable scenario for current conditions at each site and defines the assumptions that are the basis for identifying appropriate sampling strategy and data collection methods. An accurate CSM is important as it serves as the basis for all subsequent inputs and decisions throughout the DQO process.

The CSM was developed for CAU 569 using information from the physical setting, potential contaminant sources, release information, historical background information, knowledge from similar sites, and physical and chemical properties of the potentially affected media and COPCs.

The CSM consists of the following:

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

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

The applicability of the CSM to each study group is summarized in Table A.2-1 and discussed below. Table A.2-1 provides information on CSM elements that will be used throughout the remaining steps of the DQO process. Figure A.2-1 depicts a representation of the conceptual pathways to receptors from CAU 569 sources. Figure A.2-2 depicts a graphical representation of the CSM.

A.2.2.1 Release Sources

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

- **Primary releases.** This release category 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. Atmospheric releases of radionuclides that have been distributed at the NNSS from nuclear testing have been found to be concentrated in the upper 5 cm of

Table A.2-1
Conceptual Site Model Description of Elements for Each Study Group in CAU 569
(Page 1 of 3)

Study Group	1	2	3	4	5	6	7
Study Group Components	**Catron, Coulomb-B**	**Pike**	**Annie, George, Franklin, Moth**	**Humboldt**	**Harry, Hornet, Rio Arriba, Coulomb-A**	**Fizeau**	**Waste Consolidation Site 3A**
Site Status	Site is located within the Area 3 RWMS	Sites are inactive and/or abandoned					
Exposure Scenario	Industrial Area	Occasional Use					
Sources of Potential Soil Contamination	Atmospheric deposition of radionuclides from nuclear testing; subsequent migration of contaminated soil due to reworking operations; spills, waste, and debris associated with testing support	Atmospheric deposition from nuclear testing; accidental release of radiological contamination from subsurface nuclear testing; spills, waste, and debris associated with testing support	Atmospheric deposition of radionuclides from nuclear testing; spills, waste, and debris associated with testing support				Spills, waste, debris, and contaminated soil associated with testing/testing support

Table A.2-1
Conceptual Site Model Description of Elements for Each Study Group in CAU 569
(Page 2 of 3)

Study Group	1	2	3	4	5	6	7
Study Group Components	**Catron, Coulomb-B**	**Pike**	**Annie, George, Franklin, Moth**	**Humboldt**	**Harry, Hornet, Rio Arriba, Coulomb-A**	**Fizeau**	**Waste Consolidation Site 3A**
Location of Contamination/ Release Point	Surface soil in annular pattern surrounding GZs; contaminated soil may have been moved and may be present under clean soil due to soil disturbance; soil directly below debris	Surface soil from venting from nuclear test; subsurface soil within fissure; soil directly below debris	Surface soil in annular pattern surrounding GZs; soil directly below debris				Shallow subsurface or subsurface soil at or near location(s) of waste/materials
Amount Released	Unknown						
Affected Media	Surface and shallow subsurface soil; debris such as concrete, steel, and wood	Surface, shallow subsurface, and subsurface soil; debris such as concrete, steel, and wood	Surface and shallow subsurface soil; debris such as concrete, steel, and wood				Shallow subsurface and subsurface soil; debris such as concrete, steel, and wood
Potential Contaminants	See Table A.2-2						

Table A.2-1
Conceptual Site Model Description of Elements for Each Study Group in CAU 569
(Page 3 of 3)

Study Group	1	2	3	4	5	6	7
Study Group Components	**Catron, Coulomb-B**	**Pike**	**Annie, George, Franklin, Moth**	**Humboldt**	**Harry, Hornet, Rio Arriba, Coulomb-A**	**Fizeau**	**Waste Consolidation Site 3A**
Transport Mechanisms	Percolation of precipitation through subsurface media serves as the major driving force for migration of contaminants. Surface water runoff may provide for the transportation of some contaminants within or outside the footprints of the study groups. Wind may serve as a means for migration of contaminants.						
Migration Pathways	Vertical transport expected to dominate over lateral transport due to the lack of surface drainage features						
Lateral and Vertical Extent of Contamination	Contamination, if present, is expected to be contiguous to the release points. Concentrations are expected to decrease with distance and depth from the source. Contamination at depth at Pike is addressed under the UGTA Subproject. Groundwater contamination is not expected. Lateral and vertical extent of COC contamination is expected to be within the spatial boundaries.						
Exposure Pathways	The potential for contamination exposure is limited to industrial and construction workers, and military personnel conducting training. These human receptors may be exposed to COPCs through oral ingestion, inhalation, and dermal contact (absorption) of soil and/or debris due to inadvertent disturbance of these materials or irradiation by radioactive materials.						

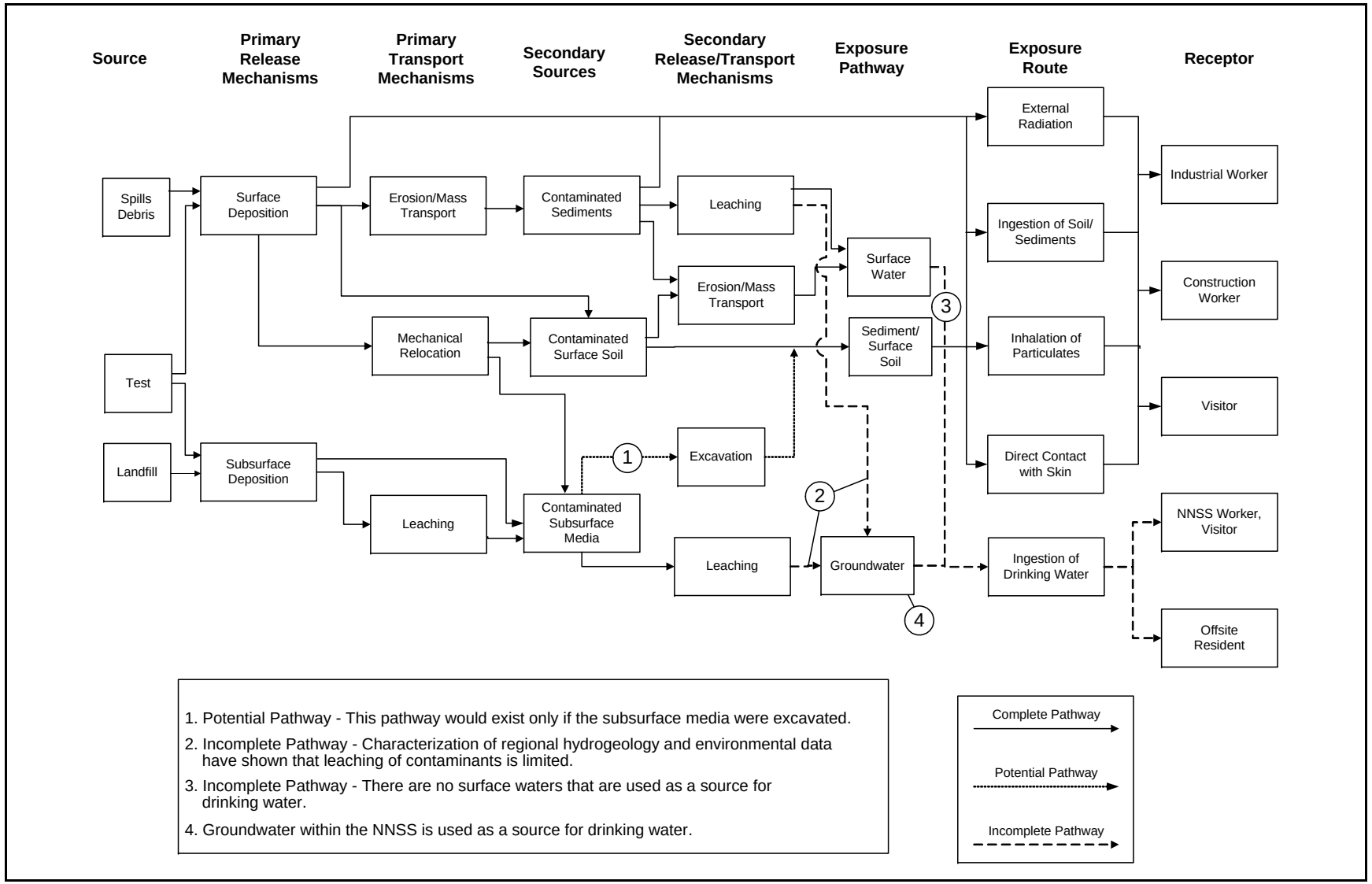

Figure A.2-1
CAU 569 Conceptual Site Model Diagram

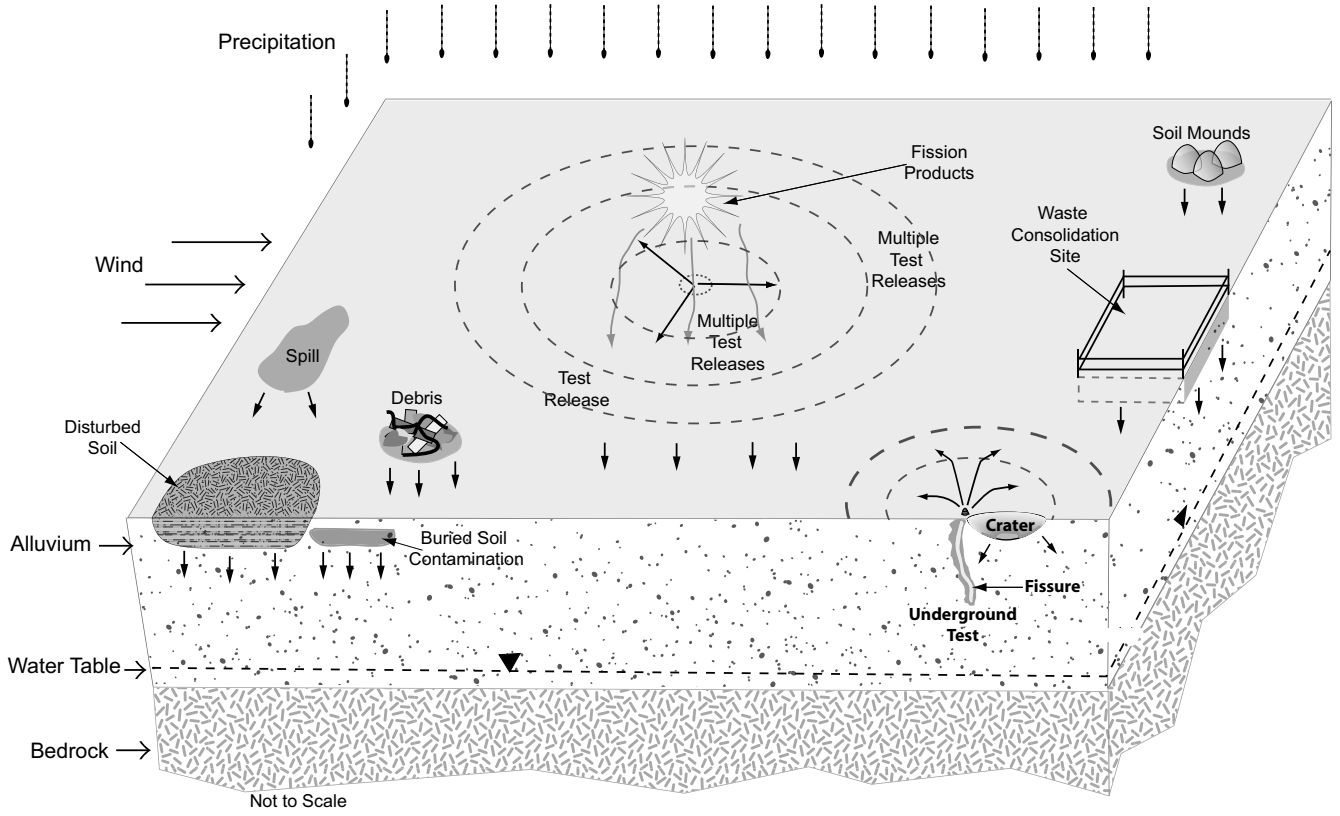

Figure A.2-2
Conceptual Site Model for CAU 569 Study Groups

undisturbed soil (McArthur and Kordas, 1983 and 1985; Gilbert et al., 1977; Tamura, 1977). Therefore, for the purposes of this CAIP, surface is defined as the upper 5 cm of soil.

- **Other releases.** This release category includes any radionuclide contamination from test activities that is not atmospheric deposition of radionuclides. This includes radionuclide contaminants that were initially deposited onto the soil surface (as in the primary release category) but have been displaced through subsequent activities. This category also includes radionuclides that were deposited under mechanisms other than atmospheric deposition (such as radionuclides being driven into the soil by high explosives at each of the GZ areas). This includes any other chemical or radiological contamination that may be discovered during the investigation through the identification of biasing factors that are not a part of a previously identified release.

Corrective Action Unit 569 is a complicated site containing many types of releases (i.e., underground test that vented, atmospheric safety experiments, atmospheric weapons-related experiments, and a waste consolidation site). To simplify the investigation of these sites, they were grouped into seven study groups based on geographic proximity. The following identifies the releases from each study group (DOE/NV, 2000):

- **Study Group 1.** The Catron source was a safety experiment with a yield of 21 tons detonated on the 72.5-ft T-3T tower on October 24, 1958. The Coulomb-B source was a surface safety experiment with a yield of 300 tons detonated at location S-3G on September 6, 1957. The GZs for these tests are located within the Area 3 RWMS. The release consists of the surface soil contamination resulting from the atmospheric deposition of radionuclides during the tests. Another release associated with Study Group 1 consists of the potential subsurface (buried) soil contamination resulting from soil reworking operations within the Area 3 RWMS. Additionally, any portion of the release associated with Study Group 5 that falls within the RWMS boundary will be investigated as part of Study Group 1.

- **Study Group 2.** The Pike source was a weapons-related shaft test with a yield of less than 20 kt detonated in borehole U-3cy on March 13, 1964. The release consists of the surface soil contamination resulting from the venting of radionuclides through a fissure during the test. The surface expression of the fissure was covered by a soil berm.

- **Study Group 3.** The George source was a weapons-related test with a yield of 15 kt detonated on the 300-ft T-3 tower on June 1, 1952. The Annie source was a weapons-related test with a yield of 16 kt detonated on the 300-ft T-3 tower on March 17, 1953. The Moth source was a weapons-related test with a yield of 2 kt detonated on the 300-ft T-3 tower on February 22, 1955. The Franklin source was a weapons-related test with a yield of 140 tons detonated on the 300-ft T-3 tower on June 2, 1957. The release consists of the surface soil contamination resulting from the atmospheric deposition of radionuclides during the tests.

- **Study Group 4.** The Humboldt source was a weapons-related test with a yield of 7.8 tons detonated on the 25-ft T-3V tower on October 29, 1958. The release consists of the surface soil contamination resulting from the atmospheric deposition of radionuclides during this test.

- **Study Group 5.** The Harry source was a weapons-related test with a yield of 32 kt detonated on the 300-ft T-3A tower on May 19, 1953. The Hornet source was a weapons-related test with a yield of 4 kt detonated on the 300-ft T-3A tower on March 12, 1955. The Rio Arriba source was a weapons-related test with a yield of 90 tons detonated on the 72.5-ft T-3S tower on October 18, 1958. The Coulomb-A source was a surface safety experiment with a zero yield detonated at location S-3H on July 1, 1957. The release consists of the surface soil contamination resulting from the atmospheric deposition of radionuclides during the tests. Another release at Study Group 5 is associated with elevated Am-241 levels that were detected just south of the RWMS. The source for these elevated levels is unknown; however, there is the potential for buried soil contamination to be present. This release will be investigated within the scope of Study Group 5. Additionally, any portion of the release associated with Study Group 1 that is located outside the Area 3 RWMS boundary will be investigated as part of Study Group 5.

- **Study Group 6.** The Fizeau source was a weapons-related test with a yield of 11 kt detonated on the 500-ft T-3b tower on September 14, 1957. The release consists of the surface soil contamination resulting from the atmospheric deposition of radionuclides during this test.

- **Study Group 7.** A contaminated waste dump was identified on a historical engineering drawing northeast of the Annie, Franklin, George, Moth GZ. Historical documentation identifies this area as Waste Consolidation Site 3A. Cleanup operations conducted in 1980 and 1981 removed approximately 8,000 yd^3 of soil from the site. The release at this study group consists of potential surface or buried soil contamination.

- For all study groups, other releases such as from batteries, lead bricks, and transformers have been identified within the area encompassing CAU 569. These releases and any additional releases such as from spills or wastes found at the site during the investigation, or contamination that has migrated as a result of wind or water will be addressed.

The most likely locations of the contamination and releases to the environment are the soils directly below or adjacent to the CSM's surface and subsurface components (i.e., soils impacted by fallout and other releases).

A.2.2.2 Potential Contaminants

The list of COPCs is intended to encompass all contaminants reasonably expected at each site that could contribute to a dose or risk exceeding action levels. The study group-specific COPCs are based on a conservative evaluation of possible site activities identified during the planning process through

the review of site history, process knowledge, personal interviews, past investigation efforts (where available), and inferred activities associated with the study groups. Additional COPCs associated with other releases may be discovered during the investigation. Specific COPCs (and subsequently the analyses requested) will be determined for other potential releases based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks). If the nature of the potential release cannot be determined, the potential release will be analyzed for the following: VOCs, SVOCs, RCRA metals, and gamma spectroscopy. The list of COPCs (Table A.2-2) is intended to encompass all of the significant contaminants that could potentially be present at each study group. Significant contaminants are defined as contaminants that are present at concentrations exceeding the PAL. The COPCs applicable to environmental samples from Study Groups 1 through 6 are listed in Table A.2-2. Table A.2-3 lists the analytical methods required for these COPCs, while Table A.2-4 lists all the analytes that are reported by the analytical laboratory for each of the analytical methods. For Study Group 7, COPCs have been identified based on historical documentation and process knowledge of COPCs detected at similar sites (e.g., CAS 01-08-01, 03-17-01, 07-23-02). Based on the fact that contaminated soil from atmospheric testing operations was consolidated at this study group, COPCs for Study Group 7 include the same radionuclide COPCs identified for Study Groups 1 through 6.

Table A.2-2
Contaminants of Potential Concern[a]
(Page 1 of 2)

	Study Group					
COPC	**1**	**2**	**3**	**4**	**5**	**6**
Radionuclide COPCs						
U-234	X	X	X	X	X	X
U-235	X	X	X	X	X	X
U-238	X	X	X	X	X	X
Pu-238	X	X	--	X	X	X
Pu-239/240	X	X	--	X	X	X
Eu-152	X	X	X	X	X	X
Eu-154	X	X	X	X	X	X
Th-232	X	X	X	X	X	X
Cs-137	X	X	X	X	X	X
Am-241	X	X	X	X	X	X

Table A.2-2
Contaminants of Potential Concern[a]
(Page 2 of 2)

	Study Group					
COPC	**1**	**2**	**3**	**4**	**5**	**6**
Chemical COPCs						
Lead	--	X	X	--	X	X
PCBs	--	--	X	--	X	--

[a]The COPCs are the constituents that, based on process knowledge and historical documentation, are likely to be present.

-- = COPC not associated with this study group
X = COPC associated with this study group

Table A.2-3
Analytical Method[a]

Analyses	**Study Group**					
	1	**2**	**3**	**4**	**5**	**6**
Organic COPCs						
PCBs[b]	--	--	X	--	X	--
Inorganic COPCs						
RCRA Metals[c]	--	X	X	--	X	X
Radionuclide COPCs						
Gamma Spectroscopy[d]	X	X	X	X	X	X
Isotopic Am	X	X	--	X	X	X
Isotopic U	X	X	--	X	X	X
Isotopic Pu	X	X	--	X	X	X

[a]The analytical method has been determined based on the site specific COPCs.
[b]For transformer areas only.
[c]For lead brick or battery locations only.
[d]Results of gamma analysis will be used to determine whether further isotopic analysis is warranted.

X = Analytical method required for this study group
-- = Analytical method not required for this study group

A.2.2.3 Contaminant Characteristics

Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. In general, contaminants with low solubility, high affinity for media, and high density can be expected to be found relatively close to release points. Contaminants with small particle size, high

Table A.2-4
Laboratory Analytical Methods with Reported Analytes

VOCs		SVOCs		PCBs	Metals	Radionuclides
1,1,1,2-Tetrachloroethane	Carbon tetrachloride	2,3,4,6-Tetrachlorophenol	Di-n-octyl phthalate	Aroclor 1016	Arsenic	**Gross Alpha/Beta**
1,1,1-Trichloroethane	Chlorobenzene	2,4,5-Trichlorophenol	Dibenzo(a,h)anthracene	Aroclor 1221	Barium	Am-241
1,1,2,2-Tetrachloroethane	Chloroethane	2,4,6-Trichlorophenol	Dibenzofuran	Aroclor 1232	Beryllium	Pu-238
1,1,2-Trichloroethane	Chloroform	2,4-Dimethylphenol	Diethyl phthalate	Aroclor 1242	Cadmium	Pu-239/240
1,1-Dichloroethane	Chloromethane	2,4-Dinitrotoluene	Dimethyl phthalate	Aroclor 1248	Chromium	U-234
1,1-Dichloroethene	Chloroprene	2-Chlorophenol	Fluoranthene	Aroclor 1254	Lead	U-235
1,2,4-Trichlorobenzene	cis-1,2-Dichloroethene	2-Methylnaphthalene	Fluorene	Aroclor 1260	Mercury	U-238
1,2,4-Trimethylbenzene	Dibromochloromethane	2-Methylphenol	Hexachlorobenzene	Aroclor 1268	Selenium	
1,2-Dibromo-3-chloropropane	Dichlorodifluoromethane	2-Nitrophenol	Hexachlorobutadiene		Silver	**Gamma-Emitting**
1,2-Dichlorobenzene	Ethyl methacrylate	3-Methylphenol[a] (m-cresol)	Hexachloroethane			Ac-228
1,2-Dichloroethane	Ethylbenzene	4-Methylphenol[a] (p-cresol)	Indeno(1,2,3-cd)pyrene			Am-241
1,2-Dichloropropane	Isobutyl alcohol	4-Chloroaniline	n-Nitroso-di-n-propylamine			Co-60
1,3,5-Trimethylbenzene	Isopropylbenzene	4-Nitrophenol	Naphthalene			Cs-137
1,3-Dichlorobenzene	Methacrylonitrile	Acenaphthene	Nitrobenzene			Eu-152
1,4-Dichlorobenzene	Methyl methacrylate	Acenaphthylene	Pentachlorophenol			Eu-154
1,4-Dioxane	Methylene chloride	Aniline	Phenanthrene			Eu-155
2-Butanone	n-Butylbenzene	Anthracene	Phenol			K-40
2-Chlorotoluene	n-Propylbenzene	Benzo(a)anthracene	Pyrene			Nb-94
2-Hexanone	sec-Butylbenzene	Benzo(a)pyrene	Pyridine			Pb-212
4-Isopropyltoluene	Styrene	Benzo(b)fluoranthene				Pb-214
4-Methyl-2-pentanone	tert-Butylbenzene	Benzo(g,h,i)perylene				Th-234
Acetone	Tetrachloroethene	Benzo(k)fluoranthene				Tl-208
Acetonitrile	Toluene	Benzoic acid				U-235
Allyl chloride	Total xylenes	Benzyl alcohol				
Benzene	Trichloroethene	Bis(2-ethylhexyl)phthalate				
Bromodichloromethane	Trichlorofluoromethane	Butyl benzyl phthalate				
Bromoform	Vinyl acetate	Carbazole				
Bromomethane	Vinyl chloride	Chrysene				
Carbon disulfide		Di-n-butyl phthalate				

[a]May be reported as 3,4-Methylphenol or m,p-cresol.

Ac = Actinium
K = Potassium
Pb = Lead
Tl = Thallium

solubility, low density, and/or low affinity for media can be expected to be found further from release points or in low areas where evaporation of ponding will concentrate dissolved contaminants.

The radionuclide contaminants in CAU 569 are all moderately to highly adsorbed on the alluvial materials present at the site. A summary of the inherent vertical migration potential of these contaminants through the vadose zone due to their adsorption properties are presented in Table A.2-5. This table also presents the contaminant sorption coefficients (K_d) along with the equivalent retardation factor (based on an average bulk density of 1.5 grams per milliliter and porosity of 0.3) (SNJV, 2007). Based on these properties and the maximum estimated recharge rate of 50 m in 1,000 years (see Section 3.1.4), the major radionuclide contaminants at CAU 569 are estimated to migrate no more than 1/10 of a meter in 1,000 years except for uranium, which could migrate up to 8 m in 1,000 years.

Table A.2-5
Vertical Migration Potential through the Vadose of the Major Radionuclide Contaminants

COC	Approximate Range of K_d Values (mL/g)	Equivalent Retardation Factor	Migration Distance in 1,000 years (m)
Uranium	1 - 10	6 - 50	1 - 8
Plutonium	100 - 10,000	500 - 50,000	0.001 - 0.1
Europium	1,000 - 100,000	5,000 - 500,000	0.0001 - 0.01
Thorium	100 - 10,000	500 - 50,000	0.001 - 0.1
Cesium	1,000 - 10,000	5,000 - 50,000	0.001 - 0.01
Americium	10,000 - 100,000	50,000 - 500,000	0.0001 - 0.001

mL/g = Milliliters per gram

The migration potential of radionuclides released from a nuclear detonation was demonstrated in a long-term radionuclide migration study of an underground nuclear test. A well installed into the groundwater 91 m away from the Cambric test GZ (and much closer to the nearest extent of the test cavity) was continuously pumped from 1975 to 1991 in order to draw radionuclides from the detonation cavity. The May 1965 Cambric test released a yield of 750 tons at a depth of 294 m below the land surface and 73 m below the water table (DOE/NV, 2000; Hoffman and Daniels, 1984). No radionuclides associated with nuclear fission tests (including the major contributing radionuclides plutonium, uranium, cesium, europium, strontium, or cobalt) other than tritium and krypton (which are considered to be conservative tracers in groundwater as they do not interact with the geologic media through which the water moves) were detected in the pumped groundwater during the 29 years of pumping (Bryant, 1992; Hoffman and Daniels, 1984). This test demonstrated the relative immobility of the fission radionuclides under conditions of very high mass flow (over 1.5 billion gallons of water) in a saturated matrix. Under unsaturated conditions (such as atmospheric deposition nuclear test releases), infiltrating water percolating through the vadose zone provides a much smaller fraction of the migration potential (mass flow is on the order of less than 3 cm of recharge per year). Therefore, it can be assumed that while the major fission radionuclides are relatively immobile in saturated conditions with an artificial gradient (i.e., under pumping conditions), they will be even less mobile under unsaturated conditions with limited net infiltration of precipitation.

Based on this evidence, the radionuclides associated with these detonations (e.g., Am-241; Cs-137; Pu-238, -239/240; and U-234, -235, -238) are classified as adsorbing radionuclides with low solubilities that are located within unsaturated media. Therefore, these contaminants are expected to be found relatively close to release points.

A.2.2.4 Site Characteristics

Site characteristics are defined by the interaction of physical, topographical, and meteorological attributes and properties. Topographical and meteorological properties and attributes include slope stability, precipitation frequency and amounts, precipitation runoff pathways, drainage channels and ephemeral streams, and evapotranspiration potential. Meteorological data are presented in Section 2.1.

Corrective Action Unit 569 is located in Area 3 of the NNSS in Yucca Flat. The area is relatively flat, gently sloping to the southeast. The area is sparsely vegetated with native plants. The soil at CAU 569 is made up of sand to gravel-sized alluvium of various lithologies and includes areas of disturbed soil (from road construction, Area 3 RWMS construction, and underground testing). No perennial streamflow exists in this region. The only ephemeral streams identified in the area are present in the northeast portion of the site, nearer to Study Group 2, and flow into craters.

A.2.2.5 Migration Pathways and Transport Mechanisms

Migration pathways for contamination from the study groups include windborne material and materials displaced from maintenance activities (e.g., moved during road maintenance). Contaminants may also be moved through mechanical disturbance due to maintenance or construction activities at the site. Specifically, this can include activities such as Area 3 RWMS construction and operation activities, investigation and resolution of CASs, and disassembly and removal of equipment and support structures.

No visible washes are present within the study boundary of CAU 569. However, the area within and around CAU 569 generally drains into Yucca Flat, which flows south toward the Yucca Flat dry lake.

Migration is influenced by the chemical characteristics of the contaminants (Section A.2.2.3) and the physical characteristics of the vadose material (Section A.2.2.4). In general, the contaminants that are

reasonably expected to be present at CAU 569 (i.e., Pu-239/-240, Am-241, and Cs-137) have low solubilities and high affinity for media. The physical characteristics of the vadose material generally include medium and high adsorptive capacities, low moisture contents (i.e., available water-holding capacity), and relatively long distances to groundwater (groundwater at CAU 569 is approximately 1,600 ft bgs). Based on these physical and chemical factors, contamination is expected to be found relatively close to release points.

Infiltration and percolation of precipitation serve as a driving force for downward migration of contaminants. However, due to high PET (annual PET at the Area 3 RWMS has been estimated at 61.7 in. [Yucel, 2009]) and limited precipitation for this region (6.25 in./yr at Station BJY [ARL/SORD, 2011]), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Subsurface migration pathways at CAU 569 are expected to be predominately vertical, although spills or leaks at the ground surface may also have limited lateral migration before infiltration. The depth of infiltration (shape of the subsurface contaminant plume) will be dependent upon the type, volume, and duration of the discharge as well as the presence of relatively impermeable layers that could modify vertical or lateral transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., caliche layers).

A.2.2.6 Exposure Scenarios

Human receptors may be exposed to COPCs through oral ingestion, inhalation, dermal contact (absorption) of soil or debris due to inadvertent disturbance of these materials or external irradiation by radioactive materials. The land-use zone and exposure scenarios for CAU 569 are listed in Table A.2-6 and are based on NNSS current and future land use. Study Group 1 is located in an area where operations may still be conducted (Area 3 RWMS), and facilities are present that would allow this area to be used as an assigned work station for NNSS site personnel. Therefore, the Industrial Area is the exposure scenario most representative of Study Group 1. Study Groups 2, 3, 4, 5, 6, and 7 are located where no regular work is performed. There is still the possibility, however, that site workers could occupy these locations on an occasional and temporary basis such as a military exercise. Therefore, the Occasional Use Area is the exposure scenario most representative of Study Groups 2 through 7.

Table A.2-6
Land-Use and Exposure Scenarios

Study Group	Record of Decision Land-Use Zone	Exposure Scenario
Study Group 1	**Nuclear and High Explosives Test** This area is designated within the Nuclear Test Zone for additional underground nuclear weapons tests and outdoor high-explosive tests. This zone includes compatible defense and nondefense research, development, and testing activities.	**Industrial Area** Worker will be exposed to the site full time (225 days per year, 10 hours per day for 25 years). Active powered buildings with toilets are present at the site.
Study Groups 2, 3, 4, 5, 6, and 7		**Occasional Use Area** Worker will be exposed to the site occasionally (up to 80 hours per year for 5 years). Site structures are not present for shelter and comfort of the worker.

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

Step 2 of the DQO process states how environmental data will be used in meeting objectives and solving the problem, identifies study questions or decision statement(s), and considers alternative outcomes or actions that can occur upon answering the question(s).

A.3.1 Decision Statements

The Decision I statement is as follows: "Is any COC present in environmental media within the study group?" For judgmental sampling design, any analytical result for a COPC above the FAL will result in that COPC being designated as a COC. For the probabilistic (unbiased) sampling design, any COPC that has a 95 percent UCL of the average concentration above the FAL will result in that COPC being designated as a COC. A COC may also be defined as a contaminant that, in combination with other like contaminants, is determined to jointly pose an unacceptable risk based on a multiple contaminant analysis (NNSA/NSO, 2006). If a COC is detected, then Decision II must be resolved.

The Decision II statement 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 predict potential remediation waste types and volumes
- The information needed to evaluate the feasibility of remediation alternatives (bioassessment if natural attenuation or biodegradation is considered, and geotechnical data if construction or evaluation of barriers is considered)

A corrective action will be determined for any site containing a COC. For the primary release scenario, the DQO process resulted in an assumption that TED within the subsidence crater and fissure covered by the soil berm at Study Group 2 exceeds the FAL and requires corrective action. Therefore, a DCB will be established around these features (Section 3.4). Figure A.8-2 shows the DCB for Study Group 2. Therefore, Decision I for the DCB is resolved and a corrective action is necessary. Decision I will be resolved for the remaining study groups and for the area outside the DCB at Study Group 2.

For the other release scenario, Decision I samples will be submitted to analytical laboratories to determine the presence of COCs. Decision II samples for both release scenarios will be submitted to define the extent of unbounded COCs. In addition, samples will be submitted for analyses, as needed, to support waste management or health and safety decisions.

A corrective action may also be required if a waste present within a study group contains contaminants that, if released, could cause the surrounding environmental media to contain a COC. Such a waste would be considered PSM. To evaluate wastes for the potential to result in the introduction of a COC to the surrounding environmental media, the conservative assumption was made that any physical waste containment would fail at some point and the contaminants would be released 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 to not be PSM if it is clear that it could not result in soil contamination exceeding a FAL.

- If assumptions about the waste cannot be made, then the waste material will be sampled, and the results will be compared to FALs based on the following criteria:

  - For non-liquid wastes, the concentration of any chemical contaminant in soil (after 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 to be PSM.

  - For non-liquid wastes, the dose resulting from radioactive contaminants in soil (after 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 dose exceeds the FAL, then the waste would be considered to be PSM.

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

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).

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

A.3.2 Alternative Actions to the Decisions

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

A.3.2.1 Alternative Actions to Decision I

If no COC associated with a release from the study group is detected, then further assessment of the study group is not required. If a COC associated with a release from the study group is detected, then the extent of COC contamination will be determined, and additional information required to evaluate potential CAAs will be collected.

A.3.2.2 Alternative Actions to Decision II

If the lateral and vertical extent of COC contamination have not been defined by bounding sample results, then additional bounding samples will be collected. If sample analytical results are not sufficient to predict potential remediation waste types, then additional waste characterization samples will be collected. If available information is not sufficient to evaluate the potential for COC migration, then additional information will be collected. If sufficient information is not available to evaluate potential CAAs, then additional samples will be collected. Otherwise, collection of additional information is not required.

A.4.0 Step 3 - Identify Information Inputs

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

A.4.1 Information Needs

To resolve Decision I (determine whether a COC is present at a study group) for the areas outside the DCB, samples will be collected and analyzed following these two criteria:

- Samples must either (a) be collected in areas most likely to contain a COC (judgmental sampling) or (b) properly represent contamination at the study group (probabilistic sampling)
- The analytical suite selected must be sufficient to identify any COCs present in the samples.

To resolve Decision II for primary release contamination outside the DCB, TED rates need to be established at locations that bound the FAL dose rate and provide sufficient information to establish a high (greater than 0.8) correlation to radiation survey isopleths. A boundary will then be determined around the radiation survey isopleth that correlates to the 25-mrem/yr FAL.

To resolve Decision II for other release contamination outside the DCB (determine whether sufficient information is available to evaluate potential CAAs at each study group), samples need to be collected and analyzed to meet the following criteria:

- Samples must be collected in areas contiguous to the contamination but where contaminant concentrations are below FALs.
- Samples of the waste or environmental media must provide sufficient information to determine potential remediation waste types.
- Samples of the waste must provide sufficient information to determine whether they contain PSM.
- The analytical suites selected must be sufficient to detect contaminants at concentrations equal to or less than their corresponding FALs.

A.4.2 Sources of Information

Information to satisfy Decision I and Decision II will be generated by collecting and analyzing environmental samples. Once collected, the samples will be submitted to analytical laboratories meeting the quality criteria stipulated in the Industrial Sites QAPP (NNSA/NV, 2002a). The TLDs will be submitted to the Environmental Technical Services group at the NNSS, which is certified by the DOE Laboratory Accreditation Program for dosimetry. Only validated data from analytical laboratories will be used to make DQO decisions. Sample collection and handling activities will follow standard procedures.

A.4.2.1 Sample Locations

Design of the sampling approaches for the CAU 569 study groups must ensure that the data collected are sufficient for selection of the CAAs (EPA, 2002b). To meet this objective, the samples collected from each site should either be from locations that most likely contain a COC, if present (judgmental), or from locations that properly represent overall contamination at the study group (probabilistic). These sample locations, therefore, can be selected by means of either (a) biasing factors used in judgmental sampling (e.g., a stain, likely containing a spilled substance) or (b) randomly using a probabilistic sampling design. The implementation of a judgmental approach for sample location selection, and of a probabilistic sampling approach, for CAU 569 are discussed in Section A.8.0.

A.4.2.2 Analytical Methods

Analytical methods are available to provide the data needed to resolve the decision statements. The analytical methods and laboratory requirements (e.g., detection limits, precision, and accuracy) for soil samples are provided in Tables 3-2 and 3-3.

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

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

A.5.1 Target Populations of Interest

The population of interest to resolve Decision I ("Is any COC present in environmental media within the study group?") is contaminant concentrations exceeding a FAL at any location or area within the study groups. The populations of interest to resolve Decision II ("If a COC is present, is sufficient information available to evaluate potential CAAs?") are as follows:

- For the primary release, TED and corresponding radiation survey values from locations where TED varies from above the FAL to below the FAL.
- For other releases, COC concentrations for each one of a set of locations bounding contamination in lateral and vertical directions
- Investigation waste and potential remediation waste characteristics

A.5.2 Spatial Boundaries

Spatial boundaries are the maximum lateral and vertical extent of expected contamination that can be supported by the CSM. Decision II spatial boundaries are as follows:

- **Vertical.** Primary release–5 cm below original ground surface
- **Vertical.** Other release–15 ft bgs
- **Lateral.** Primary and other release–1 mi from GZ or location of release

Contamination found beyond these boundaries may indicate a flaw in the CSM and may require reevaluation of the CSM before the investigation can continue. Each study group is considered geographically independent, and intrusive activities are not intended to extend into the boundaries of neighboring study groups or CASs.

A.5.3 Practical Constraints

Practical constraints (e.g., activities by other organizations at the NNSS, utilities, threatened or endangered animals and plants, unstable or steep terrain, and/or access restrictions) may affect the ability to investigate this site. Practical constraints that have been identified specific to CAU 569 include the presence of multiple subsidence craters from underground testing that was conducted in the areas surrounding the atmospheric testing GZs.

A.5.4 Define the Sampling Units

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

A.6.0 Step 5 - Develop the Analytic Approach

Step 5 of the DQO process specifies appropriate population parameters for making decisions, defines action levels, and generates an "If … then … else" decision rule that involves it.

A.6.1 Population Parameters

Population parameters are defined for judgmental and probablistic sampling designs in the following sections. Population parameters are the parameters compared to action levels.

A.6.1.1 Judgmental Sampling Design

For judgmental sampling results, the population parameter is the observed concentration of each contaminant from each individual analytical sample. Each sample result will be compared to the FALs to determine the appropriate resolution to Decision I and Decision II. A single sample result for any contaminant exceeding a FAL would cause a determination that a COC is present within the study group (for Decision I), or that the COC is not bounded (for Decision II).

A.6.1.2 Probabilistic Sampling Design

For probabilistic sampling results, the population parameter is the true TED over the area of the sample plot. Resolution of DQO decisions associated with the probabilistic sampling design requires determining, with a specified degree of confidence, whether the true TED at the site in question exceeds the FAL. Because a calculated TED is an estimate of the true (unknown) TED, it is uncertain how well the calculated TED represents the true TED. If the calculated TED were significantly different from the true TED, a decision based on the calculated TED could result in a decision error. To reduce the probability of making a false negative decision error, a conservative estimate of the true TED is used to compare to the FAL instead of the calculated TED. This conservative estimate (overestimation) of the true TED will be calculated as the 95 percent UCL of the average TED values. 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 95 percent UCL of the TED from each sample location will be used to establish the corrective action boundary. The 95 percent UCL of the TED for each sample location will be established as the

sum of the 95 percent UCL of the internal dose and the 95 percent UCL of the external dose. These 95 percent UCL dose estimates will be calculated using the three external dose measurements from the TLD and the RESRAD-calculated internal dose estimates from the soil samples.

The computation of appropriate UCLs depends upon the data distribution, the number of samples, the variability of the dataset, and the skewness associated with the dataset. A statistical package will be used to determine the appropriate probability distribution (e.g., normal, lognormal, gamma) and/or a suitable nonparametric distribution-free method and then to compute appropriate UCLs. To ensure that the appropriate UCL computational method is used, the sample data will be tested for goodness-of-fit to all of the parametric and nonparametric UCL computation methods described in *Calculating the Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites* (EPA, 2002a).

Computation of an appropriate UCL for each of the calculated TED averages requires the following:

- A minimum number of samples are collected.
- The data originate from a symmetric, but not necessarily normally distributed, population.
- The estimation of the variability is reasonable and representative of the population being sampled.
- The population values are not spatially correlated.

A.6.2 Action Levels

The PALs presented in this section are to be used for site screening purposes. They are not necessarily intended to be used as cleanup action levels or FALs. However, they are useful in screening out contaminants that are not present in sufficient concentrations to warrant further evaluation and, therefore, streamline the consideration of remedial alternatives. The RBCA process used to establish FALs is described in the *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). This process conforms with NAC Section 445A.227, which lists the requirements for sites with soil contamination (NAC, 2008a). For the evaluation of corrective actions, NAC Section 445A.22705 (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 remedial standard.

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

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

- **Tier 2 evaluation.** Conducted by calculating Tier 2 SSTLs using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 SSTLs are then compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis. Total concentrations of total petroleum hydrocarbons (TPH) will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemicals of concern will be compared to the SSTLs.

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

The comparison of laboratory results to FALs and the evaluation of potential corrective actions will be included in the CADD. The FALs will be defined (along with the basis for their definition) in the CADD.

A.6.2.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the *Pacific Southwest, Region 9: Regional Screening Levels (Formerly PRGs), Screening Levels for Chemical Contaminants* in industrial soils (EPA, 2011). Background concentrations for RCRA metals will be used instead of screening levels when natural background concentrations exceed the screening level (e.g., arsenic on the NNSS). Background is considered the average concentration plus two standard deviations of the average concentration for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the

protocol used by EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the CADD.

A.6.2.2 Radionuclide PALs

The PAL for radioactive contaminants is 25-mrem/yr TED, based upon the Industrial Area exposure scenario. The Industrial Area exposure scenario is described in *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). For primary releases, the TED is calculated as the sum of external dose and internal dose. External dose is determined directly from TLD measurements (Section 6.0). Internal dose is determined by comparing analytical results from soil samples to RRMGs that were established using the RESRAD computer code (Yu et al., 2001). The RRMGs presented in Table A.6-1 are radionuclide-specific values for radioactivity in surface soils. The RRMG is the value, in picocuries per gram of surface soil, for a particular radionuclide that would result in an internal dose of 25 mrem/yr to a receptor (under the appropriate exposure scenario) independent of any other radionuclide (assumes that no other radionuclides contribute dose). The internal dose associated with any specific radionuclide would be established using the following equation:

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

When more than one radionuclide is present, the internal dose will be calculated as the sum of the internal doses for each radionuclide. In the RESRAD calculation, several input parameters are not specified so that site-specific information can be used. The default and site-specific input parameters used in the RESRAD calculation of RRMGs for each exposure scenario are listed in Attachment A-1.

A.6.3 Decision Rules

The decision rules applicable to both Decision I and 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, then work will be suspended and the investigation strategy will be reconsidered, else the decision will be to continue sampling.

Table A.6-1
Residual Radioactive Material Guideline Values

Radionuclide	Exposure Scenario (pCi/g)		
	Industrial Area	Remote Work Area	Occasional Use Area
Am-241	2,816	16,120	45,550
Co-60	551,300	7,229,000	74,210,000
Cs-137	140,900	1,955,000	27,560,000
Eu-152	1,177,000	13,240,000	81,740,000
Eu-154	846,900	9,741,000	63,530,000
Eu-155	5,588,000	66,450,000	475,100,000
Nb-94	3,499,000	39,660,000	249,200,000
Pu-238	2,423	13,880	39,220
Pu-239/240	2,215	12,680	35,820
Sr-90	59,470	807,500	9,949,000
Th-232	2,274	13,410	38,520
U-234	19,600	137,900	447,000
U-235	20,890	149,600	492,200
U-238	21,200	55,400	336,100

The decision rules for Decision I are as follows:

- If the population parameter of any COPC in the Decision I population of interest (defined in Step 4) exceeds the corresponding FAL, then that contaminant is identified as a COC, 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 study group, 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.

The decision rules for Decision II are as follows:

- If the population parameter (the observed concentration of any COC) in the Decision II population of interest (defined in Step 4) exceeds the corresponding FAL 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.

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

A.7.0 Step 6 - Specify Performance or Acceptance Criteria

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

A.7.1 Decision Hypotheses

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

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

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

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

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

- Developing a CSM (based on process knowledge) that is agreed to by stakeholder participants during the DQO process.
- Testing the validity of the CSM based on investigation results.
- Evaluating the quality of data based on DQI parameters.

A.7.2 False Negative Decision Error

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

A.7.2.1 False Negative Decision Error for Judgmental Sampling

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

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

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

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

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

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

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

To satisfy the third criterion, the entire dataset of soil sample results, as well as individual soil sample results, will be assessed against the DQIs of precision, accuracy, comparability, and completeness as defined in the Industrial Sites QAPP (NNSA/NV, 2002a) and in Section 6.2.2. The DQIs of precision and accuracy will be used to assess overall analytical method performance as well as to assess the need to potentially "flag" (qualify) individual contaminant results when corresponding QC sample results are not within the established control limits for precision and accuracy. Data qualified as estimated for reasons of precision or accuracy may be considered to meet the analyte performance criteria based on an assessment of the data. The DQI for completeness will be assessed to ensure that all data needs identified in the DQO have been met. The DQI of comparability will be assessed to ensure that all analytical methods used are equivalent to standard EPA methods so that results will be comparable to regulatory action levels that have been established using those procedures. Strict adherence to established procedures and QA/QC protocol protects against false negatives. Site-specific DQIs are discussed in more detail in Section 6.2.2.

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

- Field duplicates (1 per 20 environmental samples, or 1 per study group per matrix if less than 20 collected)
- Laboratory QC samples (1 per 20 environmental samples, or 1 per study group per matrix if less than 20 collected)

A.7.2.2 False Negative Decision Error for Probabilistic Sampling

The false negative decision error rate goal was established by the DQO meeting participants at 5 percent. Upon validation of the analytical results, statistical parameters will be calculated for each significant COPC identified at each site. Protection against a false negative decision error is contingent upon the following:

- Population distribution
- Sample size
- Actual variability
- Measurement error

Control of the false negative decision error for probabilistic sampling designs is accomplished by ensuring that the following requirements are met for each of the significant COPCs:

- The population distributions fit the applied UCL determination method.
- A sufficient sample size was collected.
- The actual standard deviation is calculated.
- Analyses conducted were sufficient to detect contamination exceeding FALs.

A.7.3 False Positive Decision Error

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

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

- Trip blanks (1 per sample cooler containing VOC environmental samples)
- Equipment blanks (1 per sampling event)
- Source blanks (1 per uncharacterized source lot)
- Field blanks (minimum of 1 depending on site conditions, additional if field conditions change)

For probabilistic sampling, false positive decision error rate goal was established by the DQO meeting participants at 0.20 (or 20 percent probability). Protection against this decision error is also afforded by the controls listed in Section A.7.2 for probabilistic sampling designs.

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

Step 7 of the DQO process selects and documents a design that will yield data that will best achieve performance or acceptance criteria. Judgmental sampling schemes will be implemented to select sample plot locations for the primary releases and sample locations for the potential buried soil contamination at Study Groups 5 and 7. Probabilistic sampling schemes will be implemented to select the sample locations within each of the sample plots, and to select locations for investigating potential buried soil contamination within Study Group 1. Investigation results will be compared to FALs to determine the need for corrective action. Potential source material sample results will be evaluated against the PSM criteria listed in Section A.3.1 to determine the need for corrective action.

A.8.1 Internal Dose Sampling for Primary Releases

A.8.1.1 Decision I Sample Plot Locations

A judgmental sampling design will be implemented for locating Decision I sample plots for the primary release scenario (outside the DCB at Study Group 2). These sample locations have been determined judgmentally based on the highest results of the ground-based radiological surveys (Figures 2-7 through 2-9). This is done in an effort to find the location where the internal dose contributes the greatest amount to TED.

A.8.1.1.1 Study Group 1 Sample Plot Locations

Radiological readings, as detected during the PRM-470 survey, were fairly evenly distributed throughout this study group. The most elevated location of radiological readings was detected southeast of the Coulomb-B and Catron GZs, near the berm surrounding the Area 3 RWMS. This location was chosen for a Decision I sample plot. Results from the KIWI survey show that two areas of elevated Am-241 levels were identified. The area with the largest accumulation of elevated readings from the KIWI survey was chosen for a Decision I sample plot. The identified Decision I sample plot locations are depicted on Figure A.8-1.

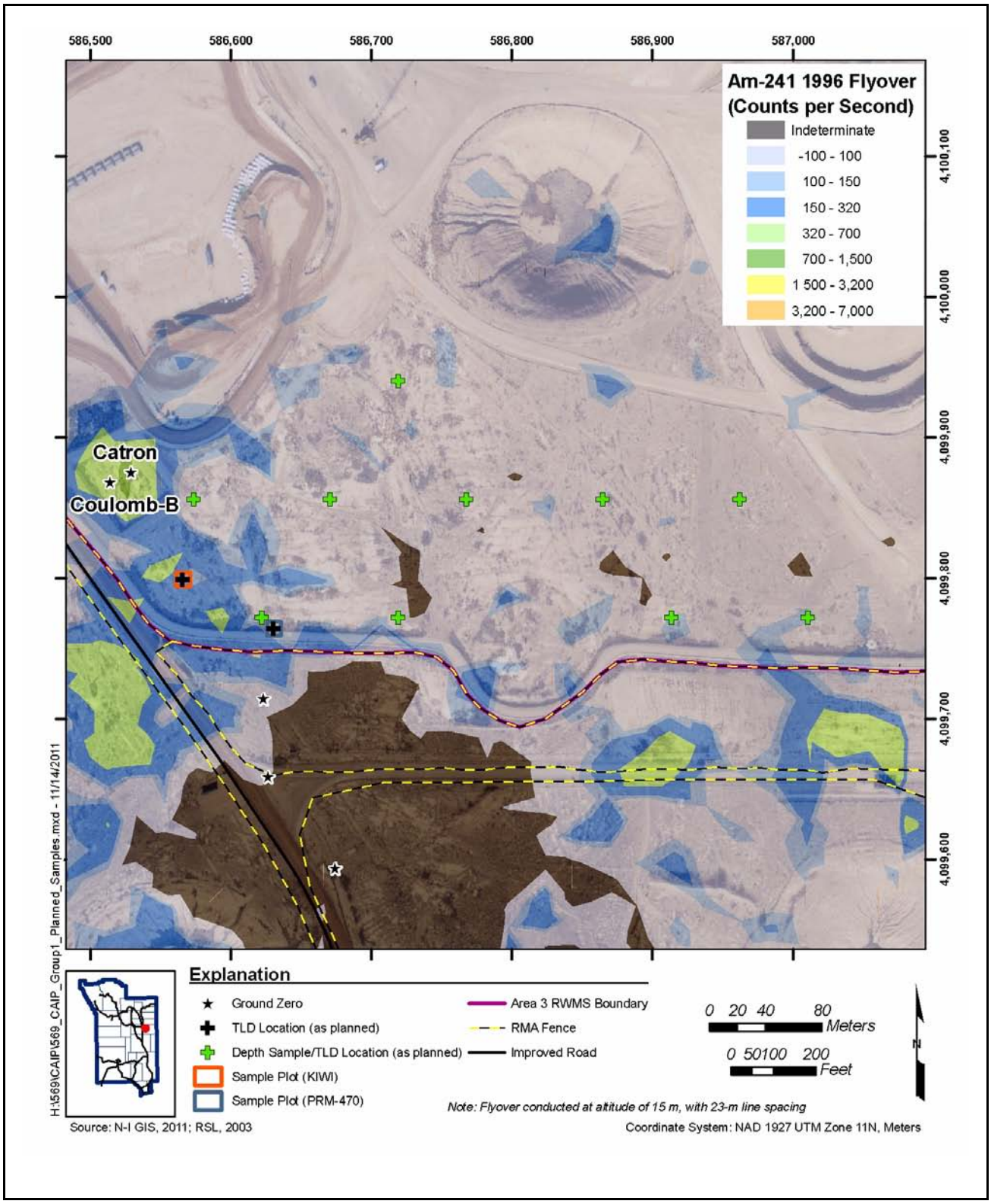

Figure A.8-1
Decision I Sample Plots and TLD Locations, Study Group 1

A.8.1.1.2 Study Group 2 Sample Plot Locations

Elevated readings were detected at the southwestern side of the crater during both the PRM-470 and FIDLER surveys. Therefore, one Decision I sample plot was placed at the location of highest radiological readings from the PRM-470 survey, and one Decision I sample plot was placed at the location of highest radiological readings from the FIDLER survey. The identified Decision I sample plot locations are depicted on Figure A.8-2.

A.8.1.1.3 Study Group 3 Sample Plot Locations

During the PRM-470 survey, multiple areas of elevated readings were detected surrounding the GZ area. The area of most elevated readings was chosen for a Decision I sample plot. The identified Decision I sample plot location is depicted on Figure A.8-3.

A.8.1.1.4 Study Group 4 Sample Plot Locations

Radiological readings, as detected during the PRM-470 survey, were fairly evenly distributed throughout this study group. The most elevated readings were detected in the southern portion of the study group (south of 3-03 Road). Two locations of elevated Am-241 levels were identified during the KIWI survey: one location north of 3-03 Road and one location south of 3-03 Road. The location south of 3-03 Road coincides with the location of elevated readings detected during the PRM-470 survey. Therefore, one Decision I sample plot was placed north of 3-03 Road, and one Decision I sample plot was placed south of 3-03 Road. The identified Decision I sample plot locations are depicted on Figure A.8-4.

A.8.1.1.5 Study Group 5 Sample Plot Locations

During the PRM-470 survey, multiple areas of elevated readings were detected surrounding the GZ area. The area of most elevated readings was chosen for a Decision I sample plot. Results from the KIWI survey show that multiple areas of elevated Am-241 levels were identified. Because multiple locations of elevated Am-241 levels were detected, four Decision I sample plots were placed based on the KIWI survey results. Two of these four sample plot locations will be investigated for possible buried soil contamination (see Section A.8.3.1.3). The identified Decision I sample plot locations are depicted on Figure A.8-5.

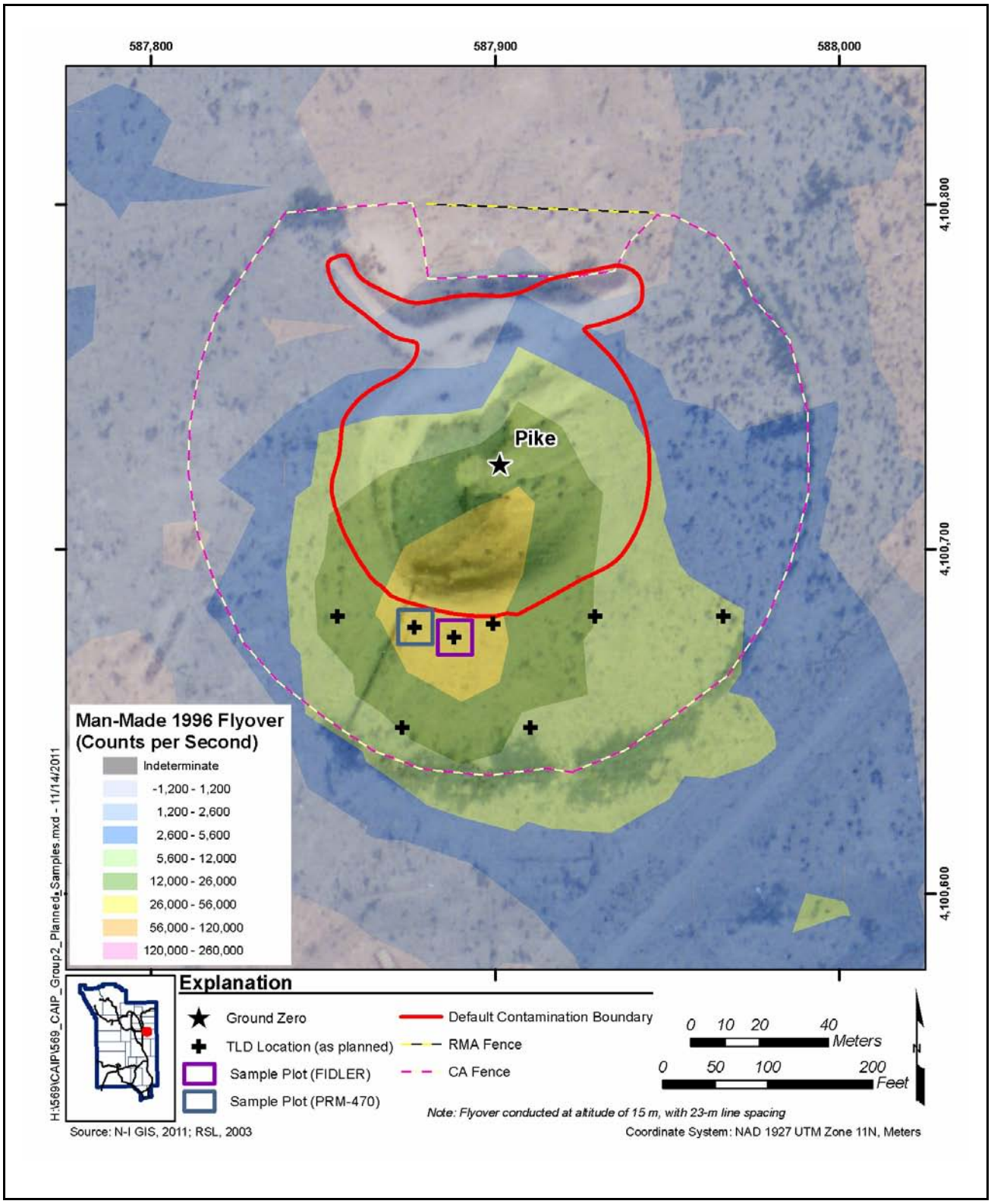

Figure A.8-2
Decision I Sample Plots and TLD Locations, Study Group 2

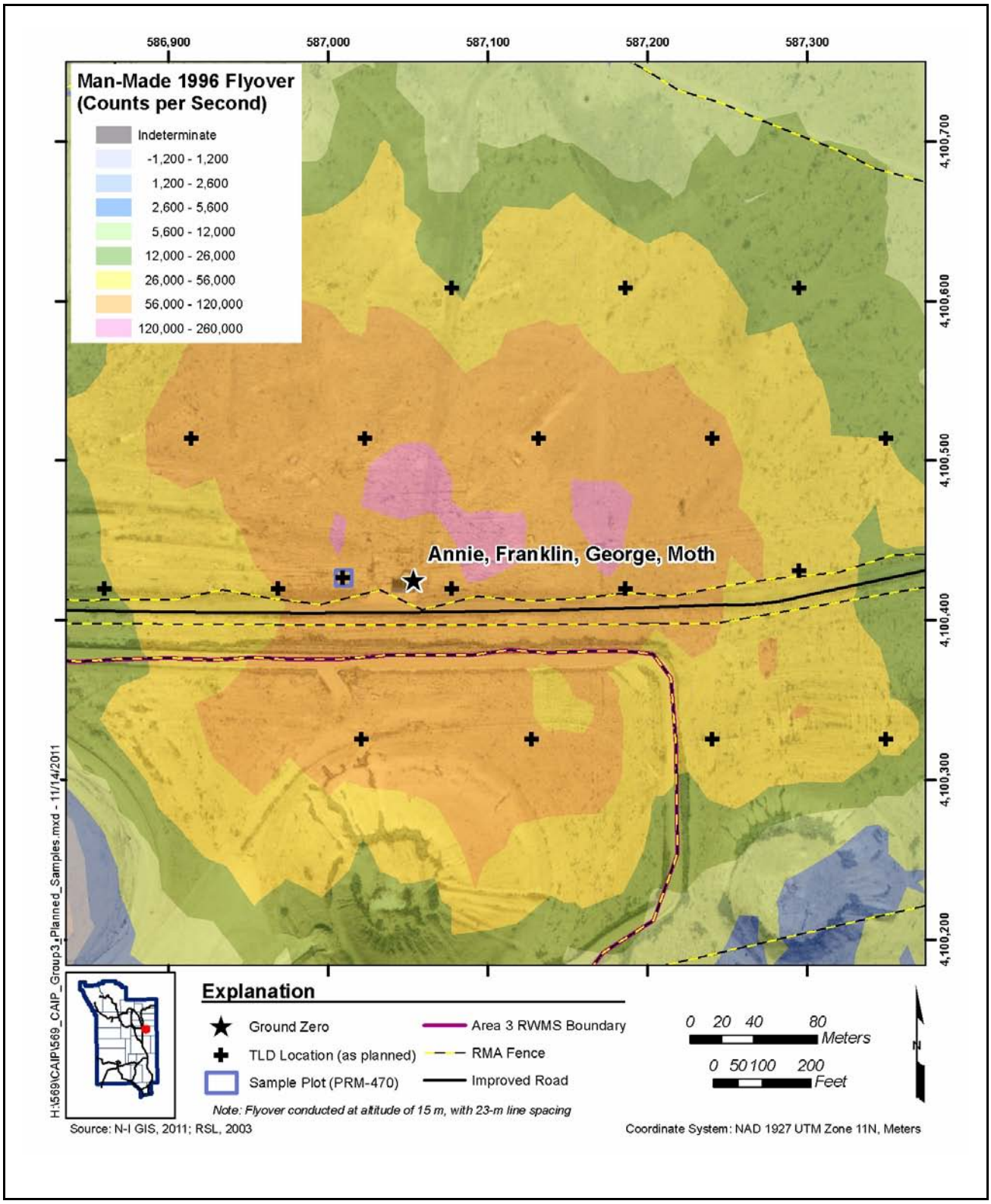

Figure A.8-3
Decision I Sample Plots and TLD Locations, Study Group 3

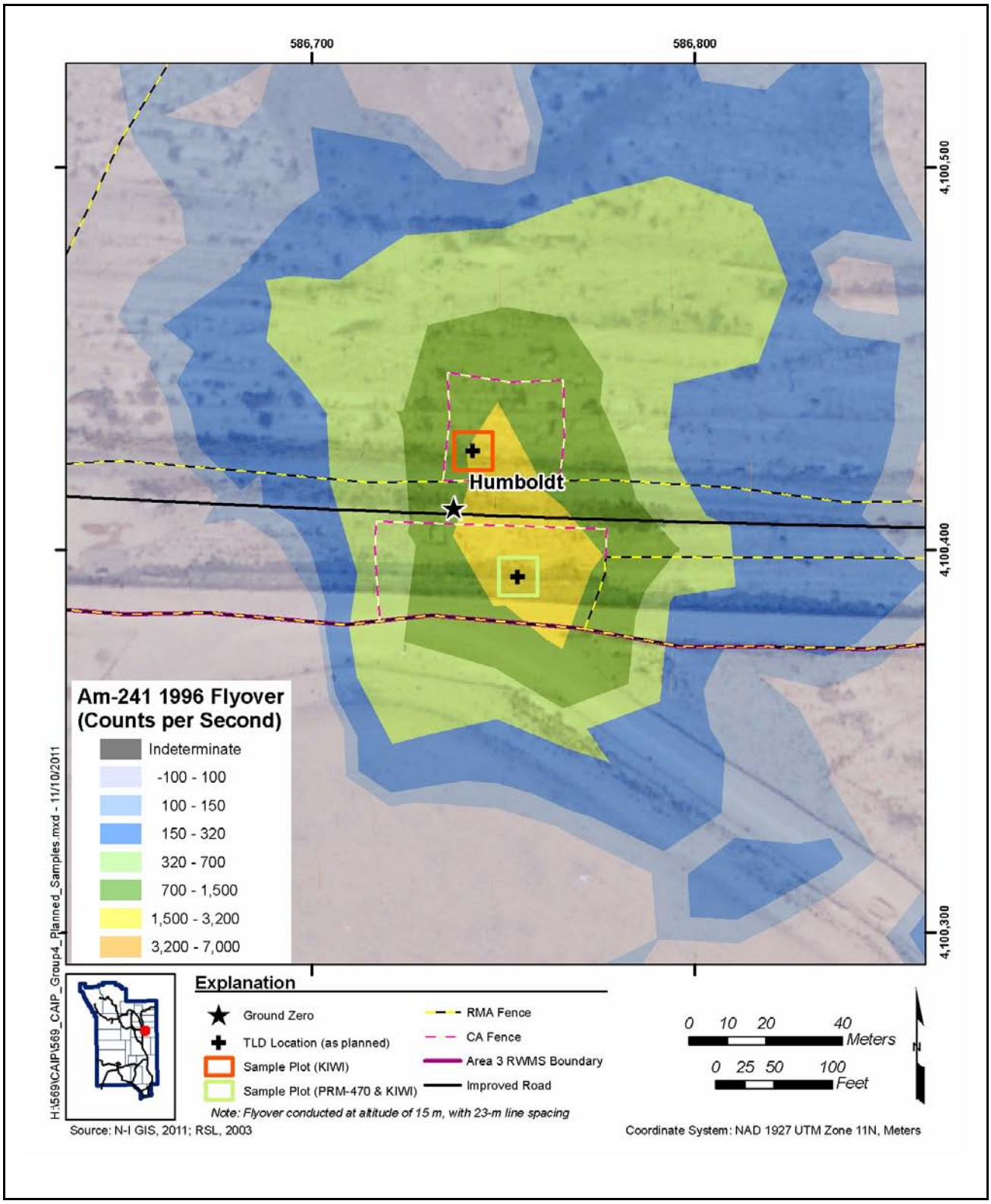

Figure A.8-4
Decision I Sample Plots and TLD Locations, Study Group 4

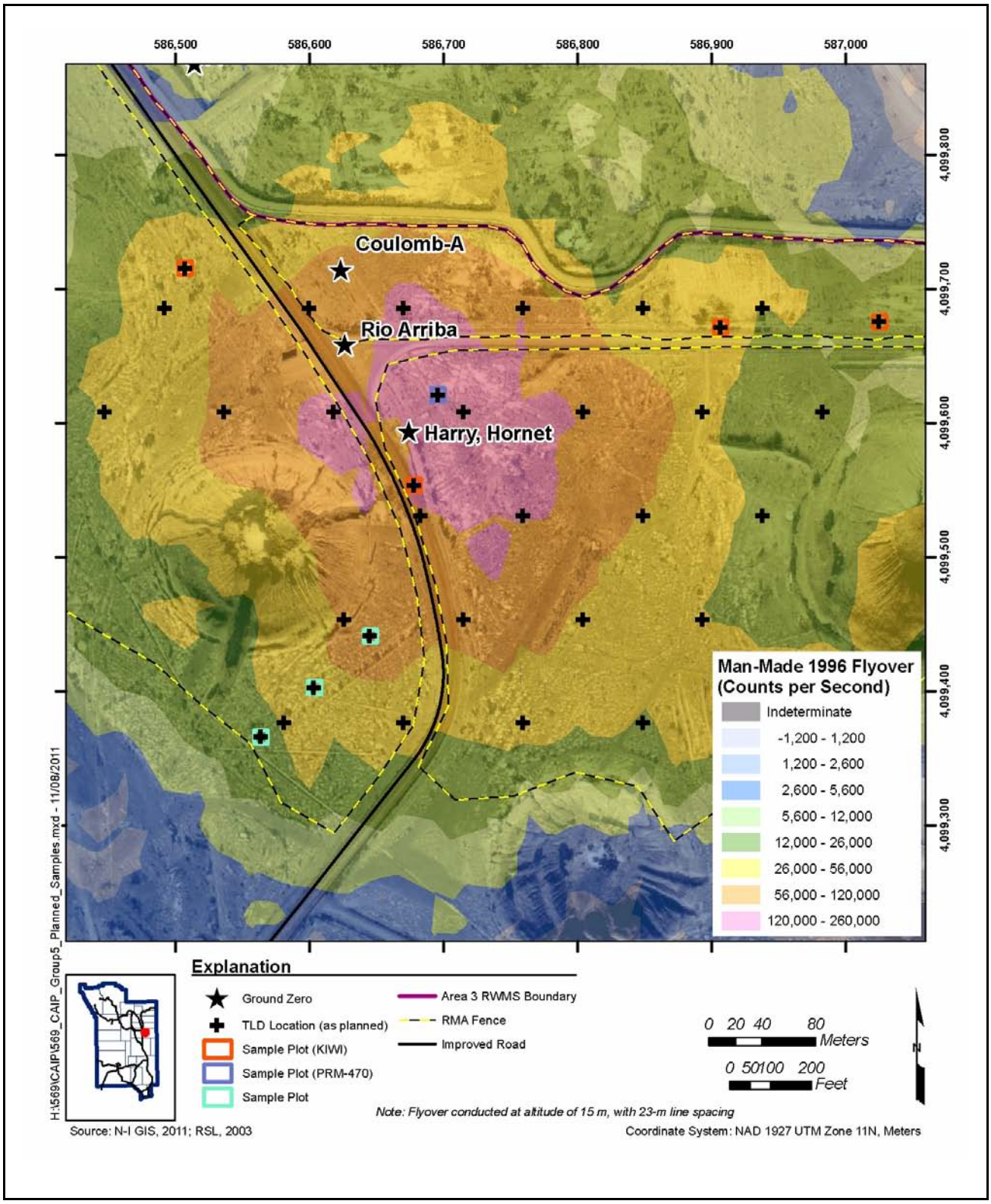

Figure A.8-5
Decision I and II Sample Plots and TLD Locations, Study Group 5

A.8.1.1.6 Study Group 6 Sample Plot Locations

During the PRM-470 survey, multiple areas of elevated readings were detected surrounding the GZ area. The area of most elevated readings was chosen for a Decision I sample plot. Results from the KIWI survey show that one area of elevated Am-241 levels was identified northeast of GZ. This area was chosen for a Decision I sample plot. The identified Decision I sample plot locations are depicted on Figure A.8-6.

A.8.1.2 Decision II Sample Plot Locations

A judgmental sampling design will also be implemented for locating Decision II sample plots. Decision II sample plots were only established at Study Groups 5 and 6. These sample plot locations were selected judgmentally within undisturbed areas based on radiological surveys. These data will be used to establish patterns of contaminant distribution. At both Study Group 5 and 6, three Decision II sample plots were judgmentally established along a vector that is approximately normal to the radiation survey isopleths with the constraint that, on each vector, at least one sample plot will present a TED less than the FAL. The identified Decision II sample plot locations are depicted on Figures A.8-5 and A.8-6. The coordinates for the Decision I and known Decision II sample plots at Study Groups 1 through 6, based on survey data discussed in the previous sections, are presented in Table A.8-1. If the coordinates for the plots are located in an area where sufficient samples cannot be obtained (e.g., located in disturbed area, shrubs, or boulders present obscuring sample locations), the Site Supervisor will establish the plot location at the nearest place that a surface sample can be obtained.

A.8.1.3 Sampling of Sample Plots

The probabilistic sampling scheme will be implemented to select sample locations within the sample plots and evaluate the analytical results. For each sample collected within the sample plot, randomly selected subsample locations will be chosen based on a random start, triangular pattern (see Figure A.8-7 for an example of this sampling scheme). If sufficient sample material cannot be collected at a specified location (e.g., rock, caliche, or buried concrete), the Site Supervisor will establish the location at the nearest place that a surface sample can be obtained.

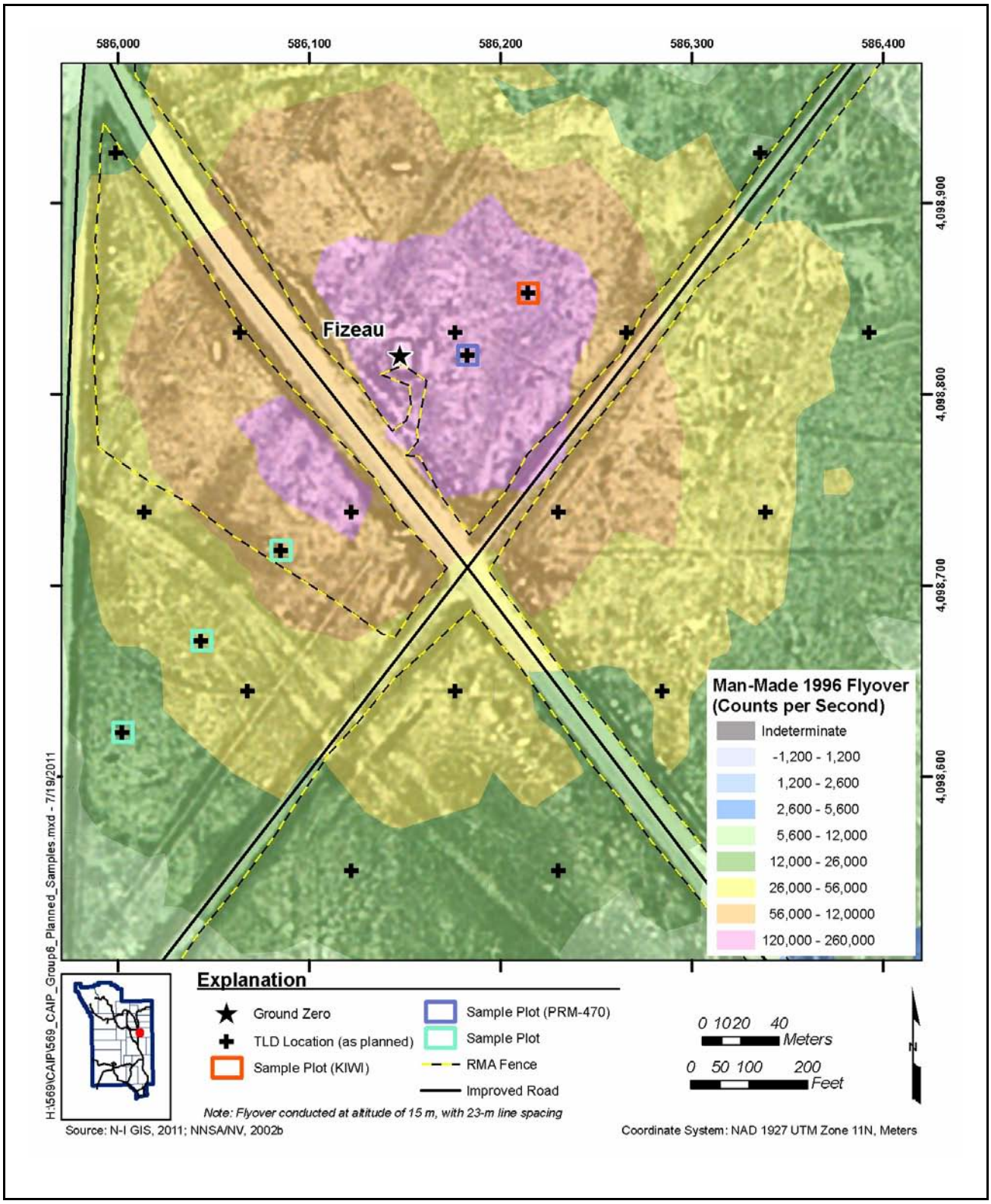

Figure A.8-6
Decision I and II Sample Plots and TLD Locations, Study Group 6

Table A.8-1
Sample Location Coordinates
(Page 1 of 4)

Location	Northing	Easting
Study Group 1		
Decision I Sample Plot	586566.0	4099799.1
Decision I Sample Plot	586630.7	4099764.3
Depth Sample/TLD 1	586622.2	4099771.9
Depth Sample/TLD 2	586719.4	4099771.9
Depth Sample/TLD 3	586913.7	4099771.9
Depth Sample/TLD 4	587010.9	4099771.9
Depth Sample/TLD 5	586573.6	4099856.1
Depth Sample/TLD 6	586670.8	4099856.1
Depth Sample/TLD 7	586767.9	4099856.1
Depth Sample/TLD 8	586865.1	4099856.1
Depth Sample/TLD 9	586962.3	4099856.1
Depth Sample/TLD 10	586719.4	4099940.3
Study Group 2		
Decision I Sample Plot	587876.7	4100677.3
Decision I Sample Plot	587888.3	4100674.4
TLD 1	587873.1	4100648.1
TLD 2	587910.4	4100648.1
TLD 3	587854.4	4100680.5
TLD 4	587899.6	4100678.3
TLD 5	587929.1	4100680.5
TLD 6	587966.5	4100680.5
Study Group 3		
Decision I Sample Plot	587009.5	4100426.6
TLD 1	587240.9	4100325.6
TLD 2	587349.7	4100325.6
TLD 3	586860.1	4100419.8
TLD 4	586968.9	4100419.8
TLD 5	587077.7	4100419.8
TLD 6	587186.5	4100419.8
TLD 7	587295.3	4100431.0
TLD 8	586914.5	4100514.0
TLD 9	587023.3	4100514.0

Table A.8-1
Sample Location Coordinates
(Page 2 of 4)

Location	Northing	Easting
Study Group 3 (continued)		
TLD 10	587132.1	4100514.0
TLD 11	587240.9	4100514.0
TLD 12	587349.7	4100514.0
TLD 13	587077.7	4100608.3
TLD 14	587186.5	4100608.3
TLD 15	587295.3	4100608.3
TLD 16	587021.3	4100325.6
TLD 17	587127.8	4100325.6
Study Group 4		
Decision I Sample Plot	586753.9	4100393.1
Decision I Sample Plot	586742.1	4100425.8
Study Group 5		
Decision I Sample Plot	586906.8	4099671.3
Decision I Sample Plot	586507.1	4099715.4
Decision I Sample Plot	586678.0	4099553.5
Decision I Sample Plot	587025.4	4099675.4
Decision I Sample Plot	586695.8	4099621.0
Decision II Sample Plot	586645.3	4099441.0
Decision II Sample Plot	586603.4	4099402.7
Decision II Sample Plot	586563.6	4099365.7
TLD 1	586581.1	4099376.2
TLD 2	586670.4	4099376.2
TLD 3	586759.7	4099376.2
TLD 4	586848.9	4099376.2
TLD 5	586625.8	4099453.5
TLD 6	586715.0	4099453.5
TLD 7	586804.3	4099453.5
TLD 8	586893.6	4099453.5
TLD 9	586683.0	4099530.8
TLD 10	586759.7	4099530.8
TLD 11	586848.9	4099530.8
TLD 12	586938.2	4099530.8

Table A.8-1
Sample Location Coordinates
(Page 3 of 4)

Location	Northing	Easting
Study Group 5 (continued)		
TLD 13	586447.2	4099608.1
TLD 14	586536.5	4099608.1
TLD 15	586618.0	4099608.1
TLD 16	586715.0	4099608.1
TLD 17	586804.3	4099608.1
TLD 18	586893.6	4099608.1
TLD 19	586982.8	4099608.1
TLD 20	586491.9	4099685.4
TLD 21	586600.0	4099685.4
TLD 22	586670.4	4099685.4
TLD 23	586759.7	4099685.4
TLD 24	586848.9	4099685.4
TLD 25	586938.2	4099685.4
Study Group 6		
Decision I Sample Plot	586214.5	4098853.1
Decision I Sample Plot	586182.8	4098820.5
Decision II Sample Plot	586002.5	4098623.4
Decision II Sample Plot	586043.6	4098671.2
Decision II Sample Plot	586085.3	4098718.5
TLD 1	586122.2	4098551.1
TLD 2	586230.5	4098551.1
TLD 3	586068.0	4098644.9
TLD 4	586176.4	4098644.9
TLD 5	586284.7	4098644.9
TLD 6	586013.9	4098738.7
TLD 7	586122.2	4098738.7
TLD 8	586230.5	4098738.7
TLD 9	586338.8	4098738.7
TLD 10	586064.0	4098832.5
TLD 11	586176.4	4098832.5
TLD 12	586266.0	4098832.5
TLD 13	586393.0	4098832.5

Table A.8-1
Sample Location Coordinates
(Page 4 of 4)

Location	Northing	Easting
Study Group 6 (continued)		
TLD 14	585999.0	4098926.3
TLD 15	586336.0	4098926.3
Background TLDs		
Background TLD 1	585291.2	4101571.5
Background TLD 2	585301.3	4101390.4
Background TLD 3	584955.6	4098465.7
Background TLD 4	585147.4	4098342.5
Background TLD 5	587469.3	4098510.1
Background TLD 6	587997.1	4099036.6

Source: N-I GIS, 2011

Statistical methods that generate site characteristics will be used to establish internal dose estimates that represent the sample plot as a whole. Composite samples will be collected at each sample plot in the following manner:

- At least four composite samples will be collected from each established sample plot.
- Each composite sample will comprise nine aliquots taken from randomly selected locations within each plot. These locations will be predetermined using a random start with a triangular grid pattern.
- The entire volume of the composited material collected will be submitted to the laboratory for analysis.

An example of the predetermined sample locations at one plot is shown in Figure A.8-7. As determination of the minimum sample size cannot be accomplished until after the data have been generated, the sufficiency of the number of samples collected will be evaluated. This will be evaluated based on TED results (composed of individual internal dose rates associated with each of the four composite samples added to the external dose rates from the TLD elements). The minimum number of samples required for each sample plot was calculated for both the internal (soil samples)

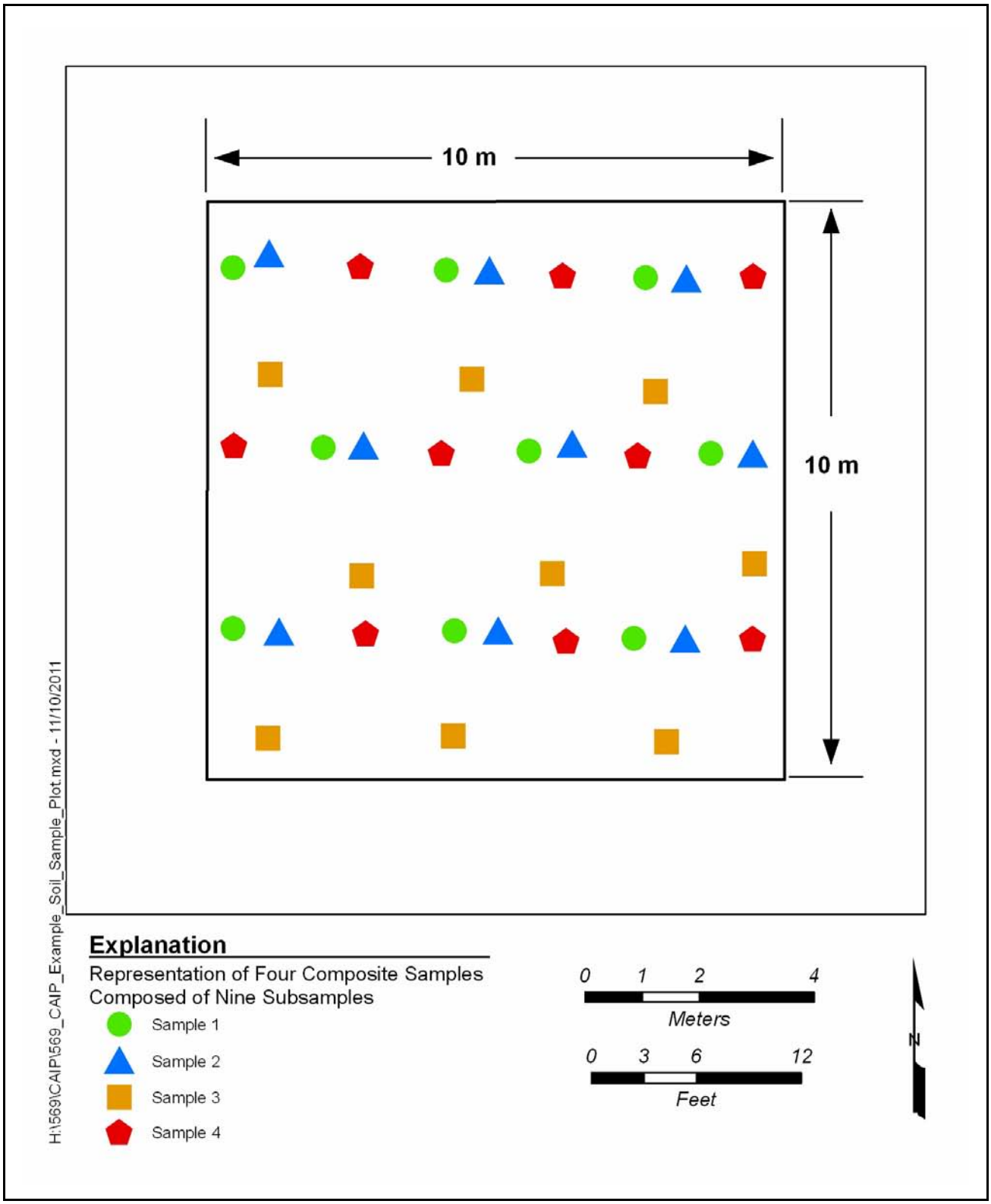

Figure A.8-7
Example of Probabilistic Sampling Scheme at a Sample Plot

and external (TLD elements) dose samples. The minimum sample size was calculated using the following EPA sample size formula (EPA, 2006):

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

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)
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.

All calculations for the determination of sample size sufficiency will be provided in the CADD. If the criteria established in this section result in a determination that the minimum sample size was not met for a plot, one of the following actions may be taken:

- Additional composite sample(s) may be collected.
- Conservatively assume that the TED for the plot exceeds the FAL.

If these criteria cannot be met, justifications for use of the resulting TED without meeting the criteria will be made in the CADD.

A.8.2 External Dose Sampling for Primary Releases

External dose (penetrating radiation dose for the purposes of this document) will be determined by collecting *in situ* measurements using TLDs. The TLD measurements will be taken at a height of approximately 1 m (3.3 ft). For sample plots, the TLDs will be located in the approximate center of the plot. Non-plot TLDs will be installed within Study Groups 2, 3, 5, and 6 using a random start with a triangular grid pattern. These TLDs will be installed at locations within the plumes identified during

the 1996 aerial radiological survey (BN, 1999b). Six non-plot TLDs will be installed at Study Group 2, 17 at Study Group 3, 25 at Study Group 5, and 15 at Study Group 6. The additional TLD locations are depicted on Figures A.8-2, A.8-3, A.8-5, and A.8-6, and coordinates for the TLDs are provided in Table A.8-1. If the coordinates for the TLDs are located in an area where it is not feasible to place a TLD (e.g., located in disturbed area, shrubs or boulders present, located on a road), the Site Supervisor will establish the TLD location at the nearest feasible location.

The TLD placement and processing will follow the protocols established in *Nevada Test Site Routine Radiological Environmental Monitoring Plan* (BN, 2003). The TLDs will be in place for a targeted total exposure time of 2,250 hours, or the resulting data will be adjusted to be equivalent to an exposure time of 2,250 hours.

Estimates of external dose, in mrem/IA-yr, will be presented as net values (e.g., a background has been subtracted from the raw result). Naturally occurring terrestrial and cosmic radiation (i.e., background) will be registered on a TLD. These background radiation values can be comparable to the value of the FAL. Therefore, the FAL is only applicable to radiation dose from man-made sources at the NNSS and is a value in excess of what would be present if there were no nuclear activities at the site.

The value for the natural background dose to be subtracted from the TLD results will be obtained from areas determined to be unaffected by man-made activities at the NNSS. Six TLDs will be placed in unaffected areas based on background isopleths developed from the 1994 aerial survey (BN, 1999a) (shown on Figure A.8-8 and listed in Table A.8-1).

A.8.3 Sampling for Other Releases

Sample locations for other releases will be determined based upon the likelihood of a contaminant release at the study group. These locations will be selected based on the identification of biasing factors during the investigation.

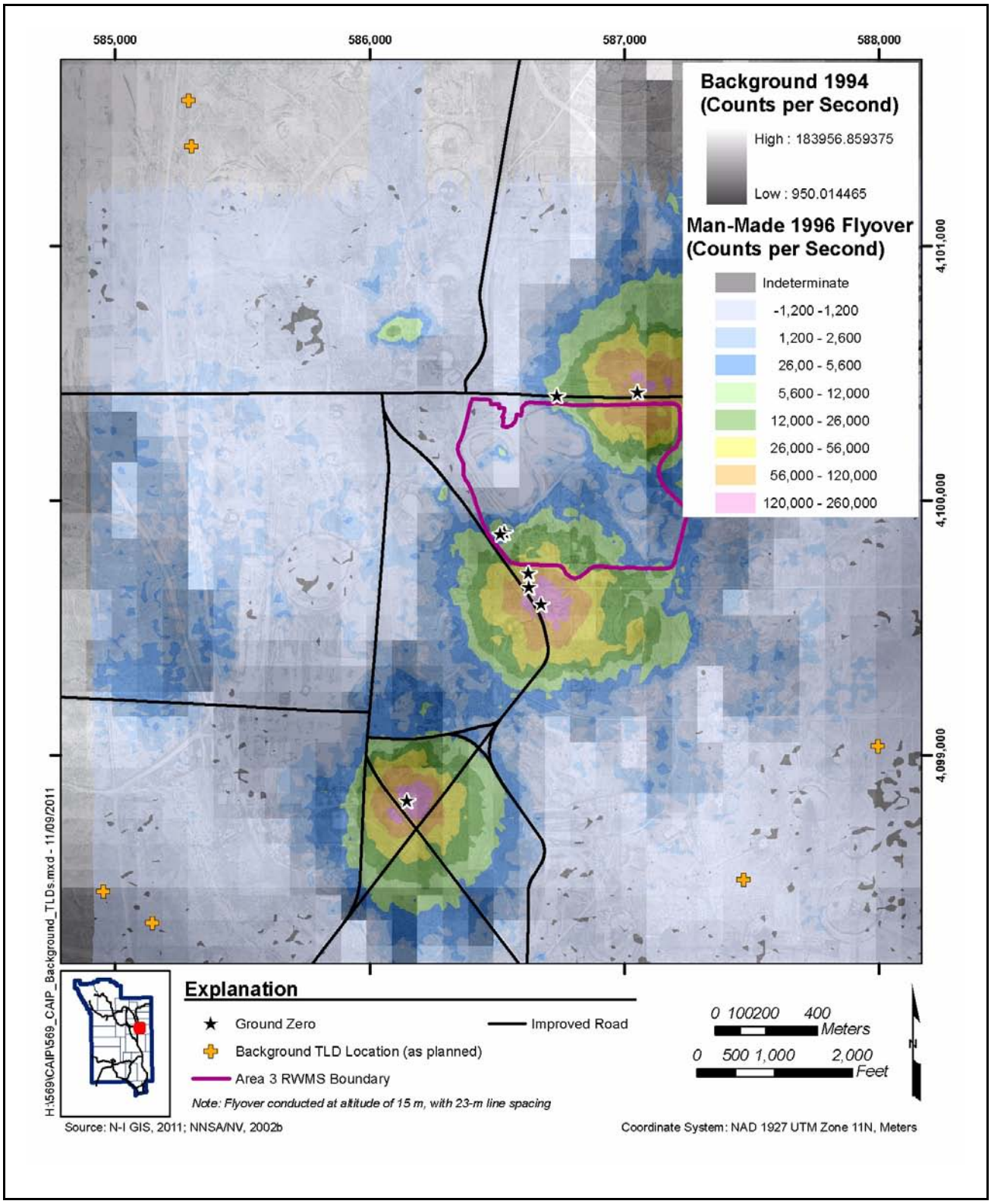

Figure A.8-8
Background TLD Locations

These biasing factors may include the following:

- *Stains.* Any spot or area on the soil surface that may indicate the presence of a potentially hazardous liquid. Typically, stains indicate an organic liquid, such as an oil, has reached the soil and may have spread out vertically and laterally.

- *Radiological survey anomalies*. Radiological survey results that are significantly higher than the surrounding area.

- *Drums, containers, equipment, or debris.* Materials that contain or may have contained hazardous or radioactive substances.

- *Preselected areas based on process knowledge of the site.* Locations for which evidence such as historical photographs, experience from previous investigations, or interviewee's input exists that a release of hazardous or radioactive substances may have occurred.

- *Preselected areas based on process knowledge of the contaminant(s).* Locations that may reasonably have received contamination, selected on the basis of the chemical and/or physical properties of the contaminant(s) in that environmental setting.

- *Previous sample results.* Locations that may reasonably have been contaminated based upon the results of previous field investigations.

- Experience and data from investigations of similar sites.

- Visual indicators such as discoloration, textural discontinuities, disturbance of native soils, or any other indication of potential contamination.

- *Other biasing factors.* Factors not previously defined for the CAI that become evident once the investigation of the site is under way.

A.8.3.1 Decision I

A judgmental sampling design will be implemented for the other releases to establish sample locations and evaluate sample results. For the other releases, individual sample results, rather than an average concentration, will be used to compare to FALs. Therefore, statistical methods to generate site characteristics will not be needed. Adequate representativeness of the entire target population may not be a requirement in developing a sampling design. If good prior information about the target site of interest is available, then the sampling may be designed to collect samples only from areas known to have the highest concentration levels on the target site. If the observed concentrations from

these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006).

A biased sampling strategy will be used to target areas with the highest potential to contain a COC, if it is present anywhere in the study group. Sample locations will be determined based on process knowledge, previously acquired data, or the field-screening and biasing factors listed in Section A.4.2.1. If biasing factors are present in soils below locations where Decision I samples were removed, additional Decision I soil samples will be collected at depth intervals selected by the Site Supervisor based on biasing factors to a depth where the biasing factors are no longer present. The Site Supervisor has the discretion to modify the judgmental sample locations, but only if the modified locations meet the decision needs and criteria stipulated in these DQOs.

A.8.3.1.1 Determination of Buried Contamination at Study Group 1

As the CSM includes the possibility of buried soil contamination (within the boundaries of Study Group 1), it will be determined whether buried contamination exists. Because the area of Study Group 1 is located within a highly disturbed area (within the southwestern portion of the Area 3 RWMS and where multiple underground tests occurred), 10 randomly selected probabilistic sample locations were chosen for investigation of potential buried soil contamination based on a random start, triangular pattern. Thermoluminescent dosimeters will be placed at all 10 locations (at a height of 1 m), and soil samples will be collected at these 10 locations. The soil and TLD sample locations for determination of buried contamination at Study Group 1 are shown on Figure A.8-1, and coordinates are provided on Table A.8-1.

Samples will be collected at 5-cm intervals (not to exceed 30 cm) until native soil is encountered. All samples will be field screened with an alpha/beta radiation meter. Figure A.8-9 provides example sampling intervals for disturbed soil. If screening results for any subsurface layer exceed the field-screening limit and are at least 20 percent greater than the surface screening results (top 5 cm interval), it will be assumed that buried contamination exists, and the surface sample and the subsurface sample with the highest screening results will be submitted for analysis. If screening results are not at least 20 percent greater than the surface screening results, it will be assumed that buried contamination does not exist, and only the surface sample will be submitted for analyses.

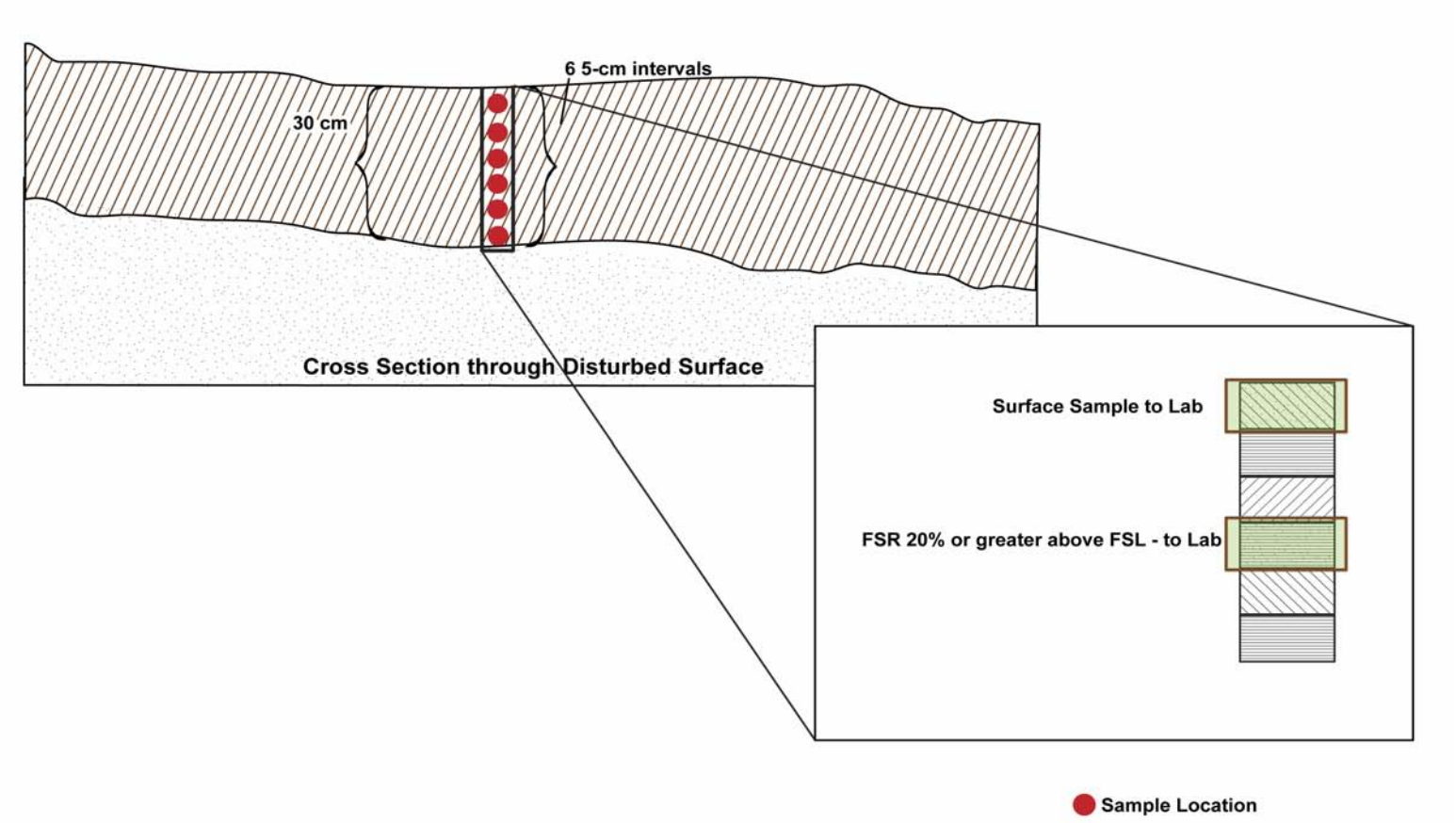

Figure A.8-9
Example of Buried Contamination Sampling Intervals

If buried contamination exists at Study Group 1, it will be conservatively assumed that the highest level of contamination observed (from surface or subsurface samples) provides dose to site workers. Therefore, the samples with the highest dose (surface or subsurface) at each location will be used for the internal dose estimate. If subsurface samples contain higher levels of contamination (that would result in a higher dose), a TLD-equivalent external dose will be calculated based on the subsurface sample results. This will be accomplished by establishing a correlation between RESRAD-calculated external dose from surface samples and the corresponding TLD readings (see equation below). The RESRAD-calculated external dose from the subsurface samples will then be adjusted to TLD-equivalent values using this correlation.

$$Ext_{subsurface\ inferred} = \frac{Ext_{TLD}}{Ext_{surface\ RESRAD}} \times Ext_{subsurface\ RESRAD}$$

A.8.3.1.2 Determination of Buried Contamination at Study Group 7

For the investigation of Study Group 7, a ground-based radiological survey will be conducted to identify any elevated levels of radioactivity. If levels are greater than two times background levels, a judgmentally located sample plot to sample the surface contamination will be established within the area of the highest values from the ground-based radiological survey. See Section A.8.1.3 for details on the sampling of sample plots.

Within the sample plot, four screening locations (one in each corner of the plot) will be used to determine whether buried soil contamination exists. At each screening location, 5-cm intervals of soil will be removed (not to exceed 30 cm) until native soil is encountered, composited among the four screening locations by depth interval, and screened with an alpha/beta contamination meter. Figure A.8-9 provides example sampling intervals for disturbed soil.

If screening results for any composited screening layer exceed the field-screening limit and are at least 20 percent greater than the surface screening results (from the composited surface interval), it will be assumed that buried contamination exists. Therefore, the plot will be sampled in the following manner:

- The surface composite sample (see Section A.8.1.3 for collecting surface samples within a plot) will be submitted for analysis and

- The composite sample from the depth(s) that exceeded screening results (as described above) will be submitted for analysis.

If screening results for a composited screening layer are not at least 20 percent greater than the surface screening results, it will be assumed that buried contamination does not exist, and only the surface composite sample within the plot will be submitted for analysis.

If buried contamination exists at Study Group 7, it will be conservatively assumed that the highest level of contamination observed (from surface or subsurface samples) provides dose to site workers. Therefore, the samples with the highest dose (surface or subsurface) at each location will be used for the internal dose estimate. If subsurface samples contain higher levels of contamination (that would result in a higher dose), a TLD-equivalent external dose will be calculated based on the subsurface sample results. This will be accomplished by establishing a correlation between RESRAD-calculated external dose from surface samples and the corresponding TLD readings (see equation in Section A.8.3.1.1). The RESRAD-calculated external dose from the subsurface samples will then be adjusted to TLD-equivalent values using this correlation.

In addition to soil sampling within Study Group 7, a geophysical survey will be conducted to verify the CSM that this area was used to consolidate contaminated soil from atmospheric testing operations. Because insufficient documentation has been identified to prove that no waste disposal operations occurred at Study Group 7, the geophysical survey will be conducted. If buried material is identified, then it will be assumed that contamination exists above FALs, and a strategy for addressing Decision II for the buried waste will be presented to and agreed upon by the stakeholders. No samples will be collected based on the geophysical survey results.

A.8.3.1.3 Determination of Buried Contamination at Study Group 5

Based on the results of the KIWI survey, two distinct elevated Am-241 areas were identified near the southeast boundary of the Area 3 RWMS within Study Group 5. These biased locations will be investigated identical to the potential buried soil contamination at Study Group 7. See Section A.8.3.1.2 for details on investigation and sampling of these locations.

A.8.3.1.4 Other Potential Releases for All Study Groups

During the course of the CAU 569 investigation, the identification of any biasing factors will be used to determine whether a potential release is present (e.g., stains, spills, debris). Samples will be collected from the material that presents the greatest degree of the biasing factor identified (surface or subsurface as discussed above). Specific analyses requested for these samples will be determined based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks).

A.8.3.2 Decision II

Decision II samples for other releases will be collected from judgmental sampling locations selected based on locations where COCs were detected, the CSM, and other field-screening and biasing factors listed in Section A.4.2. In general, sample locations will be arranged in a triangular pattern around the area containing COCs at distances based on site conditions, process knowledge, and biasing factors. If COCs extend beyond the initial step-outs, Decision II samples will be collected from incremental step-outs. Initial step-outs will be at least as deep as the vertical extent of contamination defined at the Decision I location and the depth of the incremental step-outs will be based on the deepest contamination observed at all locations. A clean sample (i.e., COCs less than FALs) collected from each step-out direction (lateral or vertical) will define extent of contamination in that direction.

If the results of the Decision I samples at Study Group 1 show contamination present that exceeds the FALs, then a Decision II sampling strategy will be presented and agreed upon by the stakeholders.

A.8.4 Establishment of Final Corrective Action Boundary

The initial corrective action boundary area will be calculated using the 95 percent UCL of the TED from each sample location and a corresponding measurement from an appropriate radiation survey. These paired values will be used to establish a correlation for each radiation survey and identify the radiation survey that has the best correlation to TED values. This correlation will be used to establish a radiation survey value corresponding to the 25-mrem/yr FAL (using the appropriate exposure scenario). An isopleth of this value from the radiological survey will be used as the initial corrective action boundary.

The final corrective action boundary will be established to include the DCB, initial corrective action boundary, and any additional areas that exceed the FAL from the other releases (e.g., spills, waste).

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Attachment A-1

Derivation of Residual Radioactive Material Guidelines for Radionuclides in Soil

(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 10 *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. $\left(\frac{2250\ hrs\ on-site}{8760\ hrs\ in\ a\ year}\right) 0.6666\ indoors = 0.1712$ 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
m^2 = Square meter
g/yr = Grams per year
m/yr = Meters per year
m = Meter
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	**$RRMG_{(RWA-I)}$** (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.

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Appendix B

Project Organization

B.1.0 Project Organization

The NNSA/NSO Federal Sub-Project Director is Kevin Cabble. He can be contacted at (702) 295-5000.

The identification of the project Health and Safety Officer and the Quality Assurance Officer can be found in the appropriate plan. However, personnel are subject to change, and it is suggested that the NNSA/NSO Federal Sub-Project Director be contacted for further information. The Task Manager will be identified in the FFACO Monthly Activity Report before the start of field activities.

Appendix C

Nevada Division of Environmental Protection Comments

(16 Pages)

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 569: Area 3 Yucca Flat Atmospheric Test Sites, Nevada National Security Site, Nevada	**2. Document Date:**	12/22/2011
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	1/22/2012
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.) Section 2.1, Page 9	Mandatory	*"…therefore, it is expected that vertical migration of contaminants would be very limited…"* This statement is too generic. Discuss potential migration of contaminants more definitively, with respect to specific radionuclides of concern, depths of migration, and time (i.e., number of years). Perhaps potential migration of contaminants (time vs. depth) based on modeling projections could be included in the discussion.	The last sentence in Section 3.1.4 was removed and replaced with the following: "For surface contamination to reach the water table, the contaminants would have to be transported by infiltrating precipitation through the vadose alluvium that extends the entire unsaturated thickness of 488 m at ER-3-2. The vertical penetration distance of infiltrating precipitation in 1,000 years would be the groundwater recharge rate (in millimeters per year [mm/yr]) divided by the volumetric moisture content (cm3/cm3) of the subsurface vadose alluvium times 1,000 years. The groundwater recharge rate in the vicinity of CAU 569 has been estimated to range from less than 0.1 mm/yr to 2.5 mm/yr based on regional infiltration studies (SNJV, 2006). The moisture content observed in the subsurface alluvium in shallow boreholes near the Area 3 RWMS indicates moisture contents in the range of 0.05 to 0.1 (Kwicklis et al., 2006). Based on these observations, penetration distances of infiltrating precipitation may be as much as 50 m in 1,000 years (using the maximum groundwater recharge rate of 2.5 mm/yr and the minimum moisture content of 0.05)." Additionally, the following paragraph has been inserted as the second paragraph in Section A.2.2.3, and Table A.2-5 has been added to the document (Table A.2-5 is attached to this DRS): "The radionuclide contaminants in CAU 569 are all moderately to highly adsorbed on the alluvial materials present at the site. A summary of the inherent vertical migration potential of these contaminants through the	

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

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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
	Mandatory		vadose zone due to their adsorption properties are presented in Table A.2-5. This table also presents the contaminant sorption coefficients (Kd) along with the equivalent retardation factor (based on an average bulk density of 1.5 g/ml and porosity of 0.3) (SNJV, 2007). Based on these properties and the maximum estimated recharge rate of 50 m in 1,000 years (see Section 3.1.4), the major radionuclide contaminants at CAU 569 are estimated to migrate no more than 1/10 of a meter in 1,000 years except for uranium, which could migrate up to 8 meters in 1,000 years."	
2.) Section 3.1.2, Page 31	Mandatory	Sources of contamination besides atmospheric detonations have been referenced (i.e., spills and debris). Provide discussion pertaining to any specific spills and debris, and explain how these qualify as contaminant sources to be investigated.	The following text has been added to the end of Section 3.1.2: "During preliminary investigations at the CAU, batteries, a lead brick, former transformer areas, and asphalt piles were identified. The batteries and lead brick may release lead to the soil; the transformers may have released polychlorinated biphenyls (PCBs) to the soil; and the asphalt may release semivolatile organic compounds (SVOCs) to the soil. Additionally, two locations of stained soil were identified. It is unknown what was spilled on the ground surface to cause the stains. Additional stained soil and debris may be identified during site characterization activities, and will be investigated as appropriate."	

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3.) Section 2.4.1, Page 16, Study Groups 1, 3, 4, 5, and 6; 2nd Sentence	Suggested	Suggest reword to state the releases are distributed in “roughly concentric patterns …. Exhibiting a pattern of decreasing surface contamination with increasing distance from ground zero”	The sentence has been reworded as follows: “The initial release of radionuclides from the tests was distributed in roughly concentric patterns on the ground surface, exhibiting a pattern of surface contamination that is generally decreasing in concentration with increasing distance from the release locations, as illustrated in the 1996 aerial radiological survey (Figures 2-4 and 2-5).”	
4.) Section 2.5.1, Page 20, Aerial Radiological Surveys - 4th Sentence	Suggested	Suggest clarify this discussion with a note on the relationship between data “accuracy” and spectral and spatial resolution produced by AMS 1996 data vs. other data sets. Are we referring to “accuracy” as discussed in 6.3.4 in Appendix A DQO?	The term "accurate" has been changed to "precise."	

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5.) Section 2.5.1, Page 17, Aerial Radiological Surveys - Figure 2-4	Mandatory	Additional interpretative information is needed for this image; a good start would be slide 31 from the Hendricks presentation of 28 Nov 11.	The text in Section 2.5 has been replaced with the following text: "All previous investigation data are assessed in the planning phase as biasing information for selecting appropriate sampling locations. A variety of different radiation surveys were conducted in the CAU 569 area. These include aerial and ground-based surveys. Table 2-2 lists the method descriptions for the different radiation surveys conducted within the area of CAU 569, advantages, limitations, spatial and spectral resolutions, measurement dates, and applied use as a comparison of the radiation survey methods. Details of the surveys are also discussed in Sections 2.5.1, 2.5.3, and 2.5.4. These data are not considered to be decision quality and are not used in making corrective action decisions. However, the radiation surveys will be evaluated for use in defining corrective action boundaries in the investigation report. For defining corrective action boundaries, the radiation surveys will be used only in terms of defining a relative spatial distribution of contamination. This relative spatial distribution will be correlated to measured dose (decision quality) to define the shape of the areas that require corrective action. The aerial radiation surveys provided spectral information that was used to differentiate specific isotopic signatures. This allowed the separate mapping of americium (Am)-241 contamination, man-made gamma activity, and gross gamma activity within the surveyed areas. The Am-241 distribution map is used as an indicator of the locations of potential plutonium contamination.	

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	Mandatory		The radionuclide activity in this area is due to a combination of fission products (primarily high-energy gamma radiation) and unfissioned nuclear material (primarily low-energy gamma, beta, and alpha radiation). The sources of these radiation types are not necessarily co-located. The Radionuclide Inventory and Distribution Program (RIDP) conducted an investigation from 1981 through 1986 that estimated the inventory of man-made radionuclides at the NNSS through *in situ* gamma spectroscopy (McArthur and Mead, 1987). These RIDP data were extrapolated to estimate levels of plutonium across CAU 569 as shown on Figure 2-6 and discussed in Section 2.5.2. More detailed discussions of these investigations are found in Appendix A.”	

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6.) Section 2.5, Page 19, Investigative Background	Suggested	Figs. 2-4 through 2-9 present data sets from different organizations at different times using very different measurement techniques; suggest adding a table or discussion summarizing and interpreting results from each technique for each study group referencing each figure; purpose would be to synthesize and compare diverse radiological measurement results for CAU 569 and present a clearer basis for data acquisition planning in Sec. A.8.0. suggestions: • Method description summary for KIWI, AMS, FIDLER, PRM-470 • Advantages and limitations of each method for site-specific conditions present at CAU 569 • spatial & spectral resolution and “accuracy” • measurement date & isotope(s)/gross count range measured; • sources of error & uncertainty • estimate and description of total area surveyed vs. “contaminated” area detected (e.g., meter2) for count ranges shown in legends • how these data will be used with reference to appropriate DQO sections in Appendix A	Information has been added as a table in the document. The added table (2-2) is attached to this DRS. Additionally, information on the last bullet has been added as text to Section 2.5 (see comment number 5). Per discussions with NDEP, information on precision and sources of error and uncertainty will not be included in this CAIP, and will be discussed in the Soils QAPP. The 6th bullet has been discussed and resolved with the commenter to not add area information to the figure legends.	
7.) Section 5.3.5, Page 53, Mixed Low-Level Waste	Mandatory	The RCRA Permit issued to NNSS is: NEV HW0101, effective 1 Dec 2010. Please review this section and revise to reflect most recent permit information.	The sentence discussing the RCRA permit has been edited to read, "Mixed waste with hazardous waste constituent concentrations below Land Disposal Restrictions may be disposed of at the NNSS Area 5 RWMS if the waste meets the requirements of the NNSS WAC (NNSA/NSO, 2011) and the NNSS NDEP permit for Hazardous Waste Management Facility (NEV HW0101 [NDEP, 2011])."	

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10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
8.) Section A.2.2.2, Page A-13, Table A.2-2	Mandatory	Provide additional explanation as to why lead as a COPC is expected only at SG 6.	Tables A.2-2 and A.2-3 have been edited to include lead from batteries present within the study groups. A footnote was added to Table A.2-3 stating that the analysis for PCBs would only be conducted for transformer areas and the analyisis for RCRA metals would only be conducted for lead brick or battery locations.	

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10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
9.) Section A.2.2.3, Page A-14, Contaminant Characteristics	Mandatory	The cited study (Thompson, et al., 1997) appears to be more relevant to radionuclide transport in the subsurface (saturated zone) than for surface processes such as mass wasting, erosion, deposition, oxidation. It's not clear how the cited study informs fate and transport of radionuclides on the surface.	The second paragraph has been rewritten as follows: "The migration potential of radionuclides released from a nuclear detonation was demonstrated in a long-term radionuclide migration study of an underground nuclear test. A well installed into the groundwater 91 m away from the Cambric test GZ (and much closer to the nearest extent of the test cavity) was continuously pumped from 1975 to 1991 in order to draw radionuclides from the detonation cavity. The May 1965 Cambric test released a yield of 750 tons at a depth of 294 m below the land surface and 73 m below the water table (DOE/NV, 2000; Hoffman and Daniels, 1984). No radionuclides associated with nuclear fission tests (including the major contributing radionuclides plutonium, uranium, cesium, europium, strontium, or cobalt) other than tritium and krypton (which are considered to be conservative tracers in groundwater as they do not interact with the geologic media through which the water moves) were detected in the pumped groundwater during the 29 years of pumping (Bryant, 1992; Hoffman and Daniels, 1984). This test demonstrated the relative immobility of the fission radionuclides under conditions of very high mass flow (over 1.5 billion gallons of water) in a saturated matrix. Under unsaturated conditions (such as atmospheric deposition nuclear test releases), infiltrating water percolating through the vadose zone provides a much smaller fraction of the migration potential (mass flow is on the order of less than 3 cm of recharge per year). Therefore, it can be assumed that while the major fission radionuclides are relatively immobile in saturated conditions with an artificial gradient (i.e., under pumping conditions), they will be even less mobile under unsaturated conditions	

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	Mandatory		with limited net infiltration of precipitation."	
10.) Section A.5.2, Page A-23, Spatial Boundaries	Mandatory	Does "lateral" mean "horizontal" (3rd bullet)? Suggest use "horizontal" throughout document if intended meaning is same.	Following a discussion with NDEP, the term "lateral" is used throughout the document, for consistency.	
11.) Section A.2.2.2, Page A-14, Table A.2-4	Mandatory	Provide a regulatory or other reference for analytes cited.	The text callout for Tables A.2-3 and A.2-4 has been changed to, "Table A.2-3 lists the analytical methods required for these COPCs, while Table A.2-4 lists all the analytes that are reported by the analytical laboratory for each of the analytical methods." The title of Table A.2-4 has been changed to "Laboratory Analytical Methods with Reported Analytes."	

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12.) Section A.2.2.1, Page A-9, Figure A.2-2	Mandatory	CSM does not appear to include all the transport mechanisms described in A.2.2.5, e.g., stormwater flow in ephemeral washes, mechanical disturbance and contaminants movement due to maintenance and construction.	The "Buried Contamination" in Figure A.2-2 (CSM) was changed to "Disturbed Soil" and "Buried Soil Contamination" was added. Section A.2.2.5 was edited to remove discusstion of lateral migration of contaminants through stormwater flows. The first paragraph has been revised as follows: "Migration pathways for contamination from the study groups include windborne material and materials displaced from maintenance activities (e.g., moved during road maintenance). Contaminants may also be moved through mechanical disturbance due to maintanance or construction activities at the site. Specifically, this can include activities such as Area 3 RWMS construction and operation activities, investigation and resolution of CASs, and disassembly and removal of equipment and support structures. No visible washes are present within the study boundary of CAU 569. However, the area within and around CAU 569 generally drains into Yucca Flat, which flows south toward the Yucca Flat dry lake."	

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10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
13.) Section 8.1.1, Page A-36, Decision 1 Sample Plot Locations	Mandatory	Provide brief methodology for field sample plot placement: how will "location of highest radiological readings … " be accurately field located for TLD and sample plots. What are the sources of potential error/uncertainty?	In Section A.8.1.1 a callout for Figures 2-7 through 2-9 was added after "…results of the ground-based radiological surveys." The text in Sections A.8.1.1.1 through A.8.1.1.6 and A.8.1.2 was edited. Information pertaining to the sources of potential error/uncertainty will be deferred to the Soils QAPP, as discussed with the commenter. The following text replaces Sections A.8.1.1.1 through A.8.1.1.6 and A.8.1.2: Sec. A.8.1.1.1: "Radiological readings, as detected during the PRM-470 survey, were fairly evenly distributed throughout this study group. The most elevated location of radiological readings was detected southeast of the Coulomb-B and Catron GZs, near the berm surrounding the Area 3 RWMS. This location was chosen for a Decision I sample plot. Results from the KIWI survey show that two areas of elevated Am-241 levels were identified. The area with the largest accumulation of elevated readings from the KIWI survey was chosen for a Decision I sample plot. The identified Decision I sample plot locations are depicted on Figure A.8-1." Sec. A.8.1.1.2: "Elevated readings were detected at the southwestern side of the crater during both the PRM-470 and FIDLER surveys. Therefore, one Decision I sample plot was placed at the location of highest radiological readings from the PRM-470 survey, and one Decision I sample plot was placed at the location of highest radiological readings from the FIDLER survey. The identified Decision I sample plot locations are depicted on Figure A.8-2." Sec. A.8.1.1.3: "During the PRM-470 survey, multiple areas of	

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	Mandatory		elevated readings were detected surrounding the GZ area. The area of most elevated readings was chosen for a Decision I sample plot. The identified Decision I sample plot locations are depicted on Figure A.8-3." Sec. A.8.1.1.4: “Radiological readings, as detected during the PRM-470 survey, were fairly evenly distributed throughout this study group. The most elevated readings were detected in the southern portion of the study group (south of 3-03 Road). Two locations of elevated Am-241 levels were identified during the KIWI survey: one location north of 3-03 Road and one location south of 3-03 Road. The location south of 3-03 Road coincides with the location of elevated readings detected during the PRM-470 survey. Therefore, one Decision I sample plot was placed north of 3-03 Road, and one Decision I sample plot was placed south of 3-03 Road. The identified Decision I sample plot locations are depicted on Figure A.8-4." Sec. A.8.1.1.5: “During the PRM-470 survey, multiple areas of elevated readings were detected surrounding the GZ area. The area of most elevated readings was chosen for a Decision I sample plot. Results from the KIWI survey show that multiple areas of elevated Am-241 levels were identified. Because multiple locations of elevated Am-241 levels were detected, four Decision I sample plots were placed based on the KIWI survey results. Two of these four sample plot locations will be investigated for possible buried soil contamination (see Section A.8.3.1.3). The identified Decision I sample plot locations are depicted on Figure A.8-5."	

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	Mandatory		Sec. A.8.1.1.6: "During the PRM-470 survey, multiple areas of elevated readings were detected surrounding the GZ area. The area of most elevated readings was chosen for a Decision I sample plot. Results from the KIWI survey show that one area of elevated Am-241 levels was identified northeast of GZ. This area was chosen for a Decision I sample plot. The identified Decision I sample plot locations are depicted on Figure A.8-6." Sec. A.8.1.2: Change paragraph, beginning with the second sentence to, "…, Decision II sample plots were only established at Study Groups 5 and 6. These sample plot locations were selected judgmentally within undisturbed areas based on radiological surveys. These data will be used to establish patterns of contaminant distribution. At both Study Group 5 and 6, three Decision II sample plots were judgmentally established…"	

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14.) Section 8.1.2, Page A-44, Table A.8-1	Mandatory	What is (are) the source(s) of the geocoordinates in this table, provide reference.	The "N-I GIS, 2011" reference was added as a table footnote. Additionally, the sentence which references Table A.8-1 in Section A.8.1.2 has been changed to, "The coordinates for the Decision I and known Decision II sample plots at Study Groups 1 through 6, based on survey data discussed in the previous sections, are presented in Table A.8-1."	
15.) general	Mandatory	An additional comment was received from a reviewer, which states, "Reference is made to NTS, should be NNSS. Fix Reference."	Text reference to the "NTS" has been replaced with "NNSS" throughout the document.	
16.) Page 53	Mandatory	An additional comment was received from a reviewer, which states that the Mutual Consent Agreement is over. Review the section and make changes as necessary.	The sentence at the end of Section 5.3.5 has been rewritten to read, "Mixed waste constituent concentrations exceeding Land Disposal Restrictions will be transferred to the management and operating contractor for treatment and disposal." Additionally, references in Section 5.0 have been updated to the most recent versions, as necessary.	

Table 2-2
Comparison of Radiation Survey Methods

	KIWI	FIDLER	PRM-470	Aerial Radiological Survey
Method Description Summary	Ground-based, sodium iodide gamma spectroscopy unit	Ground-based instrument that detects low-energy gamma emissions	Ground-based organic plastic scintillator instrument that detects gamma emissions	Helicopter-mounted thallium-activated sodium iodide, gamma-ray scintillation detectors
Advantages and Limitations	Advantages: Can post-process data to identify specific gamma-emitting radionuclides of interest Limitations: Detector mounted on a vehicle, may have issues with terrain and a higher potential for contamination	Advantages: Lightweight hand-held instrument designed to see low-energy gamma emissions Limitations: Does not discriminate between low energy gamma emissions from different isotopes	Advantages: Lightweight hand-held instrument that detects gamma emissions Limitations: Does not distinguish between the radionuclides emitting the gamma emissions	Advantages: Gives a wide area of view (as opposed to ground-based surveys); can survey large areas quickly Limitations: Because it is elevated and moving at a fast rate, does not distinguish small localized areas of contamination or materials that are contaminated
Spatial Resolution	Mounted ~2.5 ft above ground surface; stationary KIWI has an Am-241 footprint of ~3 m wide and 1.2 m long; travelling at 5 miles per hour, the footprint for each 1-second measurement is ~3 m wide by 3.4 m long	Held at approx. 6 in. above ground surface, has a small field of view	Held at approx. 1 m above ground surface, has a small field of view	Altitude: 15 m Line Spacing: 23 m 30-m diameter window
Spectral Resolution	28 to 4,000 keV	10 to 100 keV	All gamma emitters	38 to 3,026 keV
Measurement Date	1996	08/2011 and 09/2011	08/2011 and 09/2011	12/1996
Applied Use	Processed for energies in the 57- to 70-keV range (Am-241) relative to the 38- to 50-keV and 70- to 82-keV background windows; used to identify Am-241 contamination as an indicator of plutonium contamination	Energies in the 59-keV range, which are indicative of Am-241 or other higher-energy emitters; used to identify Am-241 contamination as an indicator of plutonium contamination	Nondiscriminatory gamma count used to identify contamination from nuclear testing	For Am-241: Processed for energies in the 57- to 70-keV range (Am-241) relative to the 38- to 50-keV and 70- to 82-keV background windows. Used to identify Am-241 contamination as an indicator of plutonium contamination. For man-made: Processed for energies in the 38- to 1,294-keV window relative to the 1,394- to 3,026-keV background window. Used to identify contamination from nuclear testing.

FIDLER = Field instrument for the detection of low-energy radiation
keV = Kiloelectron volt
m = Meter

Source: N-I GIS, 2011; BN, 1999b; Hendricks, 2011; Riedhauser, 1999; Buchheit and Marianno, 2005; TSA Systems, 2005

Table A.2-5
Vertical Migration Potential through the Vadose of the Major Radionuclide Contaminants

COC	Approximate Range of K_d Values (mL/g)	Equivalent Retardation Factor	Migration Distance in 1,000 years (m)
Uranium	1 - 10	6 - 50	1 - 8
Plutonium	100 - 10,000	500 - 50,000	0.001 - 0.1
Europium	1,000 - 100,000	5,000 - 500,000	0.0001 - 0.01
Thorium	100 - 10,000	500 - 50,000	0.001 - 0.1
Cesium	1,000 - 10,000	5,000 - 50,000	0.001 - 0.01
Americium	10,000 - 100,000	50,000 - 500,000	0.0001 - 0.001

mL/g = Milliliters per gram

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