

Nevada
Environmental
Restoration
Project

DOE/NV--1361



Corrective Action Investigation Plan for Corrective Action Unit 374: Area 20 Schooner Unit Crater Nevada Test Site, Nevada

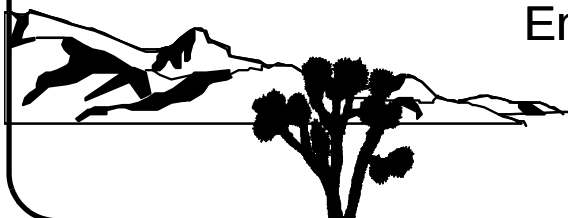
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CORRECTIVE ACTION INVESTIGATION PLAN FOR CORRECTIVE ACTION UNIT 374: AREA 20 SCHOONER UNIT CRATER NEVADA TEST SITE, NEVADA

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

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**CORRECTIVE ACTION INVESTIGATION PLAN FOR
CORRECTIVE ACTION UNIT 374:
AREA 20 SCHOONER UNIT CRATER
NEVADA TEST SITE, NEVADA**

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List of Acronyms and Abbreviations

Ac	Actinium
Am	Americium
amsl	Above mean sea level
ASTM	American Society for Testing and Materials
Ba	Barium
bgs	Below ground surface
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
Ce	Cerium
CFR	<i>Code of Federal Regulations</i>
Ci	Curie
cm	Centimeter
cm/yr	Centimeters per year
Co	Cobalt
COC	Contaminant of concern
COPC	Contaminant of potential concern
cpm	Counts per minute
cps	Counts per second
Cs	Cesium
CSM	Conceptual site model

List of Acronyms and Abbreviations (Continued)

DCG	Derived Concentration Guideline
DoD	U.S. Department of Defense
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
DQI	Data quality indicator
DQO	Data quality objective
DRO	Diesel-range organics
EPA	U.S. Environmental Protection Agency
Eu	Europium
FAL	Final action level
FFACO	<i>Federal Facility Agreement and Consent Order</i>
ft	Foot
GPS	Global Positioning System
GRO	Gasoline-range organics
GZ	Ground zero
IDW	Investigation-derived waste
in.	Inch
K	Potassium
km	Kilometer
kt	Kiloton
LCS	Laboratory control sample
LF2	Little Feller 2
m	Meter
m ²	Square meter

List of Acronyms and Abbreviations (Continued)

MDC	Minimum detectable concentration
mg/kg	Milligrams per kilogram
mi	Mile
mrem/IA-yr	Millirem per Industrial Access year
mrem/yr	Millirem per year
MS	Matrix spike
MSD	Matrix spike duplicate
NAC	<i>Nevada Administrative Code</i>
NAD	North American Datum
NAEG	Nevada Applied Ecology Group
Nb	Niobium
Nd	Neodymium
ND	Normalized difference
NDEP	Nevada Division of Environmental Protection
NEPA	<i>National Environmental Policy Act</i>
NNES	Navarro Nevada Environmental Services, LLC
NNSA/NSO	U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office
NRDL	U.S. Naval Radiological Defense Laboratory
NTS	Nevada Test Site
PAL	Preliminary action level
Pb	Lead
PCB	Polychlorinated biphenyl
pCi/g	Picocuries per gram

List of Acronyms and Abbreviations (Continued)

PET	Potential evapotranspiration
PM1	Pahute Mesa 1
PPE	Personal protective equipment
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	<i>Resource Conservation and Recovery Act</i>
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
RWMS	Radioactive waste management site
Sr	Strontium
SSTL	Site-specific target level
SVOC	Semivolatile organic compound
TCLP	Toxicity Characteristic Leaching Procedure
TED	Total effective dose
Th	Thorium

List of Acronyms and Abbreviations (Continued)

Tl	Thallium
TLD	Thermoluminescent dosimeter
TPH	Total petroleum hydrocarbons
U	Uranium
UCL	Upper confidence limit
USGS	U.S. Geological Survey
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
W	Tungsten
Zr	Zirconium
%R	Percent recovery

Executive Summary

Corrective Action Unit 374 is located in Areas 18 and 20 of the Nevada Test Site, which is approximately 65 miles northwest of Las Vegas, Nevada. Corrective Action Unit 374 comprises the five corrective action sites (CASs) listed below:

- 18-22-05, Drum
- 18-22-06, Drums (20)
- 18-22-08, Drum
- 18-23-01, Danny Boy Contamination Area
- 20-45-03, U-20u Crater (Schooner)

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 CAS. 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 data quality objectives (DQOs) developed on October 20, 2009, 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 374.

The releases for CASs 18-23-01 and 20-45-03 were the radiological contamination released and distributed from the nuclear tests conducted at the Danny Boy site and the Schooner site. Corrective Action Sites 18-22-05, 18-22-06, and 18-22-08 are potential releases associated with drums identified in and around the Danny Boy crater.

The presence and nature of contamination at CAU 374 will be evaluated based on information collected from a field investigation. Surface-deposited radiological contamination will be evaluated for the test releases based on a comparison of the total effective dose at sample plot locations to the dose-based final action level. The total effective dose will be calculated as the total of separate estimates of internal and external dose. Results from the analysis of soil samples collected from

sample plots will be used to calculate internal radiological dose. Thermoluminescent dosimeters placed at the center of each sample plot will be used to measure external radiological dose.

The presence and nature of contamination from non-test releases (i.e., the drums associated with CASs 18-22-05, 18-22-06, and 18-22-08, as well as any potential releases discovered during the investigation) will be evaluated using soil samples collected from the locations most likely containing contamination, if present.

[Appendix A](#) provides a detailed discussion of the DQO methodology and the DQOs specific to each CAS.

The scope of the corrective action investigation for CAU 374 includes the following activities:

- Move surface debris and/or materials, as needed, to facilitate sampling.
- Conduct radiological surveys.
- Collect and submit environmental samples for laboratory analysis to determine whether contaminants of concern are present.
- If contaminants of concern are present, collect additional step-out samples to define the extent of the contamination.
- Collect samples of investigation-derived waste, as needed, for waste management purposes.

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

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) 374: Area 20 Schooner Unit Crater, Nevada Test Site (NTS), Nevada.

This CAIP has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense (DOD); and DOE, Legacy Management (FFACO, 1996; as amended February 2008).

Corrective Action Unit 374 is located in Areas 18 and 20 of the NTS, which is approximately 65 miles (mi) northwest of Las Vegas, Nevada ([Figure 1-1](#)). Corrective Action Unit 374 comprises the five corrective action sites (CASs) shown on [Figure 1-2](#) and listed below:

- 18-22-05, Drum (referred to herein as crater drums)
- 18-22-06, Drums (20) (referred to herein as the north yard drums)
- 18-22-08, Drum (referred to herein as the southwest rim drums)
- 18-23-01, Danny Boy Contamination Area (referred to herein as Danny Boy)
- 20-45-03, U-20u Crater (Schooner) (referred to herein as Schooner)

The corrective action investigation (CAI) will include field inspections, radiological surveys, sampling of environmental media, analysis of samples, and assessment of investigation results. Data will be obtained to support corrective action alternative (CAA) evaluations and waste management decisions.

1.1 Purpose

The CASs in CAU 374 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 CASs. Additional information will be generated by conducting a CAI before evaluating and selecting CAAs.

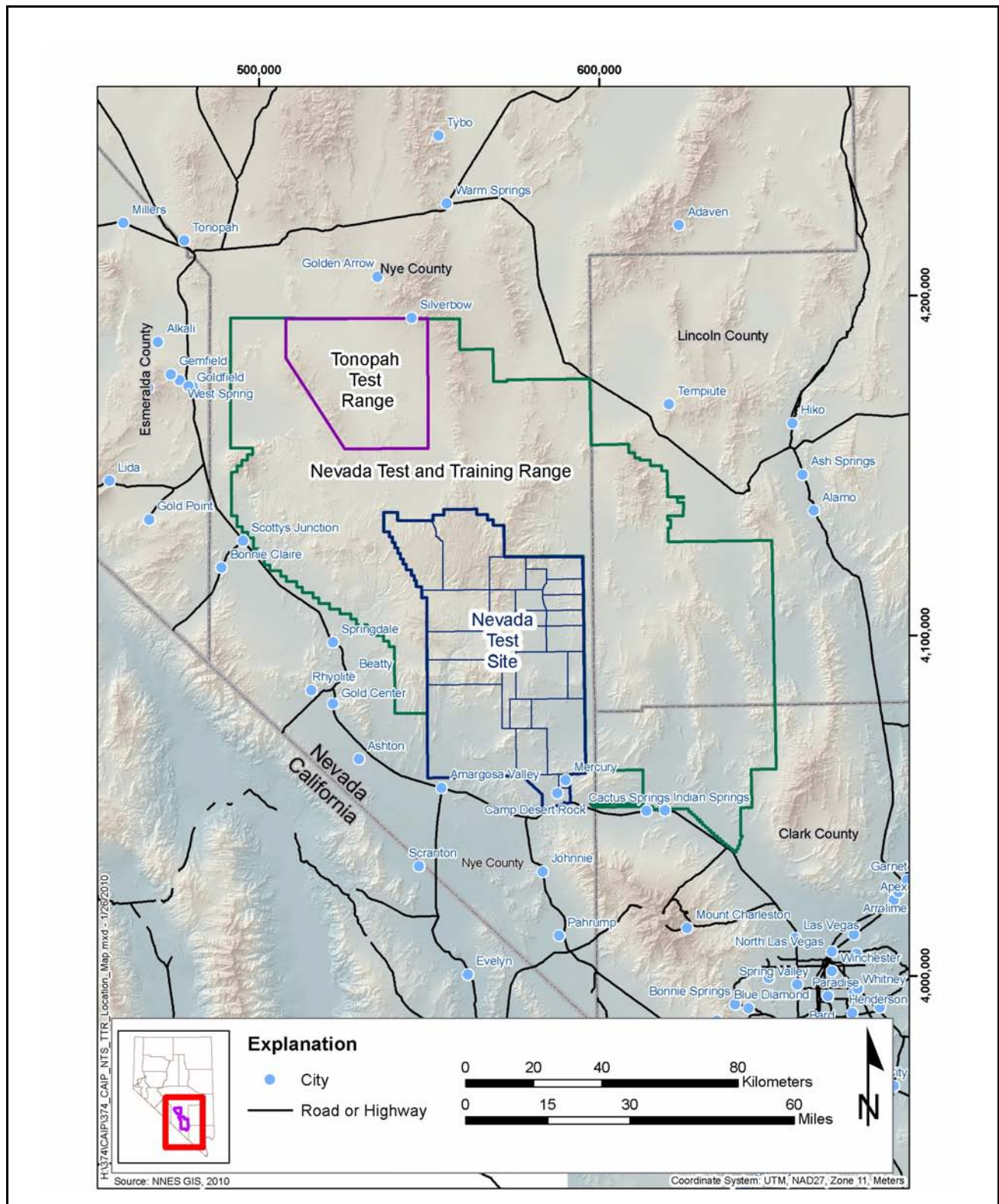


Figure 1-1
Nevada Test Site

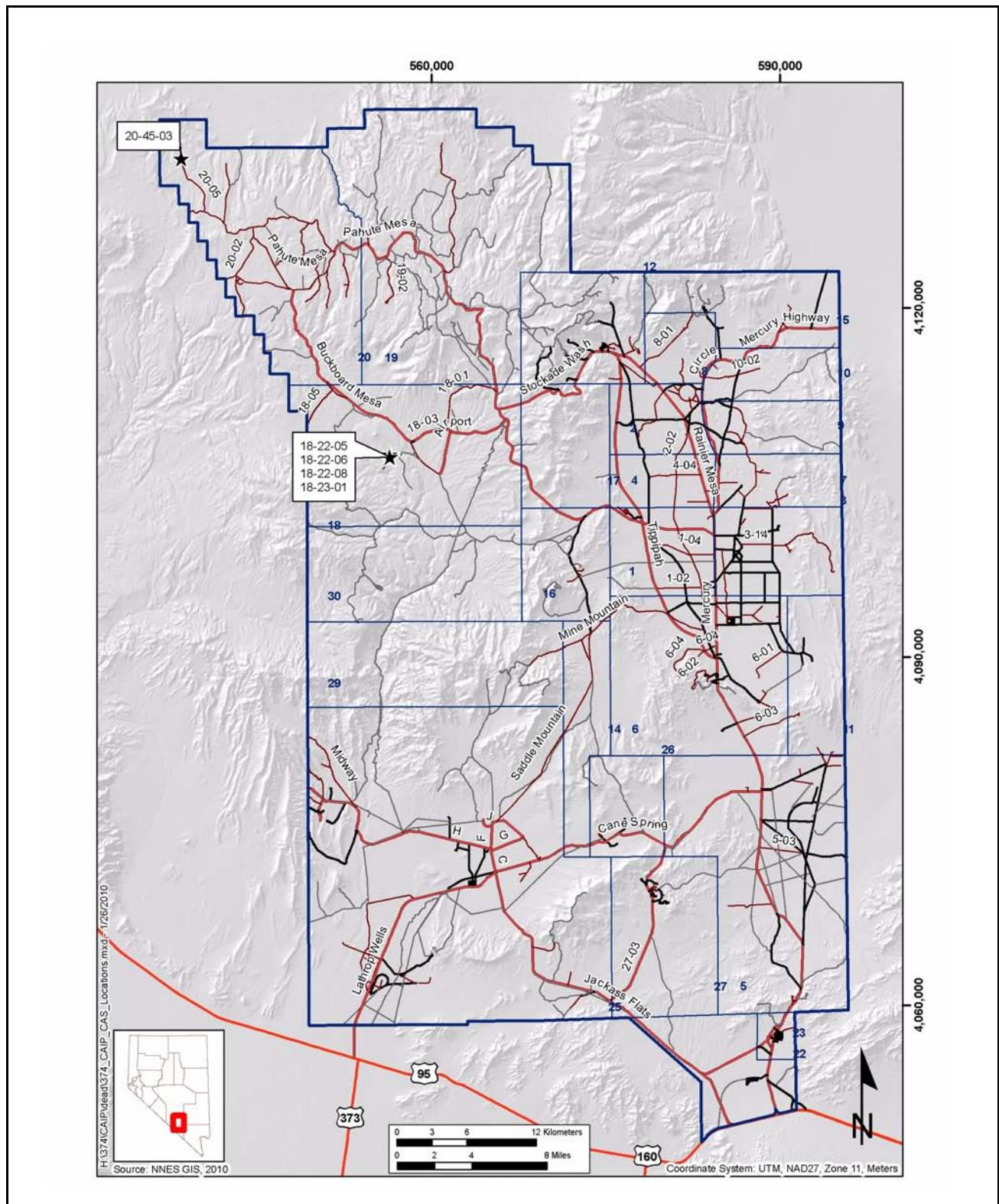


Figure 1-2
CAU 374, CAS Location Map

1.1.1 CAU 374 History and Description

Corrective Action Unit 374, Area 20 Schooner Unit Crater, consists of five inactive sites located in the central portion of Area 18 and the northwestern portion of Area 20. The five CAU 374 sites consist of land areas impacted by the release of radionuclides from a shallow subsurface (34 meters [m] below ground surface [bgs]) weapons-effects test (Danny Boy) and shallow subsurface (111 m bgs) Plowshare test (Schooner), and subsequent area re-entry operations (e.g., soil and rock excavation and staging). The three CASs which address drums, CASs 18-22-05, 18-22-06, and 18-22-08, present at the Danny Boy site may contain hazardous and/or radioactive materials that could be released to the soil. The CAU 374 sites were used to support nuclear testing conducted in the Buckboard Mesa and Pahute Mesa areas in the 1960s. Operational histories for each CAU 374 CAS are detailed in [Section 2.2](#).

1.1.2 Data Quality Objective Summary

The sites 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 374. This CAIP describes the investigative approach developed to collect the data needs identified in the DQO process. While a detailed discussion 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 374 is: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 374.” To address this problem, resolution of the following decision statements is required:

- Decision I: “Is any contaminant of concern (COC) associated with the CAS present in environmental media?” For judgmental sampling decisions, any contaminant of potential concern (COPC) associated with a CAS that is present at concentrations exceeding its corresponding final action level (FAL) will be defined as a COC. For probabilistic sampling decisions, any COPC for which the 95 percent upper confidence limit (UCL) of the mean 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 lateral and vertical extent of COC contamination
 - The information needed to determine potential remediation waste types

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 374 CAS by collecting and analyzing samples, emplacing and analyzing thermoluminescent dosimeters (TLDs), and collecting radiological instrumentation readings during a field investigation. The presence of a COC at each CAS will be determined by collecting and analyzing the necessary information from samples following these two criteria:

- For judgmental sampling, samples must be collected in areas most likely to contain a COC.
- For probabilistic sampling, samples must be collected from random locations that represent contamination within the sampling unit.

Additional information needed to determine the presence of a COC at each CAS will be generated from TLDs emplaced at additional predetermined locations and by collecting radiological instrumentation readings around each site.

The DQOs for CAU 374 defined the following two release scenarios to appropriately address the types of releases that may be present at the CASs:

- The test release is defined as the initial atmospheric deposition of radiological contaminants from each nuclear test. The initial test release is generally observed as an annular (ringlike) geometric pattern of contamination (i.e., soil particle activation and initial fallout) that generally decreases in intensity with distance from ground zero (GZ).

- The non-test release is defined as the subsequent movement of contaminants from test releases (either migration or mechanical displacement) and other potential releases of contaminants from site operations (e.g., from spills and abandoned materials).

For the test release scenario, it is assumed that an area exists within and surrounding the craters that contains much of the radioactivity released from the subsurface detonation of the test devices. As the presence and nature of this contamination is known, and investigating within and around the crater rims poses significant technical challenges, a default contamination boundary was established for each crater where it is assumed that contamination exceeds the FAL and a corrective action will be required (see [Section 3.4](#)). The default contamination boundaries will include the area of the craters and ejecta mounds at the crater rims.

1.2 Scope

To generate information needed to resolve the decision statements identified in the DQO process, the scope of the CAI for CAU 374 includes the following activities:

- Move surface debris and/or materials, as needed, to facilitate sampling.
- Conduct radiological surveys.
- Measure *in situ* external dose rates using TLDs or other dose-measurement devices.
- Collect and submit environmental samples for laboratory analysis to determine internal dose rates.
- Collect and submit environmental samples for laboratory analysis to determine the nature and extent of any COCs released at each CAS.
- Collect samples of source material to determine the potential for a release to result in contamination exceeding FALs.
- Collect quality control (QC) samples.

Contamination of environmental media originating from activities not identified in the conceptual site model (CSM) of any CAS will not be considered as part of this CAU unless the CSM and the DQOs are modified to include the release. If not included in the CSM, contamination originating from these sources will not be considered for sample location selection and/or will not be considered COCs. If

such contamination is present, 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 374. 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 CAS, while [Appendix B](#) contains information on the project organization. [Appendix C](#) contains NDEP comments on the draft version of this document.

2.0 Facility Description

Corrective Action Unit 374 comprises five CASs that were grouped together based on the geographical location of the sites and technical similarities (i.e., drums for CASs 18-22-05, 18-22-06, and 18-22-08; nuclear tests conducted in shallow subsurface rock for CASs 18-23-01 and 20-45-03). The Danny Boy site and co-located drums are located in Area 18 and include CASs 18-22-05, 18-22-06, 18-22-08, and 18-23-01. The Schooner site is located in Area 20 and comprises CAS 20-45-03.

2.1 Physical Setting

The following sections describe the general physical settings of Areas 18 and 20 of the NTS. General background information pertaining to topography, geology, hydrogeology, and climatology are provided for these specific areas of the NTS region in the *Geologic Map of the Nevada Test Site, Southern Nevada* (USGS, 1990); *USGS/DOE Cooperative Studies in Nevada* (USGS and DOE, 2009); and the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996).

Geological and hydrological setting descriptions for each of the CASs are detailed in the following subsections based on the hydrogeographic area in which they are located.

2.1.1 Area 18

The Danny Boy site is located within the Alkali Flat Furnace Creek Ranch Sub-basin. The groundwater in this area primarily flows in a south-southwest direction towards the Death Valley and Ash Meadows discharge areas.

Precipitation data collected from 1977 to 2008 at the nearest rain gauge, Little Feller 2 (LF2), indicate an average annual rainfall of 18.26 centimeters (cm) (7.19 inches [in.]) (ARL/SORD, 2009). Average annual potential evapotranspiration (PET) for the NTS has been estimated for the Area 3 Radioactive Waste Management Site (RWMS) as 157 cm (61.8 in.) (Shott et al., 1997; Lacznia et al., 1996). Additional rainfall and PET information is presented in [Table 2-1](#). It is expected that vertical migration of contaminants would be very limited at this site due to the low annual rate of precipitation and high annual PET rate.

Table 2-1
Rainfall and PET Information for Areas 18 and 20

	PET (cm)	Little Feller 2 Precipitation (cm)	Pahute Mesa 1 Precipitation (cm)
Minimum	150.2	4.37	6.68
Maximum	160.8	34.21	36.78
Mean	157	18.26	18.31
95% UCL	160.2	21.11	20.60

The nearest well, ER-18-2, is located in the west-central portion of Buckboard Mesa in Area 18, 1,050 m southwest of CAS 18-23-01. Depth to groundwater averages 369 m bgs (USGS and DOE, 2009).

The immediate area outside the contamination area fence around the site is relatively flat, except for the presence of a gully to the immediate northeast that drains into a shallow sediment-collection area apparently created by the excavation of a few inches of surface soil (see [Figure A.2-5](#)). Further to the east of this sediment-collection area, a mapped, unnamed wash departs the area to the east, flowing into the Fortymile Canyon Wash, as do two other unnamed washes (one north, one south) within a radius of approximately a half mile (see [Figure A.2-5](#)). These washes join other washes and flow into Fortymile Canyon Wash and ultimately the Death Valley dry lake.

2.1.2 Area 20

The Schooner site is located within the East Thirsty Canyon and Gold Flat East drainage basin. The groundwater in this area primarily flows in a south-southwest direction towards the Death Valley and Ash Meadows discharge areas.

Precipitation data collected from 1977 to 2008 at the nearest rain gauge, Pahute Mesa 1 (PM1), indicate an average annual rainfall of 18.31 cm (7.21 in.) (ARL/SORD, 2009). Average annual PET for the NTS has been estimated for the Area 3 RWMS as 157 cm (61.8 in.) (Shott et al., 1997; Lacznia et al., 1996). Additional rainfall and PET information is presented in [Table 2-1](#). It is expected that vertical migration of contaminants would be very limited at this site due to the low annual rate of precipitation and high annual PET rate.

The nearest well, PM-2, is located approximately 260 m northwest of the Schooner site and was drilled to a depth of 2,679 m bgs (USGS and DOE, 2009). Depth to groundwater averages 262 m bgs.

The ground surface is relatively flat (Tewes, 1970) and tilted towards the east. Three washes draining the immediate area in and around the continuous ejecta area (see [Figure A.2-16](#)) lose from 29.5 to 41 m of elevation as they cross the site, flowing to the eastern portion of the radioactive material area (RMA) fencing (see [Figures A.2-16](#) and [A.2-17](#)). These washes join other washes draining the Pahute Mesa and flow into the Gold Flat dry lake (see [Figure A.2-18](#)).

2.2 Operational History

The following subsections provide a description of the use and history of each CAS in CAU 374 that may have resulted in potential releases to the environment. The CAS-specific summaries are designed to describe the current definition of each CAS and document all significant, known activities.

2.2.1 CAS 18-22-05, Drum

This CAS consists of five drums inside the Danny Boy crater and any potential releases to surrounding soil. As the history of the drums is unknown, it will be conservatively assumed that they may have originated from other, unknown NTS activities. A drum was first identified in 1991 (REECo, 1991). See [Figure A.2-6](#) for photographs of the five drums identified within the Danny Boy crater.

2.2.2 CAS 18-22-06, Drums (20)

This CAS consists of the drums outside the Danny Boy crater and rim area, to the north and northwest of GZ, and within the contamination area fence (i.e., generally the rock piles area), and any potential releases to surrounding soil. Twenty drums were originally identified (REECo, 1991), and the removal of empty drums in 1991 (see [Section 2.5.2](#)) (REECo, 1992) left at least three drums containing soil-like material. Two additional drums were recently identified in the area. As the history of the drums is unknown, it will be conservatively assumed that they may have originated from other, unknown NTS activities. See [Figure A.2-7](#) for photographs of the five drums identified in this CAS.

2.2.3 CAS 18-22-08, Drum

This CAS consists of the two drums outside the Danny Boy crater, along the rim to the west and southwest of GZ, and within the contamination area fence, and any potential releases to surrounding soil. As the history of the drums is unknown, it will be conservatively assumed that they may have originated from other, unknown NTS activities. A drum was first identified in 1991 (REECo, 1991). See [Figure A.2-8](#) for photographs of the two drums identified in this CAS.

2.2.4 CAS 18-23-01, Danny Boy Contamination Area

This CAS consists of the releases associated with the Danny Boy test. The Danny Boy test was conducted on March 5, 1962, in drill hole U-18a as part of Operation Nougat, and was a weapons-effects cratering test with a yield of 430 tons (DOE/NV, 2000). The depth of burial for the device was 33.5 m (NRDL, 1967), and the resulting crater measured approximately 80.8 m in diameter and 25.6 m deep. The test (see [Figure A.2-10](#)) created 1) a base surge milliseconds after the device was detonated, which led to the deposition of ejecta surrounding the crater; and 2) the release of hot cavity gases creating a dust cloud that rose to a height of approximately 610 m, and split into upper and lower clouds, both of which traveled northerly and completely dispersed within 29 minutes (Powell and Wilsey, 1963). The crater itself emitted dust over the next 4 to 5 days. See [Figure A.2-2](#) for an aerial view of the Danny Boy site and vicinity.

2.2.5 CAS 20-45-03, U-20u Crater (Schooner)

This CAS consists of the releases associated with the Schooner test. The Schooner test was conducted on December 8, 1968, in drill hole U-20u as part of Operation Bowline, and was a Plowshare test with a yield of 30 kilotons (kt) (DOE/NV, 2000). The depth of burial for the device was 111.2 m bgs, and the resultant crater measured approximately 260 m in diameter and 63 m deep (USGS, 1997; DOE/NV, 1996). The test (see [Figure A.2-20](#)) created 1) a base surge milliseconds after the device was detonated, which led to the deposition of ejecta deposited in and around the crater; 2) the venting of hot cavity gases, which became the main cloud; 3) a separate, second cloud forming from the dust and dirt released from the excavation of the crater (Crawford, 1970); and 4) individual “missile” ejecta sent on trajectories terminating as far as approximately 3,050 m out (Henny, 1970). The main cloud contained approximately 10 times the radioactivity that the second

cloud contained (Crawford, 1970) and rose to a height of approximately 4,880 m above mean sea level (amsl), then traveled to the east-northeast. The second cloud rose to a height of approximately 670 m and traveled to the north.

2.3 Waste Inventory

Available documentation, interviews with former site employees, process knowledge, and general historical NTS practices were used to identify wastes that may be present. Historical information and site visits indicate that the sites contain wastes such as construction materials, metal spools, metal and concrete pipes, drums (Danny Boy site), a lead-acid battery (Schooner site) and other miscellaneous debris. Wastes generated during the CAI may include debris, investigation-derived waste (IDW), decontamination liquids, and contaminated soils. Potential waste types include sanitary waste, *Resource Conservation and Recovery Act* (RCRA) hazardous waste, radioactive waste, and mixed waste.

2.3.1 CAS 18-22-05, Drum

Solid waste items identified for the crater drums include the drums themselves and possible contents. The recently observed contents of the original drum identified for this CAS appear to consist of a granular, whitish material (see [Figure A.2-6](#)). In a recent site visit, material was identified that is similar in appearance to the whitish material in the drum and exists in a pile adjacent to a bucket at the crater bottom (see [Figure A.2-9](#)).

2.3.2 CAS 18-22-06, Drums (20)

Solid waste items identified for the north yard drums include the drums themselves and possible contents. The three standing drums (see [Figure A.2-7](#)) were reported to contain varying levels of soil-like material (from 10 percent to 70 percent full) (IT, 2001). One drum to the northwest of the crater has a bung-type of lid that indicates the drum likely contained a liquid (see [Figure A.2-7](#)).

2.3.3 CAS 18-22-08, Drum

Solid waste items identified for the southwest rim drums include the original drum and a recently identified half-drum and possible contents (see [Figure A.2-8](#)). The drums are within the contamination area along the crater rim, and the openings and insides have not been inspected.

2.3.4 CAS 18-23-01, Danny Boy Contamination Area

Solid waste items identified at the Danny Boy site include recently identified construction materials, metal spools and buckets, metal and concrete pipes, and other miscellaneous debris.

2.3.5 CAS 20-45-03, U-20u Crater (Schooner)

Solid waste items identified at the Schooner site include recently identified construction materials, a metal pipe, a lead-acid battery and related sampling devices (see [Figure A.2-19](#)), and other miscellaneous debris.

2.4 Release Information

The releases of contamination to the CAU 374 CASs are directly or indirectly associated with the Danny Boy and Schooner nuclear tests. The investigation of specific releases at CAU 374 will depend upon the nature of these releases. Therefore, the releases at CAU 374 have been categorized into one of the two release scenarios defined in [Section 1.1.2](#).

The test release scenario includes the prompt injection of radionuclides and activated material into the geological formation around the test devices following detonation, resulting in contamination below and around the crater and rim (see [Section 3.1.3](#)). This scenario also includes the atmospheric deposition of radioactive contamination onto surface soils from fallout of activated soil ejected from the crater, and radionuclides carried by the venting of hot cavity gases.

The non-test release scenario includes the drums left in and around the Danny Boy crater, comprising CASs 18-22-05, 18-22-06, and 18-22-08. The contents of the drums are not known but are suspected to be related to post-test re-entry and drilling activities. Contamination associated with the drums is unknown. The non-test release scenario also includes subsequent migration of radioactivity associated with atmospheric deposition under the test release scenario, and any other

contamination that may be present at the CAU 374 CASs. Migration may occur due to sheet and gully erosion from stormwater runoff and/or movement through excavation and grading associated with entry into the craters for sample recovery, drilling, or clearing of contaminated surfaces to provide a clean work area.

The non-test release scenario also includes other potential releases such as spills, wastes, or debris from ancillary activities conducted in support of the tests.

Exposure routes to receptors include internal exposure through ingestion and inhalation of radionuclides in surface soil, and external exposure through proximity to radiologically contaminated materials.

The following subsections contain CAS-specific descriptions of known or suspected releases associated with CAU 374.

2.4.1 CAS 18-22-05, Drum

Information concerning a release from the crater drums was not identified. Exposure routes to receptors include ingestion, inhalation, and dermal exposure to contamination. The relationship of the granular whitish material presently in the originally identified drum to the drum's original contents is not known. Materials contained in each of these drums may have leaked or been spilled onto the soil inside the crater.

2.4.2 CAS 18-22-06, Drums (20)

Information concerning a release from the north yard drums was not identified. Exposure routes to receptors include ingestion, inhalation, and dermal exposure to contamination. Previous observations of the three standing drums (see [Section 2.5.2](#)) report three small buckets containing "rad contaminated sand and rocks," but it is not known whether the buckets are these three drums. Materials contained in each of the drums may have leaked or been spilled onto the soil at the site.

2.4.3 CAS 18-22-08, Drum

Information concerning a release from the southwest crater rim drums was not identified. Exposure routes to receptors include ingestion, inhalation, and dermal exposure to contamination. Materials contained in each of these drums may have leaked or been spilled onto the soil at the site.

2.4.4 CAS 18-23-01, Danny Boy Contamination Area

Release of contamination at the site from the test release includes fallout due to the Danny Boy crater test; neutron activation of elements within the rock and soil, such as europium; and ejected fractured rock containing radioactive slag and Trinity glass. The initial release of radionuclides from the Danny Boy test, with the subsequent distribution in an annular pattern, is considered a test release.

Other CASs present at Danny Boy include 18-99-05, in CAU 4000, and 18-99-05, in CAU 5000, consisting of drilling cores that were placed in boxes. These CASs are within the plume for Danny Boy and may impact the investigation. Corrective Action Sites 18-22-04, 18-24-05, and 18-22-07 consist of housekeeping waste sites where the waste was removed, and the sites were clean closed. These CASs are within the plume for Danny Boy, and they should not impact the investigation.

2.4.5 CAS 20-45-03, U-20u Crater (Schooner)

Release of contamination at the site from the test release includes fallout due to the Schooner crater test; neutron activation of elements within the rock and soil, such as europium; and ejected fractured rock and sands containing radioactive slag and Trinity glass. Also, the lead-acid battery identified northeast of GZ may have released lead to the surface soil. The initial release of radionuclides from the Schooner test, with the subsequent distribution in an annular pattern, is considered a test release.

Corrective Action Sites that are present within the plume for Schooner consist of 20-14-01, 20-24-01, and 20-99-01, which are housekeeping waste sites where the waste was removed, and the sites were clean closed. These CASs should not impact the investigation.

2.5 Investigative Background

The following subsections summarize the investigations conducted at the CAU 374 sites. More detailed discussions of these investigations are found in [Appendix A](#).

2.5.1 CAS 18-22-05, Drum

No previous investigations of the drums within the Danny Boy crater have been identified. Knowledge about the presence and condition of the drums, and the material within the original drum identified for this CAS, comes from visual observations from the wooden viewing platform along the south rim of the crater. The original drum was first identified in 1990 (REECo, 1991).

2.5.2 CAS 18-22-06, Drums (20)

Previous investigations of the three standing drums within the contamination area fence north of the crater have been limited to observation of the drums from outside of the fence, and from observations of the drum contents from inside the fence boundary. During a site visit in 2001, the three drums were noted to not have any visible staining present near the drums; the northernmost drum was approximately 70 percent full of a soil-type material, the southernmost drum was approximately 10 percent full of a soil-type material, and the northeastern drum was 40 percent full of a soil-type material (IT, 2001). The drums were originally identified as 20 drums, all reported to be empty (REECo, 1991). Twenty drums were reported to have been removed in 1992 (REECo, 1992), with three small buckets containing “rad contaminated sand and rocks” remaining at the site. The relationship of the three small buckets to the three standing drums containing soil-like material is not known.

2.5.3 CAS 18-22-08, Drum

No previous investigations of the drums along the western and southwestern rim area of the Danny Boy crater have been identified. Knowledge about the presence of the drums comes from visual observations from outside of the contamination area fence. The original drum was first identified in 1990 (REECo, 1991).

2.5.4 CAS 18-23-01, Danny Boy Contamination Area

Previous investigations at the Danny Boy site included studies of samples of fallout and cloud debris from Danny Boy collected after the test, surface soil inventory studies by the Radionuclide Inventory and Distribution Program (RIDP) and the Nevada Applied Ecology Group (NAEG), aerial radiological surveys, and a recent gamma walkover survey.

Miskel and Bonner (1964), Bonner and Miskel (1965), and the U.S. Naval Radiological Defense Laboratory (NRDL) (1967) studied samples of close-in fallout and the cloud releases from Danny Boy. Their analyses concluded that much of the total radioactivity produced by the Danny Boy test was trapped in and below the crater (all but a few tenths of 1 percent of refractory [i.e., nonvolatile] mass chain radionuclides, and 80 percent to 90 percent of volatile mass chain radionuclides remained in the crater). Their studies also included the distribution of radionuclides from fallout onto the soil surface from GZ outward. Of the radioactivity released from the crater, most of the refractory mass chain radionuclides (e.g., zirconium [Zr]-95, cerium [Ce]-144, and neodymium [Nd]-147) were deposited within 15 kilometers (km) of GZ, but most of the volatile mass chain radionuclides (e.g., strontium [Sr]-90 and barium [Ba]-140) that were released were deposited further away.

Data collected for the RIDP and by NAEG in the 1980s allowed for estimates of surface soil inventories around the Danny Boy area (Friesen, 1992; DRI, 1988) (see [Figure A.2-11](#)). The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy and through limited confirmatory soil sampling (DRI, 1988 and 2007). Estimates of the soil surface inventories of radionuclides are shown in [Table 2-2](#).

In an analysis of the RIDP data in 2009 (Anagnostopoulos, 2009a), the results for the Danny Boy site were extrapolated to the present (i.e., adjusted for radioactive decay and growth) to estimate the current activities of selected radionuclides at the RIDP points. From this work, the following inferences were made:

- The Cs-137 levels ranged from approximately 13 picocuries per gram (pCi/g) to 253 pCi/g inside the contamination area, and from approximately 9 pCi/g to 103 pCi/g in areas just outside the fence. The highest levels inside the fence were generally indicated in the eastern and northern areas, and in the eastern and western areas outside the fence.
- The Eu-152 levels ranged from approximately 2 pCi/g to 34 pCi/g inside the contamination area, and from less than 1 pCi/g to 32 pCi/g in areas just outside the fence. The highest levels inside the fence were generally indicated in the southeastern and eastern areas, and in the western areas outside the fence.
- The Pu-239 levels ranged from approximately 155 pCi/g to 11,739 pCi/g inside the contamination area, and from approximately 6 pCi/g to 5,132 pCi/g in areas just outside the fence. The highest levels inside the fence were generally indicated in the eastern and northern areas, and in the eastern and western areas outside the fence.

Table 2-2
RIDP Soil Surface Inventory, Danny Boy and Schooner Sites

Radionuclide	Surface Soil Inventory (Ci) ^a	
	Danny Boy	Schooner
Am-241	6.6	9.4
Co-60	0.2	9.7
Cs-137	2.3	1.5
Eu-152	0.5	14.0
Eu-154	0.1	17.0
Eu-155	0.3	5.2
Pu-238	0.8	16.0
Pu-239/240	26.0	6.4
Sr-90	1.4	1.5

^aOriginal values as published in April 1988 (DRI, 1988).

Am = Americium
Ci = Curie
Co= Cobalt

Cs = Cesium
Eu = Europium
Pu = Plutonium

An aerial radiological survey flown in 1994 (NNSA/NSO, 2002b) used radiological detection systems to identify gamma radiation. From the data collected, the gross count rates, man-made radiation, and Am-241 count rates were published for the NTS. The aerial survey results show gross count gamma results ranged from 18 to 120 counts per minute (cpm) within the fenced area at the Danny Boy site, and from 12 to 50 cpm in areas just outside the fenced site (see [Figure A.2-11](#)). The Am-241 count rates ranged from 200 to 5,000 counts per second (cps) within the fenced site, and from 50 to 2,000 cps just outside the fenced site (see [Figure A.2-12](#)). These results confirm the expectation that gamma and Am-241 levels are higher near the crater and decrease with distance.

A gamma radiation walkover survey (Anagnostopoulos, 2009b) was conducted along the perimeter of the Danny Boy contamination area fence (see [Figure A.2-13](#)). From the data, five ranges of results were created. In general, the areas northeast and west of the crater along the fence are expected to be near the preliminary action level (PAL) for radiological dose, and are indicated to be the most likely areas outside the fence to exceed the PAL.

2.5.5 CAS 20-45-03, U-20u Crater (Schooner)

An extensive study of the Schooner ejecta was conducted in the months following the test (Henny, 1970; Koranda et al., 1970). The depth and extent of the continuous ejecta field was determined from pretest and post-test topographical maps of the area prepared for the U.S. Army Nuclear Cratering Group (Henny, 1970). From these maps, an isopach map was prepared in addition to a graph of the minimum, maximum and mean ejecta-uplift radial profiles (see [Figure A.2-21](#)). In general, the maximum ejecta-uplift height was approximately 18 m at approximately 17 m distance from the crater edge, and the average depth of the ejecta was found to be more than 3 m extending radially to more than 150 m from the crater's edge.

During May and June 1969, a trench was excavated from the south crater edge outward for approximately 457 m (Henny, 1970; Koranda et al., 1970). Both the physical and radiological nature of the ejecta along the vertical face of this trench were studied. The ejecta itself was found to have a bimodal population of fines (sand) and discrete blocks and fragments; in general, numerous isolated and a few prominent zones of competent missile blocks were found among the fines that dominated the profile.

Radiological results from samples collected from the face of the trench at regular intervals from the crater edge in general were highest at the surface layer, which was impacted last by the fallout of fine-grained material. The radionuclide levels decreased with depth through the ejecta to the original ground surface (see [Figure A.2-22](#)). At the time of sample collection, tungsten (W) isotopes, such as W-181 in [Figure A.2-22](#), dominated the radiological readings throughout the site and in fallout to the north; all tungsten isotopes have since undergone multiple half-lives (e.g., W-181 half-life is 121.2 days) and are only present today in trace amounts.

Data collected for the RIDP and by NAEG in the 1980s allowed for estimates of surface soil inventories from the Schooner area (Friesen, 1992; DRI, 1988) (see [Figure A.2-23](#)). The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy and through limited confirmatory soil sampling (DRI, 1988 and 2007). Estimates of radionuclides released to local surface soils are shown in [Table 2-2](#).

In an analysis of the RIDP data in 2009 (Anagnostopoulos, 2009a), the results for the Schooner site were extrapolated to the present (i.e., adjusted for radioactive decay and growth) to estimate the current activities of selected radionuclides at the RIDP points. From this work, the following inferences were made:

- The Cs-137 levels ranged from approximately 1 pCi/g to 19 pCi/g inside the RMA fence. The highest levels were generally nearest the crater at the areas measured (east, and south to northwest).
- The Eu-152 levels ranged from less than 1 pCi/g to 208 pCi/g inside the RMA fence. The highest levels inside were generally to the west side of the ejecta field.
- The Pu-239 levels ranged from approximately 1 pCi/g to 354 pCi/g inside the RMA fence. The highest levels were generally to the northwest side of the ejecta field.

An aerial radiological survey flown in 1994 (NNSA/NSO, 2002b) used radiological detection systems to identify gamma radiation. From the data collected, the gross count rates, man-made radiation, and Am-241 count rates were published for the NTS. The aerial survey results show gross count gamma results ranging from 12 to 270 cps within the fenced area at the Schooner site, and from 12 to 39 cps in areas just outside the fenced site (see [Figure A.2-23](#)). When overlain by the isopach map (i.e., continuous ejecta), most of the outer boundary of the continuous ejecta is contained within 120 cps and above isopleths. These results confirm the expectation that gamma levels are higher near the crater and decrease with distance. The Am-241 survey data were unusable due to rapidly changing results and high count rates (BN, 1999).

Gamma walkover surveys were performed in 2009 with a PRM-470 plastic scintillator (Anagnostopoulos, 2009b). In addition, existing NTS environmental monitoring program TLDs around the Schooner site (NNSA/NSO, 2008) were read and the results converted to millirem per Industrial Access Year (mrem/IA-yr). The PRM-470 readings were taken at the site of each TLD. The TLD data were correlated to PRM-470 radiation survey readings, resulting in a high correlation ($R^2 = 0.99$). See [Figure A.2-24](#) for the results of the surveys and data conversion. The blue bar along each transect indicates the approximate position at which external radiation doses within that limit are estimated to exceed 25 mrem/IA-yr (i.e., areas where PRM-470 results are greater than 449 cps).

2.5.6 *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 374.

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 374. 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.

3.0 Objectives

This section presents an overview of the DQOs for CAU 374 and formulation of the CSM. Also presented is a summary listing of the COPCs, the PALs for the CAU 374 CAI, 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 374 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 374 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.3.1](#) 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 374.

3.1.1 Land Use and Exposure Scenarios

Land-use zones where the CAU 374 CASs are located dictate future land use, and restrict current and future land use to nonresidential (i.e., industrial) activities.

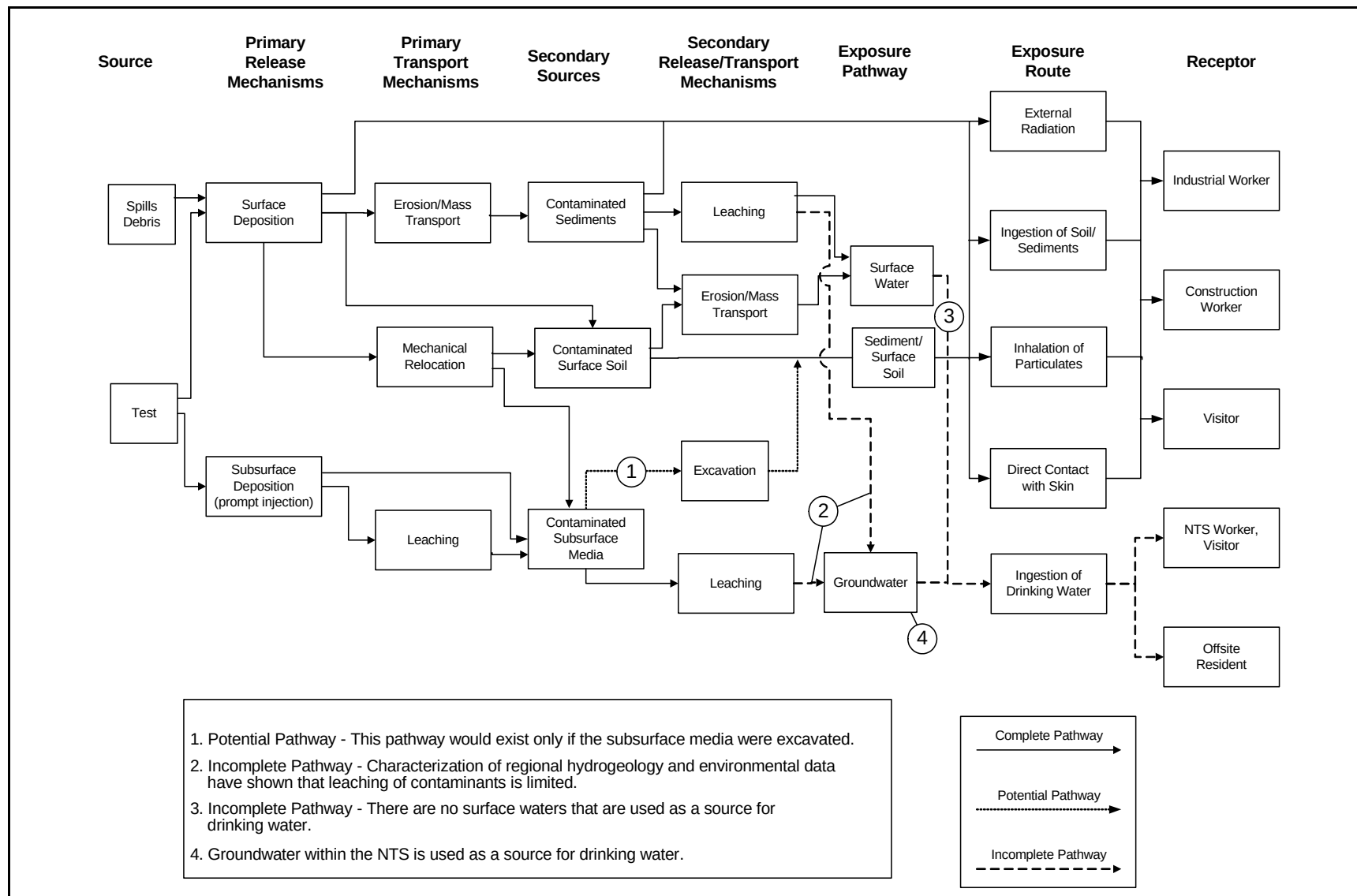


Figure 3-1
Conceptual Site Model Diagram

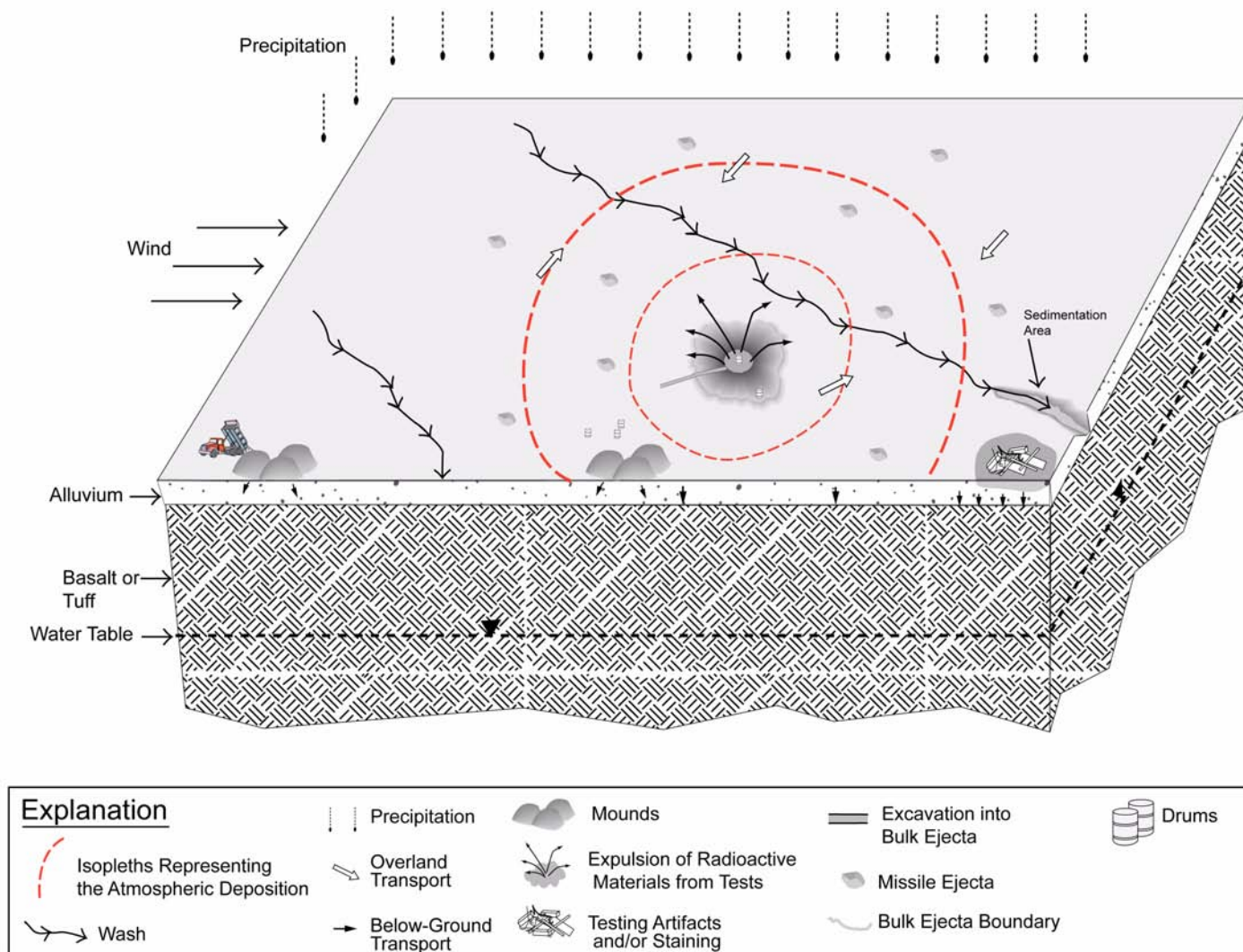


Figure 3-2
CAU 374 Conceptual Site Model

Corrective Action Sites 18-22-05, 18-22-06, 18-22-08, and 18-23-01 are located in the land-use zone described as “reserved” within the NTS. This area includes land and facilities that provide widespread flexible support for diverse short-term testing and experimentation. The reserved zone is also used for short-duration exercises and training such as nuclear emergency response, Federal Radiological Monitoring and Assessment Center training, and DoD exercises and training (DOE/NV, 1998).

Corrective Action Site 20-45-03 is located in the land-use zone described as “nuclear test zone” within the NTS. This area is reserved for dynamic experiments, hydrodynamic tests, and underground nuclear weapons and weapons-effects tests. This zone includes compatible defense and nondefense research, development, and testing activities (DOE/NV, 1998).

The exposure scenario for the CAU 374 CASs based on current and projected future land uses is the Occasional Use Area. This exposure scenario assumes exposure to industrial workers who are not assigned to the area as a regular work location but may occasionally use the area for intermittent or short-term activities. Site workers under this scenario are assumed to be on the site for an equivalent of 8 hours per day, 10 days per year, for 5 years.

3.1.2 Contaminant Sources

The contamination sources for the CAU 374 CASs are releases of radiological contamination to the atmosphere and soil as a result of weapons-effects (CAS 18-23-01) and Plowshare (CAS 20-45-03) nuclear tests, and contamination that was and/or is present in the drums (CAS 18-22-05, 18-22-06, and 18-22-08). Contamination on the soil surface, and in the drums may be sources for future migration.

3.1.3 Release Mechanisms

Release mechanisms for the test release portions of CASs 18-23-01 and 20-45-03 in CAU 374 include neutron activation of soil and structural components, release of fission products, and release of unfissioned nuclear fuel from the detonation of nuclear devices. The detonations irradiated the surrounding soil with neutrons, causing the activation of some elements in the soil (primarily europium elements). Fission fragments were released in an annular pattern around GZ with a bias

towards the prevailing wind direction at the time of detonation (to the north). Radionuclides with a low melting point (e.g., iodine) traveled significant distances before condensing and falling out of the airborne 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., Pu-239) has a very high melting point and is generally found very near to GZ. The release mechanisms for radioactive contamination include the prompt injection of material into the crater that occurred from the detonation, as well as the fallout found around GZ.

Release mechanisms for the non-test releases are spills and leaks onto surface soils from equipment or stored materials, and migration of contaminants in washes and by mechanical displacement. Materials stored in containers may have leaked or have been spilled.

3.1.4 Migration Pathways

Migration pathways include the lateral migration of potential contaminants across surface soils/sediments and vertical migration of potential contaminants through subsurface soils. Contaminants present in the washes are subject to much higher transport rates than contaminants present in other areas. These washes and the ones nearest to the Danny Boy site are generally dry but are subject to infrequent, potentially intense stormwater flows. These stormwater flow events provide an intermittent mechanism for both vertical and horizontal transport of contaminants. Contaminated sediments entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as sediment-collection areas.

The washes located near the CASs in Area 18 drain into Fortymile Canyon Wash offsite, and ultimately to Death Valley. The washes around the CAS 20-45-03 in Area 20 ultimately flow to Gold Flat dry lake (see [Figure A.2-18](#)). Other migration pathways of contamination from the site include wind-borne material and material excavated for post-test access to the craters, and the investigation trench excavated through the continuous ejecta up to the Schooner crater.

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 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.

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 62.6 in. [Shott et al., 1997]) and limited precipitation for this region (18.26 centimeters per year [cm/yr] at Station LF2 in Area 18 and 18.31 cm/yr at Station PM1 in Area 20 [ARL/SORD, 2009]), percolation of infiltrated precipitation at the NTS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

Subsurface migration pathways at CASs 18-22-05, 18-22-06, 18-22-08, 18-23-01, and 20-45-03 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 horizontal transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., caliche layers).

3.1.5 Exposure Points

Exposure points for 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 to 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 374 CASs 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. Areas of erosion and deposition within the washes will be qualitatively evaluated to provide additional information on potential offsite migration of contamination. Movement of ephemeral stream channels may be identified based on a comparison of historical photographs and visual observations where erosion and deposition have occurred within the washes.

3.2 Contaminants of Potential Concern

Based on the suspected contaminants identified in [Section 2.4](#), the COPCs for CAU 374 are defined as the list of constituents represented by the analytical methods identified in [Table 3-1](#) for Decision I environmental samples taken at each of the CASs. The COPCs reported for each analytical method are chemical and radiological:

- Chemical: Total petroleum hydrocarbons (TPH)-diesel-range organics (DRO), polychlorinated biphenyls (PCBs), semivolatile organic compounds (SVOCs), volatile organic compounds (VOCs), RCRA metals
- Radiological: Gamma spectroscopy, isotopic Am, isotopic uranium (U), isotopic Pu, Sr-90

The list of COPCs is intended to encompass all contaminants that could potentially be present at each CAS. 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 CASs and other non-test releases (including those identified during the investigation). Specific COPCs (and subsequently the analyses requested) will be determined for newly identified potential releases based on the nature of the potential release (e.g., hydrocarbon staining, lead bricks). As the origins of the drums are unknown, samples of the contents of any of the drums outside of the crater (CASs 18-22-05 and 18-22-08) will be submitted to the analytical laboratory for analysis of the full suite of COPCs.

Table 3-1
Constituents Reported by Analytical Methods

VOCs		SVOCs		TPH	PCBs	Metals	Radionuclides
1,1,1,2-Tetrachloroethane	Carbon tetrachloride	2,3,4,6-Tetrachlorophenol	Chrysene	GRO	Aroclor 1016	Arsenic	Am-241
1,1,1-Trichloroethane	Chlorobenzene	2,4,5-Trichlorophenol	Di-n-butyl phthalate		Aroclor 1221	Barium	Pu-238
1,1,2,2-Tetrachloroethane	Chloroethane	2,4,6-Trichlorophenol	Di-n-octyl phthalate		Aroclor 1232	Beryllium	Pu-239/240
1,1,2-Trichloroethane	Chloroform	2,4-Dimethylphenol	Dibenzo(a,h)anthracene		Aroclor 1242	Cadmium	Sr-90
1,1-Dichloroethane	Chloromethane	2,4-Dinitrotoluene	Dibenzofuran		Aroclor 1248	Chromium	U-234
1,1-Dichloroethene	Chloroprene	2-Chlorophenol	Diethyl phthalate		Aroclor 1254	Lead	U-235
1,2,4-Trichlorobenzene	cis-1,2-Dichloroethene	2-Methylnaphthalene	Dimethyl phthalate		Aroclor 1260	Mercury	U-238
1,2,4-Trimethylbenzene	Dibromochloromethane	2-Methylphenol	Fluoranthene		Aroclor 1268	Selenium	
1,2-Dibromo-3-chloropropane	Dichlorodifluoromethane	2-Nitrophenol	Fluorene			Silver	
1,2-Dichlorobenzene	Ethyl methacrylate	3-Methylphenol ^a	Hexachlorobenzene				Gamma-Emitting
1,2-Dichloroethane	Ethylbenzene	(m-cresol)	Hexachlorobutadiene				Ac-228
1,2-Dichloropropane	Isobutyl alcohol	4-Methylphenol ^a	Hexachloroethane				Am-241
1,3,5-Trimethylbenzene	Isopropylbenzene	(p-cresol)	Indeno(1,2,3-cd)pyrene				Co-60
1,3-Dichlorobenzene	Methacrylonitrile	4-Chloroaniline	n-Nitroso-di-n-propylamine				Cs-137
1,4-Dichlorobenzene	Methyl methacrylate	4-Nitrophenol	Naphthalene				Eu-152
1,4-Dioxane	Methylene chloride	Acenaphthene	Nitrobenzene				Eu-154
2-Butanone	n-Butylbenzene	Acenaphthylene	Pentachlorophenol				Eu-155
2-Chlorotoluene	n-Propylbenzene	Aniline	Phenanthrene				K-40
2-Hexanone	sec-Butylbenzene	Anthracene	Phenol				Nb-94
4-Isopropyltoluene	Styrene	Benzo(a)anthracene	Pyrene				Pb-212
4-Methyl-2-pentanone	tert-Butylbenzene	Benzo(a)pyrene	Pyridine				Pb-214
Acetone	Tetrachloroethene	Benzo(b)fluoranthene					Tl-208
Acetonitrile	Toluene	Benzo(g,h,i)perylene					Th-234
Allyl chloride	Total xylenes	Benzo(k)fluoranthene					U-235
Benzene	Trichloroethene	Benzoic acid					
Bromodichloromethane	Trichlorofluoromethane	Benzyl alcohol					
Bromoform	Vinyl acetate	Bis(2-ethylhexyl)phthalate					
Bromomethane	Vinyl chloride	Butyl benzyl phthalate					
Carbon disulfide		Carbazole					

^aMay be reported as 3,4-Methylphenol or m,p-cresol.

Ac = Actinium
GRO = Gasoline-range organics
K = Potassium
Nb = Niobium

Pb = Lead
Th = Thorium
Tl = Thallium

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, they are useful in screening out contaminants that are not present in sufficient concentrations to warrant further evaluation, therefore 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, 2008b). For the evaluation of corrective actions, NAC Section 445A.22705 (NAC, 2008c) requires the use of American Society for Testing and Materials (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 (i.e., FALs) or to establish that corrective action is not necessary.”

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

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.3.1](#) will be obtained before any interim action is implemented. Evaluation of DQO

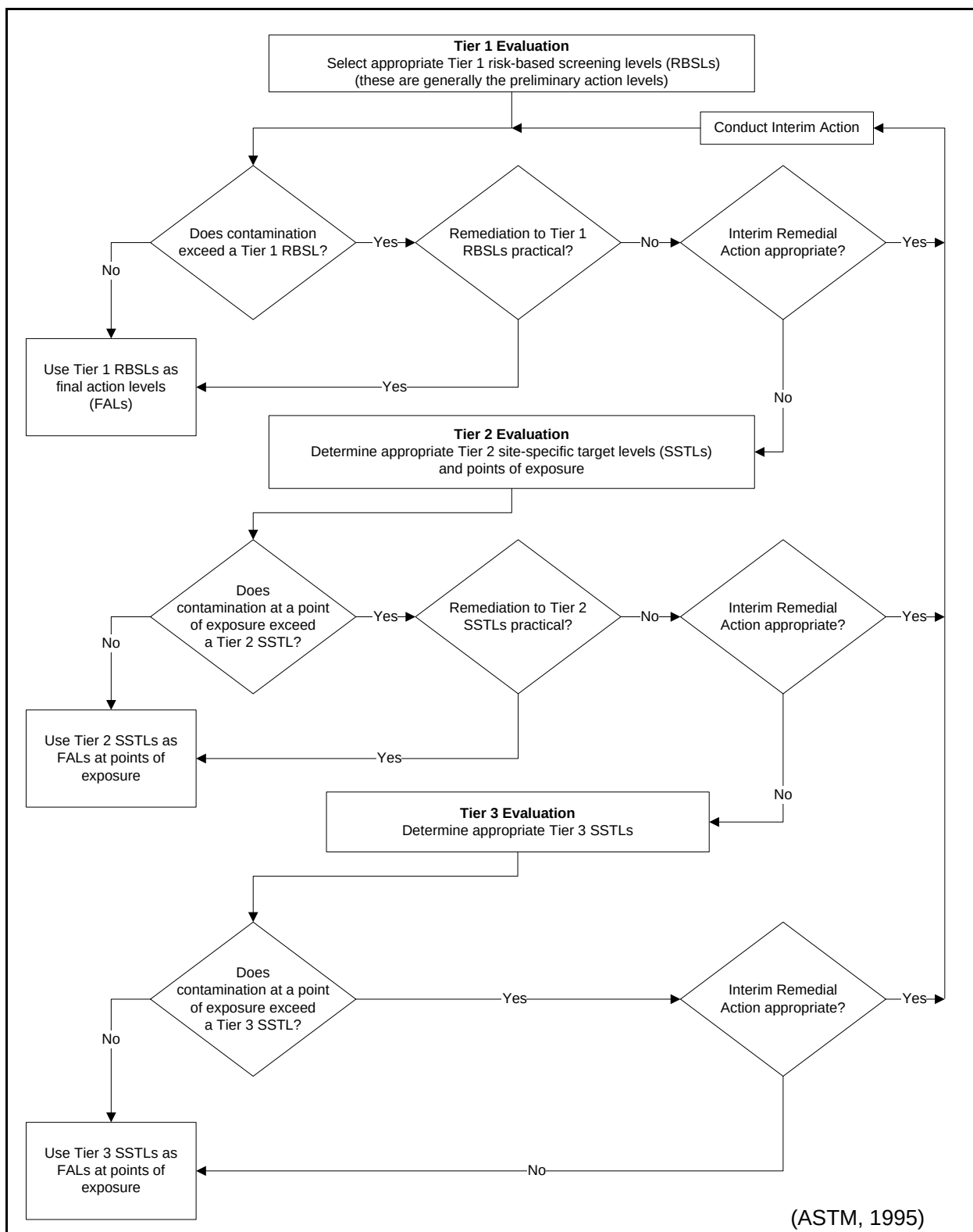


Figure 3-3
Risk-Based Corrective Action Decision Process

decisions will be based on conditions at the site following completion of any interim actions. Any interim actions conducted will be reported in the Corrective Action Decision Document (CADD).

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) *Region 9: Superfund, Preliminary Remediation Goals, Screening Levels for Chemical Contaminants* in industrial soils (EPA, 2009). 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 NTS. 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 the EPA Region 9 in establishing screening levels will be used to establish PALs. If used, this process will be documented in the CADD.

3.3.2 Total Petroleum Hydrocarbon PALs

The “Adopted Regulation of the State Environmental Commission, LCB File No. R189-08” (Nevada Legislature, 2009) eliminated the action level of 100 milligrams per kilogram (mg/kg) specific to petroleum hydrocarbons in soil. Therefore, a single PAL for TPH is not defined. However, PALs are defined for the hazardous constituents of TPH in [Section 3.3.1](#).

3.3.3 Radionuclide PALs

The PAL for radioactive contaminants is 25-mrem/IA-yr total effective dose (TED), based upon the modified Industrial Area exposure scenario. The Industrial Area exposure scenario is described in *Industrial Sites Project Establishment of Final Action Levels* (NNSA/NSO, 2006). That document establishes the default exposure conditions and Residual Radioactive (RESRAD) computer code input parameters to be used to calculate the potential radiation dose over a land area. Several input parameters are not specified so that site-specific information can be used.

For test releases, the Industrial Area scenario has been modified by specifying values for several input parameters (such as an area of contamination of 1,000 square meters [m²], applied to areas of 100 m², and a depth of contamination of 5 cm to match the CSM). In addition, Derived Concentration Guideline (DCG) values for each individual radionuclide COPCs were calculated. The DCG is the value, in picocuries per gram for surface soil, for a particular radionuclide and exposure scenario that would result in a dose of 25 mrem/IA-yr. Using DCGs in site evaluation facilitates the determination of a radiation dose estimate for each soil sample.

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).

As presented in [Section 1.1.2](#), the DQOs address two types of potential contaminant releases:

- Test releases of contaminants are defined as the initial release of radionuclides from the nuclear test detonations.
- Non-test releases of contaminants include the translocation of test release contamination (e.g., migration in stormwater runoff, excavated material, and grading of roads), and other potential releases (e.g., spills, lead bricks) that are associated with pretest and post-test activities.

The test releases will be investigated through a combination of probabilistic and judgmental sampling, and the non-test releases through judgmental sampling. Therefore, discussions related to these two release scenarios are presented separately.

The DQO strategy for CAU 374 was developed at a meeting on October 20, 2009. 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 374 is: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 374.” To address this problem statement, resolution of the following decision statements is required:

- Decision I: “Is any COC present in environmental media within the CAS?” 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 lateral and vertical extent of COC contamination
 - The information needed to determine potential remediation waste types

The presence of a COC would require a corrective action. For the test release scenario, the DQO process resulted in an assumption that TED within the areas of the craters, crater rims, and related mounding around the craters exceeds the FAL and requires corrective action. Process knowledge from test data (e.g., studies of Danny Boy; see [Section 2.5.4](#)) indicates that much of the radioactivity associated with the test was captured within the craters and in fractures around the crater. The extent of the subsurface contamination in and around the craters has not been determined but has been conservatively assumed that contamination within the default contamination boundaries exceed the FAL. [Figure 3-4](#) shows the default contamination boundaries at the sites. The default contamination boundary at Schooner was determined by a walkover examination of the area around the crater rim. Those locations that were suitable for emplacement of a 10-m-by-10-m sample plot were identified, and the location coordinates recorded to create the default contamination boundary ([Figure 3-4](#)). Because the default contamination boundary is well within the area where external dose is indicated to exceed the PAL (see [Section 2.5.5](#)), Decision I for the test release scenario is resolved for Schooner, corrective action is necessary, and Decision II must be resolved at Schooner.

For the test release scenario at the Danny Boy site, Decision I must be resolved for the areas outside the default contamination boundary. Because most of the land surface area within the fence at Danny Boy is covered by the crater, boulders, or rock piles, the default contamination boundary was established at the fence ([Figure 3-4](#)). As the investigation progresses, locations within the fence that are identified to be suitable for emplacement of a 10-m-by-10-m sample plot will be used to realign the default contamination boundary. The results of the gamma walkover survey conducted at the site, ([Section 2.5.4](#)) indicated two areas with elevated readings that may exceed the PAL. Because NTS

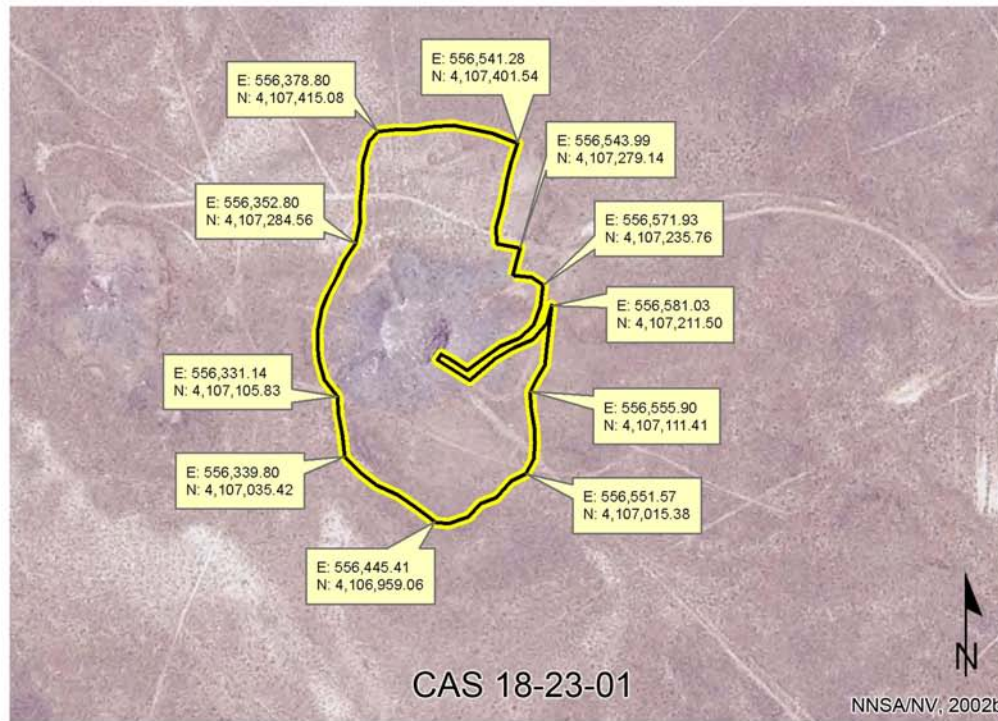


Figure 3-4
Default Contamination Boundaries

environmental TLDs have not been posted in the area around the Danny Boy site, the PRM-470 radiological results cannot be correlated to environmental TLD data. Therefore, the presence of an area exceeding the PAL outside the default contamination boundary cannot be estimated, and Decision I must be resolved for the area outside the default contamination boundary at the Danny Boy site. Decision I samples will be submitted to analytical laboratories to determine the presence of COCs.

For the non-test releases (e.g., drums at the Danny Boy site) Decision I will be resolved based on the presence of COCs in samples from the drums. The specific analyses for samples from other non-test releases will be selected dependent upon the type and nature of the identified release.

Decision II samples for both release scenarios will be resolved by defining the extent of unbounded COCs.

A corrective action may also be necessary if wastes that are present at a site could potentially result in the introduction of COCs into site environmental media (potential source material [PSM]). To evaluate the potential for wastes to result in the introduction of a COC to the surrounding environmental media, the following conservative assumptions were made:

- Any containment of waste (e.g., fuel/oil reservoirs, pipe, concrete vaults and walls, drums) would fail at some point, and the waste would be released to the surrounding soil.
- A waste, regardless of concentration or configuration, may be assumed to be PSM and handled under a corrective action.
- Based on process knowledge and/or professional judgment, some waste may be assumed to not be PSM if it is clear that it could not result in soil contamination exceeding a FAL.
- If assumptions about the waste cannot be made, then the waste material will be sampled and the results will be compared to FALs based on the following criteria:
 - For non-liquid wastes, the concentration of any chemical contaminant in soil (following degradation of 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. Note: For example, a small contaminant mass contained in a large mass such as a concrete wall would not be considered to be PSM, whereas that same mass of contaminant lying directly on soil would be considered to be PSM.

- For non-liquid wastes, the dose resulting from radioactive contaminants in soil (following degradation of the waste and release of contaminants into soil) would be calculated using the activity of the contaminant in the waste divided by the mass of the waste (for each radioactive contaminant) and calculating the combined resulting dose using the RESRAD code (Murphy, 2004).
- For liquid wastes, the resulting concentration of contaminants in the surrounding soil would be calculated based on the concentration of contaminants in the wastes and the liquid holding capacity of the soil.

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.

To satisfy the DQI of sensitivity (see [Section 6.2.8](#)), 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. Analytical methods and target minimum detectable concentrations (MDCs) for each CAU 374 COPC are provided in [Tables 3-2](#) and [3-3](#). The MDC is the lowest concentration of a chemical or radionuclide parameter that can be detected in a sample within an acceptable level of error. The criteria for precision and accuracy listed in [Tables 3-2](#) and [3-3](#) may vary from information in the QAPP as a result of the laboratory used or updated/new methods (NNSA/NV, 2002a).

Table 3-2
Analytical Requirements for Radionuclides for CAU 374
 (Page 1 of 2)

Analysis ^a	Medium or Matrix	Analytical Method	MDC ^b	Laboratory Precision	Laboratory Accuracy
Gamma-Emitting Radionuclides					
Gamma Spectroscopy	Aqueous	EPA 901.1 ^c	< FALs	RPD 35% (non-aqueous) ^d 20% (aqueous) ^d	LCS Recovery (%R) 80-120 ^f
	Non-aqueous	GA-01-R ^g		ND -2<ND<2 ^e	

Table 3-2
Analytical Requirements for Radionuclides for CAU 374
(Page 2 of 2)

Analysis ^a	Medium or Matrix	Analytical Method	MDC ^b	Laboratory Precision	Laboratory Accuracy
Other Radionuclides					
Isotopic U	All	U-02-RC ^g	< FALS	RPD 35% (non-aqueous) ^d 20% (aqueous) ^d ND -2<ND<2 ^e	Chemical Yield Recovery (%R) 30-105 ^h LCS Recovery (%R) 80-120 ^h
Isotopic Pu	Aqueous	Pu-10-RC ^g			
	Non-aqueous	Pu-02-RC ^g			
Isotopic Am	Aqueous	Am-03-RC ^g			
	Non-aqueous	Am-01-RC ^g			
Sr-90	Aqueous	EPA 905.0 ^c			
	Non-aqueous	Sr-02-RC ^g			

^aA list of constituents reported for each method is provided in [Table 3-1](#).

^bThe MDC is the minimum concentration of a constituent that can be measured and reported with 95% confidence (Standard Methods).

^c*Prescribed Procedures for Measurement of Radioactivity in Drinking Water* (EPA, 1980).

^d*Sampling and Analysis Plan Guidance and Template* (EPA, 2000).

^e*Evaluation of Radiochemical Data Usability* (Paar and Porterfield, 1997).

^f*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2008).

^g*The Procedures Manual of the Environmental Measurements Laboratory* (DOE, 1997).

^hProfessional judgment and other industry acceptance criteria are used.

ⁱ*Standard Methods for the Examination of Water and Wastewater* (Clesceri, et al., 1998).

LCS = Laboratory control sample
ND = Normalized difference

RPD = Relative percent difference
%R = Percent recovery

Table 3-3
Analytical Requirements for Chemical COPCs for CAU 374

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
TPH-GRO	All	8015 Modified ^c		Lab-specific ^d	Lab-specific ^d
TPH-DRO	All	8015 Modified ^c		Lab-specific ^d	Lab-specific ^d
Pesticides	All	8081 ^c		Lab-specific ^d	Lab-specific ^d
TCLP Pesticides	Leachate	1311/8081 ^c	< Regulatory Levels	Lab-specific ^d	Lab-specific ^d
Herbicides	All	8151 ^c	< FALs	Lab-specific ^d	Lab-specific ^d
TCLP Herbicides	Leachate	1311/8151 ^c	< Regulatory Levels	Lab-specific ^d	Lab-specific ^d
Explosives	All	8330 ^c	< FALs	Lab-specific ^d	Lab-specific ^d
Inorganics					
Metals	All	6010/6020 ^c	< FALs	RPD 35% (non-aqueous) 20% (aqueous) ^e	MS Recovery (%R) 75-125 ^c
Mercury	Aqueous	7470 ^c		< Regulatory Levels	Absolute Difference ±2x RL (non-aqueous) ^f ±1x RL (aqueous) ^f
	Non-aqueous	7471 ^c			
TCLP Metals	Leachate	1311/6010/7470 ^c			

^aA list of constituents reported for each method is provided in [Table 3-1](#).

^bThe MDC is the minimum concentration of a constituent that can be measured and reported with 99% confidence (SW-846).

^c*Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2008).

^dPrecision and accuracy criteria are developed in-house using approved laboratory standard operating procedures in accordance with industry standards and the NNES Statement of Work requirements (NNES, 2009).

^e*Sampling and Analysis Plan Guidance and Template* (EPA, 2000).

^f*Contract Laboratory Program National Functional Guidelines for Inorganic Data Review* (EPA, 2004).

MS = Matrix spike

NNES = Navarro Nevada Environmental Services, LLC

RL = Reporting limit

TCLP = Toxicity Characteristic Leaching Procedure

4.0 *Field Investigation*

This section contains a description of the activities to be conducted to gather and document information from the CAU 374 field investigation.

4.1 *Technical Approach*

The information necessary to satisfy the DQO data needs will be generated for CAU 374 by collecting and analyzing samples generated during a field investigation. The investigation will generate information required to evaluate potential CAAs. However, at the Danny Boy and Schooner sites, significant contamination is present within and around each of the craters due to the prompt injection of radionuclides from the nuclear tests (see [Section A.3.2.1](#)). A default contamination boundary has been defined around each of the craters that bounds this contamination ([Section 3.4](#)). Information needed to evaluate the corrective action of clean closure for the contamination within the default contamination areas will not be generated during the investigation due to the technical infeasibility of excavating such large masses of subsurface contamination. This contamination is currently effectively contained in near-surface unsaturated media and in its current state is sufficiently isolated that it is not exposed to site workers or the public. For the area outside the default contamination boundaries, information will be generated to evaluate CAAs through the probabilistic determination of TED at judgmentally placed sample plots.

The drums within the Danny Boy crater (CAS 18-22-05) will not be investigated due to safety concerns regarding entry into the crater. Contamination at the north yard drums (CAS 18-22-06) and the southwest rim drums (CAS 18-22-08) will be evaluated through analytical results of judgmentally placed samples.

If it is determined that a COC is present at any CAS, that CAS will be further addressed by determining the extent of contamination before evaluating CAAs.

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

4.2 Field Activities

Field activities at CAU 374 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 obstructing staging and/or sampling areas; establishing site exclusion zones; providing sanitary facilities; and temporarily moving emplaced equipment.

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

- Perform radiological surveys of CASs 18-23-01 and 20-45-03.
- Emplace TLDs at potential sample plot locations and other locations across the sites.
- Perform visual surveys at all CASs within CAU 374 to identify any staining, discoloration, disturbance of native soils, or any other indication of potential contamination.

4.2.2 Sample Location Selection for Test Releases

For the test releases at the Danny Boy and Schooner sites, sample plot placements will be determined judgmentally based on the results of the radiological survey. Four composite samples will be collected from each plot, and a TLD will be emplaced at 1 m above ground surface near the center of the plot.

The selection of nine subsample locations within each plot for each composite sample will be implemented probabilistically (e.g., random placement of the locations). For each composite sample, the first subsample location will be selected randomly; the remaining eight subsample locations will be established on a systematic triangular grid (see [Section A.9.0](#)). Selection of probabilistic subsample locations at these CASs, including an example of the predetermined sample locations at one plot (see [Figure A.9-4](#)), are presented in [Sections A.5.2.1.2](#) and [A.9.1.2](#). [Section A.5.2.1.2](#) briefly reviews the methodology and computation approach for the probabilistic sampling, while [Section A.9.1.2](#) describes the sample location selection process.

If the initial sample plots at either Danny Boy or Schooner do not define the 25-mrem/IA-yr dose boundary, additional sample plots will be established outward from GZ until a sample plot is located beyond the 25-mrem/IA-yr dose boundary on each vector.

4.2.2.1 Test Release at Danny Boy

For the test release at Danny Boy, initial sampling will be conducted to identify the presence and nature of a radiological dose above the FAL outside the default contamination boundary (Decision I). At least one location likely to exceed a dose rate of 25 mrem/IA-yr will be identified. A sample plot will be established in one or more of these locations. It is not known whether dose present outside the fence exceeds the FAL ([Section 2.5.4](#)).

The default contamination boundary at the Danny Boy site is established at the fence delineating the contamination area (see [Section A.9.1](#)). The area within this fence contains the crater, crater rim, continuous ejecta field, and rock piles. The logistics for sample plot placement within the fenced area are made difficult due to the coverage of boulders across the site. Also, the presence of the crater, the steep slopes on the rim, the boulders, and the rock piles increase the safety concerns for sampling inside the contamination area. The area within the fence is a default contamination area and is assumed to exceed the FAL ([Section 3.4](#)). If the results from the Decision I sample plot at Danny Boy yield a 95 percent UCL of the TED above 25-mrem/IA-yr dose, additional sample plots will be required for Decision II. For Decision II, eight additional sample plots will be established along three sampling vectors (i.e., for a total of three plots per vector) outward from GZ (see [Figure A.9-2](#)), based upon the 1994 flyover radiological survey (BN, 1999) and refined by radiological walkover surveys.

4.2.2.2 Test Release at Schooner

For the test release at Schooner, initial sampling will be conducted to identify the extent of a radiological dose outside the default contamination boundary (Decision II). The Schooner site default contamination boundary (see [Figure A.9-3](#)) lies inside the area expected to exceed the PAL on all three vectors ([Section 2.5.5](#)). The dose at the first one or two sample plots along each vector is expected to exceed the PAL. A total of four sample plots will be established on each of three vectors.

4.2.3 Sample Location Selection for Non-test Releases

For non-test releases at the CAU 374 CASs, a judgmental sampling approach will be used to investigate the likelihood of the soil containing a COC if biasing factors are present. Non-test releases of contamination include potential releases (e.g., spills, PSM that are associated with pretest and post-test activities). The drums identified in CASs 18-22-06 and 18-22-08 (see [Section A.2.2](#)) that contain material are identified as non-test releases (see [Section A.9.2.1](#)). Within the drums, biasing factors such as stains and radiological survey results will be used to select the most appropriate locations to collect a sample for submittal to the analytical laboratory.

For the investigation of drainages, sample locations will be the center of the sediment-collection areas (see [Section A.9.2.1](#)). For the other non-test releases, 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 submittal to the analytical laboratory. Biasing factors to be used for selection of sampling locations are listed in [Section A.5.2.1](#). As biasing factors are identified and used for selection of sampling locations, they will be documented in the appropriate field documents.

Decision II sampling will consist of further defining the extent of contamination where COCs have been confirmed. Step-out (Decision II) sampling locations at non-test releases will be selected based on the CSM, biasing factors, field-survey results, existing data, and the outer boundary sample locations where COCs were detected. In general, step-out sample locations will be arranged in a triangular pattern around areas containing a COC at distances based on site conditions, COC concentrations, process knowledge, and biasing factors. If COCs extend beyond step-out locations, additional Decision II samples will be collected from locations further from the source. 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 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.

4.2.4 Sample Collection

The CAU 374 sampling program will consist of the following activities:

- Collect and analyze samples from locations as described in this section.
- Measure *in situ* external dose rates using TLDs or other dose-measurement devices.
- Collect required QC samples.
- Collect waste management samples as necessary.
- Collect soil samples from locations outside the influence of releases from the CAS, 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.

Decision I sampling for the test release at Danny Boy, and Decision II sampling for the test releases at Danny Boy and Schooner will consist of collecting four composite samples from each sample plot. Each composite sample will comprise nine surface subsamples collected from 0 to 5 cm bgs at the locations described in [Section 4.2.2](#). Data collected will be used to estimate the TED for each sample. The TED will be determined for each sample by summing the internal and external dose components. 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 dose measurement device (e.g., TLDs). These TLDs will be 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). Each TLD contains three elements from which external dose measurements will be reported. Decision criteria are compared to the 95 percent UCL of the average TED for each plot based on the four internal dose estimates from the soil samples and the three external dose estimates from the TLD elements (see [Section A.9.1.3](#)).

For non-test releases, Decision I surface soil samples (0 to 15.24 cm [6 in.] bgs) will be collected. 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.

For Decision I sampling in the washes, a sampling location will be established at the center of the nearest two sediment accumulation areas outside the initial corrective action boundary (established using gamma survey data). At each location, a sample will be collected from each 5-cm depth interval until native material is encountered (see [Figure A.9-5](#)). Each sample will be screened with an alpha/beta contamination meter, and the sample with the highest screening value at each sample location will be submitted for analysis. If the screening result values are not significantly different, the surface sample will be submitted for analysis. Each wash that departs the corrective action boundary at Danny Boy and Schooner will be visually and radiologically surveyed to areas at a distance of 1 mi or more to the point where greater amounts of sediment accumulate than at sediment-collection areas closer to the corrective action boundary (e.g., large flat areas that extend for approximately two or more times the aerial extent of smaller areas).

Decision II sampling will not be conducted for each of the drainage sediment-collection areas (non-test release). If a COC is present in the sediment, the entire volume of the sediment will be assumed to contain the COC and will require corrective action.

Decision II sampling of the test releases and other non-test releases will consist of further defining the extent of contamination where COCs have been confirmed. If a spatial boundary is reached, the CSM is shown to be inadequate, or the Site Supervisor determines that extent sampling needs to be re-evaluated, then work will be temporarily suspended, NDEP will be notified, and the investigation strategy will be re-evaluated. 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 (if necessary) extent of COCs will be established based on validated laboratory analytical results (i.e., not field screening).

4.2.5 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 for each CAS is presented in

Section 3.2. 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 Safety

A site-specific health and safety document will be prepared and approved before the field effort. This document defines the requirements for protecting the health and safety of the workers and the public. The following safety issues will be taken into consideration when evaluating the hazards and associated control procedures for field activities:

- Potential hazards to site personnel and the public including, but not limited to, radionuclides, chemicals (e.g., heavy metals, VOCs, SVOCs, and petroleum hydrocarbons), adverse and rapidly changing weather, remote location, and motor vehicle operations.
- Proper training of all site personnel to recognize and mitigate the anticipated hazards.
- Work controls to reduce or eliminate the hazards, including engineering controls, substitution of less hazardous materials, and use of appropriate personal protective equipment (PPE).
- Occupational exposure monitoring to prevent overexposures to hazards such as radionuclides, chemicals, and physical agents (e.g., heat, cold, and high wind).
- Radiological surveying for alpha/beta and gamma emitters to minimize and/or control personnel exposures; use of the “as-low-as-reasonably-achievable” principle when addressing radiological hazards.
- Emergency and contingency planning to include medical care and evacuation, decontamination, spill control measures, and appropriate notification of project management. The same principles apply to emergency communications.
- If presumed asbestos-containing material is identified (CFR, 2009d; NAC, 2008a), it will be inspected and/or samples collected by trained personnel.

4.4 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 signage and fencing (unless part of a corrective action) will be removed from the site.
- Site will be regraded to pre-investigation conditions (unless changed condition is necessary under a corrective action).
- Site will be inspected and certified that restoration activities have been completed.

5.0 Waste Management

Management of the waste generated during the CAU 374 field investigation will be in accordance with all applicable DOE orders, U.S. Department of Transportation (DOT) regulations, state and federal waste regulations, permits, and agreements between DOE and NDEP. Wastes may be characterized based on these requirements using process knowledge, field-screening results, and analytical results from investigation and waste samples. Waste types that may be generated during the CAI include sanitary, industrial, low-level radioactive, hazardous, hydrocarbon, or mixed wastes.

Disposable sampling 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., metal and concrete). Therefore, these wastes may be characterized based on CAI sample results. 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 by using process knowledge, visual examination, and/or radiological survey and swipe results. 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. Other waste minimization practices will include, as appropriate, avoiding contact with contaminated materials, performing dry decontamination or wet decontamination over source locations, and carefully segregating waste streams.

5.2 Potential Waste Streams

The expected waste streams to be generated during the CAU 374 field investigation include sanitary and low-level radioactive wastes from the sampling activities. However, because of the uncertainty about what wastes are present within the CAS boundaries (e.g., lead debris, batteries, historic 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)
- Contents in drums in CASs 18-22-06 and 18-22-08
- 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., sanitary, low-level, hazardous, hydrocarbon, mixed), or the combination of waste types. The following subsections describe how specific waste types will be managed.

5.3.1 Industrial and Sanitary Waste

Sanitary and industrial IDW, if generated, will be collected, managed, and disposed of in accordance with the sanitary waste management regulations and the permits for operation of the NTS Waste Landfills.

5.3.2 Hydrocarbon Waste

Hydrocarbon 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 *Nevada Test Site Waste Acceptance Criteria* (NNSA/NSO, 2009). Potential radioactive waste drums containing soil, PPE, disposable sampling equipment, and/or rinsate may be staged and managed at a designated RMA.

5.3.4 Hazardous Waste

Suspected hazardous wastes, if generated, will be placed in DOT-compliant containers. All containerized hazardous waste will be handled, inspected, and managed in accordance with 40 *Code of Federal Regulations* (CFR) 265 Subpart I (CFR, 2009b).

5.3.5 Mixed Low-Level Waste

Mixed wastes, if generated, shall be managed according to the requirements for hazardous wastes and the requirements for low-level waste.

5.3.6 Polychlorinated Biphenyls

Polychlorinated biphenyl wastes, if generated, will be managed according to 40 CFR 761 (CFR, 2009c), State of Nevada requirements (NAC, 2008b), and DOE guidance.

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 CASs in CAU 374.

The data from the project-specific TLD measurements will meet rigorous data quality requirements. The project-specific TLDs will be obtained from, and processed by, the Environmental Technical Services group at the NTS. This group is responsible for a routine environmental monitoring program at the NTS. The program includes a campaign of environmental TLDs that are emplaced at pre-established locations across the NTS for the monitoring of external dose. The environmental TLDs are replaced and read quarterly. Details of this campaign can be found in the *Nevada Test Site Environmental Report 2006* (NNSA/NSO, 2007). The project-specific TLDs will be submitted to the Environmental Technical Services group for inclusion in their routine quarterly read of the NTS 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 quality control efforts and results can be found in Section 5.2.1 of the *Nevada Test Site Environmental Report 2006* (NNSA/NSO, 2007). 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:

1. The TLDs will be exposed at the sample plots for approximately 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 exposure 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, 2009a) 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 are:

- For radiological samples:
 - Field duplicates (1 per 20 environmental samples or 1 per matrix, if less than 20 collected)
 - Laboratory QC samples (1 per 20 environmental samples or 1 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 matrix, if less than 20 collected)
 - Field blanks (may be 1 per 20 environmental samples, 1 per day, or 1 per CAU depending on site conditions and agreement of DQO participants)
 - Laboratory QC samples (1 per 20 environmental samples or 1 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 according to company-specific procedures. The data will be reviewed to ensure that all required samples were appropriately collected, analyzed, and 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 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).

Table 6-1
Laboratory and Analytical Performance Criteria for CAU 374 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 CAS 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 CAS 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 CAS-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.

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 to assess 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 percent and 35 percent for aqueous and soil samples, respectively. When either result is less than 5x RL, a control limit of $\pm 1x$ RL and $\pm 2x$ 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 percent 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 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 employed 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 according to 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 of 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 is not met, an assessment will be conducted in the CADD on the impacts to DQO decisions specific to affected contaminants and the CAU.

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 assured 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:

- For Decision I judgmental sampling, having a high degree of confidence that the sample locations selected will identify COCs if present anywhere within the CAS.
- For Decision I probabilistic sampling, having a high degree of confidence that the sample locations selected will represent contamination of the CAS.
- 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 for COPCs 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 number of samples do not meet completeness criteria.

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). The evaluation criterion for this parameter will be that measurement sensitivity (i.e., MDCs) will be 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. This assessment will be presented in the CADD.

7.0 *Duration and Records Availability*

7.1 *Duration*

Field and analytical activities will require approximately 120 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 NNSA/NSO Federal Sub-Project Director.

8.0 References

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

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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 374, Area 20 Schooner Unit Crater, 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 CASs in CAU 374 is insufficient to evaluate and select preferred corrective actions; therefore, a CAI will be conducted.

The CAU 374 CAI will be based on the DQOs presented in this appendix as developed by representatives of NDEP and NNSA/NSO. The seven steps of the DQO process presented in [Sections A.3.0](#) through [A.9.0](#) 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:

- 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.
 - 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 Background Information

The following five CASs that comprise CAU 374 are located in Areas 18 and 20 of the NTS, as shown in [Figure A.2-1](#):

- 18-22-05, Drum (referred to as herein as crater drums)
- 18-22-06, Drums (20) (referred to as herein as the north yard drums)
- 18-22-08, Drum (referred to as herein as the southwest rim drums)
- 18-23-01, Danny Boy Contamination Area (referred to as herein as Danny Boy)
- 20-45-03, U-20u Crater (Schooner) (referred to as herein as Schooner)

[Section A.2.1](#) presents general information common to both the Danny Boy and Schooner sites.

[Sections A.2.2](#) and [A.2.3](#) provide the CAS description, physical setting, operational history, release information, and previous investigation results for each CAS in CAU 374.

A.2.1 CAU 374 General Information

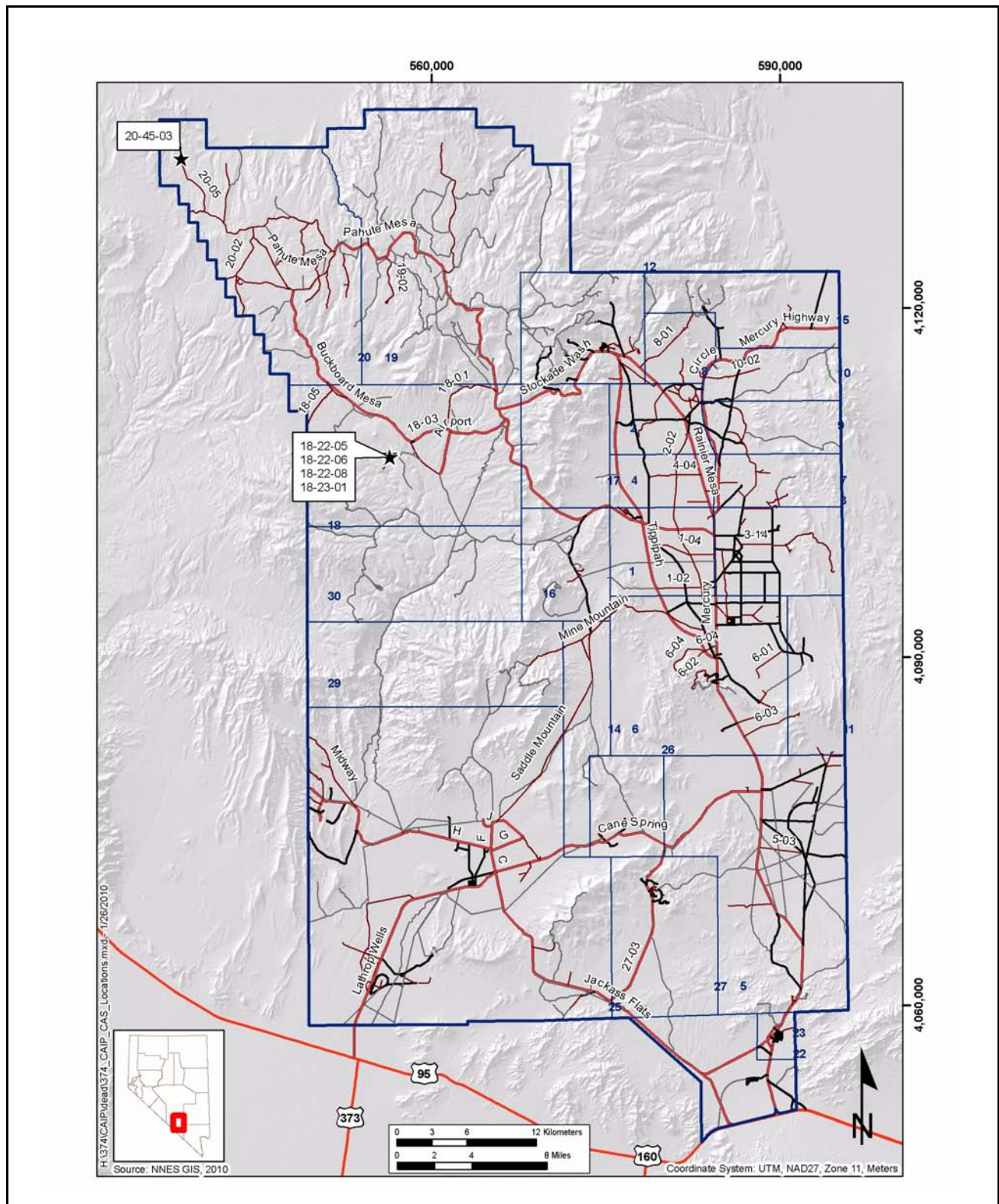
Physical Setting and Operational History

All CAU 374 CASs are located on relatively flat mesas (Buckboard and Pahute Mesas). The Danny Boy and Schooner test areas were the setting for nuclear tests conducted in the 1960s, and both tests were conducted in shallow subsurface rock (basalt at Danny Boy and tuff at Schooner) (USGS, 2007; Slate et al., 1999).

Release Information

The releases of contamination to the CAU 374 CASs are assumed to be directly or indirectly associated with the Danny Boy and Schooner nuclear tests. However, the investigation of specific releases at CAU 374 will depend upon the nature of these releases. Therefore, the releases at CAU 374 have been categorized into one of the following two release scenarios (i.e., release mechanisms):

- Test releases of contaminants are defined as the initial deposition of radionuclides from the nuclear test detonations onto or into soils.
- Non-test releases of contamination include the translocation of test release contamination (e.g., migration in stormwater runoff, excavated material, and grading of roads), and other potential releases (e.g., spills, lead bricks) that are associated with pretest and post-test activities.



The test release scenario includes the prompt injection of radionuclides into the geological formation around the test devices, and the instantaneous activation of susceptible elements in rock and soil such as europium. This scenario also includes the atmospheric deposition of radioactive contamination onto surface soils from ejecta and fallout of activated soil expelled from the crater and radionuclides carried out with the fireball. The ejecta from the craters includes some boulders and cobbles that are coated with slag-like material, which was formed from molten material immediately following detonation. Because both sites are not significantly impacted by other nuclear tests, the test release scenario assumes that the original soil surface was not previously contaminated by a radiological release before the Danny Boy and Schooner tests.

The non-test release scenario includes the drums within the footprint of the Danny Boy site that comprise CASs 18-22-05, 18-22-06, and 18-22-08. The source of the drums is not known. Any contamination associated with these drums is unknown but may include radioactivity from contaminated materials at the site. A lead-acid battery identified at Schooner is also included in the non-test release scenario.

The non-test release scenario includes subsequent migration of radioactivity associated with atmospheric deposition under the test release scenario. This may occur due to sheet and gully erosion from stormwater runoff. The non-test release scenario also includes subsequent movement of surface-deposited radionuclides through excavation or grading associated with entry into the craters for recovering samples or drilling; clearing of contaminated surfaces to provide a clean work area; and construction or maintenance of roadways. The non-test scenario also includes contamination identified as spills and wastes from activities conducted at the test sites or debris from the nuclear test structures.

Exposure pathways to receptors include ingestion and inhalation from disturbance of, or direct contact with, contaminated media. Site workers also may also be exposed to radiation by performing activities in proximity to radioactive materials (i.e., external exposure).

**A.2.2 CAS 18-22-05, Drum; CAS 18-22-06, Drums (20); CAS 18-22-08, Drum;
CAS 18-23-01, Danny Boy Contamination Area**

Corrective Action Site 18-23-01 is located on the Buckboard Mesa in Area 18 and consists of the release of radionuclides to the surrounding rock and soil from the Danny Boy test. Corrective Action Sites 18-22-05, 18-22-06, and 18-22-08 are co-located with the Danny Boy CAS. Each consists of an unknown release to the site from material that either was or presently is held within the drums.

[Figure A.2-2](#) shows an aerial view of the Danny Boy site and vicinity.

Physical Setting and Operational History

The Danny Boy site consists of the crater; a fractured, uplifted zone around the rim of the crater; a continuous area of ejecta (crater throw-out material) covered by fallout; and an area encompassed by a barbed-wire fence posted with signs that read “Contamination Area.” The continuous ejecta (i.e., boulder field) is depicted in [Figure A.2-3](#). Some boulders and cobbles within the continuous ejecta area are coated with slag-like material ([Figure A.2-3](#)).

The Danny Boy crater consists of loose boulders along steep slopes ([Figure A.2-4](#)), with various wooden and metallic debris along the sides and bottom of the crater, and a wooden viewing platform on the southeast side. The area to the north of the crater, which has a repeating row-like pattern on the aerial photograph, consists of rock piles ([Figure A.2-4](#)) that were excavated from the bulk ejecta surrounding the crater during crater-access operations; this area is included in the fenced contamination area. Other debris (e.g., concrete pipes, metal spools, wooden boards, cables, metal pipes, drums, drilling cores) are distributed at various places within the fenced area.

The immediate area outside the contamination area fence around the site is relatively flat, except for the presence of a gully to the immediate northeast that drains into a shallow sediment-collection area apparently created by the excavation of a few inches of surface soil ([Figure A.2-5](#)). Further to the east of this sediment-collection area, a mapped, unnamed wash departs the area to the east, flowing into the Fortymile Canyon Wash, as do two other unnamed washes (one north, one south) within a radius of approximately a half mile ([Figure A.2-5](#)). These washes join other washes and flow into Fortymile Canyon Wash and ultimately the Death Valley dry lake.

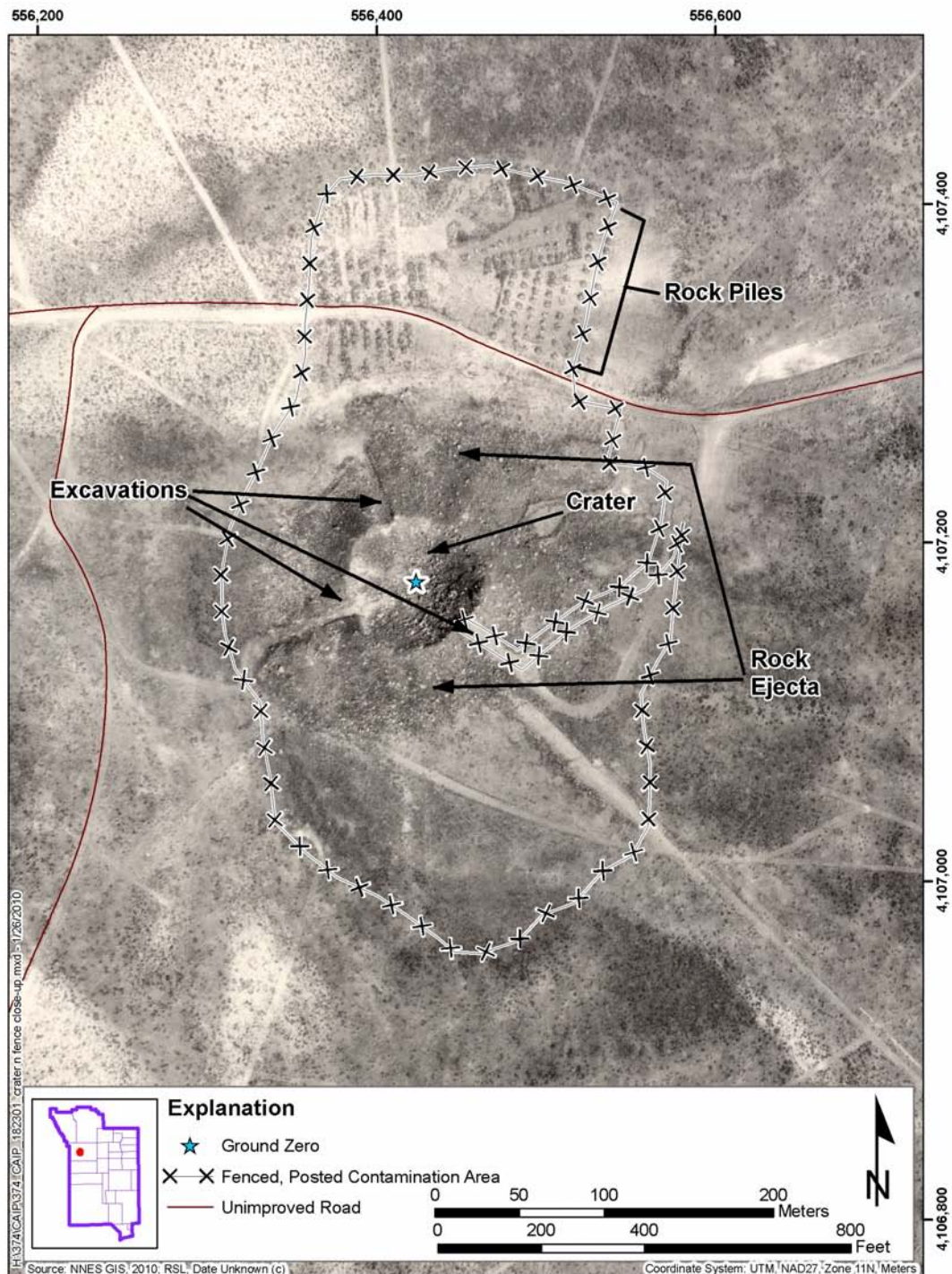


Figure A.2-2
CAS 18-23-01, Aerial View of Danny Boy Contamination Area



Figure A.2-3
CAS 18-23-01, Continuous Ejecta Area and Slag-Coated Rock



Figure A.2-4
CAS 18-23-01, Crater Interior and Rock Piles North of the Crater

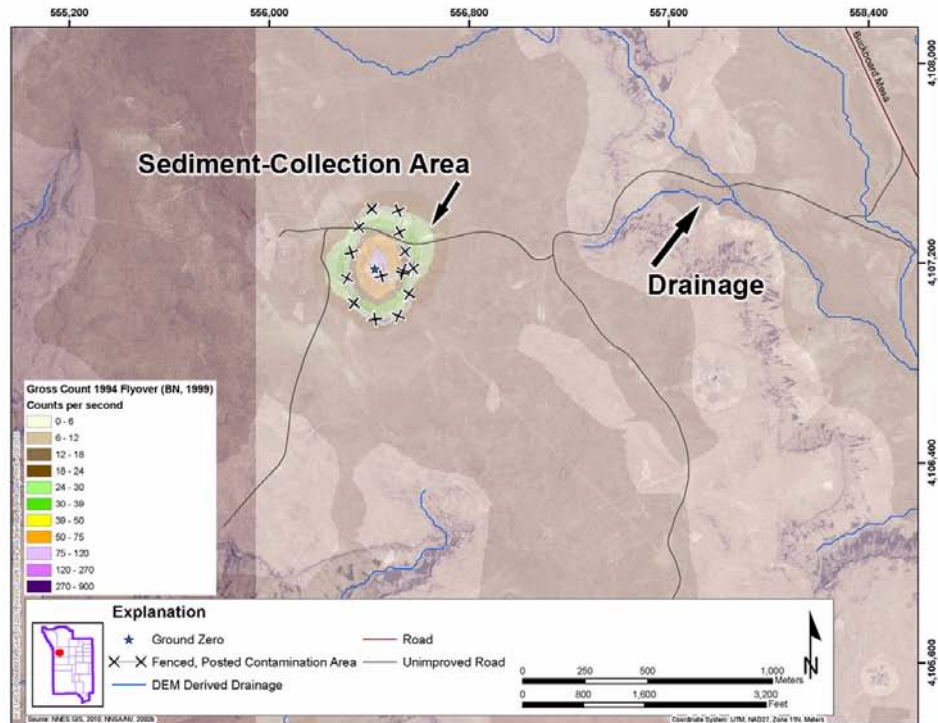


Figure A.2-5
CAS 18-23-01, Sediment-Collection Area and Drainage System

The nearest well, ER-18-2, is located in the west-central portion of Buckboard Mesa in Area 18, 1,050 m southwest of CAS 18-23-01. Depth to groundwater averages 369 m bgs (USGS and DOE, 2009).

Precipitation in the area is infrequent. Annual average precipitation from 1976 through 2008 is 18.26 cm (7.19 in.) at Station LF2 at an approximate elevation of 1,561 m amsl, near the Little Feller 2 site in Area 18 (ARL/SORD, 2009). Annual average PET for the NTS has been estimated as 157 cm (Shott et al., 1997; Lacznia et al., 1996). Under these conditions, vertical migration of contaminants would be very limited due to the low annual rate of precipitation and high annual PET rate at the site.

Vegetation in the area consists of a sagebrush community with individual plants up to approximately 3 feet (ft) in height.

Of the debris present at the site, several 20- to 55-gallon drums are addressed by the three drum-related CASs inside the contamination area. The original drum (inside the crater) identified for CAS 18-22-05, containing a light-color material, is depicted in [Figure A.2-6](#). From this photograph (taken during a site visit in October 2009), the original drum was determined to be nestled inside another drum ([Figure A.2-6](#)). Other drums also identified inside the crater include a crushed drum west of the original drum ([Figure A.2-6](#)), a lacerated and crushed drum northwest of the original drum ([Figure A.2-6](#)), and a drum pinned beneath a boulder north of the original drum ([Figure A.2-6](#)).

Outside the crater, three drums to the north, identified for CAS 18-22-06 as remaining from the original group of 20 are depicted in [Figure A.2-7](#). During a site visit in 2001, the three drums were noted to not have any visible staining present near the drums; the northernmost drum was approximately 70 percent full of a soil-type material, the southernmost drum was approximately 10 percent full of a soil-type material, and the northeastern drum was 40 percent full of a soil-type material (IT, 2001). The drums were originally identified as 20 drums, all reported to be empty (REECo, 1991). Twenty drums were reported to have been removed in 1992 (REECo, 1992), with three small buckets containing “rad contaminated sand and rocks” remaining at the site. Additional drums identified in October 2009 near the three drums are one drum with a bung-type opening, indicating the drum likely contained liquids, identified to the northwest of the crater ([Figure A.2-7](#)), and one drum barely visible from the fence, to the north-northwest of the crater ([Figure A.2-7](#)).



Figure A.2-6
CAS 18-22-05, Original Drum (upper left) and Newly Identified Drums at the Crater Bottom



Figure A.2-7
CAS 18-22-06, Original Drums (upper photos) and Newly Identified Drums (lower photos)

The original drum identified for CAS 18-22-08 on the crater rim to the southwest of the crater is shown in [Figure A.2-8](#). An additional half-drum, identified in October 2009, to the west-northwest of the crater along the rim is also shown in [Figure A.2-8](#).

Material similar in color to that in the drum of CAS 18-22-05 was identified in a pile ([Figure A.2-9](#)) approximately 30 ft east of the original drum in CAS 18-22-05 at the crater bottom.

The Danny Boy test was conducted on March 5, 1962, in drill hole U-18a as part of Operation Nougat, and was a weapons-effects cratering test with a yield of 430 tons (DOE/NV, 2000). The depth of burial for the device was 33.5 m (NRDL, 1967), and the resultant crater measured approximately 80.8 m in diameter and 25.6 m deep. Post-test activities evident at the site but not well documented include three excavations to the crater rim, clearing of a pathway and construction of an observation platform, staging of rock piles north of the crater, and post-test drillbacks outside the crater.

The history of each of the drums in CASs 18-22-05, 18-22-06, and 18-22-08 is not known.

Release Information

Release of contamination at the site from the test release includes fallout due to the crater test; neutron activation of elements within the rock and soil, such as europium; and ejected fractured rock containing radioactive slag and Trinity glass. The Danny Boy test created 1) a base surge milliseconds after the device was detonated ([Figure A.2-10](#)), which led to the deposition of ejecta surrounding the crater ([Figure A.2-10](#)), and 2) the release of hot cavity gases creating a dust cloud that rose to a height of approximately 610 m, and split into upper and lower clouds, both of which traveled northerly and completely dispersed within 29 minutes (Powell and Wilsey, 1963). The crater itself emitted dust over the next 4 to 5 days.

Non-test releases identified at the site include the drums within the footprint of the Danny Boy site that comprises CASs 18-22-05, 18-22-06, and 18-22-08. The source of the drums is not known. Any contamination associated with these drums is also unknown but may include radioactivity from contaminated materials at the site. Release of contamination from material that either was or presently is held within the drums at the site is not known.



Figure A.2-8
CAS 18-22-08, Original Drum (upper) and Newly Identified Drum (lower)



Figure A.2-9
White Material Pile on Danny Boy Crater Bottom

Other possible non-test releases for this site are discussed in [Section A.2.1](#).

Previous Investigation Results

Previous investigations at the Danny Boy site included studies of samples of fallout and cloud debris from Danny Boy collected after the test, surface soil inventory studies by the RIDP and NAEG, aerial radiological surveys, and a 2009 gamma walkover survey.

Miskel and Bonner (1964), Bonner and Miskel (1965), and NRD (1967) studied samples of close-in fallout and the cloud releases from Danny Boy. Their analyses concluded that much of the total radioactivity produced by the Danny Boy test was trapped in and below the crater (all but a few tenths of 1 percent of refractory [i.e., nonvolatile] mass chain radionuclides, and 80 to 90 percent of volatile mass chain radionuclides remained in the crater). Their studies also included the distribution of radionuclides from fallout onto the soil surface from GZ outward. Of the radioactivity released from the crater, most of the refractory mass chain radionuclides (e.g., Zr-95, Ce-144, and Nd-147) were deposited within 15 km of GZ, but most of the volatile mass chain radionuclides (e.g., Sr-90 and Ba-140) that were released were deposited further away.

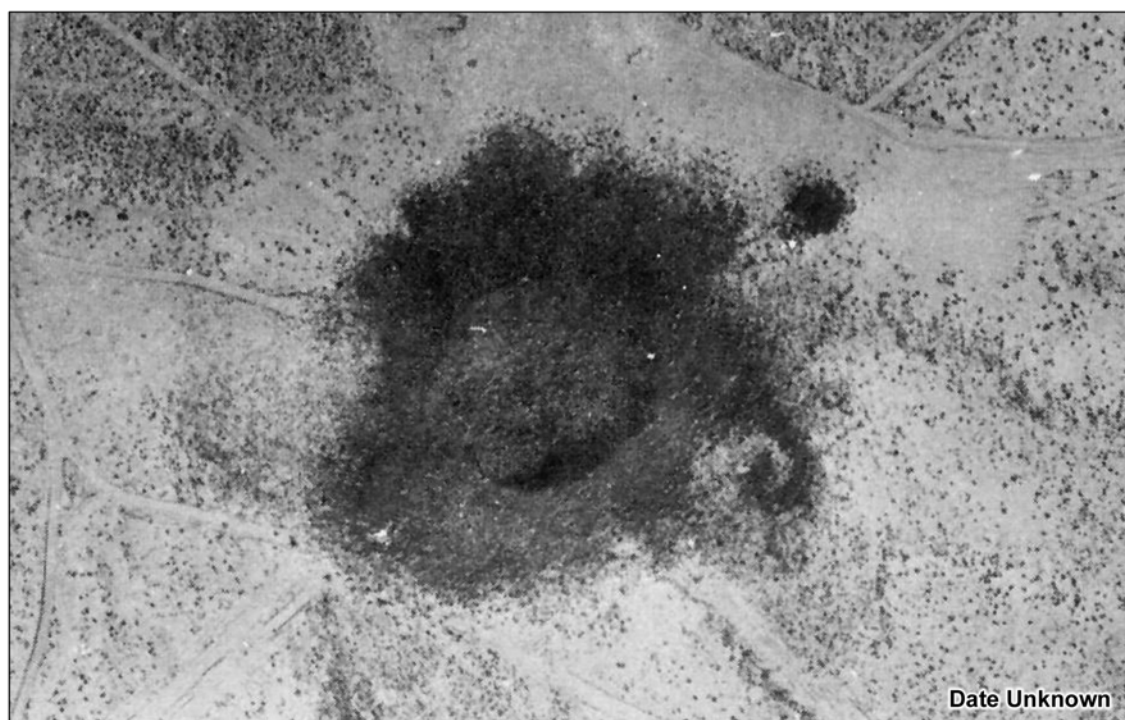
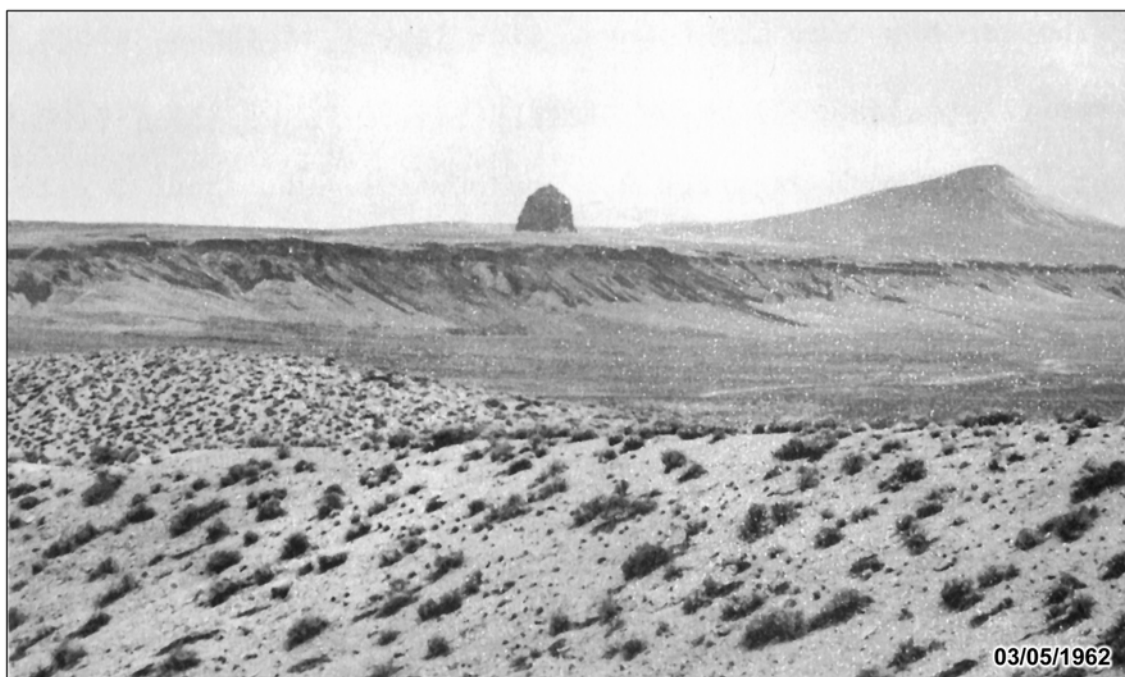


Figure A.2-10
CAS 18-23-01, Base Surge and Ejecta Deposition
Source: Hoy and Foose, 1962

Data collected for the RIDP and by NAEG in the 1980s allowed for estimates of surface soil inventories around the Danny Boy area (Friesen, 1992; DRI, 1988) (Figure A.2-11). The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy and through limited confirmatory soil sampling (DRI, 1988 and 2007). Estimates of the soil surface inventories of radionuclides released to local surface soils are shown in Table 2-2.

In an analysis of the RIDP data in 2009 (Anagnostopoulos, 2009a), the results for the Danny Boy site were extrapolated to the present (i.e., adjusted for radioactive decay and growth) to estimate the current activities of selected radionuclides at the RIDP points. From this work, the following inferences were made:

- The Cs-137 levels ranged from approximately 13 pCi/g to 253 pCi/g inside the contamination area, and from approximately 9 pCi/g to 103 pCi/g in areas just outside the fence. The highest levels inside the fence were generally indicated in the eastern and northern areas, and in the eastern and western areas outside the fence.
- The Eu-152 levels ranged from approximately 2 pCi/g to 34 pCi/g inside the contamination area, and from less than 1 pCi/g to 32 pCi/g in areas just outside the fence. The highest levels inside the fence were generally indicated in the southeastern and eastern areas, and in the western areas outside the fence.
- The Pu-239 levels ranged from approximately 155 pCi/g to 11,739 pCi/g inside the contamination area, and from approximately 6 pCi/g to 5,132 pCi/g in areas just outside the fence. The highest levels inside the fence were generally indicated in the eastern and northern areas, and in the eastern and western areas outside the fence.

An aerial radiological survey flown in 1994 (NNSA/NSO, 2002b) used radiological detection systems to identify gamma radiation. From the data collected, the gross count rates, man-made radiation, and Am-241 count rates were published for the NTS. The aerial survey results show gross count gamma results ranged from 18 to 120 cpm within the fenced area at the Danny Boy site, and from 12 to 50 cpm in areas just outside the fenced site (Figure A.2-11). The Am-241 count rates ranged from 200 to 5,000 cps within the fenced site, and from 50 to 2,000 cps just outside the fenced site (Figure A.2-12). These results confirm the expectation that gamma and Am-241 levels are higher near the crater and decrease with distance.

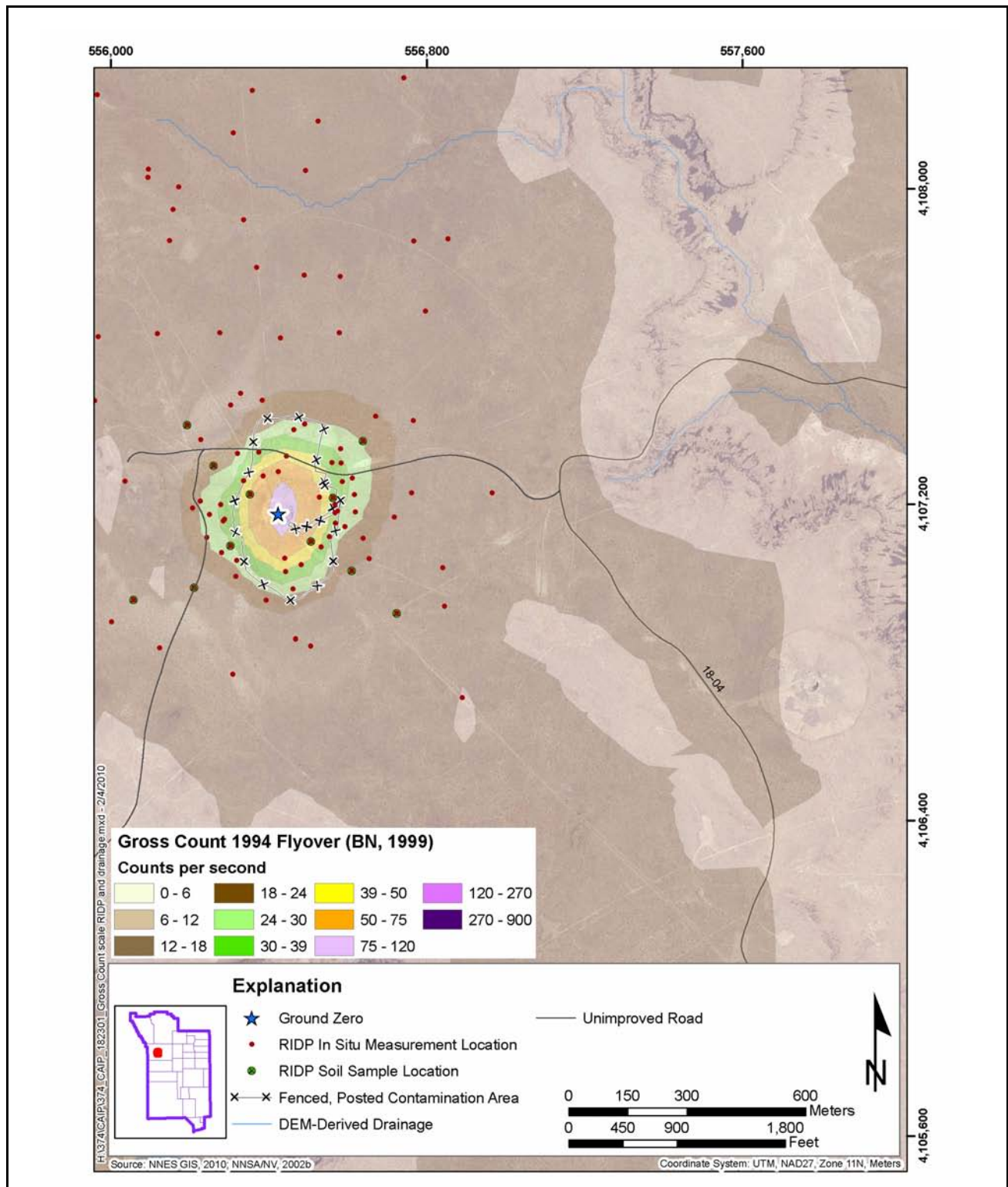


Figure A.2-11
CAS 18-23-01, 1994 Aerial Radiological Survey Gross Count Results,
and RIDP In Situ Measurement and Soil Sampling Locations

Note: The 39 to 50 cps isopleth is corrected to display accurate illustration. Original data for 39 to 50 cps were incorrectly displaying as 18 to 24 cps isopleth.

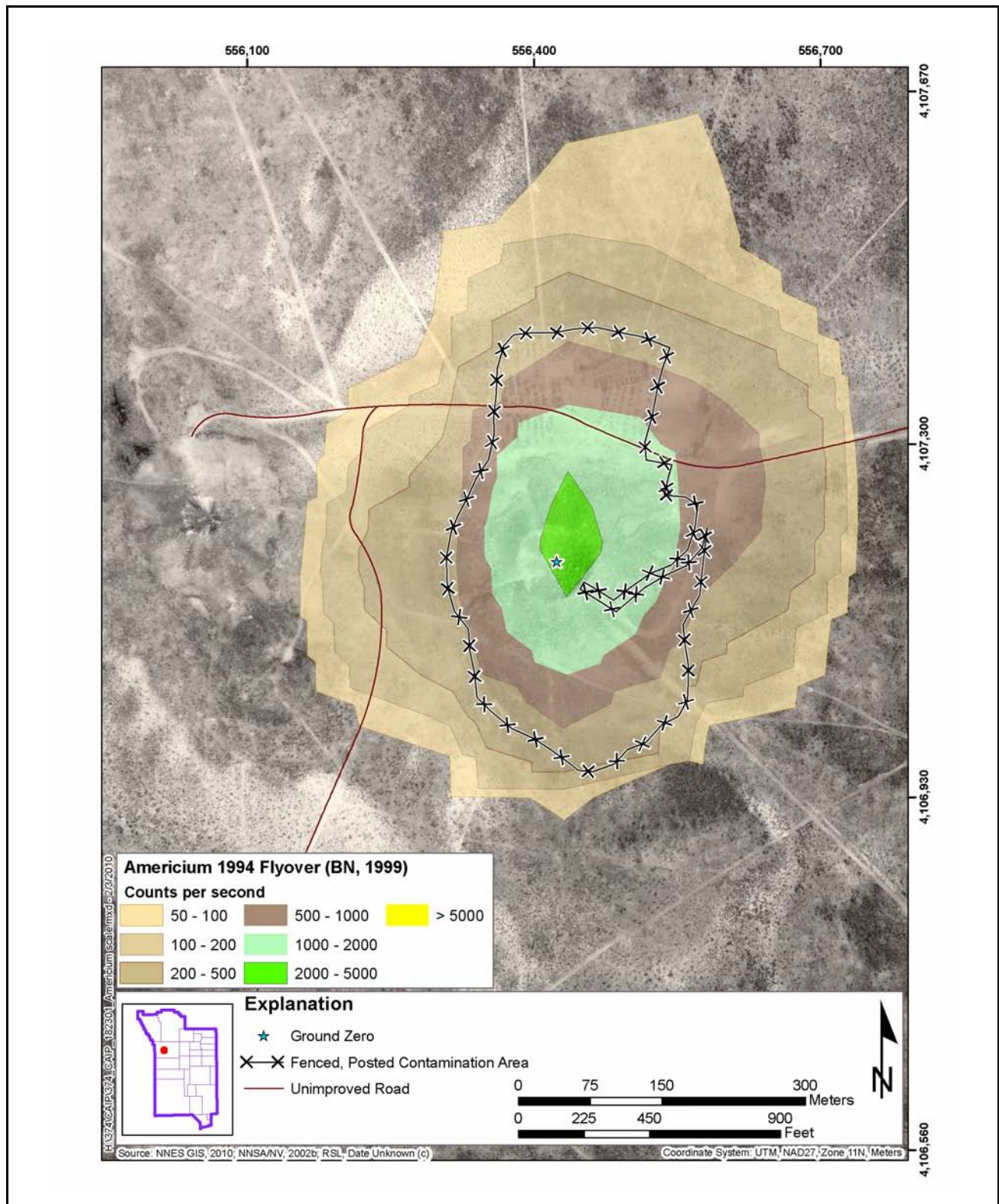


Figure A.2-12
CAS 18-23-01, 1994 Aerial Radiological Survey Am-241 Results

A gamma radiation walkover survey (Anagnostopoulos, 2009b) was conducted along the perimeter of the Danny Boy contamination area fence ([Figure A.2-13](#)). From the data, five ranges of results were created. In general, the areas northeast and west of the crater along the fence are expected to be near the PAL for radiological dose, and are indicated to be the most likely areas outside the fence to exceed the PAL.

A.2.3 CAS 20-45-03, U-20u Crater (Schooner)

Corrective Action Site 20-45-03 is located in northwest Pahute Mesa in Area 20 and consists of a release of radionuclides to the surrounding rock and soil from the Schooner Plowshare test.

[Figure A.2-14](#) shows an aerial view of the Schooner site and vicinity.

Physical Setting and Operational History

The Schooner site consists of the Schooner crater; a fractured, uplifted zone around the rim of the crater; a continuous area of ejecta (crater throw-out material); and an extended area of “missile” ejecta, all covered by a thin layer of fallout and within a barbed-wire fence posted with signs that read “Radioactive Material Area.” The continuous ejecta (i.e., boulder field) is depicted in [Figure A.2-15](#) with individual missile ejecta deposited towards the background. Numerous boulders and cobbles around the site are coated with slag-like material ([Figure A.2-15](#)), some distributed towards the extent of the fence. The slag was formed from molten material immediately following detonation. Individual pieces of debris (e.g., a metal pipe, cables, wooden boards, a lead-acid battery) are found at various locations within the fenced area.

The Schooner crater consists of cliffs and loose boulders along steep slopes. In addition to the layers of welded tuff in the crater profile (from 0 to 38 m bgs and from 104 to over 112 m bgs) (Henny, 1970) that produced the boulder and cobble material, a layer of less consolidated tuff (from 38 to 104 m bgs) produced a finer, pumice-like gravel and sand that was also distributed around the site.

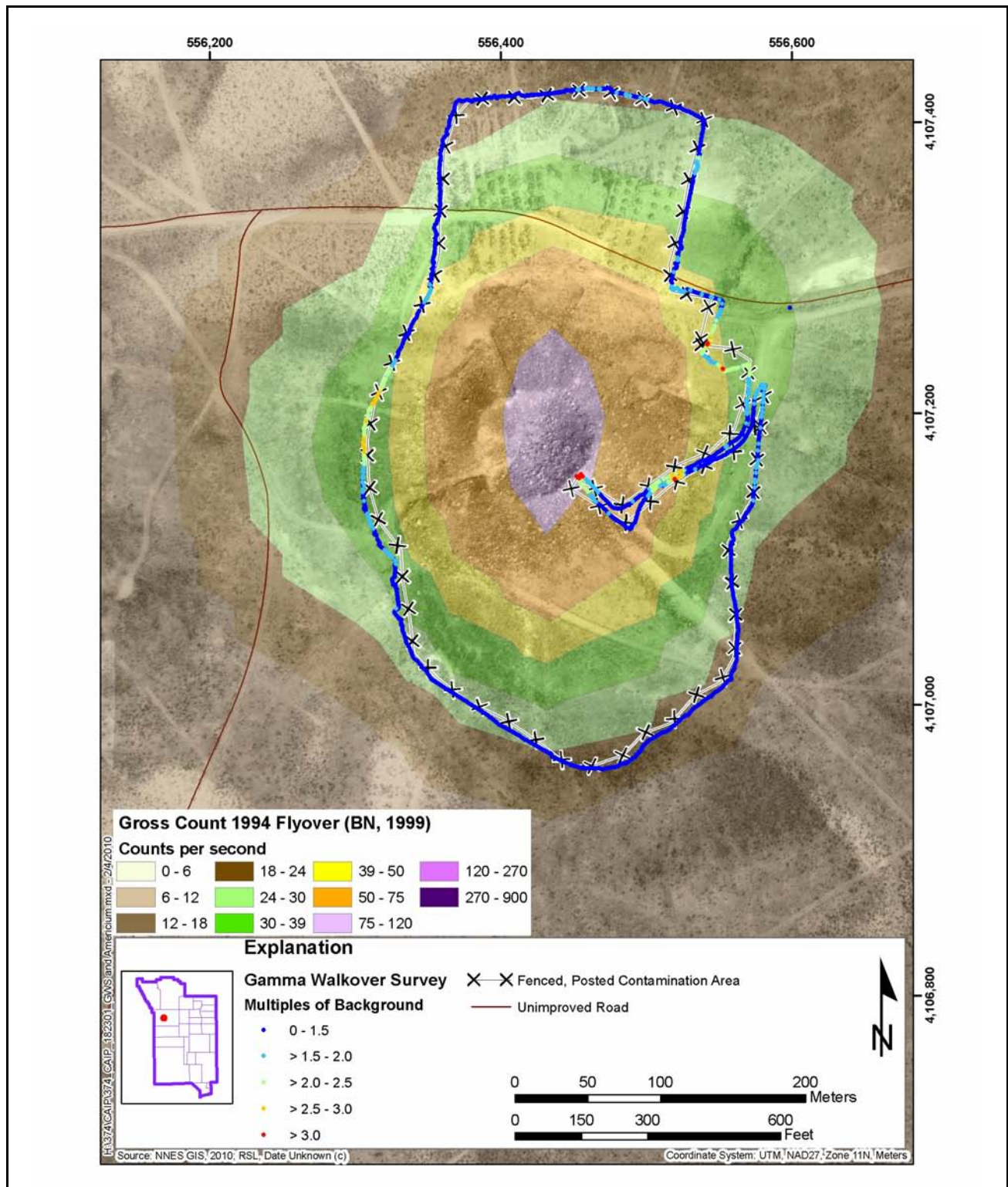


Figure A.2-13
CAS 18-23-01, Gamma Walkover Survey Results

Note: The 39 to 50 cps isopleth is corrected to display accurate illustration. Original data for 39 to 50 cps were incorrectly displaying as 18 to 24 cps isopleth.

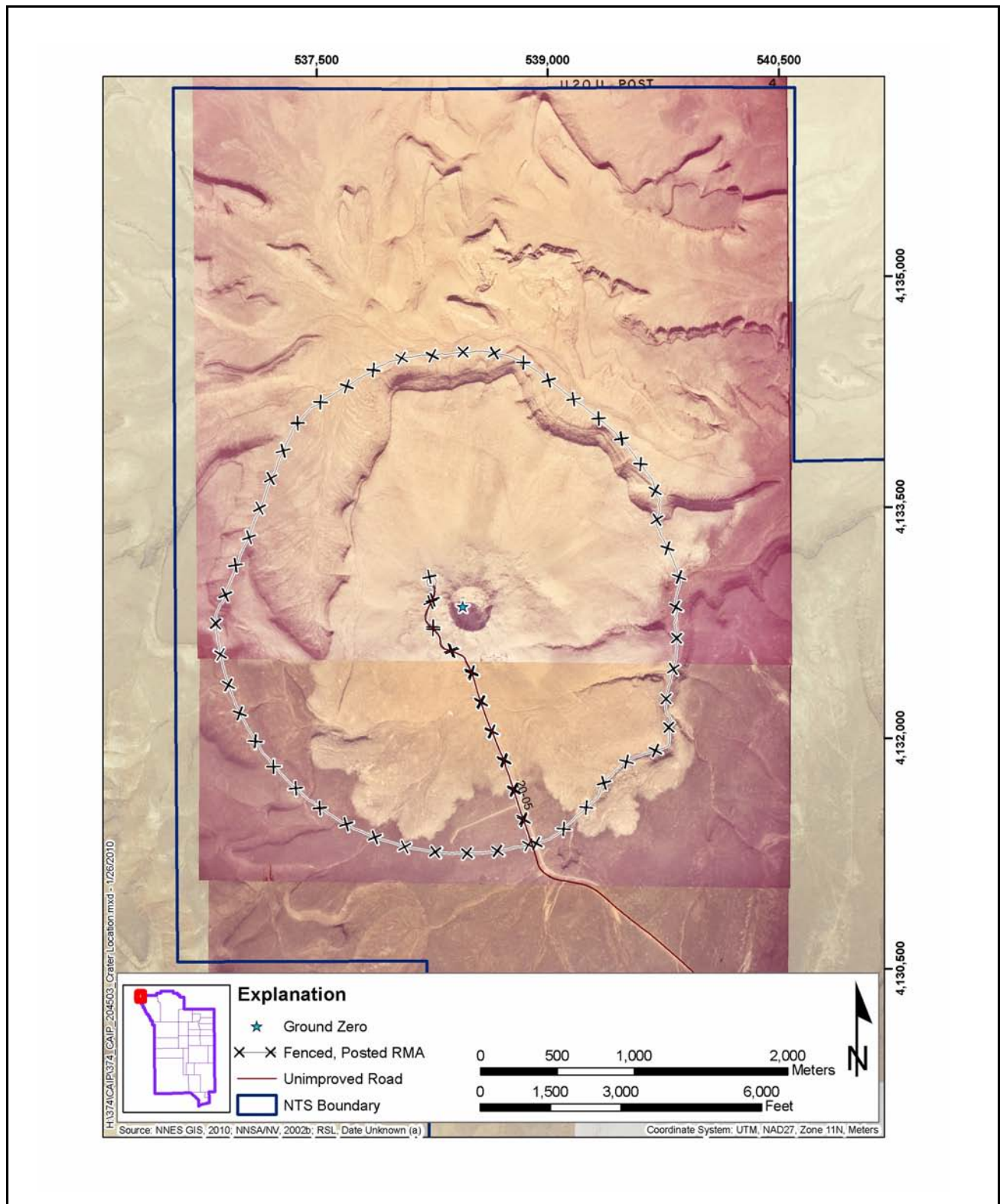


Figure A.2-14
CAS 20-45-03, Aerial View of U-20u Crater (Schooner)



Figure A.2-15
CAS 20-45-03, Continuous Ejecta Area and Individual “Missile” Ejecta
and Slag-Coated Rock

The ground surface is relatively flat (Tewes, 1970) and tilted towards the east. Three washes draining the immediate area in and around the continuous ejecta area ([Figure A.2-16](#)) lose from 29.5 to 41 m of elevation as they cross the site, flowing to the eastern portion of the RMA fencing ([Figures A.2-16](#) and [A.2-17](#)). These washes join other washes draining the Pahute Mesa and flow into the Gold Flat dry lake ([Figure A.2-18](#))

The nearest well, PM-2, is located approximately 260 m northwest of CAS 20-45-03 and was drilled to a depth of 2,697 m bgs within the volcanic rock aquifer (USGS and DOE, 2009). Depth to groundwater averages approximately 262 m bgs.

Annual average precipitation from 1964 through 2008 is 18.3 cm (7.21 in.) at Station PM1 at an approximate elevation of 1996 m amsl, on Pahute Mesa (ARL/SORD, 2009). Annual average PET for the NTS has been estimated as 157 cm (Shott et al., 1997; Lacznia et al., 1996). Under these conditions vertical migration of contaminants would be very limited due to the low annual rate of precipitation and high annual PET rate at the site.

Vegetation in the area consists of a sagebrush community with individual plants up to approximately 4 ft in height.

Of the debris present at the site, one lead-acid battery has been identified, approximately 906 m northeast of GZ. The battery was placed between two devices that appear to be air-sampling equipment, pointed in the direction of GZ ([Figure A.2-19](#)).

The Schooner test was conducted on December 8, 1968, in drill hole U-20u as part of Operation Bowline, and was a Plowshare test with a yield of 30 kt (DOE/NV, 2000). The depth of burial for the device was 111.2 m bgs, and the resultant crater measured approximately 260 m in diameter and 63 m deep (USGS, 1997; DOE/NV, 1996).

More recent operations at the site include environmental monitoring, which is being conducted at a station on the northwest side of the crater.

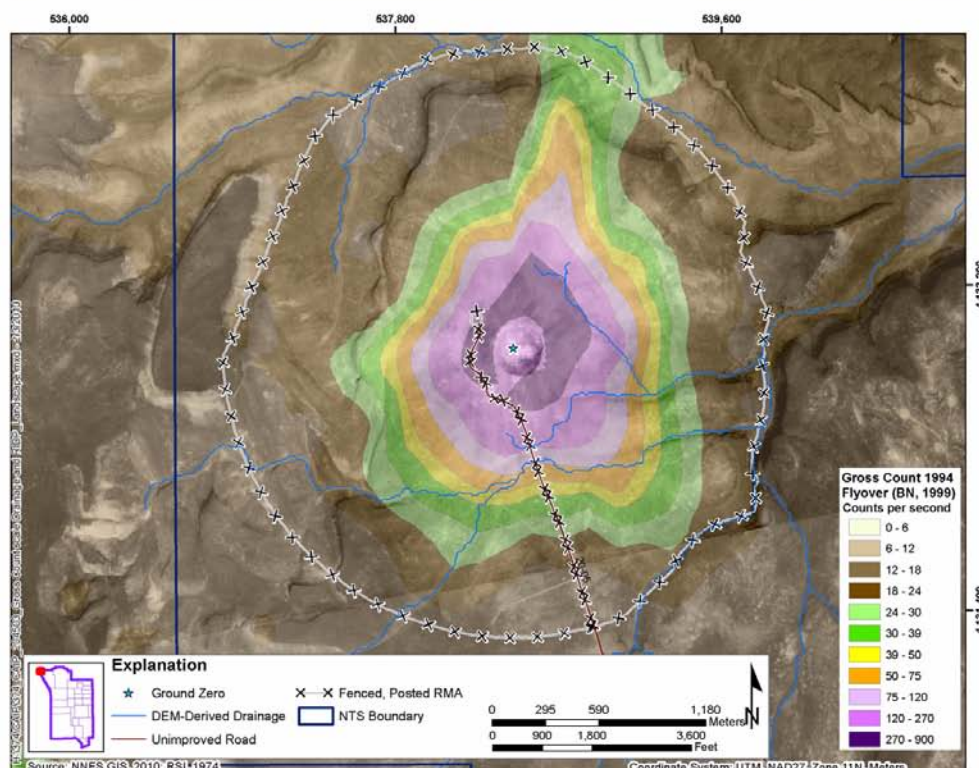


Figure A.2-16
CAS 20-45-03, Washes Draining the Area near Ground Zero

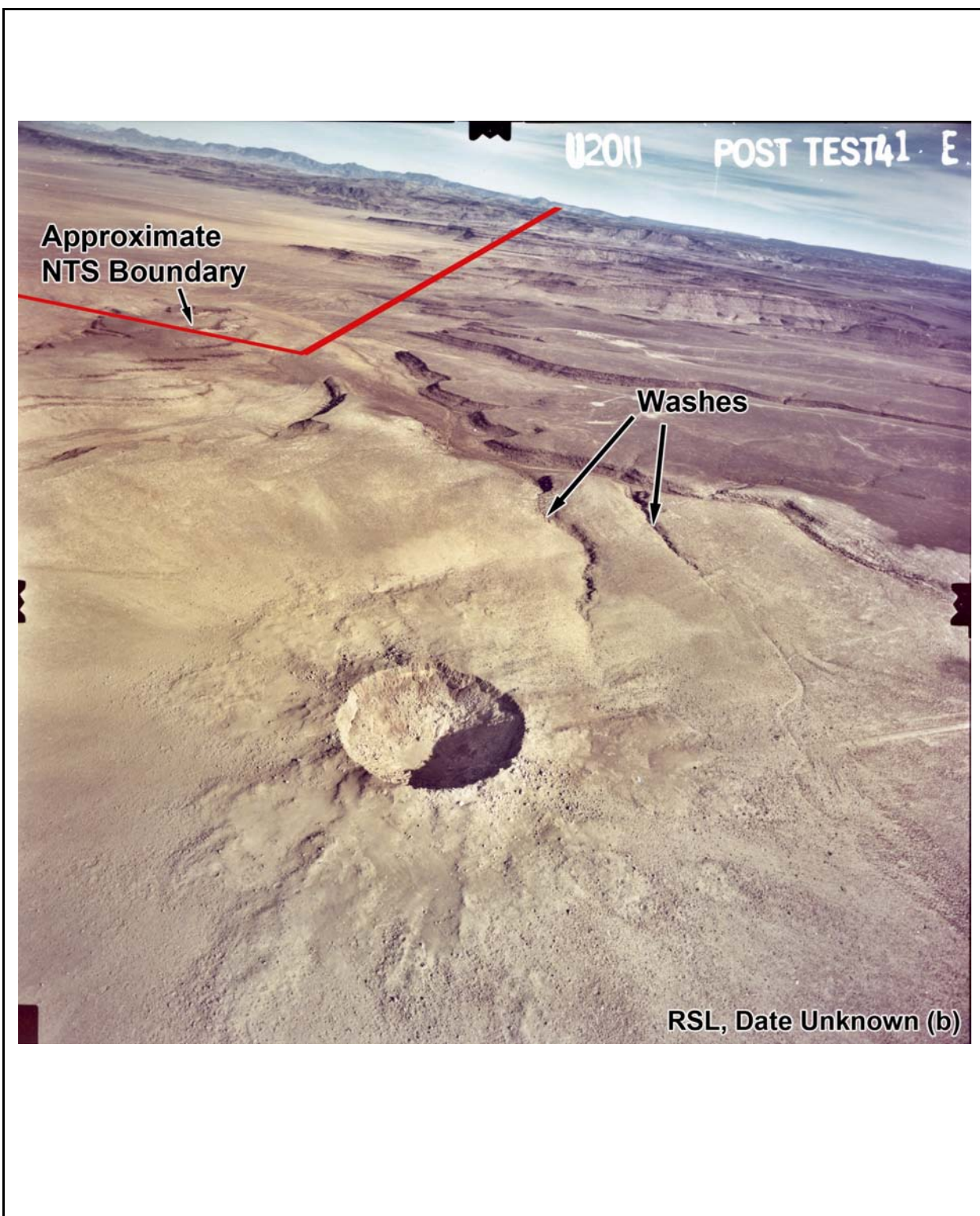


Figure A.2-17
CAS 20-45-03, Washes Departing the Site towards Gold Flat

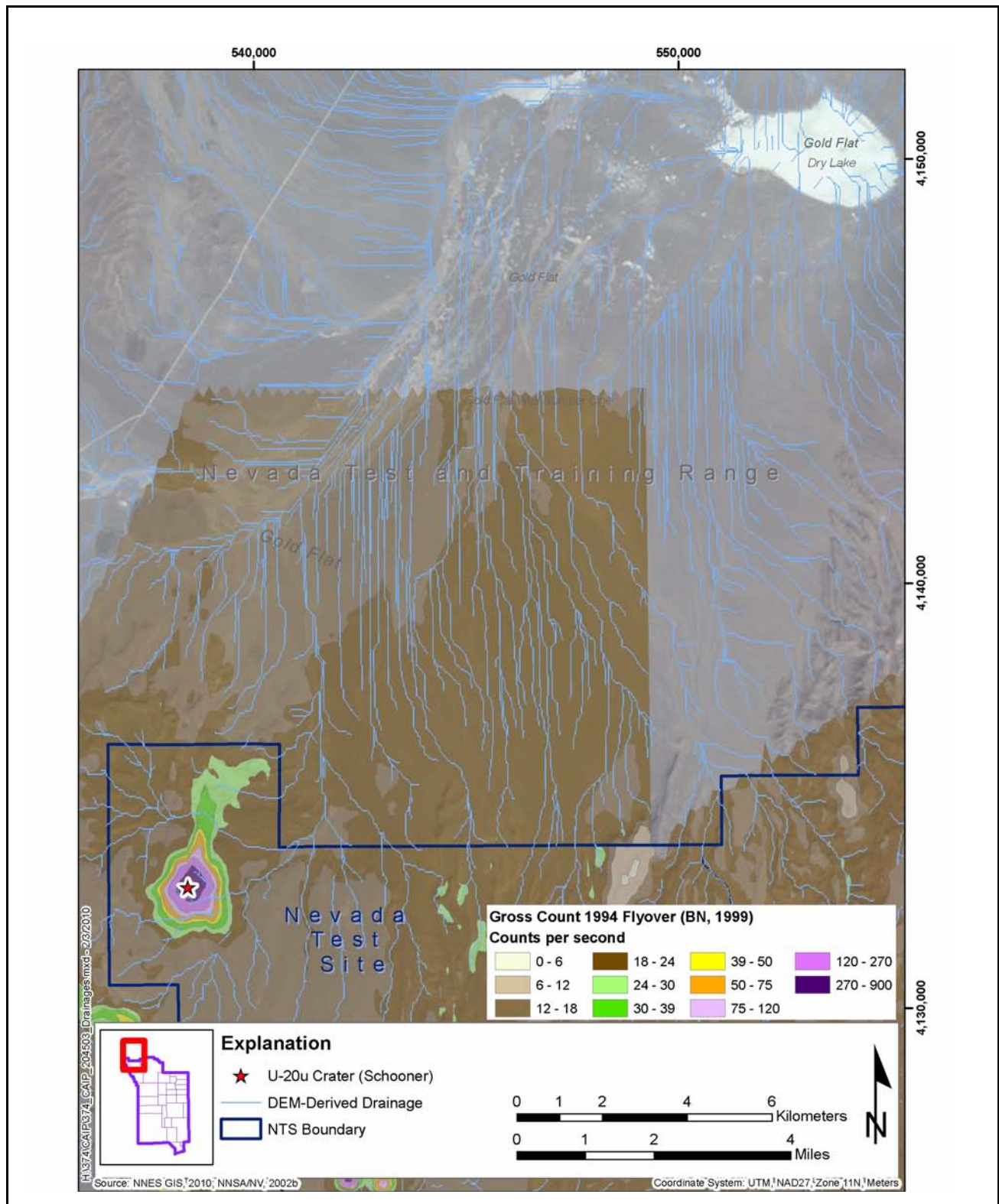


Figure A.2-18
CAS 20-45-03, Drainages from Western Pahute Mesa and Gold Flat



Figure A.2-19
CAS 20-45-03, Lead-Acid Battery and Related Equipment Northeast of Schooner Ground Zero

Release Information

See [Section A.2.1](#) for a general discussion.

Release of contamination at the site from the test release includes fallout due to the crater test; neutron activation of elements within the rock and soil, such as europium; and ejected fractured rock and sands containing radioactive slag and Trinity glass. The test created 1) a base surge milliseconds after the device was detonated ([Figure A.2-20](#)), which led to the deposition of ejecta deposited in and around the crater; 2) the venting of hot cavity gases ([Figure A.2-20](#)), which became the main cloud; 3) a separate, second cloud forming from the dust and dirt released from the excavation of the crater ([Figure A.2-20](#)) (Crawford, 1970); and 4) individual “missile” ejecta sent on trajectories terminating as far as approximately 3,050 m out ([Figure A.2-20](#)) (Henny, 1970). The main cloud contained approximately 10 times the radioactivity that the second cloud contained (Crawford, 1970) and rose to a height of approximately 4,880 m amsl, then traveled to the east-northeast. The second cloud rose to a height of approximately 670 m then traveled to the north.

Previous Investigation Results

An extensive study of the Schooner ejecta was conducted in the months following the test (Henny, 1970; Koranda et al., 1970). The depth and extent of the continuous ejecta field was determined from pretest and post-test topographical maps of the area prepared for the U.S. Army Nuclear Cratering Group (Henny, 1970). From these maps, an isopach map was prepared in addition to a graph of the minimum, maximum, and mean ejecta-uplift radial profiles ([Figure A.2-21](#)). In general, the maximum ejecta-uplift height that resulted above original ground surface was approximately 18 m at approximately 17 m distance from the crater edge, and the average depth of the ejecta was found to be more than 3 m extending radially to more than 150 m from the crater’s edge.

During May and June 1969, a trench was excavated from the south crater edge outward for approximately 457 m (Henny, 1970; Koranda et al., 1970). Both the physical and radiological nature of the ejecta along the vertical face of this trench were studied. The ejecta itself was found to have a bimodal population of fines (sand) and discrete blocks and fragments; in general, numerous isolated and a few prominent zones of competent missile blocks were found among the fines that dominated the profile.

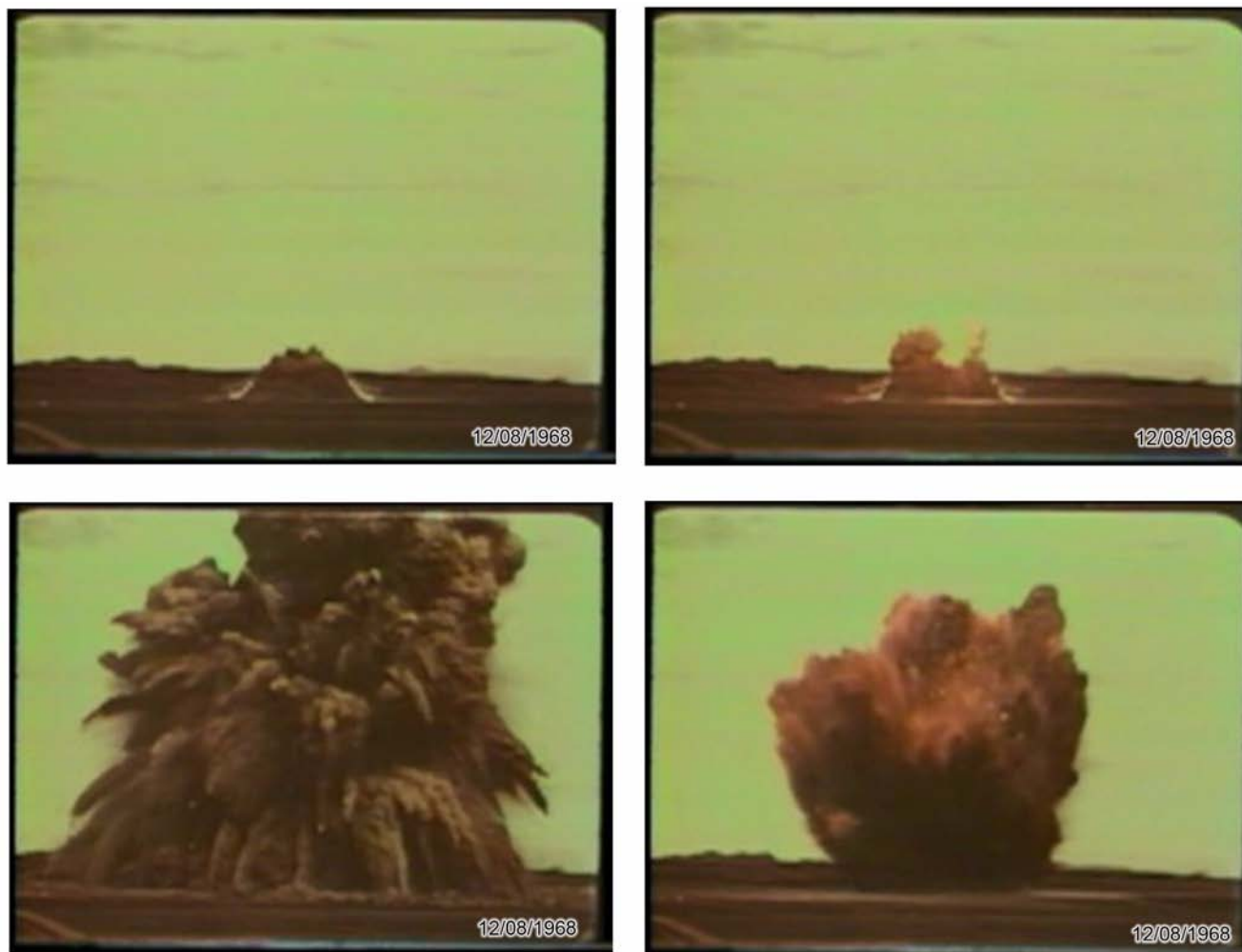


Figure A.2-20

Time Sequence Photographs following the Schooner Detonation

Base surge (upper left); ejecta (darker material, lower left and right); hot cavity gas venting (bright flash, upper right);
base surge cloud (dark dusty material rising, lower left)

Source: AEC, 1962

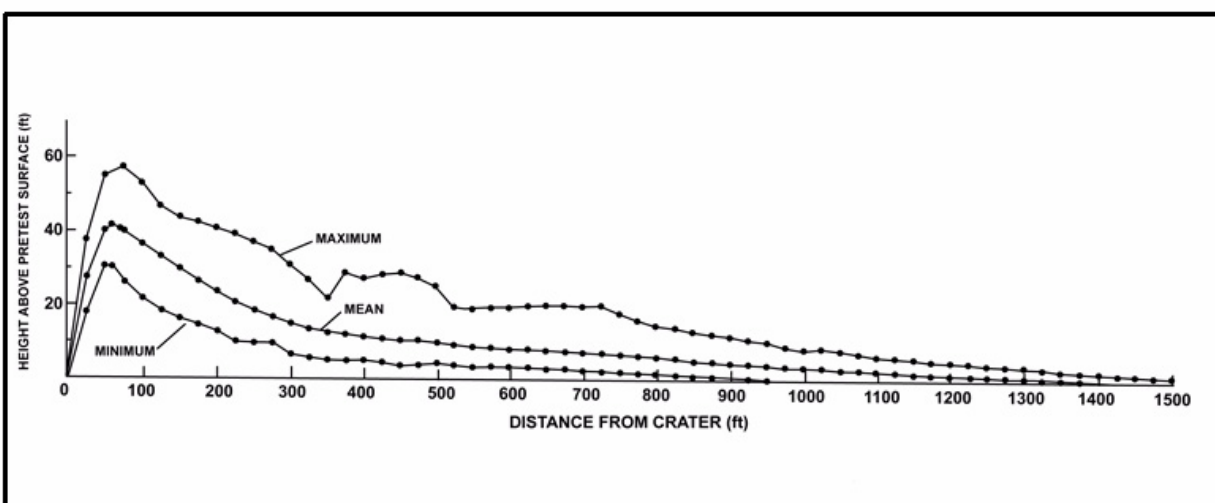


Figure A.2-21
CAS 20-45-03, Isopach Map and Maximum, Minimum, and
Average Ejecta Depths

Source: Modified from Henny, 1970

Radiological results from samples collected from the face of the trench at regular intervals from the crater edge in general were highest at the surface layer, which was impacted last by the fallout of fine-grained material. The radionuclide levels decreased with depth through the ejecta to the original ground surface (Figure A.2-22). At the time of sample collection, tungsten isotopes, such as W-181 in Figure A.2-22, dominated the radiological readings throughout the site and in fallout to the north; all tungsten isotopes have since undergone multiple half-lives (e.g., W-181 half-life is 121.2 days) and are only present today in trace amounts.

Data collected for the RIDP and by NAEG in the 1980s allowed for estimates of surface soil inventories from the Schooner area (Friesen, 1992; DRI, 1988) (Figure A.2-23). The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy, and through limited confirmatory soil sampling (DRI, 1988 and 2007). Estimates of radionuclides released to local surface soils are shown in Table 2-2.

In an analysis of the RIDP data in 2009 (Anagnostopoulos, 2009a), the results for the Schooner site were extrapolated to the present (i.e., adjusted for radioactive decay and growth) to estimate the current activities of selected radionuclides at the RIDP points. From this work, the following inferences were made:

- The Cs-137 levels ranged from approximately 1 pCi/g to 19 pCi/g inside the RMA fence. The highest levels were generally nearest the crater at the areas measured (east, and south to northwest).
- The Eu-152 levels ranged from less than one pCi/g to 208 pCi/g inside the RMA fence. The highest levels inside were generally to the west side of the ejecta field.
- The Pu-239 levels ranged from approximately 1 pCi/g to 354 pCi/g inside the RMA fence. The highest levels were generally to the northwest side of the ejecta field.

An aerial radiological survey flown in 1994 (NNSA/NSO, 2002b) used radiological detection systems to identify gamma radiation. From the data collected, the gross count rates, man-made radiation, and Am-241 count rates were published for the NTS. The aerial survey results show gross count gamma results ranging from 12 to 270 cpm within the fenced area at the Schooner site, and from 12 to 39 cpm in areas just outside the fenced site (Figure A.2-23). When overlain by the isopach map (i.e., continuous ejecta), most of the outer boundary of the continuous ejecta is contained within

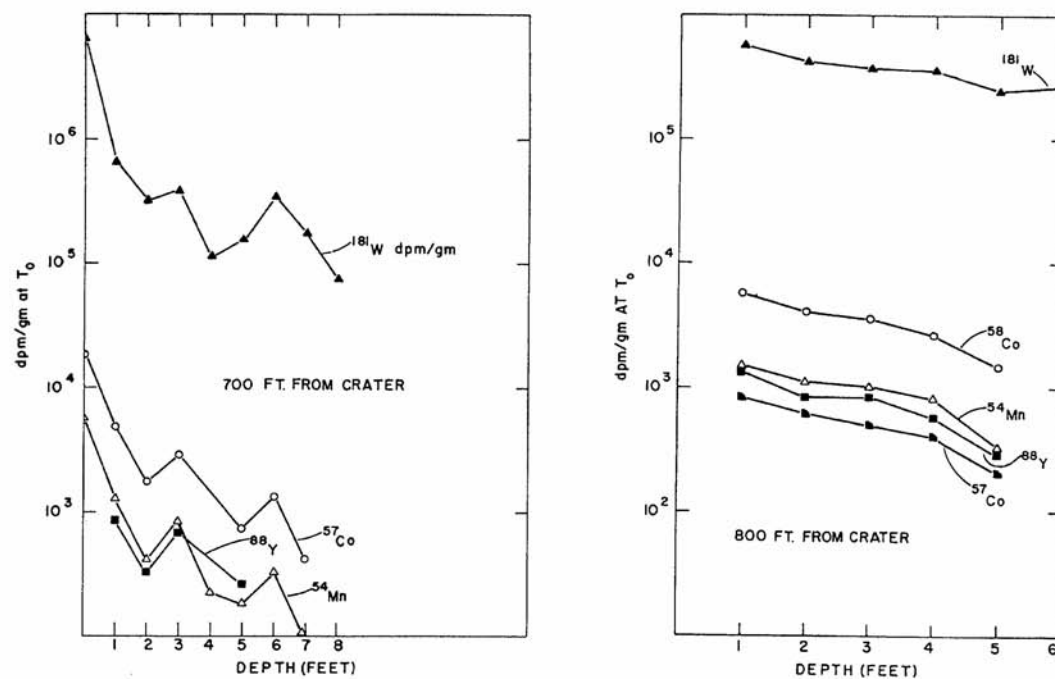


Figure A.2-22
CAS 20-45-03, Radiological Results from Trench Samples at 700 and 800 ft from Crater Edge
 Source: Modified from Koranda, et al., 1970

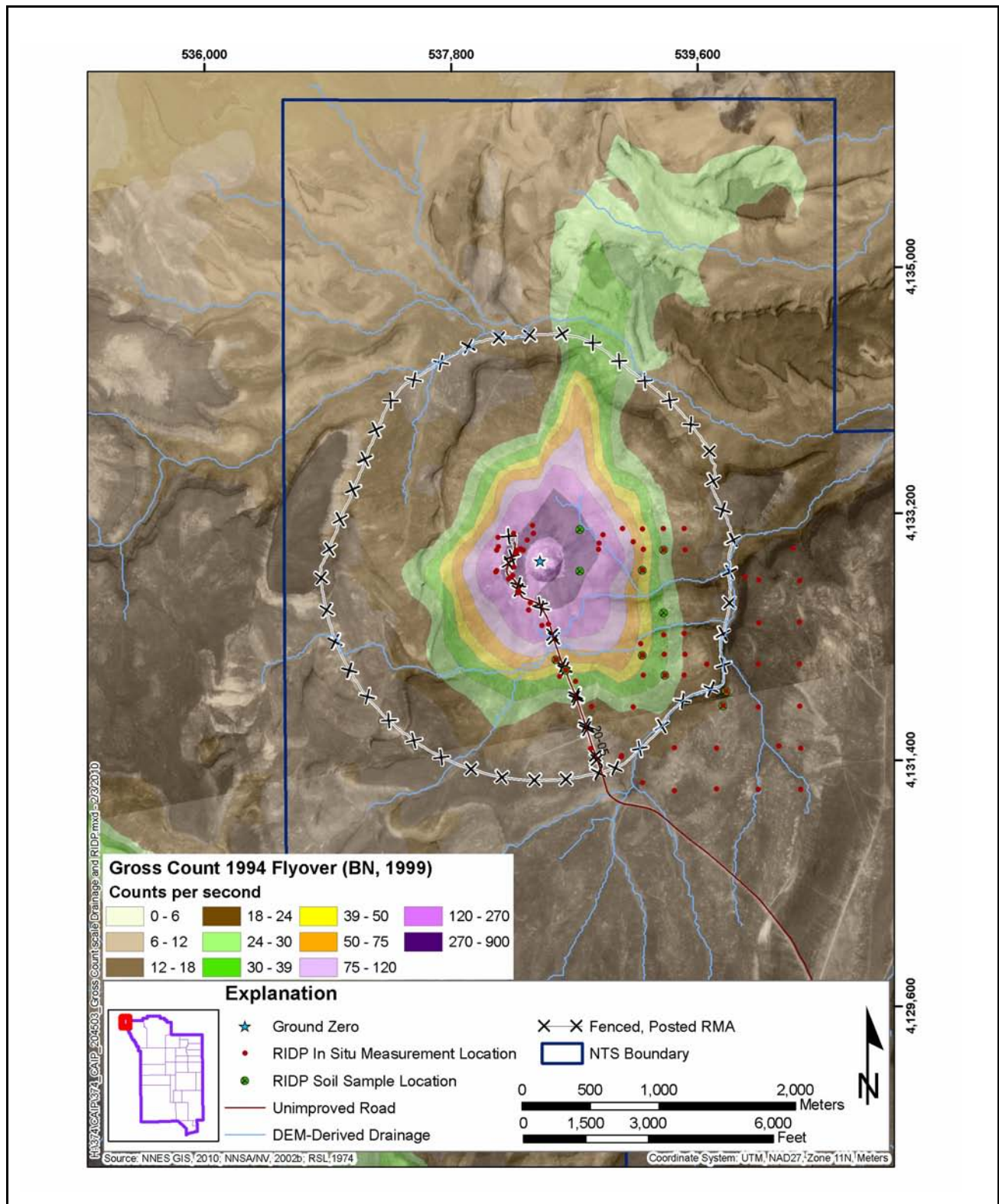


Figure A.2-23
CAS 20-45-03, 1994 Aerial Radiological Survey Gross Count Results,
and RIDP In Situ Measurement and Soil Sampling Locations

120 cps and above isopleths. These results confirm the expectation that gamma levels are higher near the crater and decrease with distance. The Am-241 were unusable due to rapidly changing results and high count rates (BN, 1999).

Gamma walkover surveys were performed in 2009 with a PRM-470 plastic scintillator (Anagnostopoulos, 2009b). In addition, existing NTS environmental monitoring program TLDs around the Schooner site (NNSA/NSO, 2008) were read and the results converted to mrem/IA-yr. The PRM-470 readings were taken at the site of each TLD. The TLD data were correlated to PRM-470 radiation survey readings, resulting in a high correlation ($R^2 = 0.99$). The results of the surveys and data conversion are shown in [Figure A.2-24](#). The blue bar along each transect indicates the approximate position at which external radiation doses are expected to exceed 25 mrem/IA-yr (i.e., areas where PRM-470 results are greater than 449 cps).

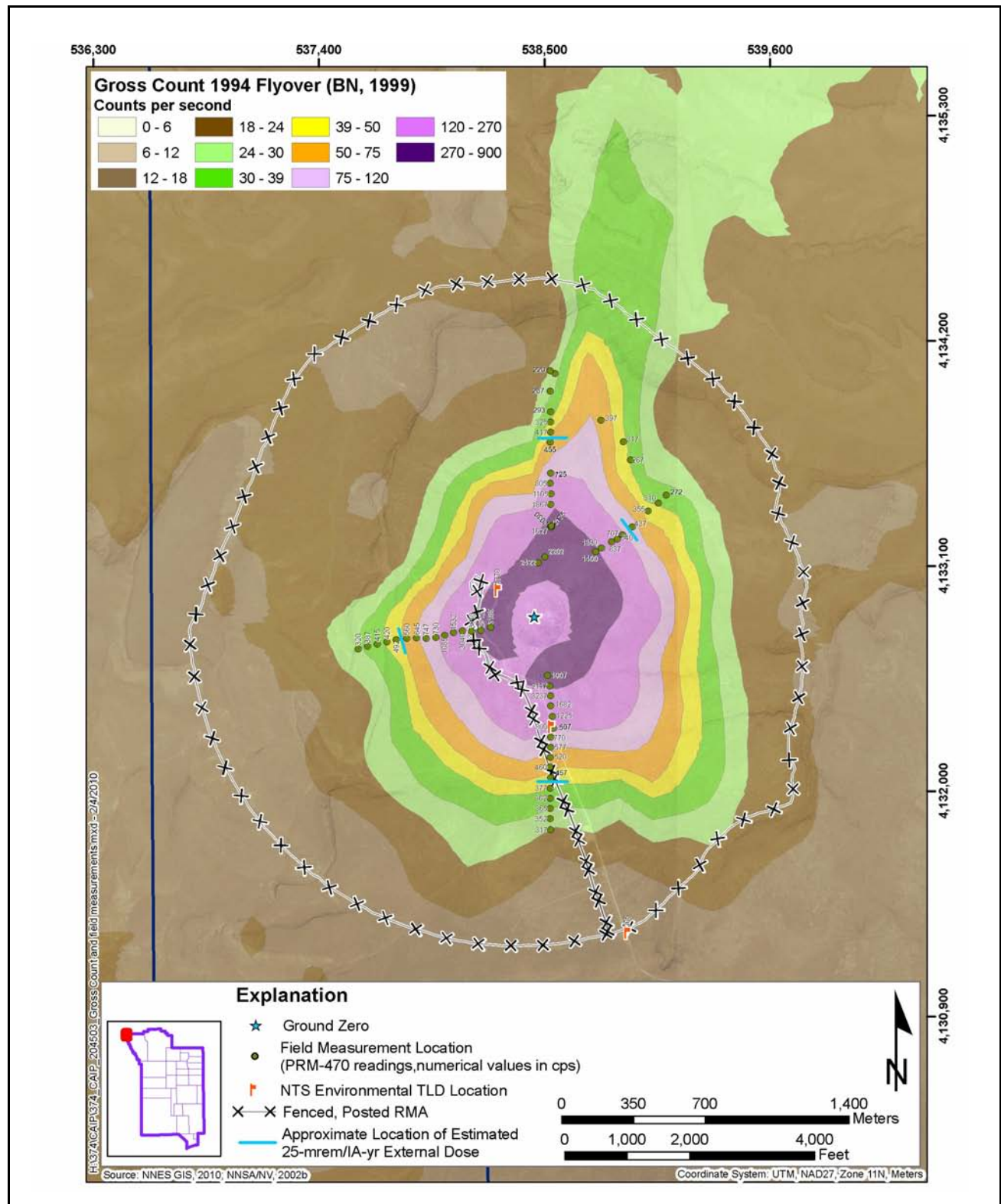


Figure A.2-24
CAS 20-45-03, Converted TLD and PRM-470 Data

A.3.0 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 374 is: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 374.”

A.3.1 Planning Team Members

The DQO planning team consists of representatives from NDEP and NNSA/NSO. The DQO planning team met on October 20, 2009, for the DQO meeting.

A.3.2 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 374 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:

- Potential contaminant releases, including media subsequently affected.
- Release mechanisms (the conditions associated with the release).

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

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

The applicability of the CSM to each CAS is summarized in [Table A.3-1](#) and discussed below.

[Table A.3-1](#) provides information on CSM elements that will be used throughout the remaining steps of the DQO process. [Figure A.3-1](#) represents site conditions applicable to the CSM.

A.3.2.1 Release Sources

The releases of contamination to CAU 374 are directly or indirectly associated with the Danny Boy and Schooner nuclear tests. The test release scenario consists of the initial deposition of radioactivity to surrounding soils from prompt injection of nuclear material, neutron activation of soils and debris, and the atmospheric deposition of fuel fragments and fission products. A typical cross-section of a crater is shown in [Figure A.3-2](#). The crater is bounded by material that may be classified into three categories: fallback and ejecta zone, rupture zone, and elastic zone (Fleming et al., 1970).

[Figure A.3-3](#) depicts the net gain in surface elevation for the test release above the original ground surface from 1) uplift of fractured rock around the crater perimeter and 2) continuous field of ejecta deposited from material thrown out of the crater following detonation.

Table A.3-1
Conceptual Site Model Description of Elements for Each CAS in CAU 374

CAS Identifier	18-22-05	18-22-06	18-22-08	18-23-01	20-45-03
CAS Description	Drum	Drums (20)	Drum	Danny Boy Contamination Area	U-20u Crater (Schooner)
Site Status	Sites are inactive and/or abandoned				
Exposure Scenario	Occasional				
Sources of Potential Soil Contamination	Leaking or spilled stored drums			Ejecta, fallout, and soil-particle activation from shallow subsurface nuclear testing; surface disposal of discarded equipment and materials	
Location of Contamination/ Release Point	Soil adjacent to drum leaks or spilled material			Interface between contaminated soil/ejecta/debris and native soil	
Amount Released	Unknown				
Affected Media	Surface and shallow subsurface soil			Surface and shallow subsurface soil; debris such as concrete, steel, and wood	
Potential Contaminants	VOCs, SVOCs, PCBs, TPH-DRO, RCRA metals, gamma and isotopic radionuclides			Gamma and isotopic radionuclides	
Transport Mechanisms	At the soil surface, surface water runoff may provide for the transportation of some contaminants within or outside of the footprints of the CASs. Within subsurface media, percolation of precipitation serves as the major driving force for migration of contaminants.				
Migration Pathways	Vertical transport expected to dominate over lateral transport due to small surface gradients.				Lateral transport expected to dominate over vertical transport due to moderate surface gradients.
Lateral and Vertical Extent of Contamination	Contamination, if present, is expected to be contiguous to the release points. Concentrations are expected to decrease with distance and depth from the source. Groundwater contamination is not expected. Lateral and vertical extent of COC contamination is assumed to be within the spatial boundaries.				
Exposure Pathways	The potential for contamination exposure is limited to industrial and construction workers, and military personnel conducting training. These human receptors may be exposed to COPCs through oral ingestion, inhalation, and dermal contact (absorption) of soil and/or debris due to inadvertent disturbance of these materials or irradiation by radioactive materials.				

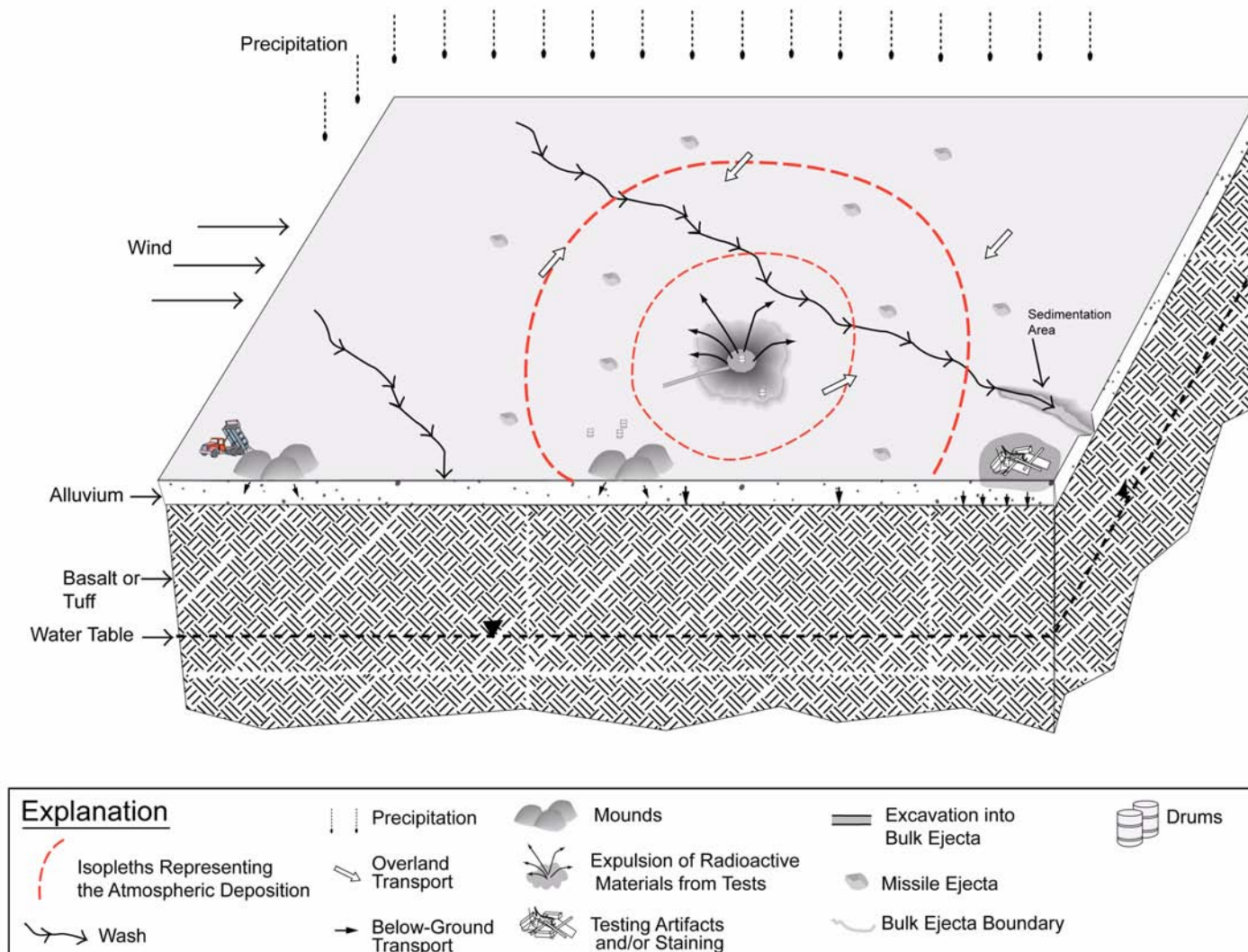


Figure A.3-1
CAU 374 Conceptual Site Model

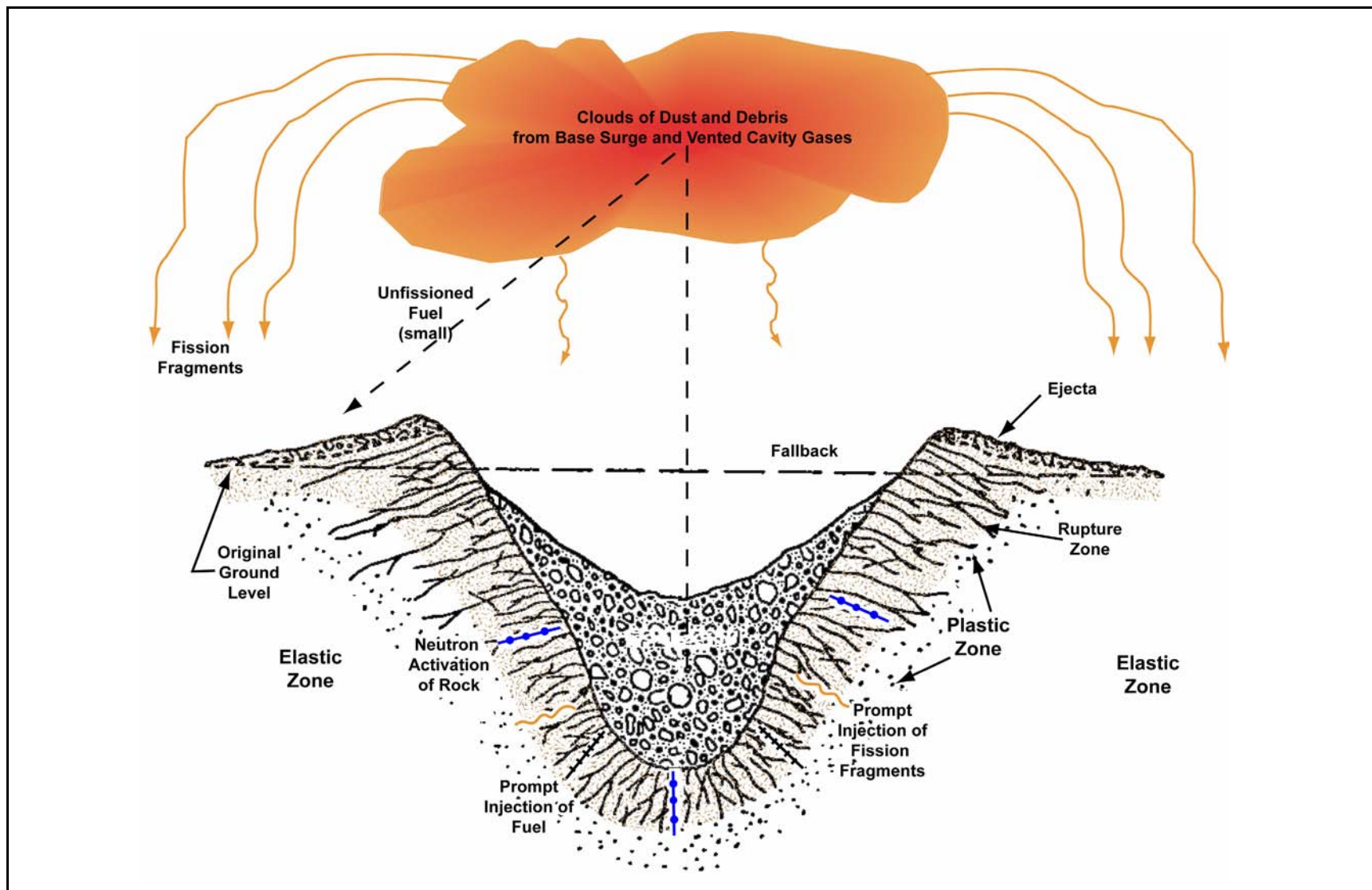


Figure A.3-2
CAU 374 Conceptual Site Model, Test Release of Radionuclides

Source: Modified from Fleming et al., 1970

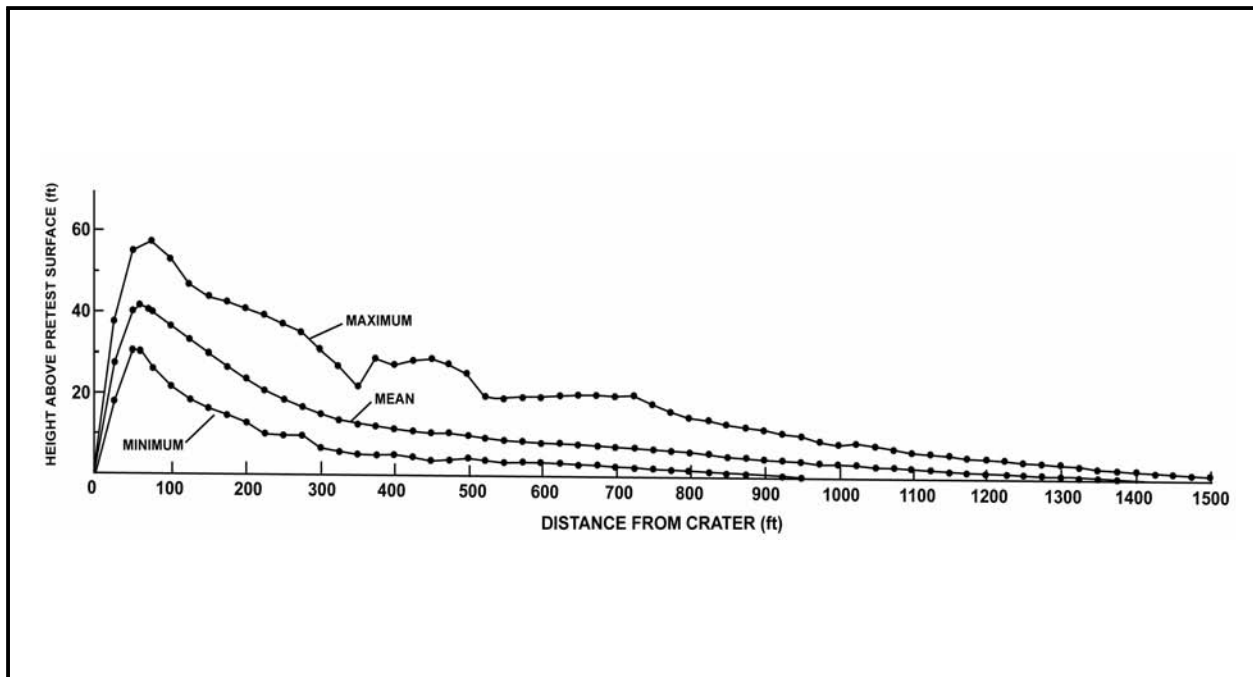


Figure A.3-3
CAU 374 Conceptual Site Model, Test Release Zone of Uplift
and Continuous Eject Impact
Source: Modified from Henny, 1970

The following identifies the test release sources specific to each CAS (DOE/NV, 2000):

- The Danny Boy source was a weapons-effect test with a yield of 430 tons buried at a depth of 33.5 m that was detonated on March 5, 1962.
- The Schooner source was a Plowshare test with a yield of 30 kt buried at a depth of 111.2 m that was detonated on December 8, 1968.

No information exists on the specific potential release for the drums.

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 ejecta, fallout, and soil-particle activation, or by stored drums). The CSM accounts for potential releases resulting from contamination present on or in the impacted soil.

A.3.2.2 Potential Contaminants

The CAS-specific COPCs are based on a conservative evaluation of possible site activities considering the incomplete site histories of the CASs and considering contaminants found at similar NTS sites. The 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 CASs. The list of COPCs is intended to encompass all of the significant contaminants that could potentially be present at each CAS. Significant contaminants are defined as contaminants that are present at concentrations exceeding the PAL. The COPCs reported for each analytical method are chemical and radiological:

- Chemical: TPH-DRO, PCBs, SVOCs, VOCs, RCRA metals
- Radiological: Gamma spectroscopy, isotopic Am, isotopic U, isotopic Pu, Sr-90

Specific COPCs (and, subsequently, the analyses requested) will be determined for newly identified potential releases based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks).

A.3.2.3 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 solubility, low density, and/or low affinity for media are found further from release points or in low areas where evaporation of ponding will concentrate dissolved contaminants.

A.3.2.4 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 A.2.1](#).

A.3.2.5 Migration Pathways and Transport Mechanisms

Migration pathways include the lateral migration of potential contaminants across surface soils/sediments and vertical migration of potential contaminants through subsurface soils.

Contamination in the drainages are subject to much higher transport rates than contaminants present in other surface areas. Washes at the Danny Boy and Schooner sites are generally dry but are subject to infrequent, potentially intense stormwater flows. These stormwater flow events provide an intermittent mechanism for both vertical and horizontal transport of contaminants. Contaminated sediments entrained by these stormwater events would be carried by the streamflow to locations where the flowing water loses energy and the sediments drop out. These locations are readily identifiable as sediment-collection areas. The washes that drain the area around Danny Boy flow into Fortymile Canyon Wash and ultimately the Death Valley dry lake. The washes that drain the area around Schooner ultimately flow into the Gold Flat dry lake bed.

Contaminants may also be moved through mechanical disturbance due to maintenance or construction activities at the site. Specifically, this can include activities such as construction of viewing and parking areas, removal of surface contamination through scraping or grading, and the construction of trench/re-entry for drilling in crater.

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 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.

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 62.6 in. [Shott et al., 1997]) and limited precipitation for this region (7 to 8 in. per year [ARL/SORD, 2009]), percolation of infiltrated precipitation at the NTS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992).

A.3.2.6 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 irradiation by radioactive materials. The land-use and exposure scenarios for the CAU 374 CASs are listed in [Table A.3-2](#). These are based on NTS current and future land use. The sites are at remote locations without any site improvements and where no regular work is performed. However, the possibility still exists that site workers could occupy these locations on an occasional and temporary basis, such as a military exercise. Therefore, these sites are classified as occasional work areas.

Table A.3-2
Land-Use and Exposure Scenarios

CAS	Record of Decision Land-Use Zone	Exposure Scenario
18-22-05 18-22-06 18-22-08 18-23-01	Research Test and Experiment Zone This area includes land and facilities that provide widespread flexible support for diverse short-term testing and experimentation. The reserved zone is also used for short-duration exercises and training such as nuclear emergency response, and Federal Radiological Monitoring and Assessment Center training and DoD land-navigation exercises and training.	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.
20-45-03	Nuclear Test This area is reserved for dynamic experiments, hydrodynamic tests, and underground nuclear weapons and weapons-effects tests. This zone includes compatible defense and nondefense research, development, and testing activities.	

A.4.0 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.4.1 Decision Statements

The Decision I statement is: “Is any COC present in environmental media within the CAS?” For judgmental sampling design, any analytical result for a COPC above the FAL will result in that COPC being designated as a COC. For probability (random) 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: “If a COC is present, is sufficient information available to evaluate potential CAAs?” Sufficient information is defined to include:

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

The presence of a COC would require a corrective action. For the test release scenario, the DQO process resulted in an assumption that TED within the areas of the craters, crater rims, and related mounding around the craters exceeds the FAL and requires corrective action. Process knowledge from test data indicates that much of the radioactivity associated with the test was captured within the craters and in fractures around the crater. The extent of the subsurface contamination in and around the craters has not been determined but has been conservatively assumed that the default contamination boundaries exceed the FAL. [Figure 3-4](#) shows the default contamination boundaries at the sites. Also, radiological results from the PRM-470 radiological survey reported in [Section 2.5.5](#) indicate that external dose will exceed the PAL outside the default contamination boundary at the Schooner site. Therefore, Decision I for the test release scenario is resolved, corrective action is necessary, and Decision II must be resolved at Schooner.

For the test release scenario at the Danny Boy site, Decision I must be resolved for the areas outside the default contamination boundary. The default contamination boundary was established at the site fence, which encompasses the crater, crater rim, ejecta (boulder) field, and rock piles. The results of the gamma walkover survey conducted at the site ([Section 2.5.4](#)) indicated two areas with elevated readings that may exceed the PAL. Because NTS environmental TLDs have not been posted in the area around the Danny Boy site, the PRM-470 radiological results cannot be correlated to environmental TLD data. Therefore, the presence of an area exceeding the PAL outside the default contamination boundary cannot be confirmed, and Decision I must be resolved for the Danny Boy site. Decision I samples will be submitted to analytical laboratories to determine the presence of COCs.

For the non-test releases (e.g., drums), Decision I will be resolved based on the presence of COCs in samples from the drums. The specific analyses for samples from other non-test releases will be selected dependent upon the type and nature of the identified release.

Decision II samples for both release scenarios will be resolved by defining the extent of unbounded COCs.

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 a site to cause the future contamination of site environmental media if the wastes were to be released. To evaluate the potential for wastes to result in the introduction of a COC to the surrounding environmental media, the following conservative assumptions were made:

- Any containment of waste (e.g., drums) would fail at some point, and the waste would be released to the surrounding soil.
- A waste, regardless of concentration or configuration, may be assumed to be PSM and handled under a corrective action.
- Based on process knowledge and/or professional judgment, some waste may be assumed to not be PSM if it is clear that it could not result in soil contamination exceeding a FAL.

- If assumptions about the waste cannot be made, then the waste material will be sampled and the results will be compared to FALs based on the following criteria:
 - For non-liquid wastes, the concentration of any chemical contaminant in soil (following degradation of 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.
 - For non-liquid wastes, the dose resulting from radioactive contaminants in soil (following degradation of the waste and release of contaminants into soil) would be calculated using the activity of the contaminant in the waste divided by the mass of the waste (for each radioactive contaminant) and calculating the combined resulting dose using the RESRAD code (Murphy, 2004).
 - For liquid wastes, the resulting concentration of contaminants in the surrounding soil would be calculated based on the concentration of contaminants in the wastes and the liquid holding capacity of the soil.

If sufficient information is not available to evaluate potential CAAs, then site conditions will be re-evaluated 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.4.2 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.4.2.1 Alternative Actions to Decision I

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

A.4.2.2 Alternative Actions to Decision II

If sufficient information is available to evaluate potential CAAs, then further assessment of the CAS is not required. If sufficient information is not available to evaluate potential CAAs, then additional samples will be collected.

A.5.0 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.5.1 Information Needs

To resolve Decision I (determine whether a COC is present at a CAS), 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 CAS (probabilistic sampling)
- The analytical suite selected must be sufficient to identify any COCs present in the samples.

To resolve Decision II (determine whether sufficient information is available to evaluate potential CAAs at each CAS), 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.
- The analytical suites selected must be sufficient to detect contaminants at concentrations equal to or less than their corresponding FALs.

The information necessary to satisfy the DQO data needs will be generated for CAU 374 by collecting and analyzing samples generated during a field investigation. The investigation will generate information required to evaluate potential CAAs. However, the potential CAA of no further action will not be evaluated for the default contamination areas at Danny Boy and Schooner because significant contamination is present within and around each of the craters due to the prompt injection of radionuclides from the nuclear tests ([Section A.3.2.1](#)). A default contamination boundary has been defined around each of the craters that bounds this contamination ([Section 3.4](#)). Information needed to evaluate the corrective action of clean closure for the contamination within the default contamination area will not be generated during the investigation due to the technical infeasibility of excavating such a large mass of subsurface contamination. This contamination is currently

effectively contained in near-surface unsaturated media and in its current state is sufficiently isolated that it is not exposed to site workers or the public. For the area outside the default contamination boundary, information necessary to evaluate CAAs will be generated.

To generate information about the test release, Decision I sampling at Danny Boy and Decision II sampling at Danny Boy and Schooner will consist of collecting four composite samples from each sample plot. Each composite sample will comprise nine surface subsamples collected from 0 to 5 cm bgs at the locations described in [Section 4.2.2](#). Data collected will be used to estimate the TED for each sample. The TED will be determined for each sample by summing the internal and external dose components. 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 dose measurement device (e.g., TLDs). These TLDs will be 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). Each TLD contains three elements from which external dose measurements will be reported. Decision criteria are compared to the 95 percent UCL of the average TED for each plot based on the four internal dose estimates from the soil samples and the three external dose estimates from the TLD elements (see [Section A.9.1.3](#)).

To generate information about the non-test releases, Decision I surface soil samples (0 to 15.24 cm [6 in.] bgs) will be collected. 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. For Decision I sampling in the washes, a sampling location will be established at the center of the nearest two sediment accumulation areas outside the initial corrective action boundary (established using gamma survey data). Each wash that departs the corrective action boundary at Danny Boy and Schooner will be visually and radiologically surveyed to areas at a distance of 1 mi or more to the point where greater amounts of sediment accumulate than at sediment-collection areas closer to the corrective action boundary (e.g., large flat areas that extend for approximately two or more times the aerial extent of smaller areas). Decision II sampling will not be conducted for each of the drainage sediment-collection areas (non-test release). If a COC is

present in the sediment, the entire volume of the sediment will be assumed to contain the COC and will require corrective action.

Decision II sampling of the test releases and non-test releases will consist of further defining the extent of contamination where COCs have been confirmed.

A.5.2 Sources of Information

Information to satisfy Decision I and Decision II will be generated by collecting environmental samples and emplacing TLDs. 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 Services group at the NTS, 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.5.2.1 Sample Locations

Design of the sampling approaches for the CAU 374 CASs 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 CAS (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. A judgmental sampling design has been developed for non-test releases, due to the presence and significance of biasing factors. A combination of probabilistic and judgmental sampling designs has been developed for test releases at the Danny Boy and Schooner sites. This combination of a judgmental approach for sample location selection, and of a probabilistic sampling approach, for CAU 374 are discussed in the following sections.

A.5.2.1.1 Judgmental Approach for Test Release Sample Plot Placements

For the test release at Danny Boy, initial sampling will be conducted to identify the presence and nature of a radiological dose above the FAL outside the default contamination boundary (Decision I). At least one location likely to exceed a dose rate of 25 mrem/IA-yr will be identified. A sample plot

will be established in one or more of these locations. It is not known whether dose present outside the fence exceeds the FAL ([Section 2.5.4](#)).

The default contamination boundary at the Danny Boy site is established at the fence delineating the contamination area (see [Section A.9.1](#)). The area within this fence contains the crater, crater rim, continuous ejecta field, and rock piles. The logistics for sample plot placement within the fenced area are made difficult due to the coverage of boulders across the site. Also, the presence of the crater, the steep slopes on the rim, the boulders, and the rock piles increase the safety concerns for sampling inside the contamination area. The area within the fence is a default contamination area and is assumed to exceed the FAL ([Section 3.4](#)). If the results from the Decision I sample plot at Danny Boy yield a 95 percent UCL of the TED above 25-mrem/IA-yr dose, additional sample plots will be required for Decision II.

For the test releases at Danny Boy and Schooner, Decision II sample plot locations will be determined judgmentally along each of three vectors that are approximately normal to the gamma radiation survey isopleths. For Decision II at Danny Boy, additional sample plots will be established along the three sampling vectors for a total of three plots per vector outward from GZ, based upon the 1994 flyover radiological survey (BN, 1999) and refined by a radiological walkover survey (Anagnostopoulos, 2009b). For Decision II at Schooner, 12 sample plots will be established along three vectors for a total of four plots per vector. The sample plot locations will be selected based on preliminary estimates of the location along each vector where TED would equal 25 mrem/IA-yr. These estimates are obtained through the use of a PRM-470 correlated to existing environmental TLDs ([Section 2.5.5](#)). The Decision II sample plot locations at both sites must meet the criterion that at least one sample plot will be located within the millirem per year (25-mrem/yr) boundary and at least one sample plot will be located outside this boundary.

A.5.2.1.2 Probabilistic Approach for Sample Locations within Sample Plots

A probabilistic sampling approach will be implemented for the selection of composite sample locations within each sample plot at the CASs. At each plot, each composite sample will consist of soil collected from nine random subsample locations within the plot. For each composite sample, the first subsample location will be selected randomly; the remaining eight subsample locations will be established on a systematic triangular grid (see [Section A.9.0](#)). Selection of probabilistic subsample

locations at these CASs, including an example of the predetermined sample locations at one plot (see [Figure A.9.2](#)), are presented in [Section A.9.1](#). [Section A.9.1](#) also describes the subsample location selection process.

A.5.2.1.3 Judgmental Approach for Non-test Sample Location Selection

Decision I sample locations for non-test releases will be determined based upon the likelihood of the soil containing a COC, if present at the CAS. The sample locations for non-test releases will be selected based on field-screening techniques, biasing factors, the CSM, and existing information. Analytical suites for Decision I samples will include all COPCs identified in [Section 3.2](#).

For CASs 18-22-06 and 18-22-08, sample locations will be the contents of the drums, if present, and soil underneath the drums that is impacted from the potential release. For the drainage samples, the sample locations will be the center of the sediment-collection areas. For the other non-test releases, 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 submittal to the analytical laboratory. The following biasing factors may be used for selection of sampling locations:

- Documented process knowledge on source and location of release (e.g., volume of release).
- 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 horizontally.
- Radiological survey anomalies: Radiological survey results that are significantly higher than the surrounding area.
- Geophysical anomalies: Geophysical survey results that are not consistent with the surrounding area (e.g., results indicating buried concrete or metal, surface metallic objects).
- Drums, containers, equipment, or debris: Materials that contain or may have contained hazardous or radioactive substances.
- Lithology: Locations where variations in lithology (soil or rock) indicate that different conditions or materials exist.

- 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.
- Presence of debris, waste, or equipment.
- Odor.
- Physical and chemical characteristics of contaminants.
- Sediment-collection areas in the washes.
- Other biasing factors: Factors not previously defined for the CAI that become evident once the investigation of the site is under way.

As biasing factors are identified and used for selection of sampling locations, they will be documented in the appropriate field documents.

For Decision I sampling in the washes, a sampling location will be established at the center of the nearest two sediment accumulation areas outside the initial corrective action boundary (established using gamma survey data). At each location, a sample will be collected from each 5-cm depth interval until native material is encountered (see [Figure A.9-5](#)). Each sample will be screened with an alpha/beta contamination meter, and the sample with the highest screening value at each sample location will be submitted for analysis. If the screening result values are not significantly different, the surface sample will be submitted for analysis. Each wash that departs the corrective action boundary at Danny Boy and Schooner will be visually and radiologically surveyed to areas at a distance of 1 mi or more to the point where greater amounts of sediment accumulate than at

sediment-collection areas closer to the corrective action boundary (e.g., large flat areas that extend for approximately two or more times the aerial extent of smaller areas).

Decision II sampling will not be conducted for each of the drainage sediment-collection areas (non-test release). If a COC is present in the sediment, the entire volume of the sediment will be assumed to contain the COC and will require corrective action.

Decision II sample step-out locations for other non-test releases will be selected based on the CSM, biasing factors, and sample results. Analytical suites will include those parameters that exceeded FALs (i.e., COCs).

A.5.2.2 Analytical Methods

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

A.6.0 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.6.1 Target Populations of Interest

The population of interest to resolve Decision I (“Is any COC present in environmental media within the CAS?”) is any location or area within the site that contains contaminant concentrations exceeding a FAL. The populations of interest to resolve Decision II (“If a COC is present, is sufficient information available to evaluate potential CAAs?”) are:

- Each one of a set of locations bounding contamination in lateral and vertical directions
- Investigation waste and potential remediation waste
- Environmental media where natural attenuation or biodegradation or construction/evaluation of barriers is considered

A.6.2 Spatial Boundaries

Spatial boundaries are the maximum lateral and vertical extent of expected contamination that can be supported by the CSM at each CAS. The spatial boundaries for CAU 374, categorized by the release, are:

- Vertical, Test Release outside the default contamination boundary: 1 ft below original ground surface
- Vertical, Non-test Release: 15 ft bgs
- Horizontal, Test and Non-test Release: 2 mi from GZ

Contamination found beyond these boundaries may indicate a flaw in the CSM and may require re-evaluation of the CSM before the investigation could continue. Each CAS is considered geographically independent, and intrusive activities are not intended to extend into the boundaries of neighboring CASs.

A.6.3 Practical Constraints

Practical constraints such as activities by other organizations at the NTS, utilities, threatened or endangered animals and plants, unstable or steep terrain, and/or access restrictions may affect the ability to investigate this site.

A.6.4 Define the Sampling Units

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

A.7.0 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.7.1 Population Parameters

Population parameters are defined for judgmental and probabilistic sampling designs in the following sections. Population parameters are the values to be compared with action levels.

A.7.1.1 Judgmental Sampling Design

For non-test releases, the population parameter is the observed TED or contaminant concentration from each location. Each result will be compared to the FALs to determine the appropriate resolution to Decision I and Decision II. A single result exceeding a FAL would cause a determination that a COC is present within the CAS (for Decision I) or that the COC is not bounded (for Decision II).

A.7.1.2 Probabilistic Sampling Design

For probabilistic sampling results, the population parameter is the true average 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 average TED at the site in question exceeds the FAL. Because calculated average TEDs are estimates of the true (unknown) average TEDs, it is uncertain how well the calculated TED averages represent the true TED averages. If a calculated average TED were directly compared to the FAL, a significant difference between the true average TED and the calculated TED average could lead to making decision errors. To reduce the probability of making a false negative decision error, a conservative estimate of the true average TED is used to compare to the FAL. This conservative estimate (overestimation) of the true TED averages will be calculated as the 95 percent UCLs of the respective calculated TED averages. By definition, there will be a 95 percent probability that the true average TED is less than the 95 percent UCL of the calculated TED average.

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 non-parametric 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 non-parametric 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 requires that:

- A minimum number of samples are collected from random locations at each site.
- 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.7.2 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 (i.e., FALs) or to establish that corrective action is not necessary.”

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 TPH concentrations 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 investigation report. The FALs will be defined (along with the basis for their definition) in the investigation report.

A.7.2.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the *Region 9: Superfund, Preliminary Remediation Goals, Screening Levels for Chemical Contaminants* in industrial soils (EPA, 2009). Background concentrations for RCRA metals and zinc will be used instead of screening levels when natural background concentrations exceed the screening levels (e.g., arsenic on the NTS). Background is considered the average concentration plus two standard deviations of the average concentration for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by the EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the investigation report.

A.7.2.2 Total Petroleum Hydrocarbon PALs

The “Adopted Regulation of the State Environmental Commission, LCB File No. R189-08” (Nevada Legislature, 2009) eliminated the action level of 100 mg/kg specific to petroleum hydrocarbons in soil. Therefore, a single PAL for TPH is not defined. However, PALs are defined for the hazardous constituents of TPH in [Section A.7.2.1](#).

A.7.2.3 Radionuclide PALs

The PAL for radioactive contaminants is 25 mrem/IA-yr 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). That document establishes the default exposure conditions and RESRAD computer code input parameters to be used to calculate the potential radiation dose over a land area. Several input parameters are not specified so that site-specific information can be used (such as an area of contamination of 100 m², applied to areas of 100 m², and a depth of contamination of 5 cm). In addition, DCG values for each individual radionuclide COPC were calculated. The DCG is the value, in picocuries per gram for surface soil, for a particular radionuclide that would result in a dose of 25 mrem/IA-yr. Using DCGs in site evaluation facilitates the determination of a radiation dose estimate for each soil sample.

A.7.3 Decision Rules

The decision rules applicable to both Decision I and Decision II are:

- If COC contamination is inconsistent with the CSM or extends beyond the spatial boundaries identified in [Section A.6.2](#), then work will be suspended and the investigation strategy will be reconsidered, else the decision will be to continue sampling.

The decision rules for Decision I are:

- 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 CAS, then a corrective action will be determined, else no further action will be necessary.

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

The decision rules for Decision II are:

- If the population parameter 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 results are available for the waste characterization samples defined in [Section A.9.0](#), 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.8.0 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.8.1 Decision Hypotheses

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

- 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:

- 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.8.2 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.8.2.1 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 CAS. For Decision II, having a high degree of confidence that the sample locations selected will identify the extent of COCs.
- Having a high degree of confidence that analyses conducted will be sufficient to detect any COCs present in the samples.
- Having a high degree of confidence that the dataset is of sufficient quality and completeness.

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

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

These characteristics were considered during the development of the CSM and selection of sampling locations. The field-screening methods and biasing factors listed in [Section A.5.2.1](#) will be used to further ensure that appropriate sampling locations are selected to meet these criteria. Radiological survey instruments and field-screening equipment will be calibrated and checked in accordance with the manufacturer's instructions and approved procedures. The investigation report will present an assessment on the DQI of representativeness that samples were collected from those locations that best represent the populations of interest as defined in [Section A.6.1](#).

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

To satisfy the third criterion, the entire dataset 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 (minimum of 1 per matrix per 20 environmental samples)
- Laboratory QC samples (minimum of 1 per matrix per 20 environmental samples or 1 per CAS per matrix, if less than 20 collected)

A.8.2.2 False Negative Decision Error for Probabilistic Sampling

The false negative error rate for CASs 18-23-01 and 20-45-03 was established by the DQO meeting participants at 0.05 (or 5 percent probability). Upon validation of the analytical results, statistical

parameters will be calculated for each significant COC identified at each site. Protection against a false negative decision error is contingent upon:

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

Control of the false negative decision error, therefore, 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.8.3 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 according to 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 per lot)
- Field blanks (minimum of 1 per CAS, additional if field conditions change)

For probabilistic sampling, false positive decision error 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.8.2](#) for probabilistic sampling designs.

A.9.0 Step 7 - Develop the Plan for Obtaining Data

Step 7 of the DQO process selects and documents a design to yield data that will best achieve performance or acceptance criteria. Judgmental and probabilistic sampling schemes will be implemented to select sample locations and evaluate analytical results for CAU 374. [Section A.9.1](#) contains information about collecting Decision I and Decision II samples from the test releases at CASs 18-23-01 and 20-45-03 using a combination of judgmental and probabilistic sampling schemes. [Section A.9.2](#) contains information about collecting Decision I and Decision II samples from non-test releases using a judgmental sampling scheme. [Section A.9.3](#) discusses the establishment of the final corrective action boundaries at CASs 18-23-01 and 20-45-03. Environmental sample 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 3.4](#) to determine the need for corrective action.

A.9.1 Sampling of Test Release Distributions

The distribution of radioactivity from the test releases at CASs 18-23-01 and 20-45-03 will be investigated through a combination of judgmental and probabilistic sampling approaches. Initial sampling at CAS 18-23-01 will be conducted to determine whether a radiological dose outside the default contamination boundary exceeds the FAL (Decision I). If dose exceeds the FAL, additional sample plots will be established to determine the extent of the area where dose exceeds the FAL (Decision II). For CAS 20-45-03, radiological results from the PRM-470 radiological survey reported in [Section 2.5.4](#) indicate that external dose exceeds the PAL outside the default contamination boundary. Therefore, sample plots will be established at this CAS only for the purpose of determining the extent of the area where dose exceeds the FAL (Decision II).

Sampling to determine the distribution of radioactivity from the test releases at both sites consists of sampling soils within sample plots and staging a TLD at the approximate center of each sample plot.

A.9.1.1 Judgmental Placement of Sample Plots

Locations for Decision I sample plots at CAS 18-23-01 and Decision II sample plots at both CASs will be selected judgmentally based on one or more of the following sources of radiological information:

- Existing or new aerial radiological surveys
- GPS-assisted gamma walkover surveys
- TLDs emplaced in advance of sample collection at both CASs
- External dose estimations derived from correlation of hand-held radiological instruments (e.g., PRM-470) to nearby environmental TLDs emplaced for monitoring purposes (i.e., existing environmental TLDs emplaced at the Schooner site; see [Section 4.1](#)).

Decision I sample plots at the Danny Boy site (CAS 18-23-01) will be placed outside the posted contamination area (i.e., default contamination boundary) at one or more locations having the highest relative radiological measurements ([Figure A.9-1](#)).

If the presence of a dose above the FAL at the Danny Boy site is confirmed at the sample plot outside the default contamination boundary, three vectors will be established with three sample plots (total) placed along each vector. The northern vector at Danny Boy will begin at the Decision I plot and will also be placed parallel to the central axis of the plume, with the remaining two vectors spaced approximately 120 degrees apart ([Figure A.9-2](#)). The first sample plot on the other two vectors will be located using the PRM-470 radiation meter.

At CAS 20-45-03, four sample plots outside the default contamination boundary will be established on each of three vectors that are approximately normal to the gamma radiation survey isopleths with the constraint that on each vector at least one sample plot will present a TED greater than the FAL and at least one sample plot will present a TED less than the FAL ([Figure A.9-3](#)). To meet this constraint, it was necessary to determine a preliminary estimate of the locations where TED may be equal to the FAL. This was accomplished by correlating estimates of external dose from existing NTS environmental monitoring TLD dose measurements to the PRM-470 radiation levels, as presented in [Section A.2.2](#). It was estimated that external dose alone would exceed 25 mrem/IA-yr at Schooner for PRM-470 readings exceeding 449 cps. Therefore, the first sample plot on each vector will be

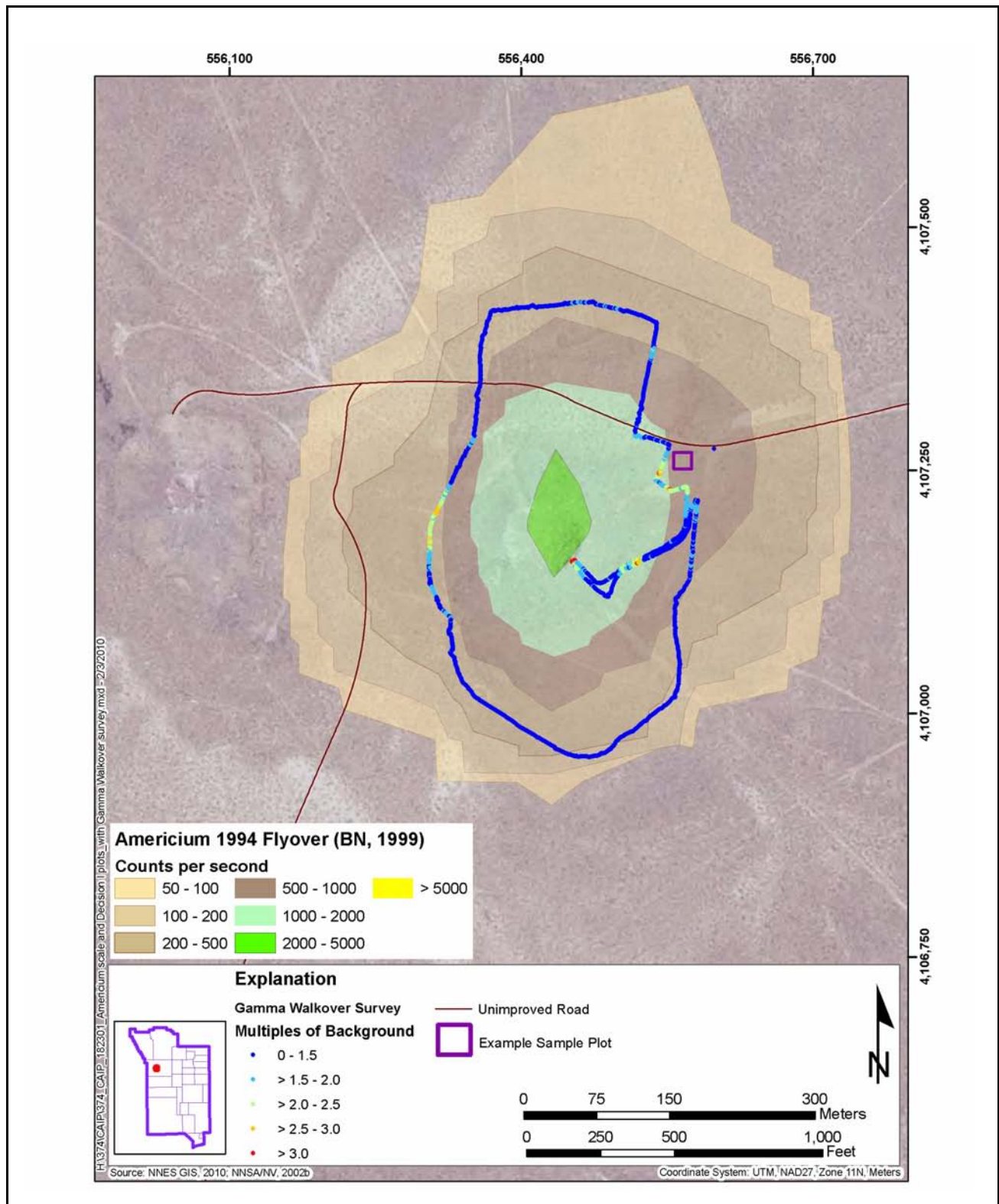


Figure A.9-1
CAS 18-23-01, Walkover Gamma Survey and Example Decision I Sample Plot

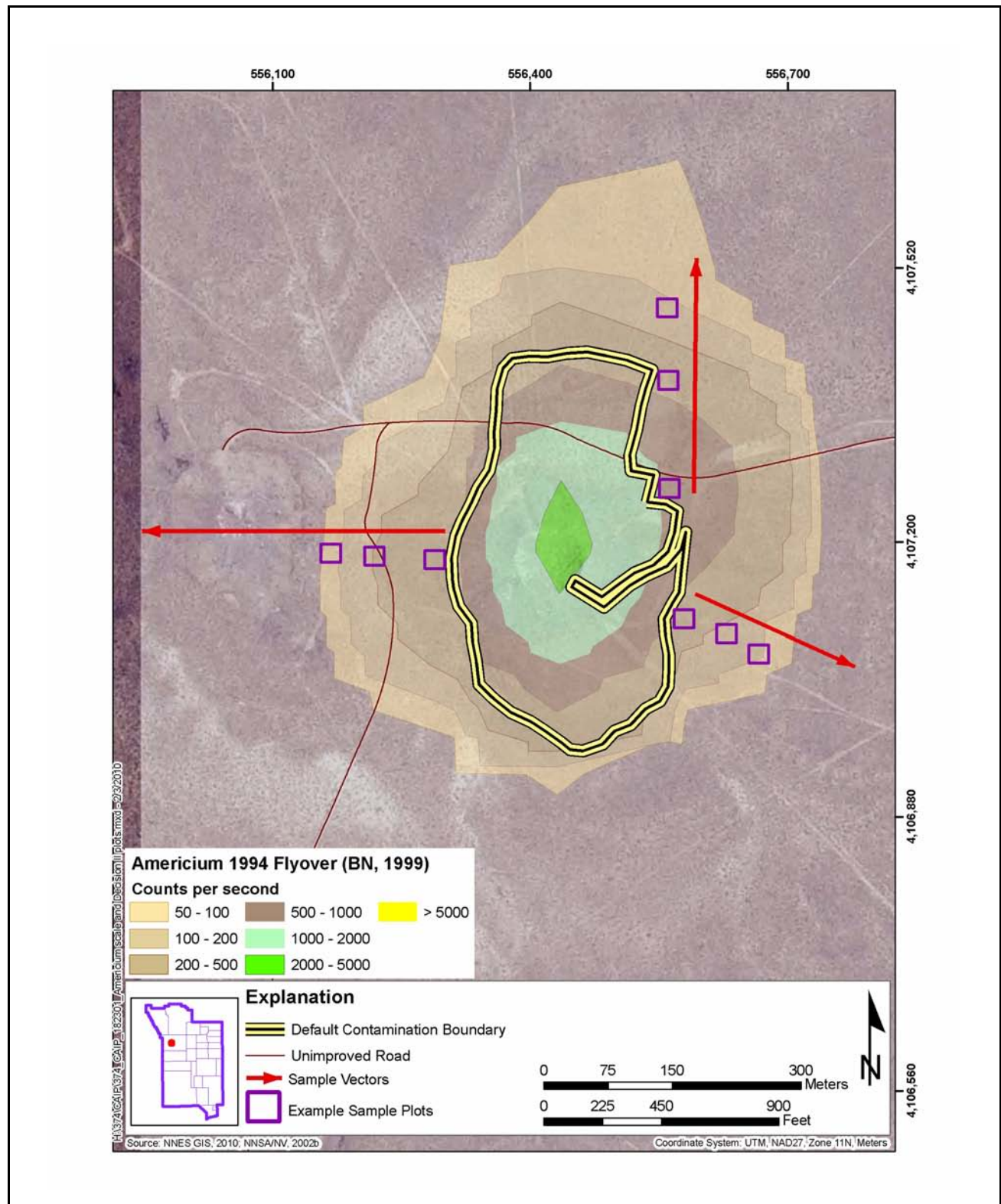


Figure A.9-2
CAS 18-23-01, Example Decision II Sample Plots and Vectors

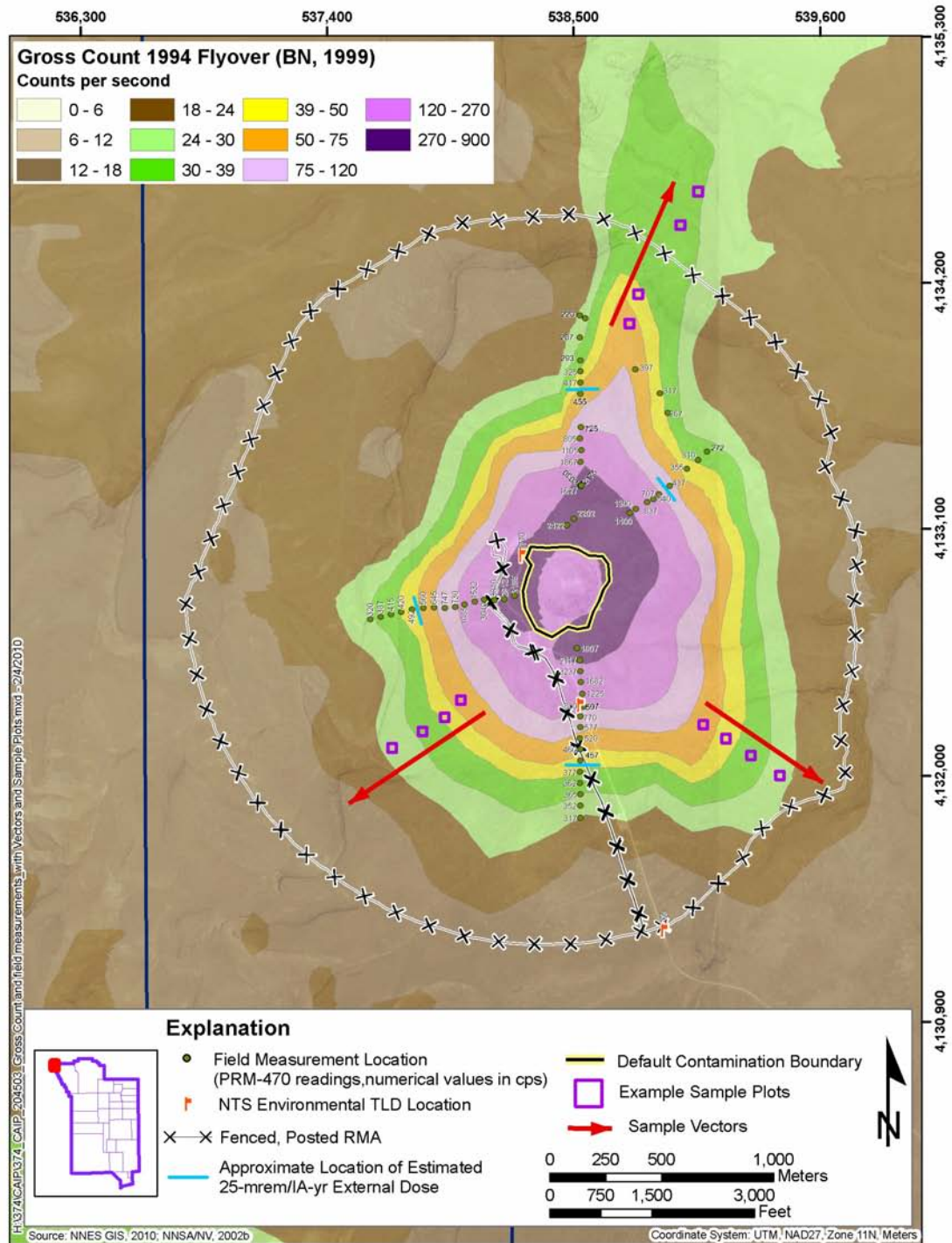


Figure A.9-3
CAS 20-45-03, Example Decision II Sample Plots and Vectors

located where the PRM-470 values exceed 449 cps. The approximate proposed sampling vectors and sample plots are shown in [Figure A.9-3](#).

A.9.1.2 Probabilistic Sampling of Sample Plots (Internal Dose)

A probabilistic sampling scheme will be implemented to select sample locations within sample plots and to evaluate analytical results at Danny Boy and Schooner. For probabilistically sampled sites, randomly selected sample locations will be chosen, with locations determined using the Visual Sample Plan software (PNNL, 2007). If a location contains a shallow, hard object (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.

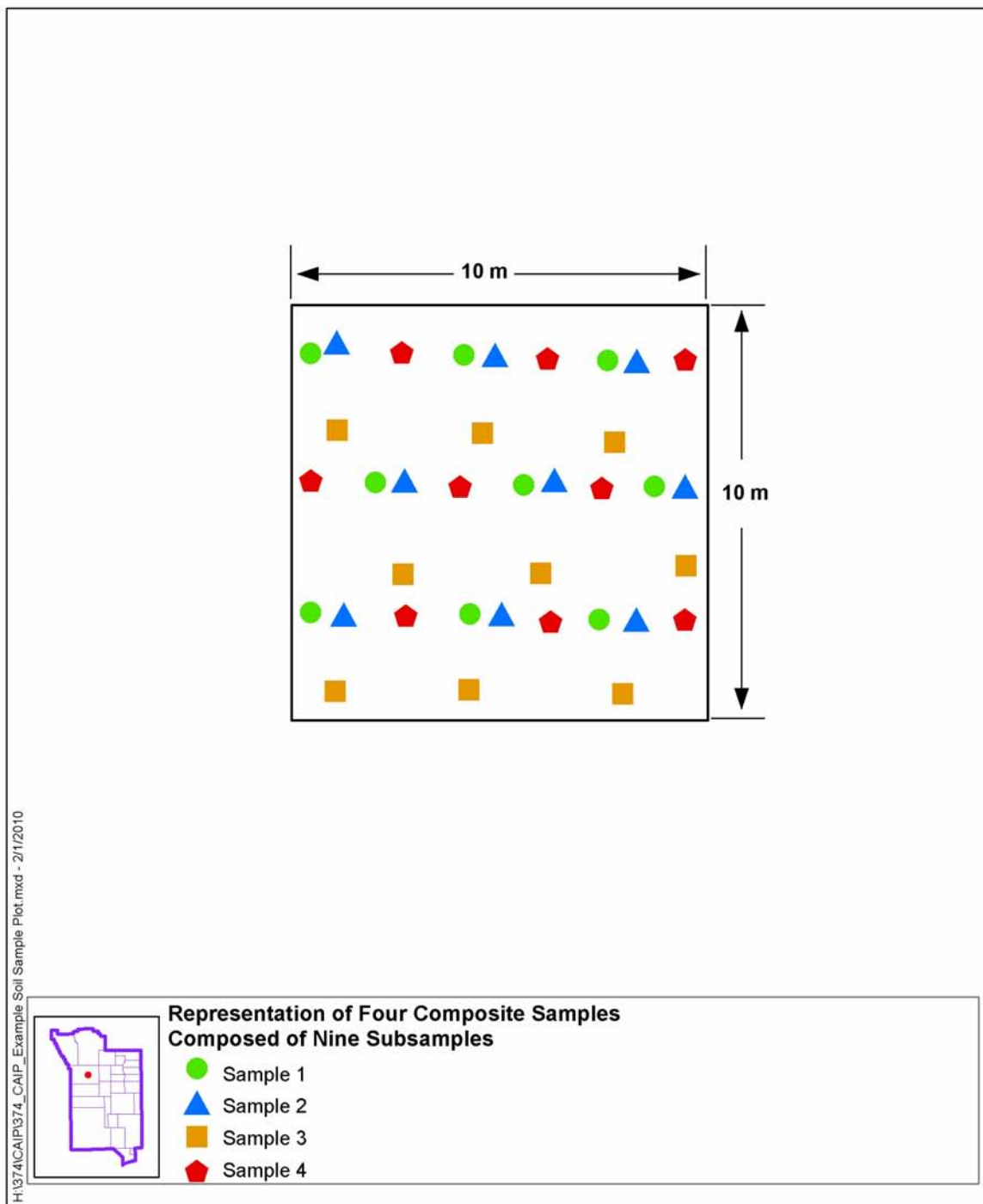
Statistical methods that generate site characteristics will be used to establish internal dose estimates that represent each sample plot as a whole at the Danny Boy and Schooner sites.

Four composite samples will be collected at each sample plot. The composite samples will be collected in the following manner:

- Each composite sample will comprise nine aliquots taken from randomly selected locations within each plot ([Figure A.9-4](#)). These locations will be predetermined using a random start with a triangular grid pattern as described in [Section A.9.1.4](#).
- Samples will be sieved to eliminate material (e.g., Trinity glass) greater than 0.25 in. diameter that cannot effectively be inhaled or ingested.
- The entire volume of the composited material collected will be submitted to the laboratory for analysis.

A.9.1.3 External Dose Measurements for Test Releases

The probabilistic sampling scheme implemented at the Danny Boy and Schooner sites also includes the evaluation of the measurement of external dose at each plot. External dose (penetrating radiation dose for the purposes of this document) will be determined by collecting *in situ* measurements using TLDs. External dose measurements will be taken at the approximate center of each sample plot at a height of 1 m.



**Figure A.9-4
Example Sample Plot**

The TLD placement and processing will follow the protocols established in *Nevada Test Site Routine Radiological Environmental Monitoring Plan* (NNSA/NSO, 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 millirem per Industrial Area year, will be presented as net values (e.g., a background value has been subtracted from the raw result). Naturally occurring terrestrial and cosmic radiation will register on a TLD, and the values can be significant in comparison to the FAL. In addition, the FAL is only applicable to radiation exposure from man-made sources at the NTS 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 to be subtracted from the TLD results will be obtained from an area determined to be unaffected by man-made activities at the NTS. Ten areas are identified in Section 5 of the *Nevada Test Site Environmental Report 2006* (NNSA/NSO, 2007) and are routinely monitored for external radiation exposure via environmental monitoring TLDs.

The project-specific TLDs are subjected to the same QA checks as the routine NTS environmental monitoring TLDs, as described in [Section 6.0](#). The Panasonic UD-814 TLD used in the NTS 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 project-specific 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.

A.9.1.4 Evaluation of Total Effective Dose (Internal plus External Dose)

As discussed in [Section A.7.1.2](#), the 95 percent UCL of the TED from each sample plot will be used to establish the corrective action boundary. The 95 percent UCL of the TED for each sample plot 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 ([Section A.9.1.3](#)) and the four RESRAD-calculated internal dose estimates from the soil samples.

A minimum number of samples (i.e., composite samples) is required to compute the UCL. This number will be calculated based on the TED results (comprising individual internal dose rates associated with each of the four composite samples added to the external dose rates from each plot). Determination of the minimum sample size cannot be accomplished until after the data have been generated. After the data evaluation is complete, the required number of samples will be calculated.

The input parameters to be used in calculating the minimum sample size are:

- A confidence level that a false negative error will not occur will be set at 95 percent.
- A confidence level that a false positive error will not occur will be set at 80 percent.
- A gray region width equal to 50 percent of the FAL (12.5 mrem/yr).
- The FAL (25 mrem/yr).
- The standard deviation of the TEDs at each plot.

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.

The initial corrective action boundary area will be calculated using the 95 percent UCL of the TED from each plot along each vector and an appropriate gamma radiation survey isopleth. A relationship will be established of the 95 percent UCL of the TED with gamma radiation survey values along each vector such that a gamma radiation survey value along each vector can be established that corresponds to the 25-mrem/yr FAL (using the appropriate exposure scenario). An isopleth from the radiological survey that encompasses the lowest value corresponding to the 25-mrem/yr FAL will be chosen as the initial corrective action boundary.

A.9.2 Sampling of Non-test Releases

A judgmental sampling design will be implemented for sampling the non-test releases. Because individual sample results, rather than averages, will be used to compare to FALs, statistical methods to generate site characteristics will not be used. Adequate representativeness of the entire target

population may not be a requirement to developing a sampling design. If good prior information is available on the target site of interest, then the sampling approach may be adjusted to collect samples only from areas known to have the highest concentration levels. If the observed results from these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006).

All non-test release sample locations will be selected to satisfy the DQI of representativeness in that samples collected from selected locations will best represent the populations of interest as defined in [Section A.6.1](#). To meet this criterion for non-test releases, a biased sampling strategy will be used to target areas with the highest potential for contamination, if it is present anywhere in the CAS. Sample locations will be determined based on process knowledge, previously acquired data, or the field-screening and biasing factors listed in [Section A.5.2.1](#). If biasing factors are present in soils below the drums, additional Decision I soil samples will be collected at depth intervals selected by the Site Supervisor based on biasing factors to a depth where the biasing factors are no longer present. The Site Supervisor has the discretion to modify the judgmental sample locations, but only if the modified locations meet the decision needs and criteria stipulated in this DQO.

A.9.2.1 Decision I

Washes

The nearest identifiable drainage to CAS 18-23-01 is located northeast of the Danny Boy crater. A small gully that drains the area to the north of the crater flows into a shallow sediment-collection area created by excavation of a few inches of surface soil ([Figure A.2-5](#)). Further to the east of this sediment-collection area, a mapped wash departs the area to the east, eventually flowing into the Fortymile Canyon Wash ([Figure A.2-5](#)). The small gully and wash will be visually surveyed to a distance of 1 mi from the Danny Boy GZ for the presence of sediment-collection areas to identify all sediment-collection areas. A sampling location will be established at the center of the nearest two sediment-collection areas outside the initial corrective action boundary (established using gamma survey data). At each location a sample will be collected from each 5-cm depth interval until native material is encountered ([Figure A.9-5](#)). Each sample will be screened with an alpha/beta contamination meter, and the sample with the highest screening value at each sample location will be

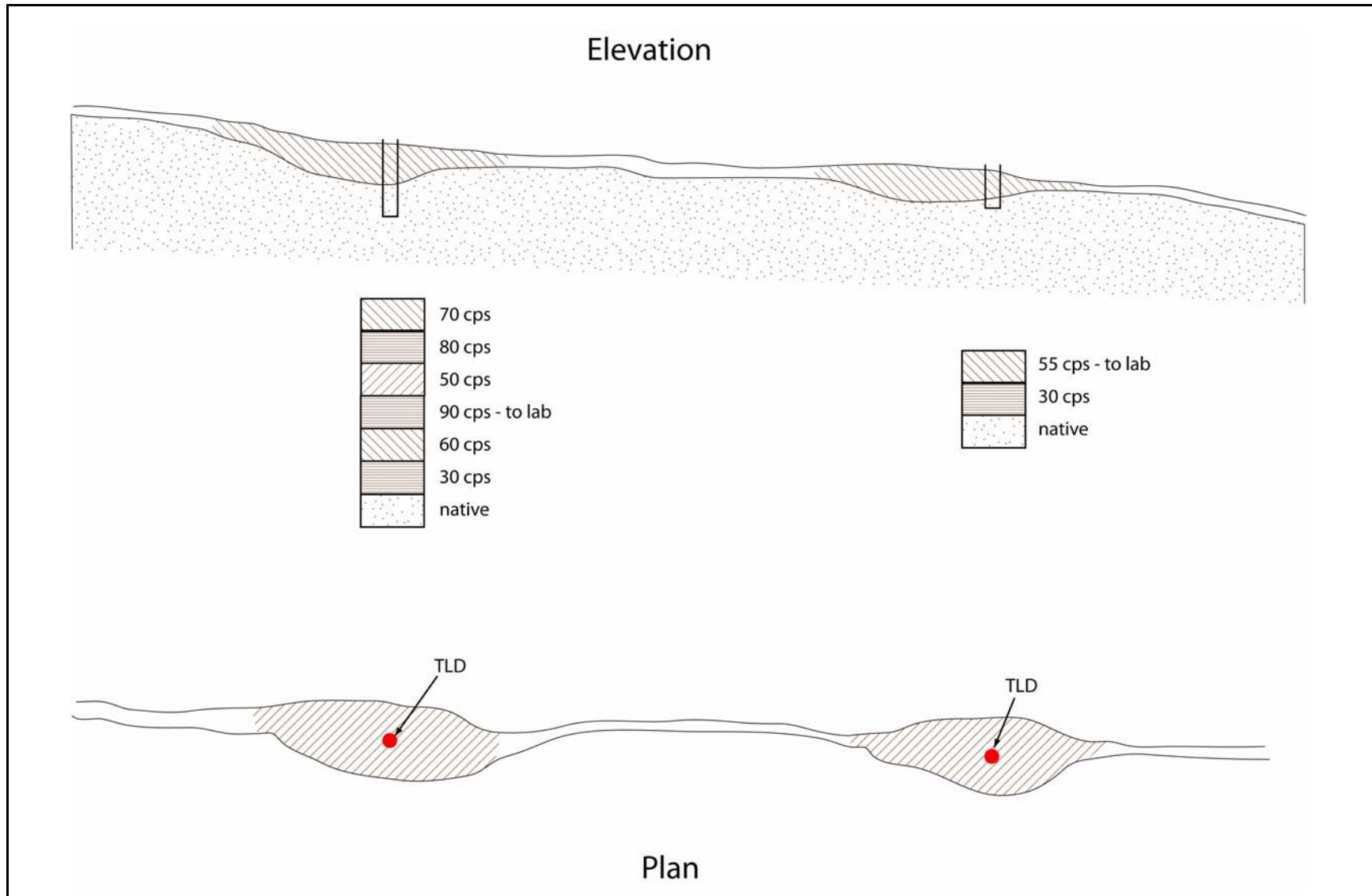


Figure A.9-5
CASs 18-23-01 and 20-45-03, Example of Wash Sampling

submitted for analysis. If the screening result values are not significantly different, the surface sample will be submitted for analysis.

Several identifiable washes exist within the Schooner site, three of which flow into two significant ravines (Figure A.9-6). Each wash that departs the corrective action boundary will be visually and radiologically surveyed to areas at a distance of 1 mi or more to the point where greater amounts of sediment accumulate than at sediment-collection areas closer to the corrective action boundary (e.g., large flat areas that extend for approximately two or more times the aerial extent of smaller areas). Sampling of these sediment-collection areas will follow the process described for the Danny Boy site.

Drums

A minimum of one sample will be collected from the drums in CASs 18-22-06 and 18-22-08 that contain material (i.e., granular [e.g., soil, powder] or liquid contents). Any stains or spilled material in the soil around the drums will also be sampled.

Stains, Spills and Debris

Samples will be collected for other non-test releases based on the type and nature of the release (i.e., the biasing factors present). During the course of the CAU 374 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 (surface or subsurface as discussed above).

A.9.2.2 Decision II Sampling

If a COC is present at a sediment-collection area sampling location, additional sediment-collection areas will be sampled until at least two consecutive sediment-collection areas are found that do not contain COCs, and other drainages will be assessed for the potential to have sediment-collection areas that contain a COC. Decision II will be resolved by the assumption that the entire volume of sediment in each sediment-collection area where a COC was identified contains the COC.

Decision II samples for non-test releases other than drainage areas will be collected from judgmental sampling locations selected based on locations where COCs were detected, the CSM, and other

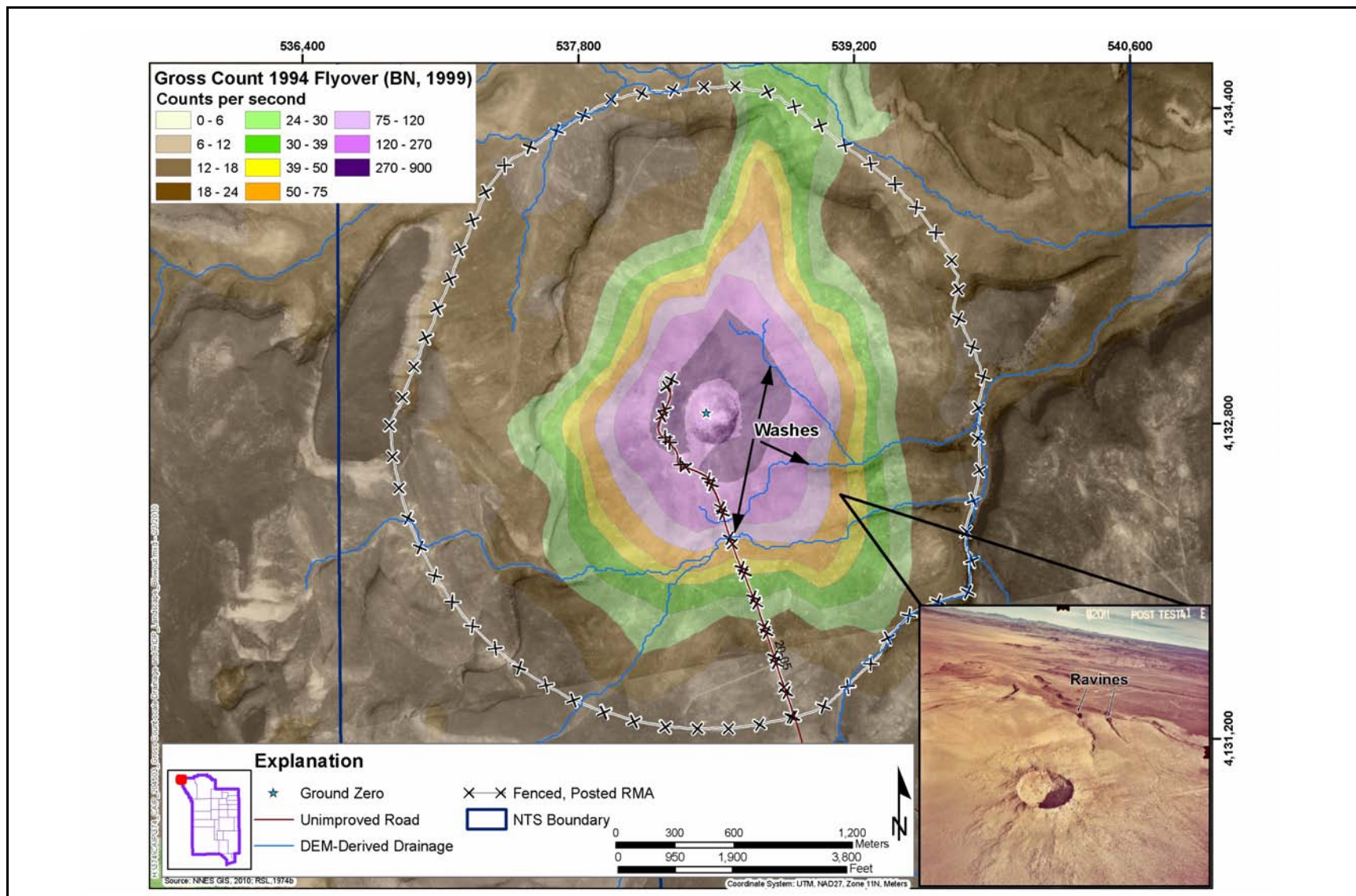


Figure A.9-6
CAS 20-45-03, Eastern Wash and Drainage System

field-screening and biasing factors listed in [Section A.5.2](#). 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. The Task Manager or Site Supervisor may modify the number, location, and spacing of step-outs as warranted by site conditions.

A.9.3 Establishment of Final Corrective Action Boundary

The final corrective action boundary will be established to include the default contamination boundary, the initial corrective action boundary, and additional areas that exceed the FAL based on Pu contamination (sample plots based on the Am survey), and any COCs identified from the non-test releases (e.g., from spills, waste, or the migration of contamination in drainages).

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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 Comment Responses

(3 Pages)

NEVADA ENVIRONMENTAL RESTORATION PROJECT

DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 374: Area 20 Schooner Unit Crater, Nevada Test Site, Nevada		2. Document Date:	12/10/2009
3. Revision Number:	0		4. Originator/Organization:	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble		6. Date Comments Due:	1/11/2010
7. Review Criteria:	Full			
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850, ext. 233		9. Reviewer's Signature:	
10. Comment Number/Locatio	11. Type*	12. Comment	13. Comment Response	14. Accept
1.) Sections 2.2.1, 2.2.2, and 2.2.3, Pages 10-11	Mandatory	With respect to operational history, if there is no evidence which supports the nature of the existing drums' contents and usage, remove the statements "...they were likely involved in some facet..." If there is information which supports the assertion above, provide it in the discussion (the proposed investigation of drums at these sites would be consistent with what is known or unknown regarding their operational history).	Because the history of all drums in the CASSs at the Danny Boy site is not known for certain, the sentence in each section that reads "The history of the drums is unknown, but they were likely involved in some facet of operations conducted at the site." was changed to read: "As the history of the drums is unknown, it will be conservatively assumed that they may have originated from other, unknown NTS activities." Additionally, the third sentence of the first paragraph in Section A.2.2 that reads "Each consists of an unknown release to the site from material that either was or presently is held within the drums assumed to be used during and/or after testing activities at the site." has been changed to remove the phrase "assumed to be used during and/or after testing activities at the site." Also, to clarify the possibility that contents of any of the drums may contain hazardous and/or radioactive substances, the following sentence was added to the end of the last paragraph of Section 3.2: "As the origins of the drums are unknown, samples of the contents of any of the drums outside of the crater (CASSs 18-22-06 and 18-22-08) will be submitted to the analytical laboratory for analysis of the full suite of COPCs."	

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10. Comment Number/Locatio	11. Type*	12. Comment	13. Comment Response	14. Accept
2.) Sections 3.4 and 4.1, Pages 34, 40	Mandatory	Provide a discussion of how the default contamination boundaries were established at both Schooner and Danny Boy craters. The discussion should clearly reveal how the boundaries, as depicted in Figure 3-4, were established (if actual distance measurements from ground zero and/or GPS coordinates are available, include them in the discussion as well).	To add the rationale for establishing the default contamination boundaries at the Danny Boy and Schooner sites, the following changes were made: In Section 3.4, fifth paragraph (which begins "The presence of a COC would require ...", after the second set of bullets), the fourth sentence which begins "The extent of the subsurface ..." was changed to read: "The extent of the subsurface contamination in and around the craters has not been determined but has been conservatively assumed that contamination within the default contamination boundaries exceed the FAL." Following the next sentence in the same paragraph, which reads "Figure 3-4 shows the default contamination boundaries at the sites.", the remaining two sentences were replaced with the following: "The default contamination boundary at Schooner was determined by a walkover examination of the area around the crater rim. Those locations that were suitable for emplacement of a 10-m-by-10-m sample plot were identified, and the location coordinates recorded to create the default contamination boundary (Figure 3-4). Because the default contamination boundary is well within the area where external dose is indicated to exceed the PAL (see Section 2.5.5), Decision I for the test release scenario is resolved for Schooner, corrective action is necessary, and Decision II must be resolved at Schooner." In the next paragraph, following the first sentence that reads "For the test release scenario at the Danny Boy site, Decision I must be resolved for the areas outside the default contamination boundary.", the second sentence	

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10. Comment Number/Locatio	11. Type*	12. Comment	13. Comment Response			14. Accept	
	Mandatory		was replaced with the following: "Because most of the land surface area within the fence at Danny Boy is covered by the crater, boulders, or rock piles, the default contamination boundary was established at the fence (Figure 3-4). As the investigation progresses, locations within the fence that are identified to be suitable for emplacement of a 10-m-by-10-m sample plot will be used to realign the default contamination boundary." Lastly, the GPS coordinates recorded during the walkover examination at Schooner were added to Figure 3-4.				

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