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DOE/NV--1522

National Nuclear Security Administration

Corrective Action Investigation Plan for Corrective Action Unit 573: Alpha Contaminated Sites Nevada National Security Site, Nevada

Controlled Copy No.: ___
Revision No.: 0

May 2014

UNCLASSIFIED

/s/ Joseph P. Johnston 05/23/2014
Joseph P. Johnston, N-I CO Date

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CORRECTIVE ACTION INVESTIGATION PLAN FOR CORRECTIVE ACTION UNIT 573: ALPHA CONTAMINATED SITES NEVADA NATIONAL SECURITY SITE, NEVADA

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

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CORRECTIVE ACTION INVESTIGATION PLAN
FOR CORRECTIVE ACTION UNIT 573:
ALPHA CONTAMINATED SITES
NEVADA NATIONAL SECURITY SITE, NEVADA

Approved by: /s/ Tiffany A. Lantow Date: 5/22/2014

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Soils Activity Lead

Approved by: /s/ Robert F. Boehlecke Date: 5/22/14

Robert F. Boehlecke
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List of Acronyms and Abbreviations

3-D	Three dimensional
Ac	Actinium
Ag	Silver
Al	Aluminum
Am	Americium
ASTM	ASTM International
bgs	Below ground surface
BMP	Best management practice
CA	Contamination area
CAA	Corrective action alternative
CAI	Corrective action investigation
CAIP	Corrective action investigation plan
CAS	Corrective action site
CAU	Corrective action unit
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act*
CFR	*Code of Federal Regulations*
Ci	Curie
cm	Centimeter
Cm	Curium
Co	Cobalt
COC	Contaminant of concern
COPC	Contaminant of potential concern
cps	Counts per second
Cs	Cesium
CSM	Conceptual site model
DCB	Default contamination boundary
DoD	U.S. Department of Defense

List of Acronyms and Abbreviations *(Continued)*

DOE	U.S. Department of Energy
DQA	Data quality assessment
DQI	Data quality indicator
DQO	Data quality objective
DU	Depleted uranium
EPA	U.S. Environmental Protection Agency
Eu	Europium
FAL	Final action level
FFACO	*Federal Facility Agreement and Consent Order*
FIDLER	Field instrument for the detection of low-energy radiation
FSL	Field-screening level
FSR	Field-screening result
ft	Foot
GPS	Global Positioning System
GZ	Ground zero
HASL	Health and Safety Laboratory
HCA	High contamination area
HWAA	Hazardous waste accumulation area
IDW	Investigation-derived waste
in.	Inch
K	Potassium
K_d	Sorption coefficient
keV	Kiloelectron volt
LCL	Lower confidence limit
m	Meter
MDC	Minimum detectable concentration
mi	Mile

List of Acronyms and Abbreviations *(Continued)*

mL/g	Milliliters per gram
mm/yr	Millimeters per year
mrem/IA-yr	Millirem per Industrial Area year
mrem/OA-yr	Millirem per Occasional Use Area year
mrem/RW-yr	Millirem per Remote Work Area year
mrem/yr	Millirem per year
NAC	*Nevada Administrative Code*
NAD	North American Datum
NAEG	Nevada Applied Ecology Group
Nb	Niobium
NDEP	Nevada Division of Environmental Protection
NEPA	*National Environmental Policy Act*
NNSA/NFO	U.S. Department of Energy, National Nuclear Security Administration Nevada Field Office
NNSS	Nevada National Security Site
Np	Neptunium
NTS	Nevada Test Site
Pa	Protactinium
PAL	Preliminary action level
Pb	Lead
PCB	Polychlorinated biphenyl
pCi/g	Picocuries per gram
PET	Potential evapotranspiration
PPE	Personal protective equipment
PSM	Potential source material
Pu	Plutonium
PuCS	Plutonium-contaminated soils
QA	Quality assurance

List of Acronyms and Abbreviations *(Continued)*

QAP	Quality Assurance Plan
QC	Quality control
r^2	Coefficient of determination
RBCA	Risk-based corrective action
RCRA	*Resource Conservation and Recovery Act*
REOP	Real Estate/Operations Permit
RIDP	Radionuclide Inventory and Distribution Program
RI/FS	Remedial Investigation/Feasibility Study
RMA	Radioactive material area
RRMG	Residual radioactive material guideline
RWMS	Radioactive waste management site
SOW	Statement of Work
Sr	Strontium
SVOC	Semivolatile organic compound
Tc	Technetium
TED	Total effective dose
Th	Thorium
Tl	Thallium
TLD	Thermoluminescent dosimeter
TPH	Total petroleum hydrocarbons
TRS	Terrestrial radiological survey
TSCA	*Toxic Substances Control Act*
U	Uranium
UCL	Upper confidence limit
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
W5B	Well 5B

Executive Summary

Corrective Action Unit (CAU) 573 is located in Area 5 of the Nevada National Security Site, which is approximately 65 miles northwest of Las Vegas, Nevada. CAU 573 is a grouping of sites where there has been a suspected release of contamination associated with non-nuclear experiments and nuclear testing. This document describes the planned investigation of CAU 573, which comprises the following corrective action sites (CASs):

- 05-23-02, GMX Alpha Contaminated Area
- 05-45-01, Atmospheric Test Site - Hamilton

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 investigation report.

The sites will be investigated based on the data quality objectives (DQOs) developed on April 3, 2014, by representatives of the Nevada Division of Environmental Protection and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Field 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 573. The site investigation process will also be conducted in accordance with the *Soils Activity Quality Assurance Plan*, which establishes requirements, technical planning, and general quality practices to be applied to this activity.

The potential contamination sources associated with CASs 05-23-02 and 05-45-01 are from non-nuclear experiments and nuclear testing activities conducted at the GMX Alpha Contaminated Area and Atmospheric Test Site - Hamilton sites. The DQO process resulted in an assumption that total effective dose (TED) within a default contamination boundary exceeds the final action level FAL and requires corrective action. The presence and nature of contamination outside the default contamination boundary at CAU 573 will be evaluated based on information collected from a field investigation. Radiological contamination will be evaluated based on a comparison of the TED at sample locations to the dose-based final action level. The TED will be calculated as the total of

separate estimates of internal and external dose. Results from the analysis of soil samples will be used to calculate internal radiological dose. Thermoluminescent dosimeters placed at the center of each sample location will be used to measure external radiological dose.

Appendix A provides a detailed discussion of the DQO methodology and the DQOs specific to each CAS.

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 after the plan is approved.

1.0 Introduction

This Corrective Action Investigation Plan (CAIP) contains activity-specific information, including facility descriptions, environmental sample collection objectives, and criteria for conducting site investigation activities at Corrective Action Unit (CAU) 573: Alpha Contaminated Sites, Nevada National Security Site (NNSS), Nevada.

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

CAU 573 is located in Area 5 of the NNSS, which is approximately 65 miles (mi) northwest of Las Vegas, Nevada. CAU 573 comprises the two corrective action sites (CASs) shown on Figure 1-1 and listed in Table 1-1.

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

1.1 Purpose

The CASs in CAU 573 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.

1.1.1 CAU 573 History and Description

CAU 573, Alpha Contaminated Sites, consists of two inactive sites located in Area 5. The CAU 573 sites consist of releases of radionuclides to the soil surface from the conduct of aboveground

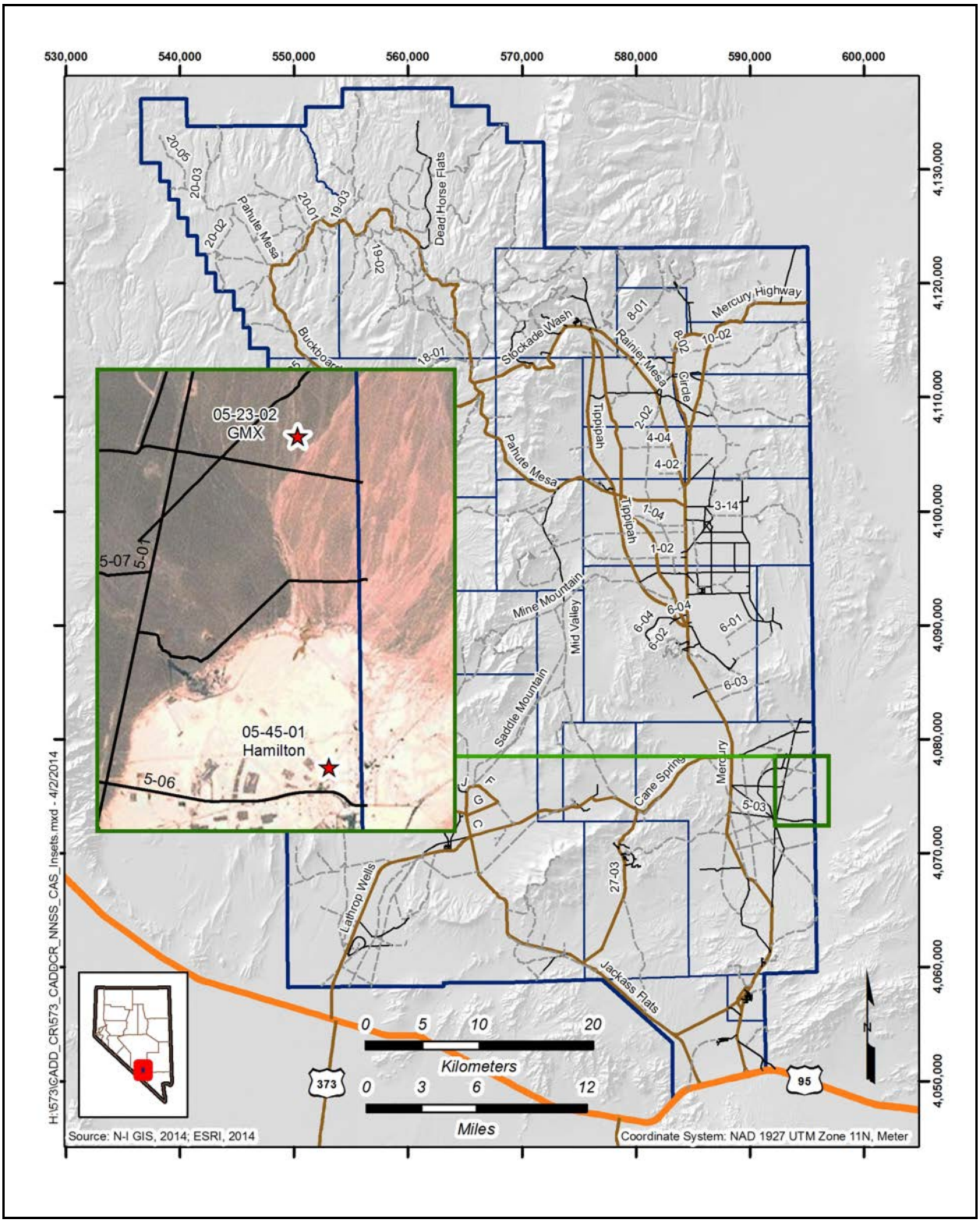

Figure 1-1
CAU 573 CAS Location Map

Table 1-1
CAU 573 CAS Information

CAS Number	CAS Description	Associated Tests	Site
05-23-02	GMX Alpha Contaminated Area	29 “equation of state” experiments	GMX Experimental Area
05-45-01	Atmospheric Test Site - Hamilton	50-ft tower test	Tf1 - Frenchman Flat

ft = Foot

non-nuclear experiments and nuclear testing in the 1950s. Operational histories for each CAU 573 site are detailed in Section 2.2.

Throughout the remainder of this document, CAS 05-23-02 will be referred to as “GMX,” and CAS 05-45-01 will be referred to as “Hamilton.”

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 Field Office (NNSA/NFO). DQOs are used to identify and define the type, amount, and quality of data needed to develop and evaluate appropriate corrective actions for CAU 573. This CAIP describes the investigative approach developed to collect the necessary data identified in the DQO process. Discussions of the DQO methodology and the DQOs specific to CAU 573 are presented in Appendix A. A summary of the DQO process is provided below.

The DQO problem statement for CAU 573 is as follows: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 573.” To address this problem, resolution of the decision statements presented in Section 3.4 is required. The informational inputs and data required to resolve the problem and decision statements were generated as part of the DQO process for this CAU and are documented in Appendix A.

A probabilistic sampling design will be used to collect samples from unbiased locations within an area that can be readily defined by distinct characteristics where the assumed distribution of contamination is relatively uniform. Results from these locations will be used to infer a characteristic representative of the sampled area as a whole (i.e., representing the average of the entire area, not the

maximum at any one location). The characteristic normally used to define contamination within an area is the 95 percent upper confidence limit (UCL) of the mean concentration or dose.

DQOs for CAU 573 defined similarities in conceptual site model (CSM) properties of several releases that would allow a common investigative approach (e.g., surface deposition of relatively immobile contaminants, migration and mixing of contaminants in drainage channels, or similarities in release sources such as weapons tests or safety experiments). Based on these similarities, study groups were established to simplify the planning and investigation of various releases.

The potential releases to be investigated in the CAU 573 CAI are grouped into study groups and assigned to CASs as presented in Table 1-2. While the need for corrective action is evaluated for each release, investigation strategies are defined at the study group level, and CAAs are implemented at the FFACO CAS level.

Table 1-2
CAU 573 Study Groups

Potential Release	Study Group	FFACO CASs
05-23-02, GMX Alpha Contaminated Area	GMX Study Group 1, Atmospheric Deposition	05-23-02
05-23-02, GMX Alpha Contaminated Area	GMX Study Group 2, Migration	
05-23-02, GMX Alpha Contaminated Area	GMX Study Group 3, Spills/Debris	
05-45-01, Atmospheric Test Site - Hamilton	Hamilton Study Group 1, Atmospheric Deposition	05-45-01
05-45-01, Atmospheric Test Site - Hamilton	Hamilton Study Group 2, Foxholes	
05-45-01, Atmospheric Test Site - Hamilton	Hamilton Study Group 3, Spills/Debris	

GMX Study Group 1 (Atmospheric Deposition): This release category is specific to the atmospheric deposition of radionuclide contamination and radioactive metallic fragments onto the soil surface that has not been displaced through excavation or migration. The contamination associated with this type of release will be limited to the top 5 centimeters (cm) of undisturbed soil. Atmospheric releases of radionuclides that have been distributed at the NNSS from nuclear testing have been found to be

concentrated in the upper 5 cm of undisturbed soil (McArthur and Kordas, 1983 and 1985; Gilbert et al., 1977; Tamura, 1977).

GMX Study Group 2 (Migration): This group investigates radionuclide contaminants that were initially deposited onto the soil surface, but have subsequently been displaced through migration or mechanical disturbance of the soil.

GMX Study Group 3 (Spills/Debris): This group investigates any chemical or radiological contamination associated with spills and/or debris. The debris will be evaluated for potential source material (PSM), and spills will be evaluated based on the presence of biasing factors such as discoloration or elevated instrument readings.

Hamilton Study Group 1 (Atmospheric Deposition): This release category is specific to the atmospheric deposition of radionuclide contamination comprised mainly of unfissioned nuclear material onto the soil surface. This contamination was initially deposited on the soil surface, but has been subject to mechanical disturbance and potential covering by subsequent depositional materials. The investigation for the contamination associated with this release will be limited to the top 30 cm of soil.

Hamilton Study Group 2 (Foxholes): This group investigates any radiological contamination associated with the foxholes that were present during testing. The area was scraped to remove the timbers that were used to cover the foxholes. The timbers can be seen in the debris pile present at the site. As the area was scraped, some of the surface soil is assumed to have filled in the foxholes. The foxholes nearest to ground zero (GZ) (one to the north and one to the south) will be investigated based on the CSM that contamination levels were higher near the GZ and generally decreased with distance. Subsurface soil samples will be collected from 60 cm below ground surface (bgs) and at the native soil interface for foxhole locations. If the native soil interface cannot be determined, a final depth sample will be collected from 120 cm bgs.

Hamilton Study Group 3 (Spills/Debris): This group investigates any chemical or radiological contamination associated with spills and/or debris. The debris will be evaluated for PSM, and spills will be evaluated based on the presence of biasing factors such as discoloration or elevated instrument readings.

The RBCA dose evaluation does not address the potential for removable contamination under different exposure scenarios if it were to be transported to other areas. A discussion on the risks associated with removable radioactive contamination is presented in the *Soils Risk-Based Corrective Action Evaluation Process* (NNSA/NFO, 2014). This discussion proposes a requirement for corrective action at areas that exceed high contamination area (HCA) criteria even though the area may not present a potential radiation dose to a receptor that exceeds the final action level (FAL). It is assumed that removable contamination that exceeds HCA criteria requires corrective action. Therefore, areas that exceed HCA criteria will be defined as default contamination boundaries (DCBs), and additional information is not normally collected during the CAI to evaluate contamination within these boundaries.

1.2 Scope

To generate information needed to resolve the decision statements identified in the DQO process, the scope of the CAI for CAU 573 includes the following activities:

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

Contamination of soil originating from activities not identified in the CSM 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 CAIP Contents

Section 1.0 presents the purpose and scope of this CAIP, while Section 2.0 provides background information about CAU 573. 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 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 *Soils Activity Quality Assurance Plan* (QAP) (NNSA/NSO, 2012b). The activity 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 activity organization. Appendix C contains responses to NDEP comments on the draft version of this document.

2.0 Facility Description

CAU 573 comprises two CASs located in Area 5 at the NNSS. Hamilton (CAS 05-45-01) is located on Frenchman Flat playa (dry) lake bed, while GMX (CAS 05-23-02) is nearby to the north in the Frenchman Flat basin in an area that gently slopes to the south toward the playa. Hamilton was a test detonated atop a 50-ft tower that created few fission products, while GMX was a series of 29 atmospheric tests that produced no fission products.

2.1 Physical Setting

The following subsections describe the general physical settings of Area 5 of the NNSS. General background information pertaining to topography, geology, hydrogeology, and climatology is provided for these specific areas of the NNSS region in the *Geologic Map of the Nevada Test Site, Southern Nevada* (Frizzell and Shulters, 1990); *CERCLA Preliminary Assessment of DOE's Nevada Operations Office Nuclear Weapons Testing Areas* (DRI, 1988); *Final Environmental Impact Statement, Nevada Test Site, Nye County, Nevada* (ERDA, 1977); and the *Final Environmental Impact Statement for the Nevada Test Site and Off-Site Locations in the State of Nevada* (DOE/NV, 1996).

GMX and Hamilton lie within the southern portion of the Frenchman Flat Hydrographic Area, a broad-lined closed basin surrounded by low-lying mountains that separate this area from the Mercury Valley Hydrographic Area to the south and from the Yucca Flat Hydrographic Area to the north (Laczniak et al., 1996). Erosion of the surrounding mountains has resulted in the accumulation of more than 1,000 ft of alluvial deposits in some areas of Frenchman Flat (DOE/NV, 1996).

Groundwater flow beneath the Frenchman Flat area occurs primarily within the carbonate-rock aquifer. Groundwater flow in this region of the aquifer is generally from the northeast to southwest. Within the overlying alluvial and volcanic aquifers, lateral groundwater flow occurs from the margins to the center of the basin, and downward into the carbonate-rock aquifer. The hydraulic gradient in most areas of the alluvial aquifer in Frenchman Flat is relatively flat (less than 1 foot per mile) except near active water wells and/or test wells (Hevesi et al., 2003). The average annual precipitation at rain gauge Well 5B (W5B), which is located near Frenchman Flat, is 4.85 inches (in.) (ARL/SORD,

2014). The Frenchman Flat unsaturated zone extends to approximately 600 ft bgs (Bright et al., 2001). Average annual potential evapotranspiration (PET) has been estimated for the Area 5 Radioactive Waste Management Site (RWMS) as 161.5 cm (Yucel, 2009). The nearest wells to GMX and Hamilton are UE-5 PW-1, UE-5n, and ER-5-4. The most recent recorded depth to the water table ranges between approximately 700 and 775 ft bgs at these wells (USGS and DOE, 2014).

2.1.1 GMX

The GMX site is located on the slopes of Frenchman Flat at mostly a 1 to 3 percent grade with a maximum 4 percent grade in the vicinity of the HCA, approximately 1.5 mi north of Frenchman Lake and 0.8 mi east of 5-01 Road. This release site is identified as the contaminated soil from the testing activities described in Section 2.4.1. According to documentation, these tests were conducted on or very near one GZ location (Lindahl, 1954). Engineering drawings indicate this location was outside and adjacent to the bunker located within the posted HCA (Silas Mason, 1954). Features associated with this site are shown in Figure 2-1. A large, oval-shaped area has been fenced and posted as a contamination area (CA) along with an attached “GMX” sign. The CA encloses an approximately 80-acre area, and an inner HCA encloses an approximately 1-acre area. An earth-covered bunker located adjacent to GZ with an open entry is present within the fenced HCA. Miscellaneous debris, such as scrap metal and wood, associated with testing activities is expected to be present at the site. The soil in this area consists of coarse alluvium and unconsolidated gravels.

2.1.2 Hamilton

The Hamilton site is centrally located on Frenchman Lake, approximately 1,000 ft north of 5-06 Road, and is within a low-lying area of the lake bed with no prominent drainages through the site. Following significant rain events, it is not uncommon for standing water to be present. The CAS at Hamilton is the contaminated soil from test activities. The Hamilton test area is identified by a posted CA encompassing approximately 1.5 acres. The area is also characterized by gravel blankets (gray rectangles), access roads and possible cable runs (linear features), patches of vegetation, and playa sediments (Figure 2-2). Within the CA are the GZ area and a large debris pile that consists of mounded soil, wood, concrete, and other miscellaneous items. This pile consists of the originally contaminated surface soils and materials remaining from the Hamilton test. Because of the large number of instrumentation stations and foxholes that were used in support of the Hamilton test and

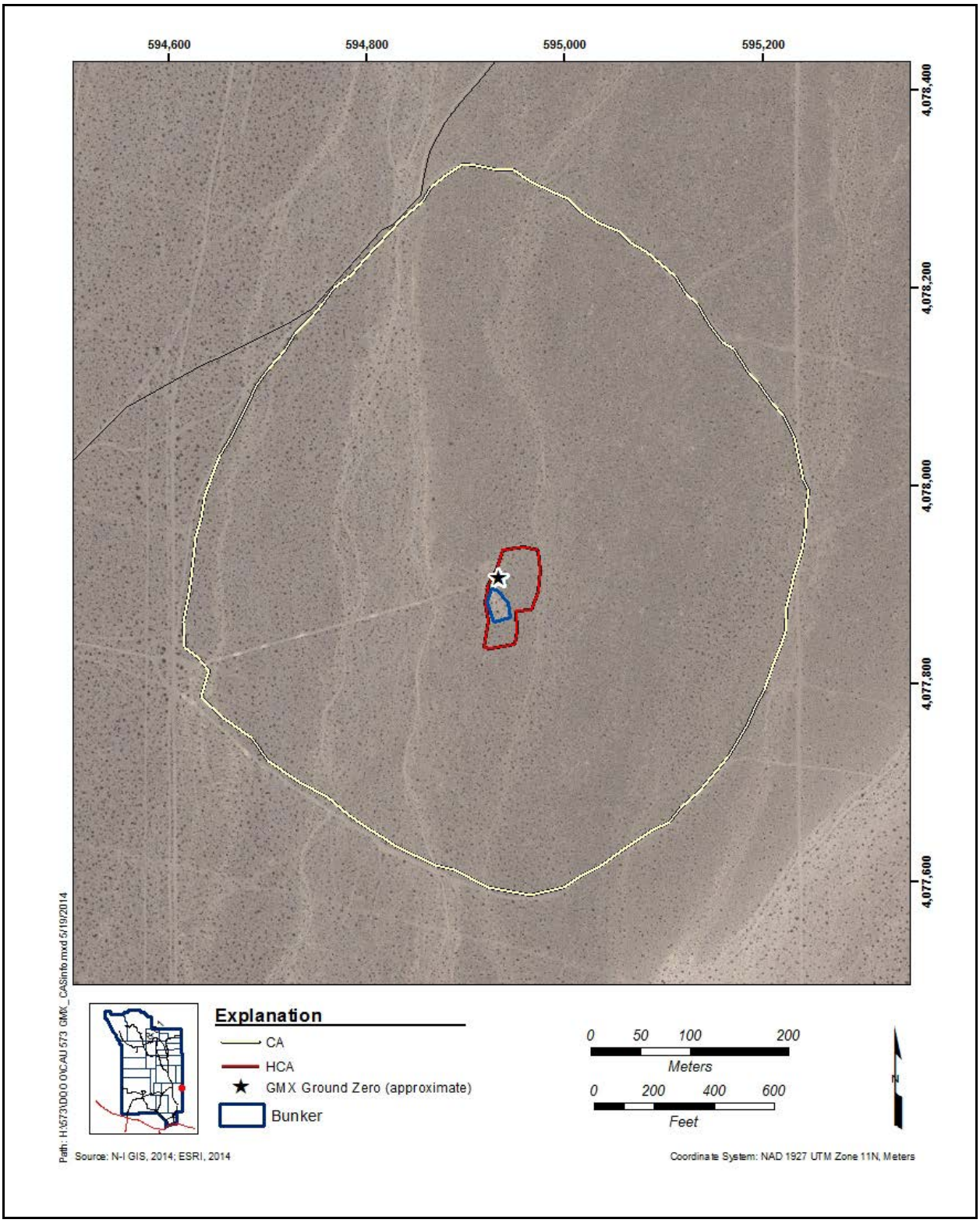

Figure 2-1
GMX Site Map

other tests in the area, there may be a significant amount of debris remaining at the site. The soil of the dry lake bed where Hamilton is located consists of hard-packed silt.

2.2 Operational History

The following subsections provide a description of the use and history of each site in CAU 573 that may have resulted in releases of contaminants to the environment. The site-specific summaries are designed to describe the releases associated with each CAS and document all significant, known activities.

2.2.1 CAS 05-23-02, GMX Alpha Contaminated Area

The GMX release is associated with the atmospheric deposition of radionuclides, primarily plutonium (Pu), to the surrounding surface soil from 29 “equation of state” experiments conducted at the site. Two of the 29 tests are listed as type “U-238,” 24 are listed as type “Pu,” and 3 are listed as type “non-active” (Malik, 1982). The Radionuclide Inventory and Distribution Program (RIDP) study estimated the quantity of Pu at the GMX site to be approximately 19 grams (DRI, 1989). These experiments were designed to examine the properties of Pu and uranium (U) when subjected to forces imposed using conventional explosives. Upon detonation of the explosives, the Pu and U targets disintegrated into small particles ranging in size from microscopic to fragments that can easily be seen with the naked eye. According to engineering drawings, these experiments were conducted on or very near one location outside and adjacent to the bunker located within the posted HCA (Silas Mason, 1954). The initial release of radionuclides from the GMX experiments was distributed in an elongated annular pattern centered over the bunker and HCA as shown in the 2011 FIDLER survey of the GMX area (Figure 2-6). The area inside the HCA was not included in the FIDLER TRS and was also not included in the subsequent analyses of the data. This survey detected the presence of discrete particles as well as a plume of continuous soil contamination as shown in Figure 2-7. To better define the soil contamination plume, the discrete point sources were removed from the survey data, and the remaining data were smoothed using a krieging technique. The resulting surface contamination plume is shown in Figure A.2-4. As shown in these figures, the contamination generally decreases with distance from the GZ, with the plume extending preferentially to the east and northeast.

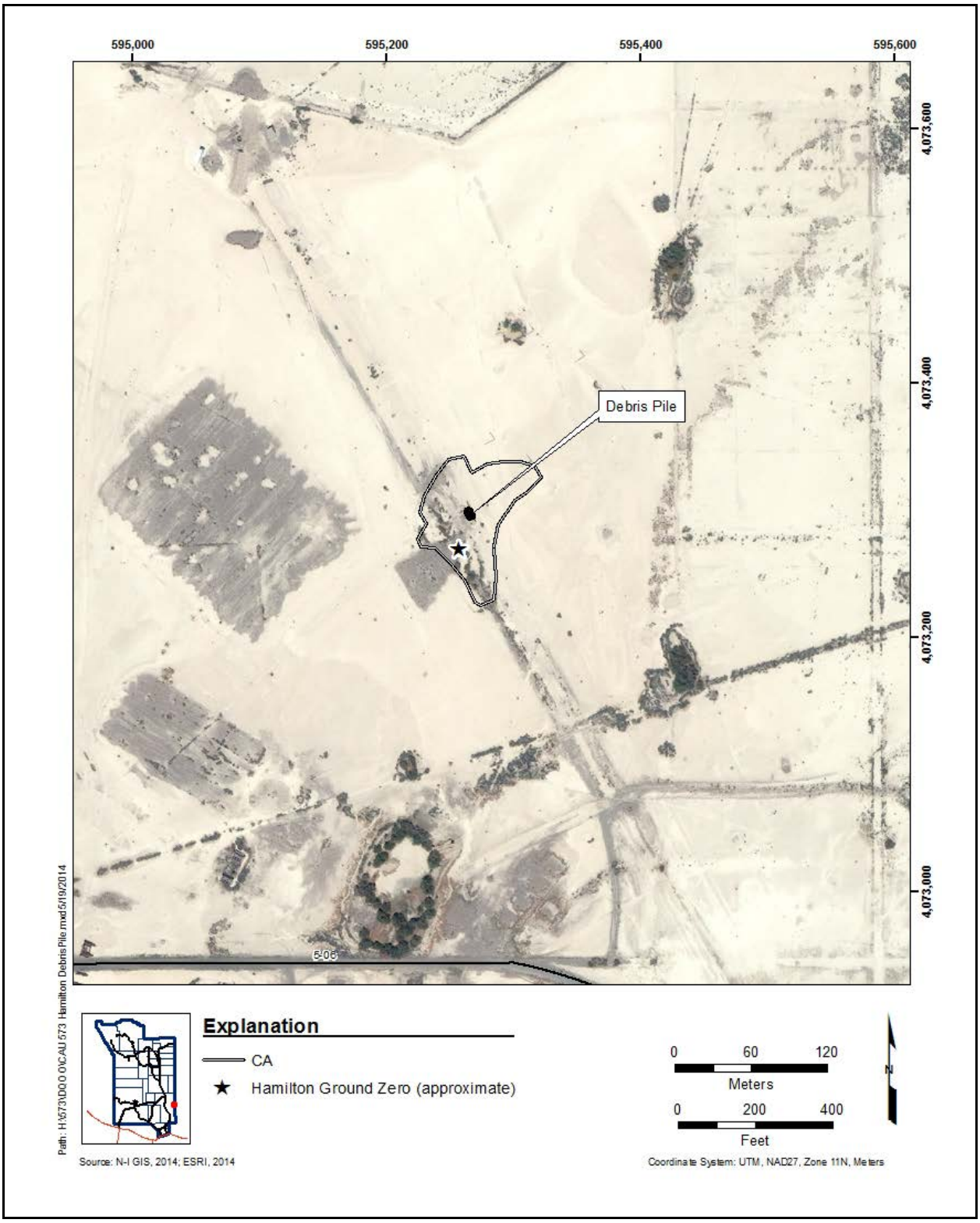

Figure 2-2
Hamilton Site Map

Based on observations from an aerial photograph, the only disturbed areas of the site appear to be the access road leading to the HCA and the area within the HCA (Figure 2-1). The experiments were observed through a periscope by cameras in the bunker (Malik, 1982). Additional uses of the bunker are unknown. According to the Remedial Investigation/Feasibility Study (RI/FS), decontamination of the test area began in 1956, consisting of shallow burial of Pu-contaminated clothing, scrap metals, and scrap wood near GZ (DOE/NV, 1992). The specific burial location is not stated, and no additional references were found for this information.

2.2.2 CAS 05-45-01, Atmospheric Test Site - Hamilton

Hamilton consists of the potential releases to the environment from the Hamilton atmospheric test conducted on October 15, 1958, on Frenchman Lake as part of Operation Hardtack II. Hamilton was a weapons-related tower test (sponsored by Lawrence Livermore National Laboratory) at a height of 50 ft (Maloney and Morgenthau, 1960) and had a yield of 1.2 tons (DOE/NV, 2000). The Hamilton test area is identified by a posted CA encompassing approximately 1.5 acres. Figure 2-2 shows several site features including gravel blankets (gray rectangles), access roads and possible cable runs (linear features), patches of vegetation, and playa sediments. Before detonation, personnel set up instrumentation for 11 U.S. Department of Defense (DoD) Effects Test Group projects (DTRA, 2007). On October 31, 1958, a memo was issued stating that the area surrounding Hamilton GZ within a 200-ft radius was contaminated with alpha and beta-gamma contamination (Wilcox, 1958). The contaminated surface soil was scraped together and relocated to existing foxholes and to other instrument holes and a large debris pile that is presently located within the posted CA that encompasses GZ. A second station (Station T-Fb) was originally planned to be a duplicate of the Hamilton test station (Station T-F1); however, that plan changed during construction, and the tower was dismantled and placed in storage (Holmes & Narver, 1959).

2.3 Waste Inventory

Available documentation, interviews with former site employees, process knowledge, and general historical NNSS practices were used to identify wastes that may be present. The potential wastes specific to each site are listed in the following subsections.

2.3.1 CAS 05-23-02, GMX Alpha Contaminated Area

Potential solid waste items at GMX include a small amount of scrap metal and miscellaneous wood, grout, wires, and plastic air samplers as identified during visual surveys. Additional wastes (e.g., depleted uranium [DU]- or Pu-impacted metal) have been identified within and surrounding the bunker located in the HCA as well as in the surrounding CA. According to the RI/FS, items including clothing, scrap metals, and scrap wood were often buried at Pu-contaminated sites. These materials may have been buried near GZ (DOE/NV, 1992).

2.3.2 CAS 05-45-01, Atmospheric Test Site - Hamilton

Potential solid waste items at Hamilton include americium (Am)- or Pu-impacted metal; miscellaneous metal, wood, and plastic; and other test-related construction materials such as cables, rope, concrete, and fencing along with a large debris pile as identified during visual surveys. The debris pile contains contaminated materials and soils scraped together after the Hamilton test.

2.4 Release Information

The releases of contamination to CAU 573 are directly or indirectly associated with the GMX "equation of state" experiments and the Hamilton nuclear weapons test. The investigation of specific releases at CAU 573 will depend upon the nature of these releases. Because of the unrelated nature of the tests and the distance between the GZs, each CAS will be investigated independently.

The sources of contamination for the CAU 573 CASs are the initial atmospheric deposition of radiological contaminants to surface soil as well as the subsequent movement or migration of radiological contaminants.

Surface and shallow subsurface soils are the impacted media at both sites. Exposure routes to receptors include ingestion and inhalation of radionuclides in surface and shallow subsurface soil (internal exposure). Site workers may also be exposed to direct radiation by performing activities in proximity to radiologically contaminated materials (i.e., external dose). Therefore, the CSM will include the potential for receptors to receive an internal dose from contaminated soil and an external dose from contaminated soil and debris.

The following subsections contain CAS-specific descriptions of known or suspected releases associated with CAU 573.

2.4.1 GMX

The source of radioactive contamination at GMX is the atmospheric deposition of radionuclides, primarily Pu metal, to the surrounding surface soil from the 29 “equation of state” experiments conducted at the site. These experiments measured the effects of conventional explosives on Pu and U, and resulted in the dispersal of contaminants throughout the area. The initial release of radionuclides from the GMX experiments was distributed in an elongated annular pattern centered over the HCA as illustrated in the 1994 radiological aerial survey (Figure 2-3).

Radioactive contaminants may be present within surface and shallow subsurface sediments in the nearby washes resulting from the subsequent migration of initially deposited radioactive contaminants. Migration may occur as stormwater runoff causes sheet and gully erosion at numerous small washes at the site. In addition to the contaminants relocated due to migration, the sources of other contamination that may be located throughout the CAS include DU and other abandoned wastes within and adjacent to the site bunker. If any other abandoned wastes that have spilled, leaked, been buried, or have the potential to release contaminants to the surface and shallow subsurface soil are identified during the investigation, they will be included in the scope of the CAU.

2.4.2 Hamilton

The source of radioactive contamination at Hamilton is the atmospheric deposition of radionuclides (e.g., fallout of fuel fragments, fission products, or neutron activation of soil) to the surface soil from the detonation of a weapons-related test with a 1.2-ton yield from a 50-ft tower (no longer present). Based on the aerial radiological survey (BN, 1999), contamination is generally distributed in an annular pattern centered over GZ (Figure 2-4). It is unknown whether this distribution pattern represents the initial surface contamination, or contaminated surface soil and materials that may have been subsequently cleaned up and/or relocated to the large debris pile located within the CA. The debris pile will be addressed as a release that was created due to excavation after the initial weapons test. It is also possible that the surface soil initially impacted by the Hamilton test has subsequently been buried by lake sedimentation that occurs when the dry lake bed fills with shallow water.

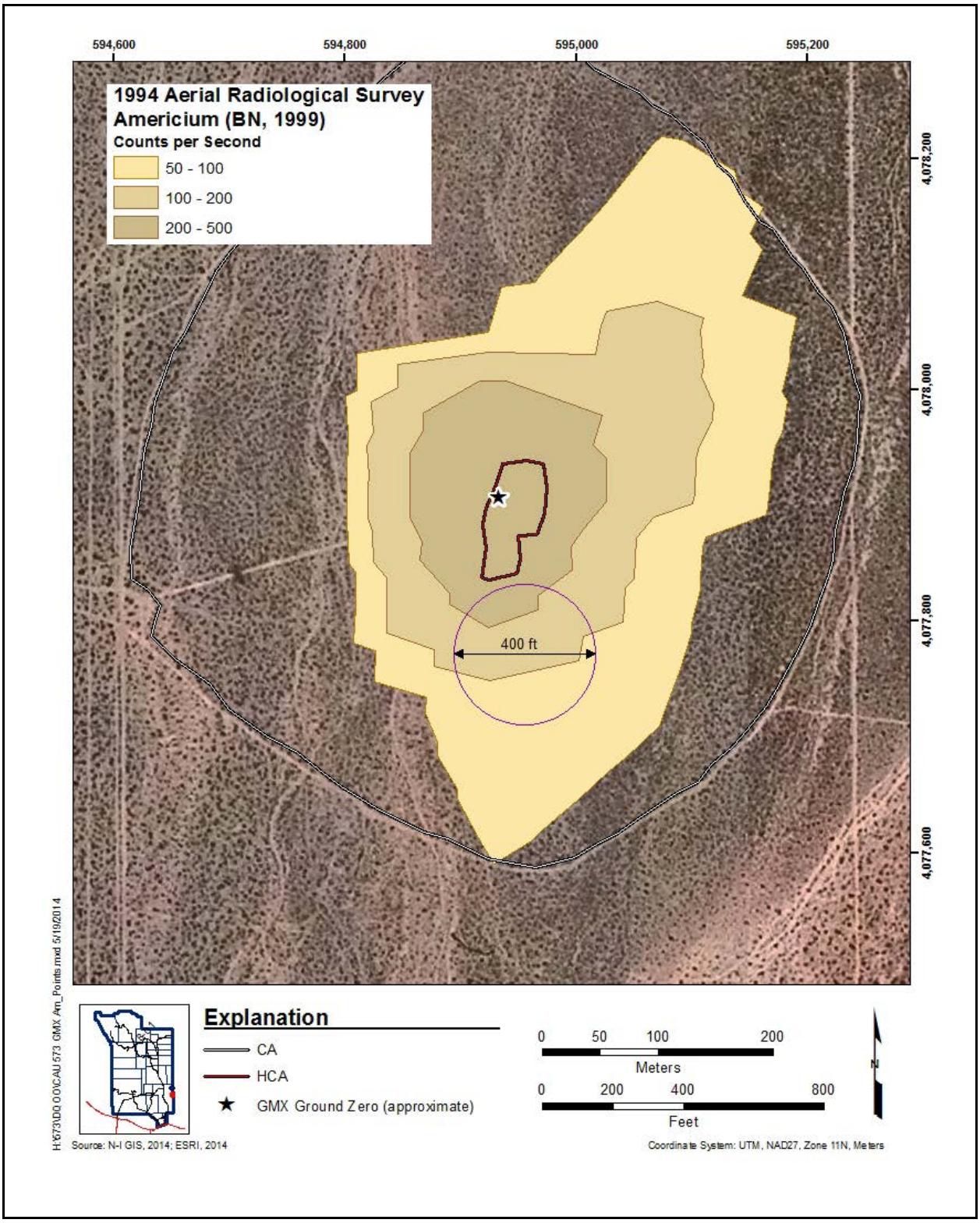

Figure 2-3
GMX Americium Aerial Survey

However, the initially impacted soil is expected to be near the surface. Additional potential release sources may include any abandoned wastes that have spilled, leaked, or have the potential to release contaminants to the surface and shallow subsurface soil.

2.5 Investigative Background

All previous investigation data are assessed in the planning phase to identify bias used in the selection of appropriate sampling locations. As part of an effort to assess the implications of contamination for future uses of the NNSS, the RIDP was established in 1981 to conduct a comprehensive survey of the important man-made radionuclides of NNSS origin in the NNSS surface soil (DRI, 1989). Data collected for the RIDP and by the Nevada Applied Ecology Group (NAEG) in the 1970s and 1980s allowed for estimates of surface soil inventories throughout the NNSS. The RIDP estimated the inventory through *in situ* soil measurements by gamma spectroscopy and limited confirmatory soil sampling. Also, the NAEG used statistical designs and soil sample analyses to estimate radionuclide inventories for select areas of the NNSS.

Aerial radiological surveys were flown in 1994 at both sites and in 2010 at the Hamilton site using radiological detection systems to identify gamma radiation (BN, 1999; NSTec, 2012). From the data collected, the gross count rates, man-made radiation, and Am-241 count rates were published for areas of the NNSS.

Ground-based field detection of Pu contamination in surface soils can be achieved via the detection of low-energy gamma rays that are emitted from the Am-241 present in the Pu as a daughter product. The isotopes of Pu primarily emit alpha radiation, which is hard to detect in soils under field conditions, while Am-241 can be readily detected in the field. Special radiation detectors that are optimized to sense the low-energy gamma rays of isotopes such as Am and to discriminate against other, higher-energy gamma rays must be used. The most common type is the field instrument for the detection of low-energy radiation (FIDLER).

In addition to the survey methods identified above, a variety of terrestrial radiation surveys (TRSs) were conducted in the CAU 573 area. Table 2-1 lists the method descriptions, advantages, limitations, spatial and spectral resolutions, measurement dates, and applied use for the different radiation surveys. Details of the surveys are also discussed in Sections 2.5.1 and 2.5.2.

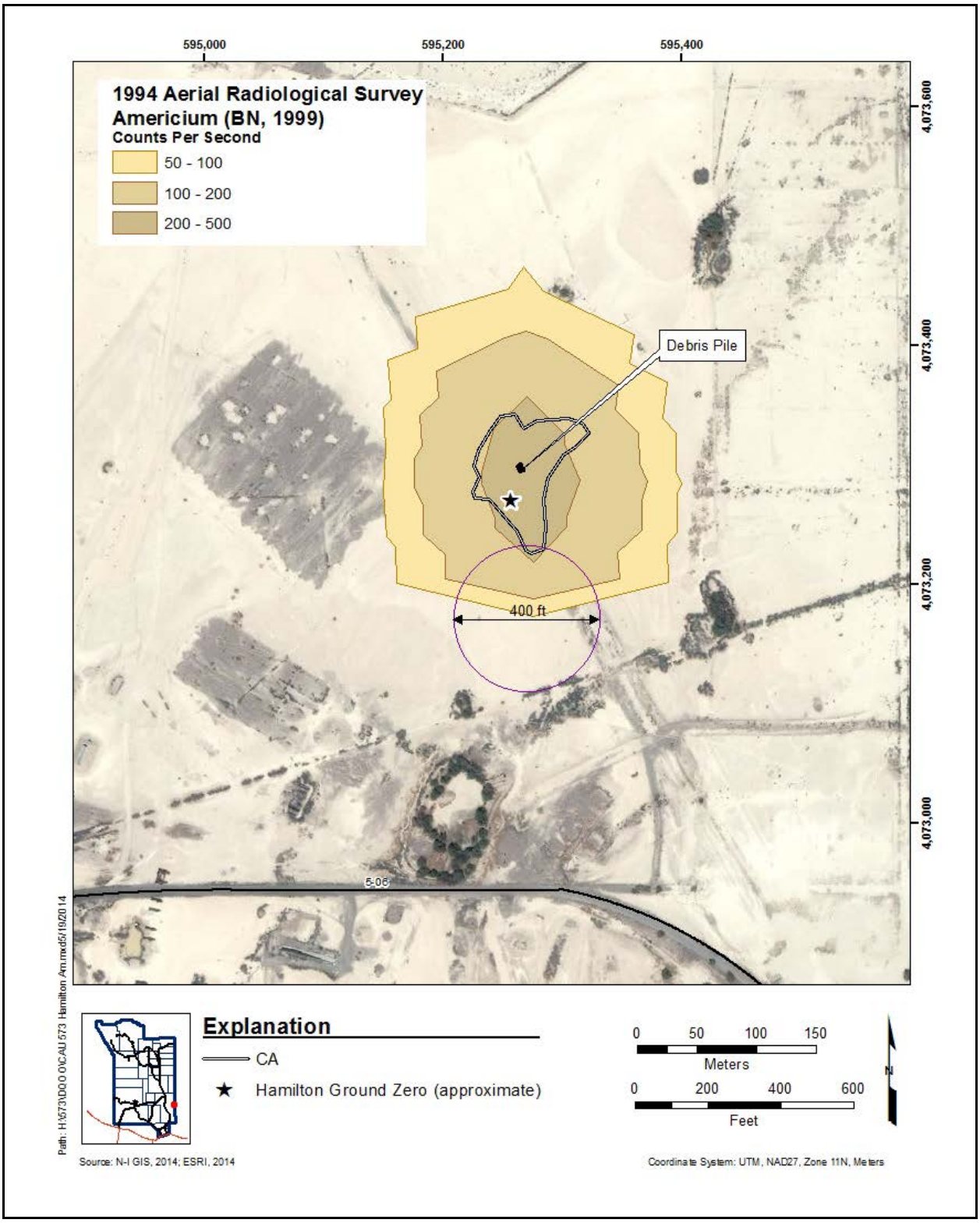

Figure 2-4
Hamilton Americium Aerial Survey

Table 2-1
Comparison of Radiation Survey Methods

	FIDLER	PRM-470	1994 Aerial Survey	2010 Aerial Survey
Method Description Summary	Ground-based instrument that detects low-energy gamma emissions	Ground-based organic plastic scintillator instrument that detects gamma emissions	Helicopter-mounted thallium-activated sodium iodide, gamma-ray scintillation detectors	Helicopter-mounted thallium-activated sodium iodide, gamma-ray scintillation detectors
Advantages and Limitations	Advantages: Lightweight hand-held instrument designed to see low-energy gamma emissions Limitations: Does not discriminate between low energy gamma emissions from different isotopes	Advantages: Lightweight hand-held instrument that detects gamma emissions Limitations: Does not distinguish between the radionuclides emitting the gamma emissions	Advantages: Gives a wide area of view (as opposed to ground-based surveys); can survey large areas quickly Limitations: Because it is elevated and moving at a fast rate, does not distinguish small localized areas of contamination or materials that are contaminated	Advantages: Gives a wide area of view (as opposed to ground-based surveys); can survey large areas quickly Limitations: Because it is elevated and moving at a fast rate, does not distinguish small localized areas of contamination or materials that are contaminated
Spatial Resolution	Held at ~6 in. above ground surface, has a small field of view	Held at ~1 m above ground surface, has a small field of view	Altitude: 60 m Line Spacing: 150 m 122-m diameter window	Altitude: 15 m Line Spacing: 30 m 30-m diameter window
Spectral Resolution	10 to 100 keV	All gamma emitters	38 to 3,026 keV	38 to 3,026 keV
Measurement Date	11/2010	08/2010	GMX - 1994 Hamilton - 1994	Hamilton - 2010
Applied Use	Energies in the 59-keV range, which are indicative of Am-241 or other higher-energy emitters; used to identify Am-241 contamination as an indicator of Pu contamination	Nondiscriminatory gamma count used to identify contamination from nuclear testing	For Am-241: Processed for energies in the 50- to 70-keV range (Am-241) relative to the 38- to 50-keV and 70- to 82-keV background windows. Used to identify Am-241 contamination as an indicator of Pu contamination. For man-made: Processed for energies in the 38- to 1,394-keV window relative to the 1,394- to 3,026 keV background window. Used to identify contamination from nuclear testing.	For Am-241: Processed for energies in the 57- to 70-keV range (Am-241) relative to the 38- to 50-keV and 70- to 82-keV background windows. Used to identify Am-241 contamination as an indicator of Pu contamination. 2010 data were subjected to additional processing to remove Europium contribution to Am-241 photopeak.

Source: N-I GIS, 2014; BN, 1999; Riedhauser, 1999; Buchheit and Marianno, 2005; TSA Systems, 2005

keV = Kiloelectron volt
m = Meter

Other investigations were performed in the vicinity of CAU 573 at surrounding CASs, as summarized in Table 2-2.

In accordance with the graded approach described in the Soils QAP (NNSA/NSO, 2012b), the quality required of a dataset will be determined by its intended use in decision making. TRS and aerial

Table 2-2
Surrounding CASs to CAU 573

CAS Description	CAS #	CAU #	Functional Category
306 GZ Rad Contamination Area	05-45-04	106	Craters
307 GZ Rad Contamination Area	05-45-05		Craters
Atmospheric Test Site - Able	05-23-05		Rad Contamination Area
Evaporation Pond (Cambric Ditch)	05-20-02		Injection Well
Kay Blockhouse	05-33-01	204	Building
Chemical Explosives Storage (Sugar Bunker)	05-18-02		Magazine/Bunker
Atmospheric Test Site - Small Boy	05-45-03	541	Rad Contamination Area
Atmospheric Tests (6) - BFa Site	05-23-04		Rad Contamination Area

radiological survey data are classified as decision supporting and are not used, by themselves, to make corrective action decisions. However, the radiation surveys are used to identify bias used in the selection of sample locations and will be evaluated for use in defining corrective action boundaries in the investigation report. For defining corrective action boundaries, the radiation surveys will be used only in terms of defining a relative spatial distribution of contamination.

2.5.1 GMX

Previous investigations that produced data relevant to the CAI at GMX include the surface soil inventory studies by the RIDP and the NAEG, 1994 aerial radiological survey, the 1992 RI/FS, and the CAU 573 preliminary investigation.

2.5.1.1 RIDP and NAEG Data

Data collected for the RIDP and by NAEG allowed for estimates of surface soil inventories from the GMX area. The locations and Pu-239 activities (up to 639 picocuries per gram [pCi/g]) from RIDP *in situ* measurements are shown in Figure 2-5, and the reported inventory estimates for GMX are shown in Table 2-3 (DRI, 1989). In addition to the RIDP data, several studies were conducted by the NAEG between 1975 and 1985 (Essington et al., 1975; Gilbert 1977; Gilbert and Eberhardt, 1978; Essington, 1985a and b). These studies conclude that 95 percent of total inventory of Pu at GMX

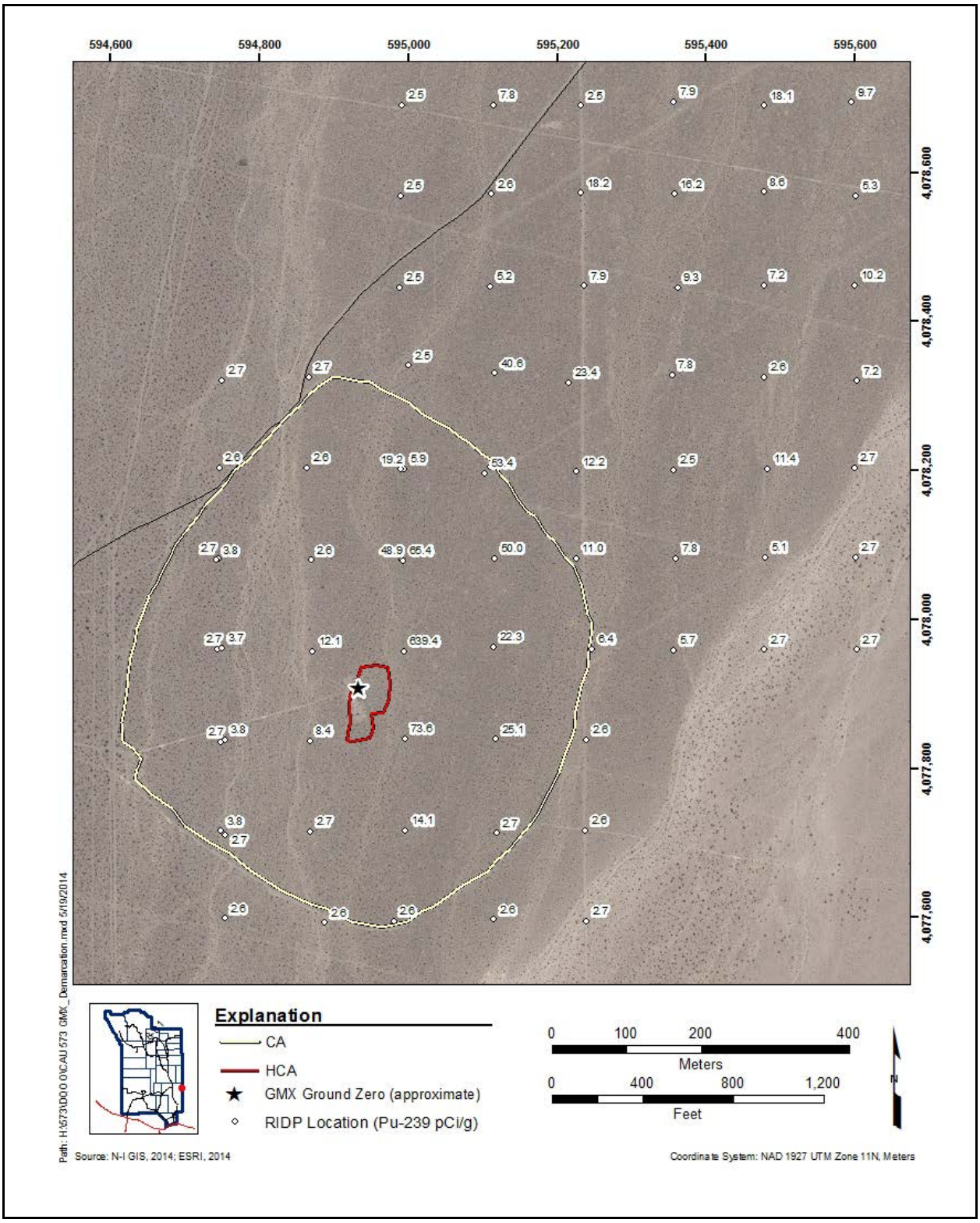

Figure 2-5
GMX RIDP Data (Pu-239) in pCi/g

Table 2-3
RIDP Surface Soil Inventory for GMX

Radionuclide	Surface Soil Inventory (Ci)
Am-241	0.20
Pu-238	0.028
Pu-239/240	1.4
Cs-137	0.026
Sr-90	0.015

Ci = Curie
Cs = Cesium
Sr = Strontium

resides in the top 5 cm of the soil profile (Essington et al., 1975), and the highest concentrations of Pu-239/240 are found slightly northeast of GZ (activities up to 3,500 pCi/g) (Gilbert et al., 1975).

2.5.1.2 Aerial Radiological Surveys

Results from the 1994 aerial radiological survey (flown at an elevation of 200 ft, which resulted in a field of view for each point on the ground surface of a 400-ft-diameter circle) show Am-241 count rates within the posted CA (and inner HCA) ranging from 50 to 500 counts per second (cps). The spatial distribution of the Am-241 data is depicted in Figure 2-3 as isopleths with an elongated pattern that may provide information regarding the radioactive contaminant plume. There was no distinguishable gamma gross count plume associated with GMX (BN, 1999).

2.5.1.3 RI/FS Data

In 1992, DOE prepared an RI/FS Work Plan for Plutonium-Contaminated Soils (PuCS) sites (DOE/NV, 1992). The RI/FS Work Plan established the objectives, procedures, tasks, and schedule for conducting an RI/FS at several PuCS sites, including the GMX site. The RI/FS Work Plan was written under the *Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA) regulatory framework before the FFACO was established in 1996, and the PuCS sites subsequently became CASs in the FFACO to be investigated under the corrective action process.

2.5.1.4 Preliminary Investigation

As part of preliminary investigative work conducted at the GMX site in 2011, a TRS with a FIDLER was completed. The FIDLER TRS was conducted with the sensor held about 12 in. above the ground surface, which results in a nominal field of view for each point of 24-in. The limited field of view provides for a much greater resolution than the aerial surveys in identifying the location of the contamination. Figure 2-6 displays the results of TRS and the 1994 aerial survey. A three-dimensional (3-D) representation of the FIDLER survey is displayed in Figure 2-7. This figure shows the point sources present in the areas surveyed, some of which were discontinuous to the contamination plume. These point sources were not detected in the aerial survey reported in Section 2.5.1.2 due to the larger field of view.

The point sources that were located outside the posted CA during the FIDLER TRS were picked up and relocated within the CA. Some of the point sources were found on the surface, while others were located as much as 4 in. bgs. These point sources ranged in size from 1/8 to 1 in. in diameter.

The preliminary investigation also included a visual inspection, which revealed several other pieces of debris.

2.5.2 Hamilton

Previous investigations that produced data relevant to the CAI at Hamilton include the RIDP, Nevada Test Site (NTS) Radiological Assessment Project, aerial radiological surveys, and the preliminary investigation.

2.5.2.1 RIDP

The Hamilton site was included in the collection of RIDP data for the Frenchman Lake. Figure 2-8 shows the locations of *in situ* Pu-239 measurements in pCi/g from Frenchman Lake in the vicinity of Hamilton. Of the sample locations collected from the Frenchman Lake region, only four sample locations were located within 100 m of the Hamilton GZ. The reported Pu-239 values for these four locations ranged from 24.3 to 124.4 pCi/g. Radionuclide concentrations for other radioactive contaminants are reported in Appendix B of the RIDP report (DRI, 1989).

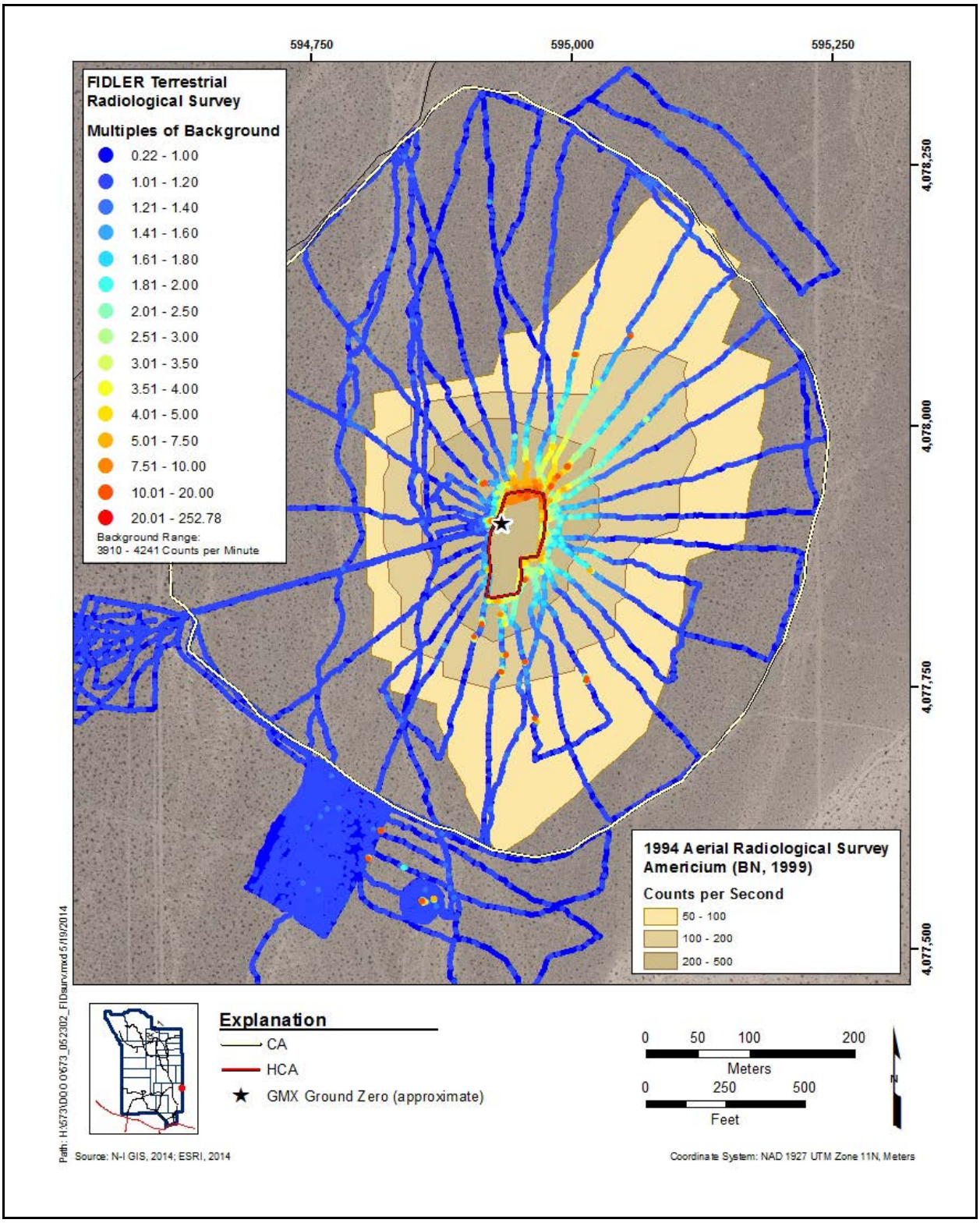

Figure 2-6
GMX FIDLER Data with Aerial Survey

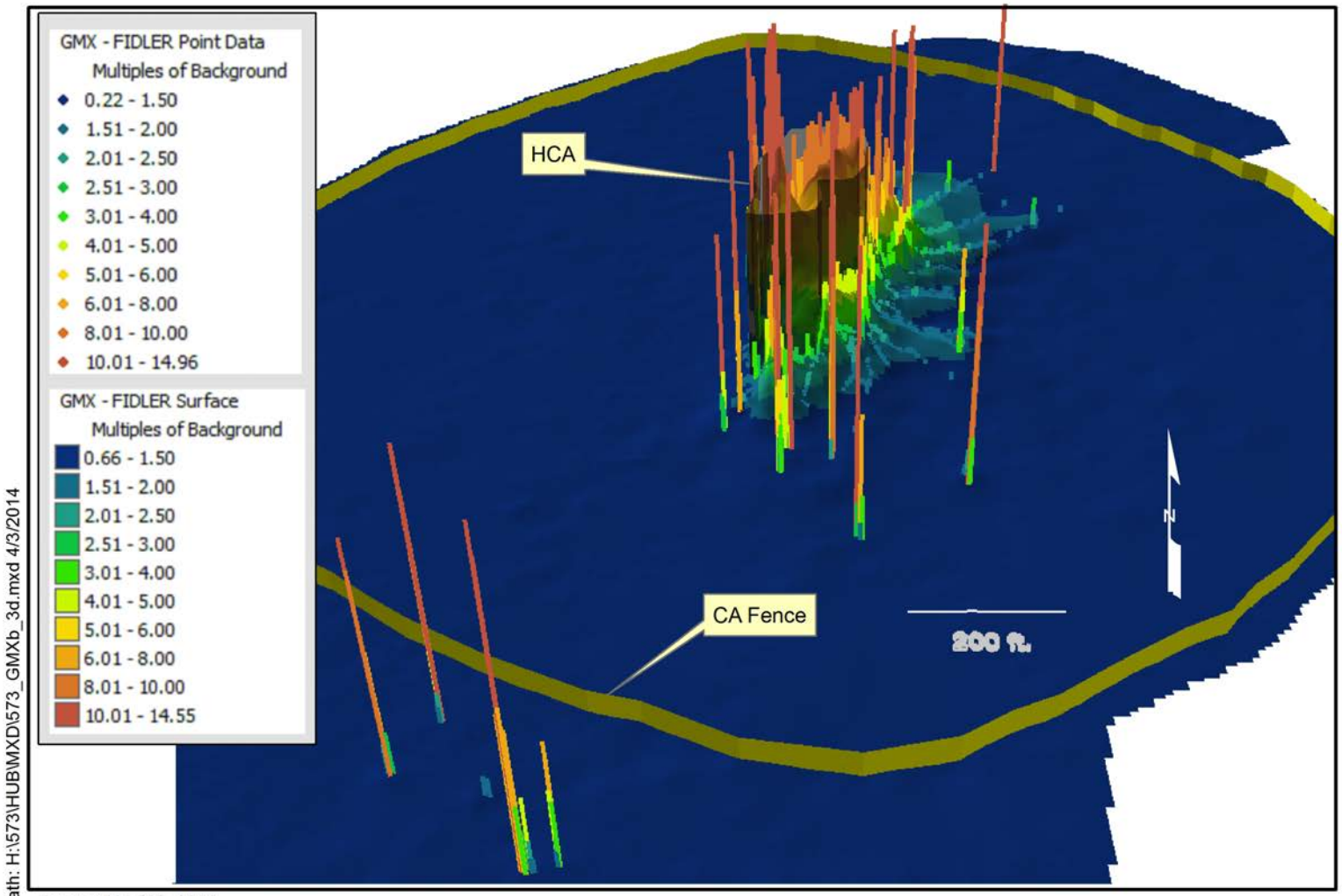

Figure 2-7
3-D Representation of 2011 GMX FIDLER Data

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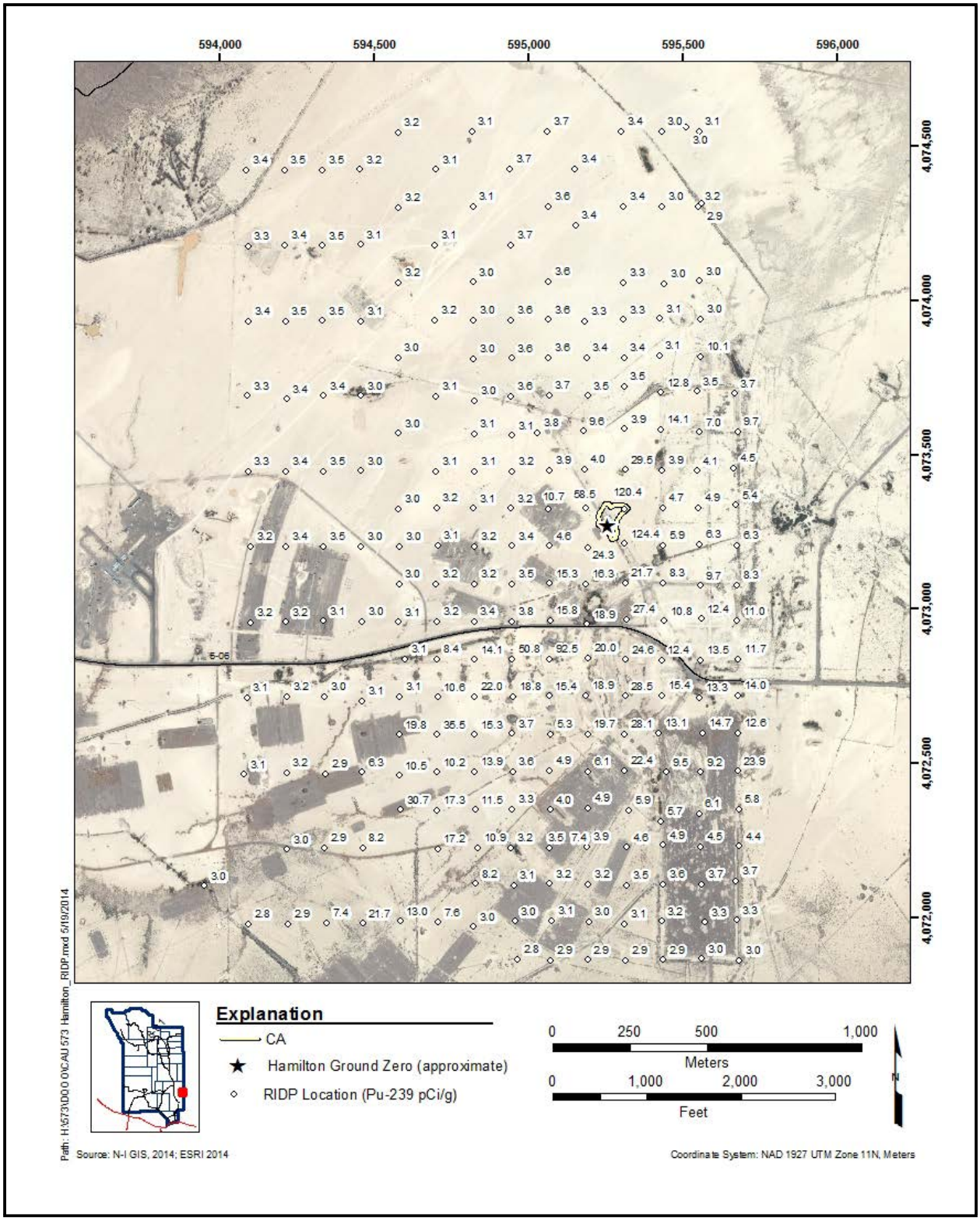

Figure 2-8
Hamilton RIDP Data (Pu-239) in pCi/g

2.5.2.2 NTS Radiological Assessment Project

A radiological characterization study of the Frenchman Lake region was conducted as part of the NTS Radiological Assessment Project and included the Hamilton site (Barnes et al., 1980). Between March 1978 and April 1979, 121 samples were collected at the Hamilton site, and the results are presented on contour maps showing isopleths of activity (pCi/g) for Am-241 and Pu-239. The maps show estimates of Am-241 activities up to 50 pCi/g (Figure 2-9) and Pu-239 activities up to 400 pCi/g (Figure 2-10) (Barnes et al., 1980). Individual sample results are not reported.

2.5.2.3 An Aerial Radiological Survey of the NTS

The 1994 aerial radiological survey was flown at an elevation of 200 ft above ground surface, which provided the sensors a nominal field of view of approximately 400 ft (BN, 1999). The 2010 aerial radiological survey was flown at an elevation of 50 ft above ground surface, which provided the sensors a nominal field of view of approximately 100 ft (NSTec, 2012). Figure 2-11 displays a comparison of results from the 1994 and 2010 aerial Am surveys. The counts per second values shown for the two surveys are not directly comparable due to differences in the instrumentation used. The greater resolution provided by the 2010 aerial survey resulted in a smaller, more refined shape of the Am/Pu contaminated area than that of the 1994 aerial survey. This pattern provides information regarding the surface soil contamination as well as the influence from the large debris pile located within the CA. The radiological aerial survey results show no distinguishable gross gamma count isopleths associated with Hamilton.

2.5.2.4 Preliminary Investigation

As part of preliminary investigative work conducted at the Hamilton site in 2011, a TRS with a FIDLER was completed. The FIDLER TRS was conducted with the sensor held about 12 in. above the ground surface, which results in a nominal field of view of approximately 2 ft in diameter. The smaller field of view provides for a much greater resolution than the aerial surveys as illustrated in Figure 2-12. The greater resolution provided by the FIDLER survey identified discrete point sources as well as more continuous contamination. A 3-D representation of the FIDLER survey is displayed in Figure 2-13. This figure shows the point sources present in the areas surveyed, some of which were

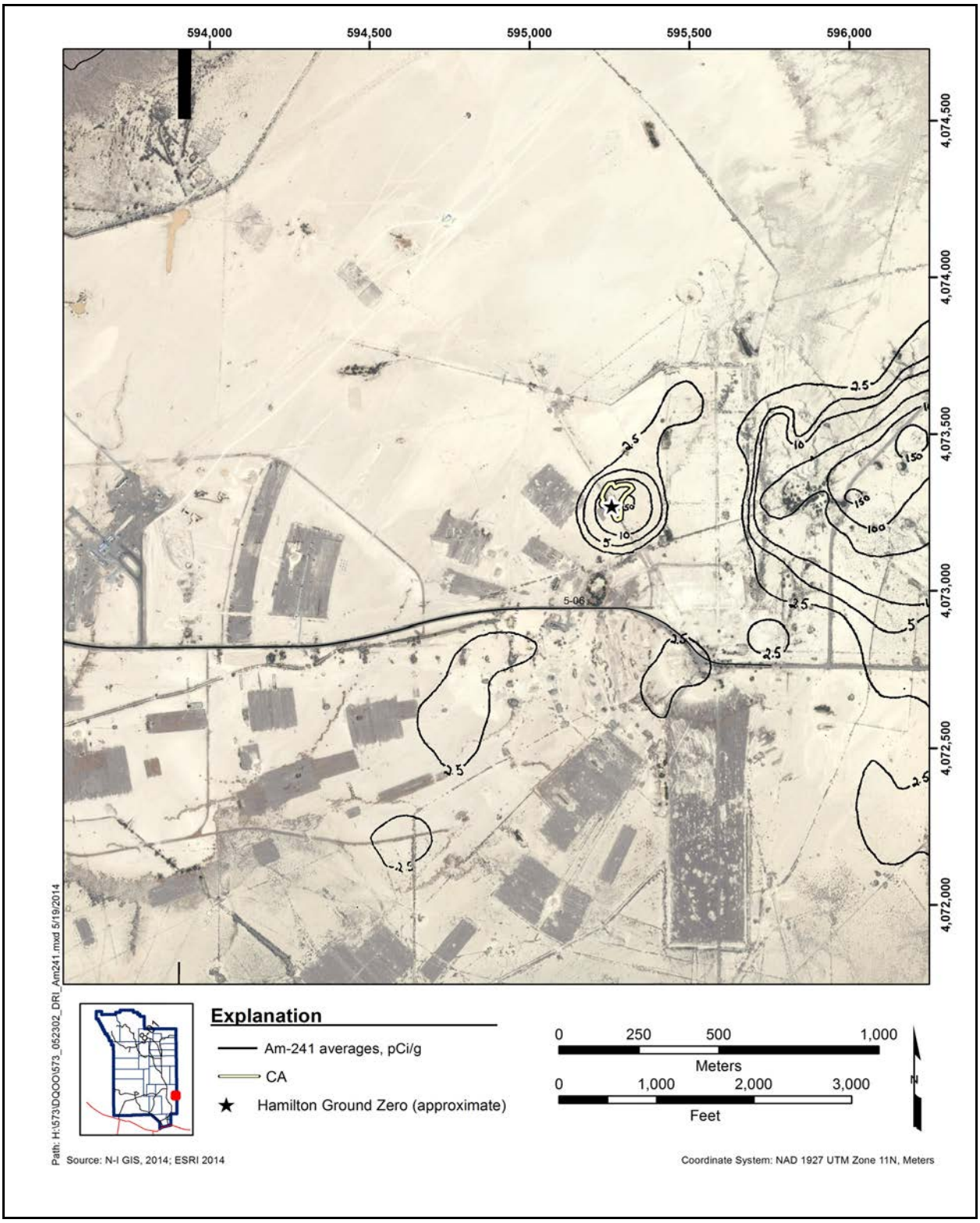

Figure 2-9
NTS Radiological Assessment Project (Am-241) in pCi/g

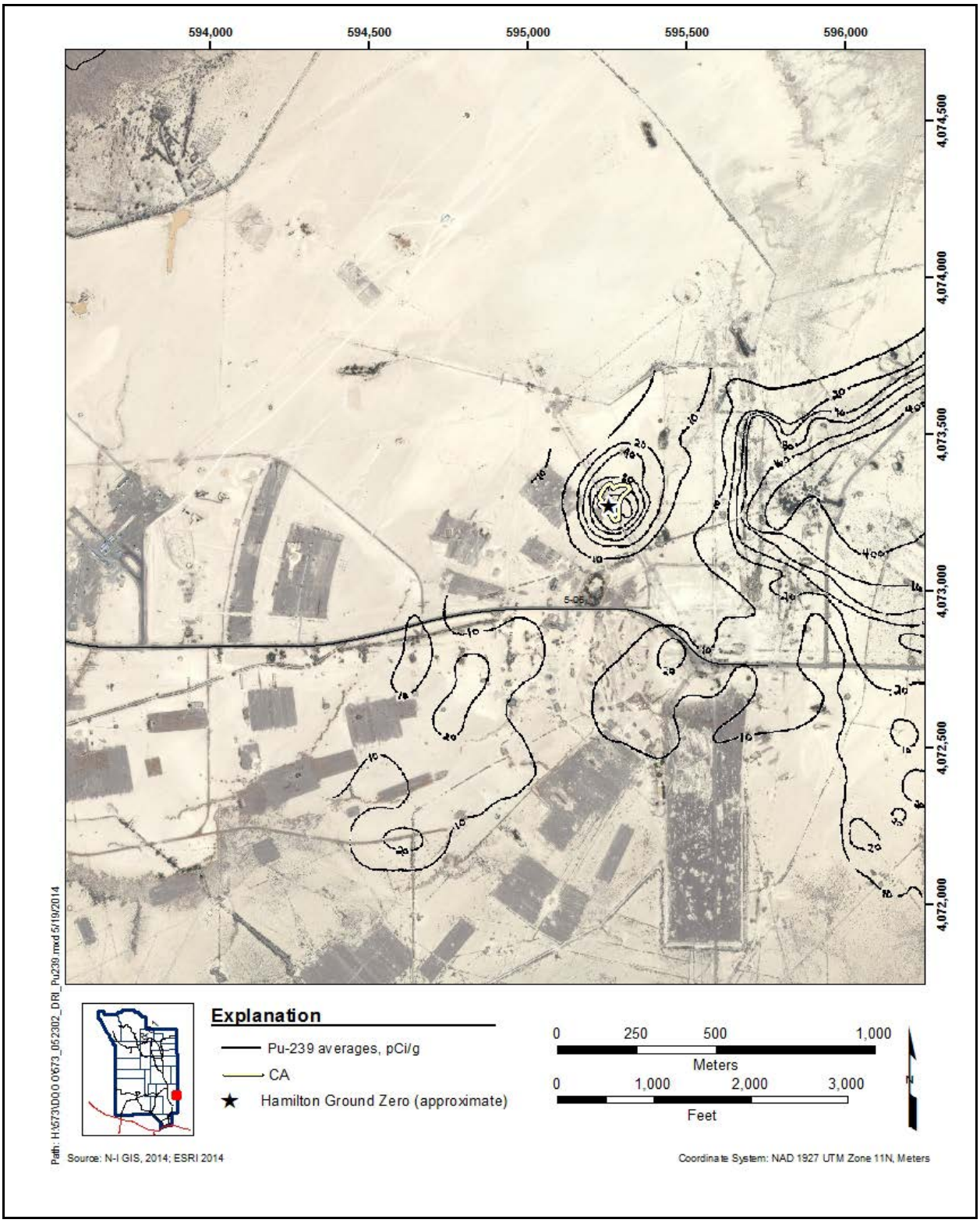

Figure 2-10
NTS Radiological Assessment Project (Pu-239) in pCi/g

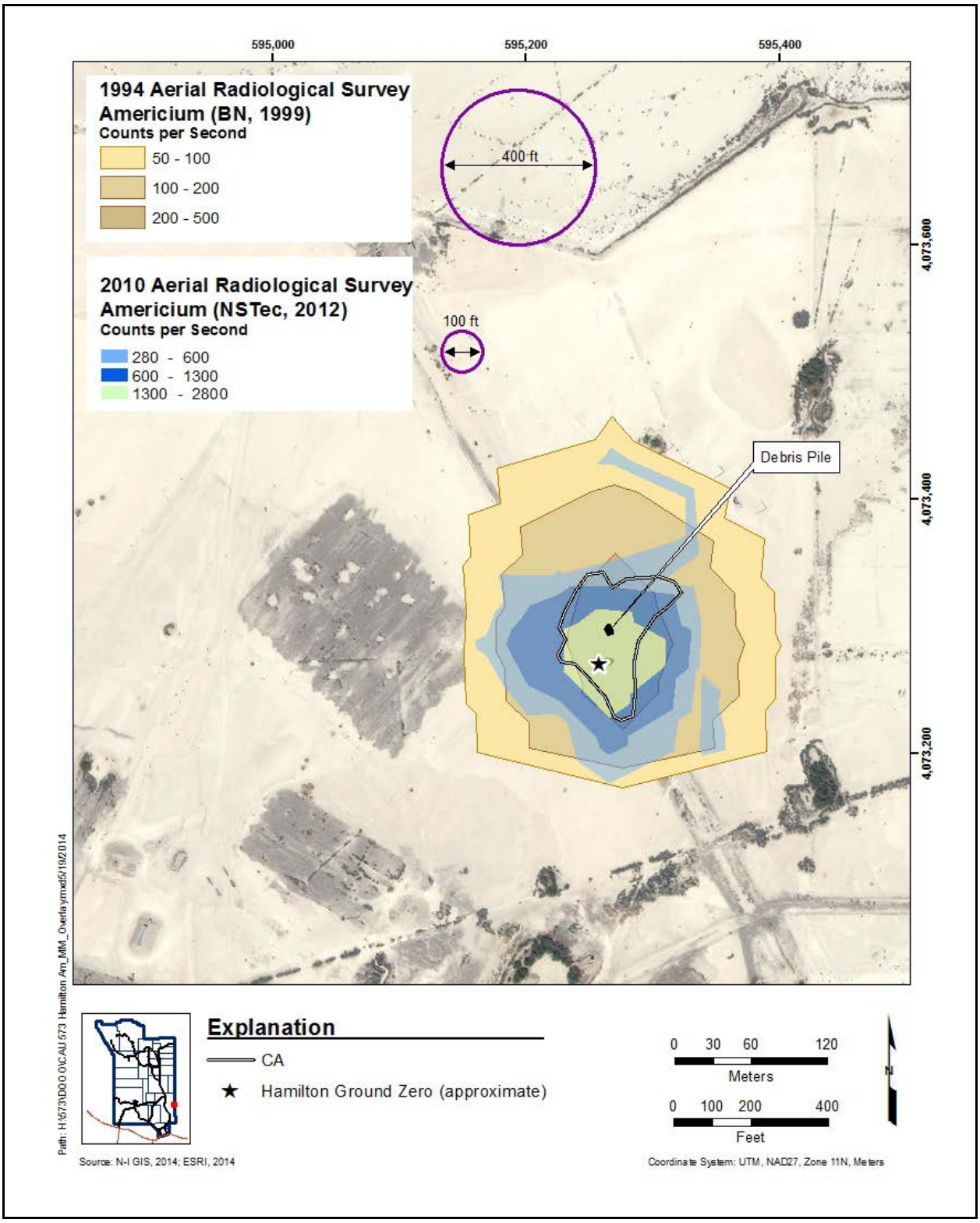

Figure 2-11
Hamilton 2010 Aerial Survey Data with 1994 Aerial Survey Data Background

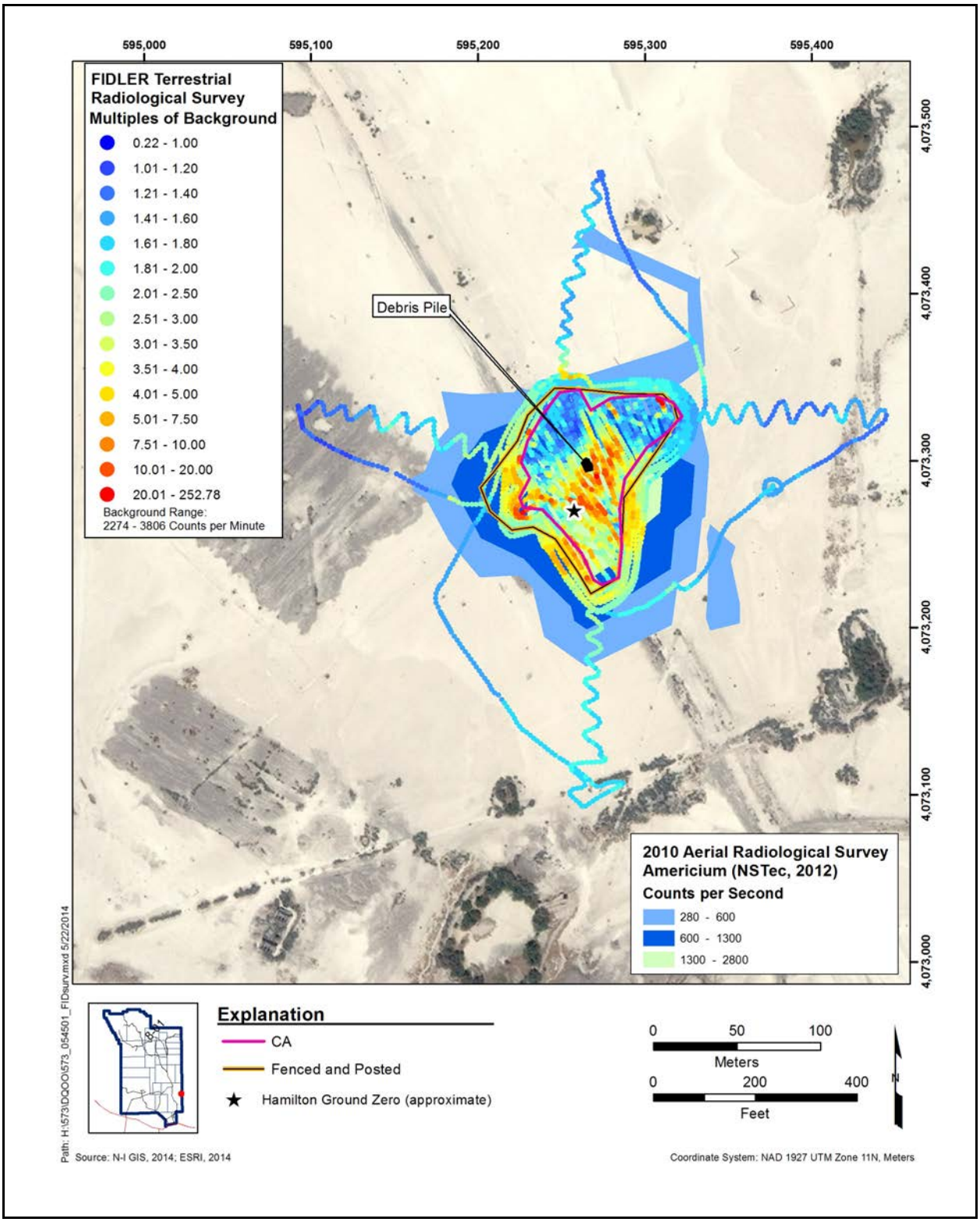

Figure 2-12
Hamilton FIDLER Data with 2010 Aerial Survey Background

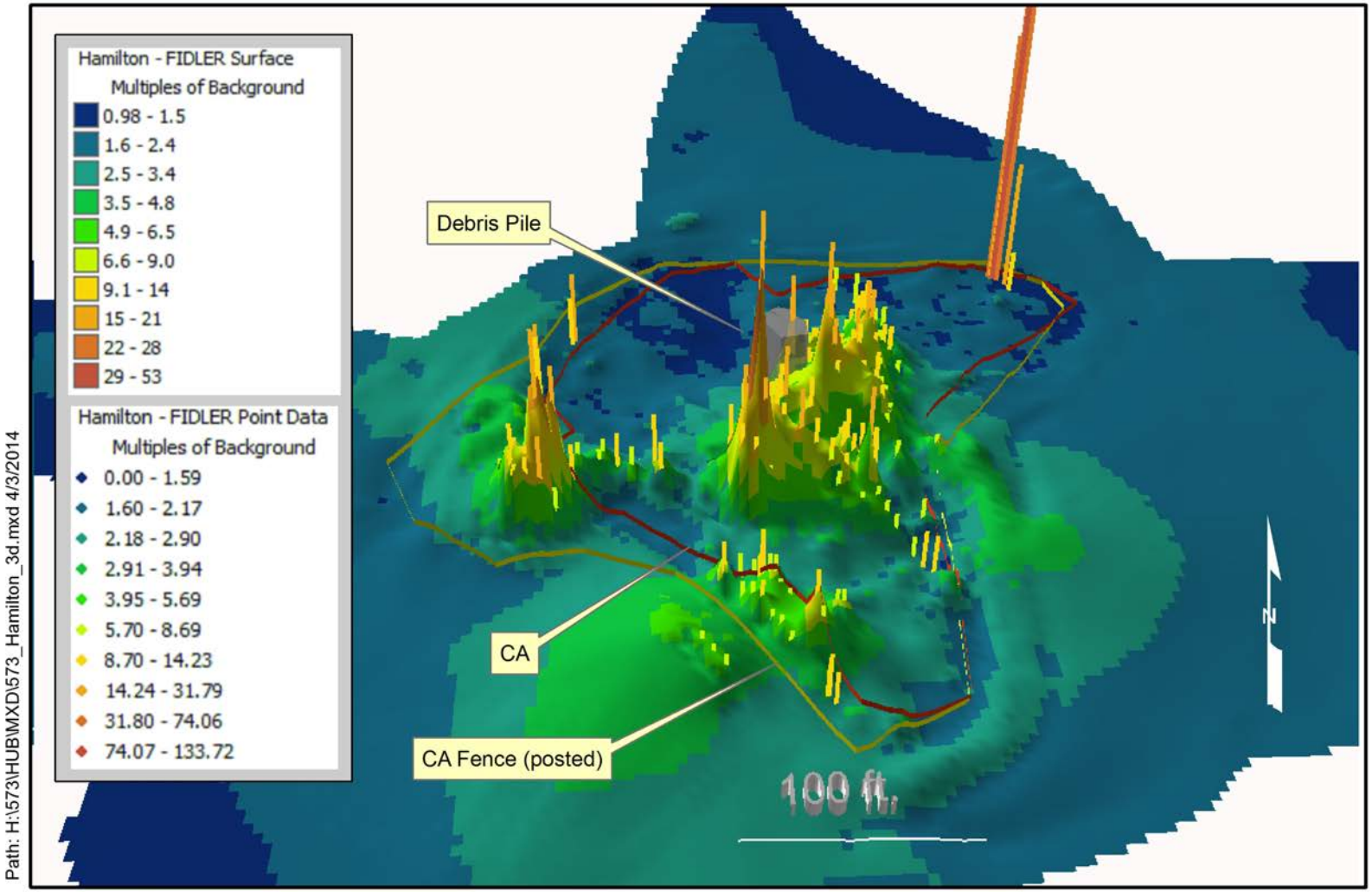

Figure 2-13
3-D Representation of 2011 Hamilton FIDLER Data

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discontinuous to the contamination plume. These point sources were not detected in the aerial survey reported in Section 2.5.1.2 due to the larger field of view.

The point sources that were located outside the posted CA as a result of the FIDLER TRS were picked up and relocated within the CA as a best management practice (BMP). The point sources were located primarily on the surface and ranged in size from small gravel-sized pieces to pieces of twisted metal as large as 2 in. in length. The exact FIDLER reading for each point source was not recorded but in most cases exceeded the detection limit of the meter.

The preliminary investigation also included a visual inspection, which revealed several pieces of debris.

2.5.3 National Environmental Policy Act

The *Final Site-Wide 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 573.

In accordance with the NNSA/NFO *National Environmental Policy Act* (NEPA) Compliance Program, a NEPA checklist will be completed before beginning site investigation activities at CAU 573. This checklist requires NNSA/NFO activity personnel to evaluate their proposed 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/NFO 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 573 and formulation of the CSM. Also presented is a summary listing of the contaminants of potential concern (COPCs), the preliminary action levels (PALs), and the process used to establish FALs. Additional details and figures depicting the CSM are located in Appendix A.

3.1 Conceptual Site Model

The CSM describes the most probable scenario for current conditions at each site and defines the assumptions that are the basis for identifying the future land use, contaminant sources, release mechanisms, migration pathways, exposure points, and exposure routes. The CSM was used to develop appropriate sampling strategies and data collection methods. The CSM was developed for CAU 573 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 soil and COPCs. Figure A.2-1 depicts a representation of the conceptual pathways to receptors from CAU 573 sources. Figures A.2-2 and A.2-3 depict graphical representations of the CSMs at GMX and Hamilton, respectively. If evidence of contamination that is not consistent with the presented CSM is identified during investigation activities, the situation will be reviewed, the CSM will be revised, the DQOs will be reassessed, and a recommendation will be made as to how best to proceed. In such cases, decision makers listed in Section A.2.1 will be notified and given the opportunity to comment on and/or concur with the recommendation.

The following subsections 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 573.

3.1.1 Land-Use and Exposure Scenarios

GMX is located in the land-use zone described as “Reserved” within the NNSS. 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).

Hamilton is located in the land-use zone described as the "Research, Test, and Experiment Zone." This area is designated for small-scale research and development projects and demonstrations; pilot projects; outdoor tests; and experiments for the development, QA, or reliability of material and equipment under controlled conditions. This zone includes compatible research, development, and testing activities (DOE/NV, 1998).

Exposure scenarios for the CAU 573 sites have been categorized into the following three types based on current and projected future land uses:

- **Industrial Area.** This scenario is based on industrial workers at established work facilities where the worker has a permanent assigned work area. This scenario assumes the worker will be on the site for an entire career (8 hours per day, 250 days per year, for 25 years). The industrial worker is assumed to spend one-third of the workday outdoors exposed to contaminated soil. The total effective dose (TED) calculated using this exposure scenario is the dose an industrial worker receives during 2,000 hours of annual exposure to site contaminants and is expressed in terms of millirem per Industrial Area year (mrem/IA-yr).

- **Remote Work Area.** This exposure scenario has the same basis as the Industrial Area scenario except that the industrial worker is not present at the work site for the entire year. This scenario assumes that the Remote Work Area has established work facilities where the worker regularly visits but is not a permanent assigned work area. A site worker under this scenario is assumed to be at the site for an equivalent of 8 hours per day, 42 days per year, for 25 years. The industrial worker is assumed to spend one-third of the workday outdoors exposed to contaminated soil. The TED calculated using this exposure scenario is the dose a remote area worker receives during 336 hours of annual exposure to site radioactivity and is expressed in terms of millirem per Remote Work Area year (mrem/RW-yr).

- **Occasional Use Area.** This scenario is based on industrial workers at locations where there are no established work facilities in an area where the worker does not regularly visit but may occasionally use for short-term activities. This scenario assumes the worker will be on the site for an equivalent of 80 hours (or 10 days) per year for 5 years. The industrial worker is assumed to spend the entire workday outdoors exposed to contaminated soil. The TED calculated using this exposure scenario is the TED an industrial worker receives during 80 hours of annual exposure to site contaminants and is expressed in terms of millirem per Occasional Use Area year (mrem/OU-yr).

The CAU 573 land-use zone and exposure scenario are based on current and future land use at the NNSS. CAU 573 is a remote location without any site improvements and where no regular work is performed. There is still the possibility, however, that site workers could occupy these locations on an occasional and temporary basis such as a military exercise. Therefore, this site is classified as an Occasional Use Area.

3.1.2 Contaminant Sources

Contaminant sources for CAU 573 CASs are the releases identified in Section 2.4 of radiological contamination to the atmosphere and soil as a result of the GMX experiments and the Hamilton test. Contamination on the soil surface may be the source for future migration.

3.1.3 Release Mechanisms

3.1.3.1 GMX

The “equation of state” tests conducted at GMX involved the demolition of small U and Pu metal targets with conventional explosives. Upon detonation, the target disintegrated into small particles ranging in size from microscopic to fragments that can easily be seen with the naked eye. The fragments were dispersed in an annular pattern around GZ with a bias toward the prevailing wind direction (elongated to the north and south) with the larger fragments being thrown further due to their increased mass. The absence of gross count activity as shown by radiological aerial surveys suggest that the predominant type of radioactive contaminant remaining at the site is Pu.

PSM may also be present in the area and its release mechanisms may include spills and leaks from abandoned surface waste onto surface soils. There is also the potential for subsequent migration of contaminants into nearby washes.

3.1.3.2 Hamilton

The release mechanisms for the distribution of surface contamination include release of fission products and neutron activation of soil and structural components as well as dispersal of unfissioned nuclear fuel. The absence of gross count and manmade activities as shown by radiological aerial surveys suggest that the release of fission and activation products to the surface soil was minor. The

release of unfissioned fuel also resulted in soil contamination and impacted debris that were initially distributed in an annular pattern around the GZ.

PSM may be present in the area, and its release mechanisms may include spills and leaks from abandoned surface waste onto surface soils. There is subsequent migration of contaminants by mechanical displacement to a debris pile located on site.

3.1.4 Migration Pathways

Migration is influenced by physical and chemical characteristics of the contaminants and soil. Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. Soil characteristics include permeability, porosity, water-holding capacity, sorting, chemical composition, and organic content. In general, contaminants with low solubility, high affinity for soil, and high density can be expected to be found relatively close to release points. Contaminants with high solubility, low affinity for soil, and low density can be expected to be found farther from release points. These factors affect the migration pathways and potential exposure points for the contaminants in soil.

Infiltration and percolation of precipitation serve as driving forces for downward migration of contaminants. However, due to high PET (annual PET at the Area 5 RWMS has been estimated at 63.5 in. [Yucel, 2009]) and limited precipitation for this region (4.85 inches per year [ARL/SORD, 2014), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992), but infiltration does provide a mechanism to move residual radionuclides in Frenchman Flat Playa soils downward into the subsurface. (Hershey et al., 2013). Reported recharge rates for the Frenchman Flat area range from below 0.1 to 2 millimeters per year (mm/yr) (SNJV, 2004).

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

the water table, the contaminants would have to be dissolved in infiltrating precipitation and then be transported through the vadose zone alluvium, which extends the entire unsaturated thickness of 705 ft at UE-5 PW-1, UE-5n, and ER-5-4 (USGS, 2014).

3.1.4.1 GMX

Surface migration pathways at this site include the lateral migration of potential contaminants across surface soils into ephemeral drainages transecting the site. The ephemeral drainages entering and leaving this area are generally dry, but are subject to infrequent stormwater flows. These stormwater events provide an intermittent mechanism for both vertical (infiltration) and lateral 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. Numerous small washes that drain to Frenchman Lake are present.

3.1.4.2 Hamilton

The initially contaminated surface may have been covered because of subsequent sedimentation on Frenchman Lake; however, the contaminated horizon is expected to be within the top 15 cm of the soil profile. There are no significant migration pathways identified, although periodic playa inundation may initiate soil-water interactions that may transport radionuclides away from areas of known contamination (Hershey et al., 2013).

3.1.5 Exposure Points

Exposure points for each 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 soil 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 soil. 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 573 sites 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 drainage 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

The COPCs for CAU 573 are defined as the contaminants reasonably expected at the site that could contribute to a dose or risk exceeding FALs. Based on the nature of the releases identified in Section 2.4 and previous investigation results presented in Section 2.5, the contaminants that could reasonably be suspected to be present at CAU 573 CASs are (1) *GMX*: plutonium, uranium, and americium; and (2) *Hamilton:* cobalt, cesium, europium, americium, and plutonium. These COPCs were identified based on the types of metals involved with the tests conducted at GMX and activation products and unfissioned fuel at Hamilton. Other specific COPCs (and subsequently the analyses requested) will be determined for discovered potential releases based on the nature of the potential release (e.g., hydrocarbon stain, lead bricks).

Although not suspected to be present, analysis for other COPCs will be performed to eliminate the possibility of their presence due to an incomplete history of site testing operations as discussed in Section A.2.2.2.

These COPCs will be reported by the analytical methods identified in Table A.2-3 for environmental samples taken at each of the sites. The analytes reported for each analytical method are listed in Table A.2-4.

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, thereby streamlining the consideration of remedial alternatives. The RBCA process used to establish FALs is described in the Soils RBCA document (NNSA/NFO, 2014). This process conforms with *Nevada Administrative Code* (NAC) 445A.227, which lists the requirements for sites with soil contamination (NAC, 2012a). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2012b) requires the use of ASTM International (ASTM) Method E1739 (ASTM, 1995) to "conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary." For the evaluation of corrective actions, the FALs are established as the necessary remedial standard.

This RBCA process, summarized in Figure 3-1, 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 action levels using site-specific information as inputs to the same or similar methodology used to calculate Tier 1 action levels. The Tier 2 action levels are then compared to individual sample results from reasonable points of exposure (as opposed to the source areas as is done in Tier 1) on a point-by-point basis. Results from total petroleum hydrocarbons (TPH) analyses will not be used for risk-based decisions under Tier 2 or Tier 3. Rather, the individual chemical constituents of diesel reported from volatile organic compound (VOC) and semivolatile organic compound (SVOC) analyses will be compared to the action levels.

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

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

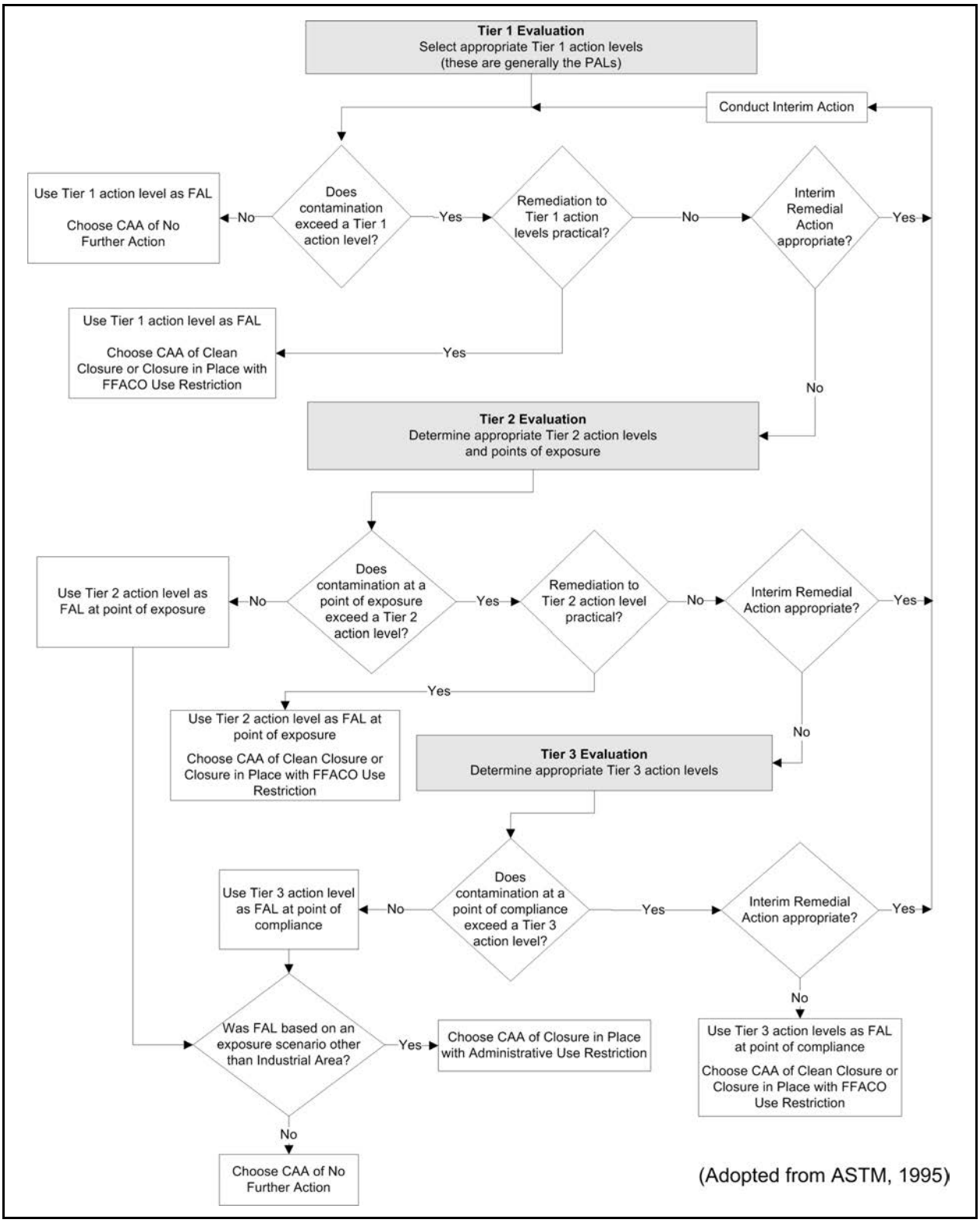

Figure 3-1
RBCA Decision Process

Section A.2.1 will be obtained before any interim action is implemented. Evaluation of DQO decisions will be based on conditions at the site after any interim actions are completed. Any interim actions conducted will be reported in the investigation report.

If, after implementation of corrective actions, contamination remains in place that is less than the site-specific exposure scenario based FAL but exceeds 25 millirem per year (mrem/yr) based on the Industrial Area exposure scenario, an administrative use restriction will be implemented to prevent future industrial use of the area. For this reason, contamination at all sites will be evaluated against industrial exposure scenario based PALs and site-specific exposure scenario based FALs. The FALs (along with the basis for their selection) will be proposed in the investigation report, 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 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2014). Background concentrations for *Resource Conservation and Recovery Act* (RCRA) metals will be used instead of screening levels when natural background concentrations exceed the screening level, as is often the case with arsenic on the NNSS. Background is considered the mean plus two standard deviations of the mean for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the investigation report.

3.3.2 Radionuclide PALs

The PAL for radioactive contaminants is a TED of 25 mrem/yr, based upon the Industrial Area exposure scenario. The Industrial Area exposure scenario is described in Soils RBCA document (NNSA/NFO, 2014). The TED is calculated as the sum of external dose and internal dose. External dose is determined directly from TLD measurements. Internal dose is determined by comparing analytical results from soil samples to residual radioactive material guidelines (RRMGs) that were established using the RESRAD computer code (Yu et al., 2001). RRMGs are radionuclide-specific

values for radioactivity in surface soils. The RRMG is the value, in picocuries per gram of surface soil, for a particular radionuclide that would result in an internal dose of 25 mrem/yr to a receptor (under the appropriate exposure scenario) independent of any other radionuclide (assuming that no other radionuclides contribute dose). The RRMGs are presented in the Soils RBCA document (NNSA/NFO, 2014).

In the RESRAD calculation, several input parameter values are not specified so that site-specific information can be used. The default and site-specific input parameter values used in the RESRAD calculation of RRMGs for each exposure scenario are listed in the Soils RBCA document.

3.4 DQO 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 4.1, it is assumed that TED within the DCB (i.e., HCA encompassing the bunker at GMX and the debris pile at Hamilton) exceeds the FAL. Figure 3-2 shows the DCB associated at GMX, and Figure 3-3 shows the DCB associated at Hamilton. For these areas, the DQO decision is resolved, and corrective action is required. DQO decisions will be resolved for the areas outside the DCB at each CAS.

As presented in Section 1.1.2, the DQOs address different potential contaminant release types that have been organized into study groups that will be investigated using different sampling techniques. Therefore, discussions related to these sample groups are presented separately.

The DQO strategy for CAU 573 was developed at a meeting on April 3, 2014. DQOs were developed to identify data needs, to 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.

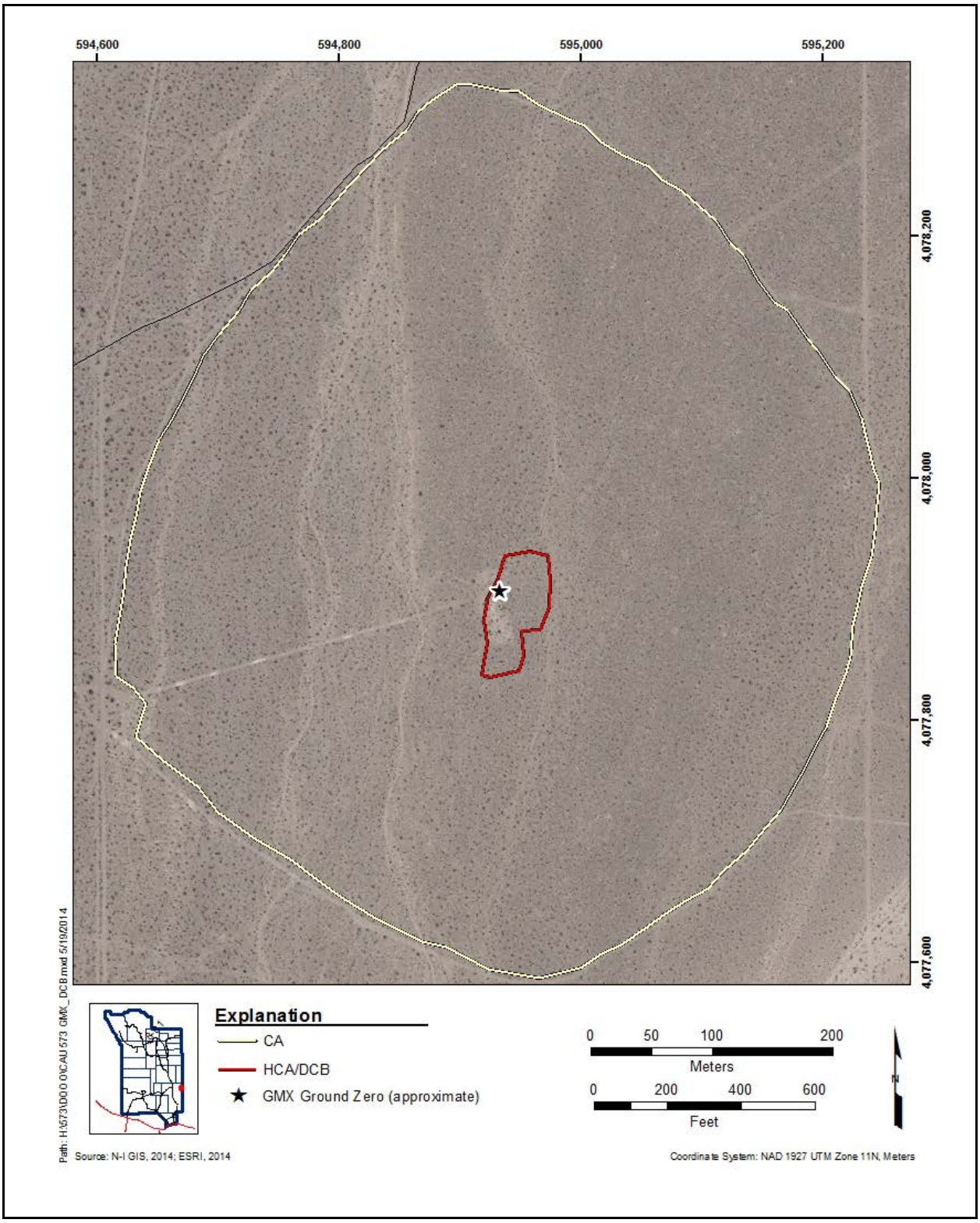

Figure 3-2
CAU 573 DCB at GMX

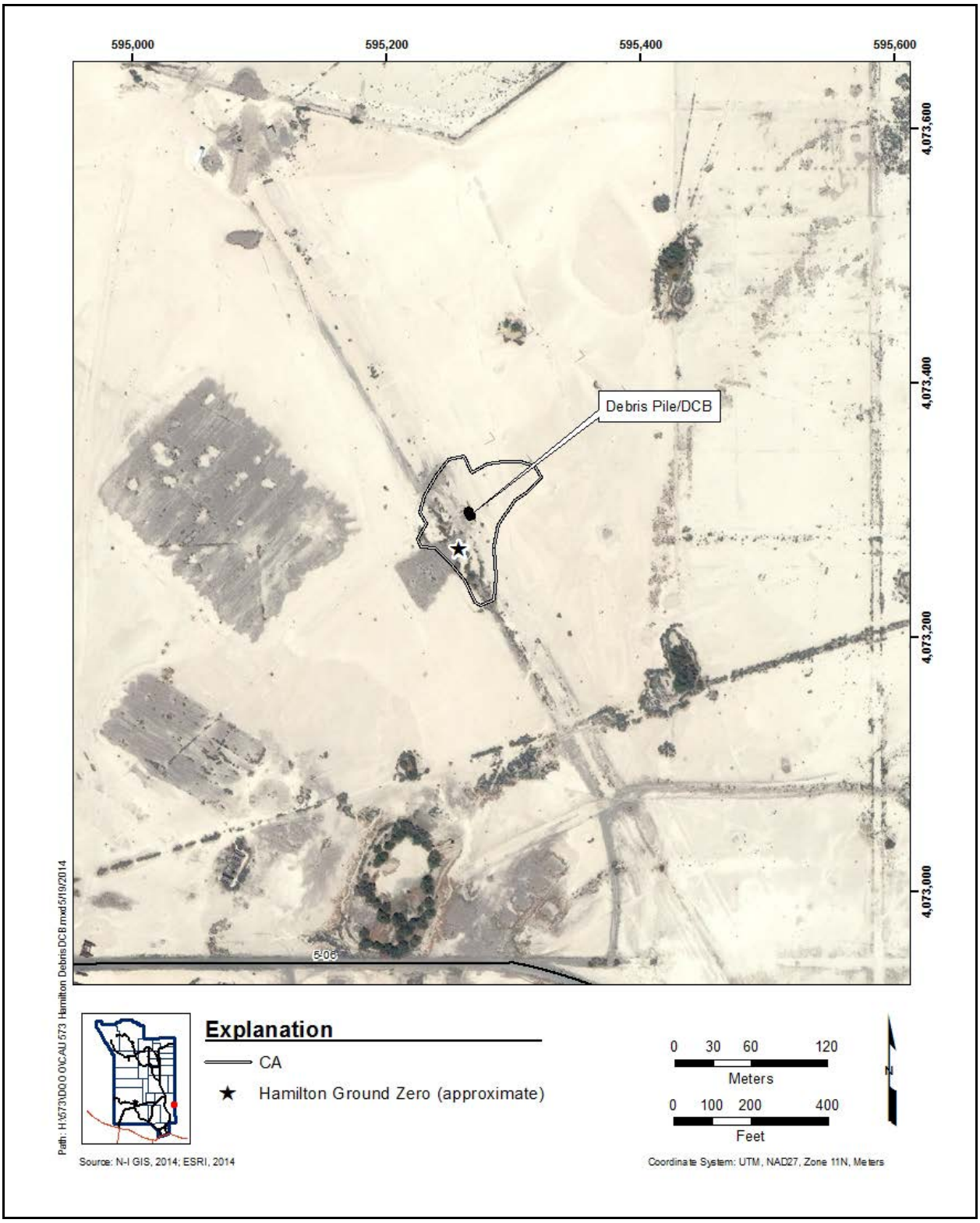

Figure 3-3
CAU 573 DCB at Hamilton

The problem statement for CAU 573 is as follows: "Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 573." To address this problem statement, resolution of the following decision statements is required:

- **Decision I.** "Is any COC associated with a CAU 573 release present in environmental media?" Any contaminant that is present (or is assumed to be present) at concentrations exceeding 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. A corrective action will also be required if an area contains removable contamination that exceeds HCA criteria (NNSA/NFO, 2014).

- **Decision II.** "Is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include the following:

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

A corrective action will be determined for any release 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 contain contaminants that, if released, could cause the surrounding environmental media to contain COCs. Such a waste will be evaluated using the PSM criteria listed in the Soils RBCA document (NNSA/NFO, 2014) to determine the need for corrective action.

The informational inputs and data required to resolve the problem and 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 573 CAS by collecting and analyzing samples generated during a field investigation. The presence of a COC will be determined by collecting and analyzing samples from locations determined most likely to contain a COC (based on the presence of a biasing factor).

A probabilistic sampling design will be used to collect samples from unbiased locations within an area that can be readily defined by distinct characteristics where the assumed distribution of contamination is relatively uniform. Results from these locations will be used to infer a characteristic representative of the sampled area as a whole (i.e., representing the average of the entire area, not the

maximum at any one location). The characteristic normally used to define contamination within an area is the 95 percent UCL of the mean concentration or dose.

Protection against false-negative decision errors are provided by the following:

- *Judgmental sampling* when contamination concentrations or dose levels from locations of the greatest degree of the selected biasing factor are used to make decisions for a larger area (e.g., a release site)
- *Probabilistic sampling* when the 95 percent UCL of the mean concentration or dose is used to make decisions for the defined sampling area

Decisions are even more conservative when probabilistic results (i.e., 95 percent UCL) from biased locations are used to make a decision on the presence of COCs for the entire release site. This is typically the case when the 95 percent UCL of contamination at a sample plot located in the area of the highest radiation survey values is used to resolve the decision on the presence of COCs (i.e., Decision I).

For the GMX Study Group 1 and Hamilton Study Group 1 scenarios, it is unknown whether COCs are present outside the DCBs. Decision I sampling for the these study groups will be conducted and samples submitted to an analytical laboratory to determine the presence of COCs. If COCs are identified, Decision II must be resolved for the affected study groups at each CAS.

For the GMX Study Groups 2 and 3, and the Hamilton Study Groups 2 and 3 scenarios, Decision I samples will be submitted for analysis to determine the presence of COCs. The specific analyses for samples from these study groups will be selected dependent upon the type and nature of the identified release. Decision II samples for both release scenarios will be submitted as necessary to define the extent of unbounded COCs.

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 the Soils QAP (NNSA/NSO, 2012b). Laboratory data will be assessed in the investigation report to confirm or refute the CSM, and determine whether the DQO data needs were met.

4.0 Field Investigation

This section contains a description of the activities to be conducted to gather and document information from the CAU 573 field investigation.

4.1 Technical Approach

The information necessary to satisfy the DQO data needs will be generated for CAU 573 by collecting and analyzing samples generated during a field investigation. However, the investigation will not include the areas within the CAU that contain removable radioactivity that exceeds the criteria for establishing an HCA, as contamination exceeding FALs is assumed to be present within these areas. For the HCA at GMX, this assumption is based on the potential for a receptor in this area to inhale, ingest, and transport this removable contamination. A DCB has been established, and corrective action is required. For the area outside the DCB, information will be generated during a site investigation to resolve DQO decisions.

The CAS at GMX will be investigated via three study groups: GMX Study Group 1 will address atmospheric deposition; GMX Study Group 2 will address migration; and GMX Study Group 3 will address spills and debris. GMX Study Group 1 will evaluate the presence and nature of contamination using a combination of judgmental and probabilistic approaches. The locations of each sample plot will be selected and evaluated judgmentally, and the samples collected within the sample plots will be collected and evaluated probablistically. GMX Study Groups 2 and 3 will be located and sample results evaluated based on judgmental criteria.

The CAS at Hamilton will be investigated via three study groups: Hamilton Study Group 1 will address atmospheric deposition; Hamilton Study Group 2 will address foxholes; and Hamilton Study Group 3 will address the spills and debris. Hamilton Study Group 1 will evaluate the presence and nature of contamination using a combination of judgmental and probabilistic approaches. The locations of each sample plot will be selected and evaluated judgmentally, and the samples collected within the sample plots will be collected and evaluated probablistically. Hamilton Study Groups 2 and 3 will be located and sample results evaluated based on judgmental criteria.

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

The TED will be calculated using the methodologies described in the Soils RBCA document (NNSA/NFO, 2014).

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

4.2 Field Activities

Field activities at CAU 573 include site preparation, sample location selection, sample collection, and demobilization.

4.2.1 Site Preparation Activities

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

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

- Perform radiological surveys to identify bias used in selecting sample locations.
- Perform visual surveys at all sites within CAU 573 to identify any staining, discoloration, disturbance of native soils, or any other indication of potential contamination.

4.2.2 Sample Location Selection

Rationale for the selection of sampling areas is discussed in the following subsections. For all investigations, if a spatial boundary is reached, the CSM is shown to be inadequate, or the Site

Supervisor determines that extent sampling needs to be reevaluated, then work will be temporarily suspended, NDEP will be notified, and the investigation strategy will be reevaluated.

The sampling strategy and the estimated locations of biased samples are presented in Appendix A. The number, location, and spacing of step-outs may be modified 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 investigation report.

As presented in Section 4.1, it is assumed that corrective action is required within the DCBs. Therefore, sampling of these areas is not necessary.

4.2.2.1 GMX Study Group 1 - Atmospheric Deposition

Decision I at GMX Study Group 1 will be evaluated by measuring TED within a sample plot established within the area of the highest radiological values as determined from the 1994 aerial survey (BN, 1999) and/or a TRS conducted with a handheld instrument (the 2010 aerial survey did not include the GMX area). This will be done in an effort to find the location where the internal dose provides the greatest contribution to TED. Because Pu and Am are the primary radionuclides of concern, a FIDLER (which measures the Am signature) will be the handheld radiological instrument used to conduct the TRS. The highest Am signature is an indicator of the greatest concentration of Pu. A sample plot will be placed in the area with the most widespread elevated radiological readings from the TRS outside the DCB (i.e., sample plot will not be placed around a single elevated reading but in an area of elevated readings).

Decision II sample plot samples will be collected from a minimum of two locations on each of a minimum of two vectors emanating from the DCB. At least one sample plot on each vector must be located outside the area where dose exceeds FALs.

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

4.2.2.2 GMX Study Group 2 - Migration

Decision I sample locations at GMX Study Group 2 will be evaluated using a visual survey and TRS of washes downgradient from GMX to Frenchman Lake, and measuring TED within sedimentation areas where the possibility of contaminant deposition exists (see Figure A.8-4). Subsurface soil samples will be collected from each 5-cm depth interval to native soil for sediment locations. Each sample will be screened with an alpha/beta contamination meter. The surface sample will submitted for analysis. Additionally, if the field-screening reading (FSR) for any depth sample exceeds the daily field-screening level (FSL) and is more than 20 percent higher than the FSR of the surface sample, the depth sample with the highest screening value at each sample location will also be submitted for analysis. If the FSR of any depth sample does not meet these criteria, only the surface sample will be submitted for analysis.

Where COCs are identified in sedimentation areas in concentrations that exceed PALs, Decision II will be resolved by assuming that the entire volume of sedimentation area contains the identified COC in equal concentration. Samples from additional sedimentation areas will be collected and analyzed until at least two consecutive sedimentation areas along the same migration path are found that do not contain a COC.

4.2.2.3 GMX Study Group 3 - Spills/Debris

Decision I sample locations for GMX Study Group 3 will be selected based on the feature being investigated to determine the presence of a COC. Biasing factors such as stains, radiological survey results, and wastes suspected of containing hazardous or radiological components will be used to select the most appropriate sample locations. Where COCs have been confirmed based on validated laboratory analytical results, Decision II sample locations will be determined using one of the methods described in Section A.4.0. If a COC is present at a PSM location, the COC may be considered for removal under an interim action. If an interim action removal is conducted, verification samples will be collected at the locations where the CSM was removed to demonstrate that no COCs remain.

4.2.2.4 Hamilton Study Group 1 - Atmospheric Deposition

Decision I sample locations at Hamilton Study Group 1 will be established within the areas of the highest radiological values as determined from the 2010 aerial survey (NSTec, 2012) and/or a TRS conducted with a handheld instrument. Because Pu and Am are the primary radionuclides of concern, a FIDLER will be the handheld radiological instrument used to conduct the TRS. The highest Am signature is an indicator of the greatest concentration of Pu. The TRS will be conducted throughout the area and around the debris pile and extend up to 200 m out from GZ to identify the locations with the highest FIDLER readings. The sample plots will be located in the areas with the most widespread elevated radiological readings from the survey (i.e., sample plot will not be placed around a single elevated reading but in an area of elevated readings). All sample locations will be sampled as described in Section 4.2.3.

4.2.2.5 Hamilton Study Group 2 - Foxholes

Decision I sample locations for Hamilton Study Group 2 will be the locations of foxholes at the time of the test. The foxholes, one to the north and one to the south, determined to have been the closest to GZ as determined by aerial photos and/or engineering drawings from the time will define the sample locations. All samples collected will be sent for analysis.

4.2.2.6 Hamilton Study Group 3 - Spills/Debris

Decision I sample locations for Hamilton Study Group 3 will be based on the feature being investigated to determine the presence of a COC. Biasing factors such as stains, radiological survey results, and wastes suspected of containing hazardous or radiological components will be used to select the most appropriate sample locations. Where COCs have been confirmed based on validated laboratory analytical results, Decision II sample locations will be defined using one of the methods described in Section A.4.0. If a COC is present at a PSM location, the COC may be considered for removal under an interim action. If an interim action removal is conducted, verification samples will be collected at the locations where the PSM was removed to demonstrate that no COCs remain.

The debris pile at Hamilton is assumed to require corrective action, so Decision II sample locations will be based on the presence of biasing factors within the pile such as stains or RCRA metals and where elevated FIDLER readings indicate the presence of a radiological COC.

4.2.3 Sample Collection

The CAU 573 sampling program will consist of the following activities:

- Collect soil samples from locations as described in Section 4.2.2.
- Collect required QC samples.
- Collect waste management samples as necessary.
- Collect external dose measurements by hanging TLDs at the sample plots or extent locations.
- Record Global Positioning System (GPS) coordinates for each environmental sample location.

To determine internal dose at GMX and Hamilton, a probabilistic sampling approach will be implemented for collecting composite samples within the sample plots. Each composite sample will consist of soil collected from the surface to a depth of 30 cm at 5-cm intervals at nine randomly located subsample locations within the plot. For each composite sample, the first location will be selected randomly; the remaining eight subsample locations will be established on a systematic triangular grid (see Section A.8.0). External dose will be sampled from a TLD installed at the approximate center of the sample plot at a height of 1 m and be left in place for approximately 2,000 hours (equivalent to an annual industrial worker exposure).

Decision I GMX Study Groups 2 or 3, and Hamilton Study Groups 2 or 3 samples will be collected from the locations described in Section 4.2.2. If biasing factors are present in soils below locations where Decision I samples are collected, subsurface soil samples will also be collected. For radiological biasing factors, subsurface soil samples will be collected from each 5-cm depth interval to native soil. Each sample will be screened with the radiation detection instrument used for the TRS. The surface sample will be submitted for analysis. Additionally, if the FSR for any depth sample exceeds the daily FSL and is more than 20 percent higher than the FSR of the surface sample, the depth sample with the highest screening value at each sample location will be submitted for analysis. If the FSR of any depth sample does not meet these criteria, only the surface sample will be submitted for analysis. Decision II sampling will also not be conducted for the drainage sedimentation area (GMX Study Group 2). 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.

4.2.4 Sample Management

The laboratory requirements (i.e., minimum detectable concentrations [MDCs], precision, and accuracy) to be used when analyzing the COPCs are presented in the Soils QAP (NNSA/NSO, 2012b). The analytical program is presented in Table A.2-3. All sampling activities and QC requirements for field and laboratory environmental sampling will be conducted in compliance with the Soils QAP.

4.3 Site Restoration

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

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

5.0 Waste Management

Waste generated during the CAU 573 field investigation will be managed in accordance with all applicable DOE orders, federal and state regulations, and agreements and permits between DOE and NDEP. Wastes will be characterized based on these regulations using process knowledge, FSRs, and analytical results from investigation and waste samples. Waste types that may be generated during the CAI include industrial, hazardous, hydrocarbon, *Toxic Substances Control Act* (TSCA) regulated (e.g., polychlorinated biphenyls [PCBs], asbestos), low-level radioactive, or mixed wastes.

Disposable sampling equipment, personal protective equipment (PPE), and rinsate are considered potentially contaminated waste only by virtue of contact with potentially contaminated soil or potentially contaminated debris (e.g., lead). These wastes may be characterized based on associated environmental sample results, waste characterization results, FSRs, or process knowledge.

Chemicals were not known to be used or present at this CAU in a manner that would generate listed hazardous waste; therefore, wastes will be characterized based on their chemical characteristics. The waste will be managed and disposed of accordingly.

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

The following subsections discuss how the field investigation will be conducted to minimize the generation of waste, what waste streams are expected to be generated, and how investigation-derived waste (IDW) will be managed.

5.1 Waste Minimization

The CAI will be conducted in a manner that will minimize the generation of wastes using process knowledge, segregation, visual examination, and/or field screening (e.g., radiological survey and swipe results) to avoid cross-contaminating uncontaminated soil or uncontaminated IDW that would otherwise be characterized and disposed of as industrial waste. As appropriate, soil and debris will be returned to their original location. To limit unnecessary generation of hazardous or mixed waste,

hazardous materials will not be used during the CAI unless required and approved by Environmental Compliance and Health and Safety. 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 following is a list of common waste streams that may be generated during the field investigation and that may require management and disposal:

- Disposable sampling equipment and field screening waste
- PPE
- Soil
- Surface debris (e.g., discarded chemicals, batteries, scrap metal)

5.3 IDW Management

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

5.3.1 Industrial Waste

Industrial solid waste, if generated, will be collected, managed, and disposed of in accordance with the solid waste regulations and the permits for operation of the NNSS Solid Waste Disposal Sites. The most commonly generated industrial solid waste includes disposable sampling equipment and PPE that will be collected in plastic bags and marked in accordance with requirements. This waste, and other waste generated such as debris or soil that is characterized as industrial waste, may be placed in the roll-off box located adjacent to Building 23-310 in Mercury or in another approved container (e.g., drum).

5.3.2 Hazardous Waste

Suspected hazardous waste, if generated, will be containerized and managed in waste accumulation areas in accordance with 40 *Code of Federal Regulations* (CFR) 262.34 (CFR, 2013a).

5.3.3 Hydrocarbon Waste

Suspected hydrocarbon solid waste, if generated, will be managed on site in a drum or other appropriate container until fully characterized and in accordance with the State of Nevada regulations (NDEP, 2006).

5.3.4 PCBs

The management of PCBs is governed by TSCA and its implementing regulations at 40 CFR 761 (CFR, 2013b), and agreements between EPA and NDEP. PCB contamination may be found as a sole contaminant or in combination with any of the types of waste discussed in this document. For example, PCBs may be a co-contaminant in soil that contains a RCRA "characteristic" waste (PCB/hazardous waste), or in soil that contains radioactive wastes (PCB/radioactive waste), or even in mixed waste (PCB/radioactive/hazardous waste). IDW will initially be evaluated using analytical results for soil samples from the CAI. If any type of PCB waste is generated, it will be managed in accordance with 40 CFR 761 (CFR, 2013b) as well as State of Nevada requirements (NAC, 2012b), guidance, and agreements with NNSA/NFO.

5.3.5 Low-Level Waste

Low-level radioactive waste, 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 National Security Site Waste Acceptance Criteria* (NNSA/NSO, 2012a). Potential radioactive waste containers will be staged and managed at a designated radioactive material area (RMA).

5.3.6 Mixed Low-Level Waste

Mixed waste, if generated, will be managed in accordance with the RCRA requirements (CFR, 2013a), agreements between NNSA/NFO and the State of Nevada, and DOE requirements for radioactive waste. Waste characterized as mixed will not be stored for a period of time that exceeds the RCRA requirements unless subject to agreements between NNSA/NFO and the State of Nevada. The mixed waste must be transported via an approved hazardous waste/radioactive waste transporter to the NNSS transuranic waste storage pad for storage pending treatment or disposal.

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 573. All characterization activities, including those related to TLD measurements, will be conducted in accordance with the Soils QAP (NNSA/NSO, 2012b) and the Soils RBCA document (NNSA/NFO, 2014), which define rigorous data quality requirements. Sections 6.1 and 6.2 discuss the collection of required QC samples in the field and QA requirements for soil samples.

6.1 QC Sampling Activities

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

- **Radiological samples**
  - Field duplicates for grab samples (1 per 20 environmental samples)
- **Chemical samples (if collected)**
  - Field duplicates for grab samples (1 per 20 environmental samples)
  - Trip blanks (1 per sample cooler containing VOC environmental samples)
  - Equipment rinsate blanks (1 per VOC decontamination event)
  - Source blanks (1 per uncharacterized source lot)

Additional QC samples may be submitted based on site conditions at the discretion of the Task Manager or Site Supervisor. Field QC samples must be analyzed using the same analytical procedures implemented for associated environmental samples. Additional details regarding field QC samples are available in the Soils QAP (NNSA/NSO, 2012b).

6.2 Laboratory/Analytical Quality Assurance

As stated in the DQOs (see Appendix A) and in the Soils QAP (NNSA/NSO, 2012b), data used for making DQO decisions will be evaluated for data quality. The Soils QAP defines and establishes data quality criteria that are evaluated in three defined steps:

1. Data Verification
2. Data Validation
3. Data Quality Assessment

Data verification will include an evaluation of all chemical and radiological laboratory data for data quality in accordance with company-specific procedures. The data will be reviewed to evaluate the completeness, correctness, and conformance of each dataset. This verification will include a review of sample collection, handling and transfer, and documentation associated with sampling activities

Data validation must be performed on a portion of the environmental sample results to determine the analytical quality of a dataset. Data validation criteria must be based upon the DQOs and the intended use of the data. Validation should include an evaluation of method and contract compliance, data calculations, QC and calibration verifications, raw data, and data generation methods. Validation can include qualifying data that may restrict or limit data use. The data validation includes an evaluation of the DQIs. DQIs are qualitative and quantitative descriptors used in interpreting the degree of acceptability or utility of data. DQIs include the following:

1. Precision
2. Accuracy/bias
3. Representativeness
4. Comparability
5. Completeness
6. Sensitivity

These DQI criteria are defined in the Soils QAP (NNSA/NSO, 2012b). The data from the CAU 573 CAI will be assessed for usability using the DQI criteria. The results of this assessment will be presented in the investigation report.

A data quality assessment (DQA) must be performed to determine whether the data meet the DQO requirements of the investigation and the performance criteria for the DQIs. The DQA considers how the data relate to decisions to be made, the intended use of the data, and whether data are suitable for

making those decisions. The results of this assessment will be documented in the investigation report. If the DQOs were not met, corrective actions will be evaluated, selected, and implemented (e.g., refine CSM or resample to fill data gaps).

7.0 Duration and Records Availability

7.1 Duration

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

7.2 Records Availability

Historical information and documents referenced in this plan are retained in the NNSA/NFO activity files in North Las Vegas, Nevada, and can be obtained through written request to the NNSA/NFO Soils Activity Lead. This document is available in the DOE public reading facilities located in Las Vegas and Carson City, Nevada, or by contacting the appropriate DOE Soils Activity Lead.

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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 573, Alpha Contaminated Sites, field investigation. 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 573 is insufficient to evaluate and select preferred corrective actions; therefore, a CAI will be conducted.

The CAU 573 CAI will be based on the DQOs presented in this appendix as developed by NDEP and NNSA/NFO representatives. The seven steps of the DQO process presented in Sections A.2.0 through A.8.0 were developed in accordance with *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

In general, the procedures used in the DQO process provide the following:

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

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

A.2.0 Step 1 - State the Problem

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

The problem statement for CAU 573 is as follows: “Existing information on the nature and extent of potential contamination is insufficient to evaluate and recommend CAAs for the CASs in CAU 573.”

A.2.1 Planning Team Members

The DQO planning team consists of representatives from NDEP and NNSA/NFO. The DQO planning team met on April 3, 2014, for the DQO meeting.

A.2.2 Conceptual Site Model

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

The CSM was developed for CAU 573 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 soil and COPCs.

The CSM consists of the following:

- Potential contaminant releases, including soil 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 release
- 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 release source is summarized in Table A.2-1 and discussed below. Table A.2-1 provides information on CSM elements that will be used throughout the remaining steps of the DQO process. Figure A.2-1 depicts a representation of the conceptual pathways to receptors from CAU 573 sources. Figures A.2-2 and A.2-3 depict a graphical representation of the CSM at GMX and Hamilton, respectively.

Table A.2-1
CSM Description of Elements for Each CAS in CAU 573
(Page 1 of 2)

CAS Number	05-23-02	05-45-01
CAS Description (Name)	GMX Alpha Contaminated Area	Atmospheric Test Site - Hamilton
Hereafter Referred to as	GMX	Hamilton
Site Status	Sites are inactive and/or abandoned	
Exposure Scenario	Occasional Use	
Sources of Potential Soil Contamination	Atmospheric deposition of radionuclides from nuclear testing Migration by water flow, mechanical excavation Spills, waste, infrastructure, and debris associated with test support	
Location of Contamination/ Release Point	Surface soil at or near GZ Surface soil below equipment or debris or around soil mounds	
Amount Released	Unknown	

Table A.2-1
CSM Description of Elements for Each CAS in CAU 573
(Page 2 of 2)

CAS Number	05-23-02	05-45-01
CAS Description (Name)	**GMX Alpha Contaminated Area**	**Atmospheric Test Site - Hamilton**
Hereafter Referred to as	**GMX**	**Hamilton**
Affected Media	Surface and shallow subsurface soil Debris such as concrete, metal, and wood	
Potential Contaminants	U, Pu, Am, RCRA metals	U, Pu, Am Eu, Cs, Co, RCRA metals
Transport Mechanisms	Surface water runoff	Mechanical disturbance
Migration Pathways	Located on an alluvial fan that drains to Frenchman Lake that provides for overland transport of contaminants	Located on dry lake bed with little or no flow provides for vertical transport of contaminants
Lateral and Vertical Extent of Contamination	Contiguous from release point with independent point sources for particles with greater mass Lateral extent: 0.5 m from GZ Vertical extent: 5 cm bgs, native soil interface in sedimentation areas	Inasmuch as area was excavated, contamination is independent without consistent relationship to GZ, debris pile comprised of area soil and debris Lateral extent: 200 m from GZ Vertical extent: 30 cm bgs, 120 cm bgs in foxholes
Exposure Pathways	The potential for contamination exposure is limited to industrial and construction workers, and military personnel conducting training. These human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact (absorption) with soil and/or debris due to inadvertent disturbance of these materials, or irradiation by radioactive materials.	

A.2.2.1 Release Sources

The following subsections identify the release sources (DOE/NV, 2000) specific to CAU 573.

A.2.2.1.1 GMX

The GMX release is associated with the atmospheric deposition of radionuclides, primarily Pu, to the surrounding surface soil from 29 “equation of state” experiments conducted at the site. Two of the 29 tests are listed as type “U-238,” 24 are listed as type “Pu,” and 3 are listed as type “non-active” (Malik, 1982). The RIDP study estimated the quantity of Pu at the GMX site to be approximately 19 grams (DRI, 1989). These experiments were designed to examine the properties of Pu and U when subjected to forces imposed using conventional explosives. Upon detonation of the explosives, the Pu and U targets disintegrated into small particles ranging in size from microscopic to fragments that can

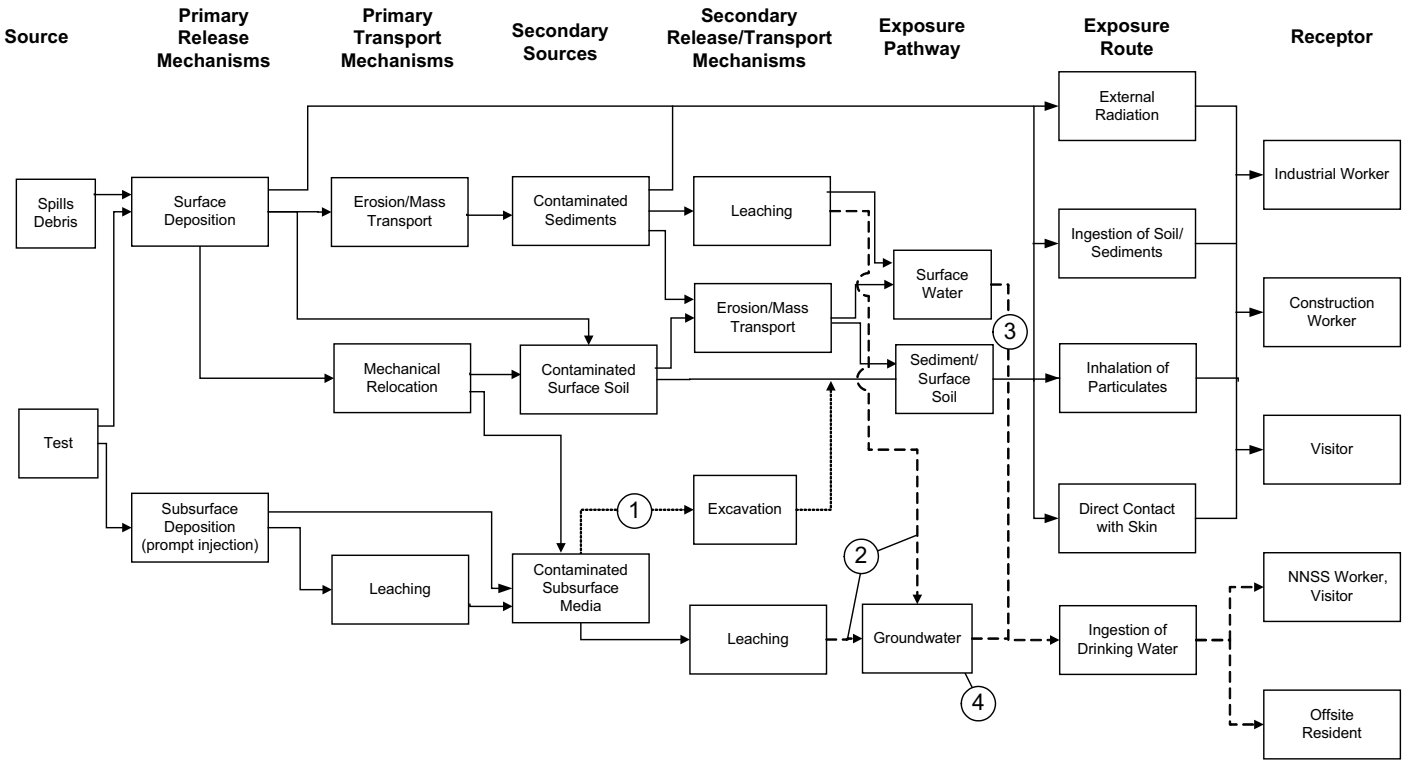

Figure A.2-1
CAU 573 CSM Pathways to Receptors

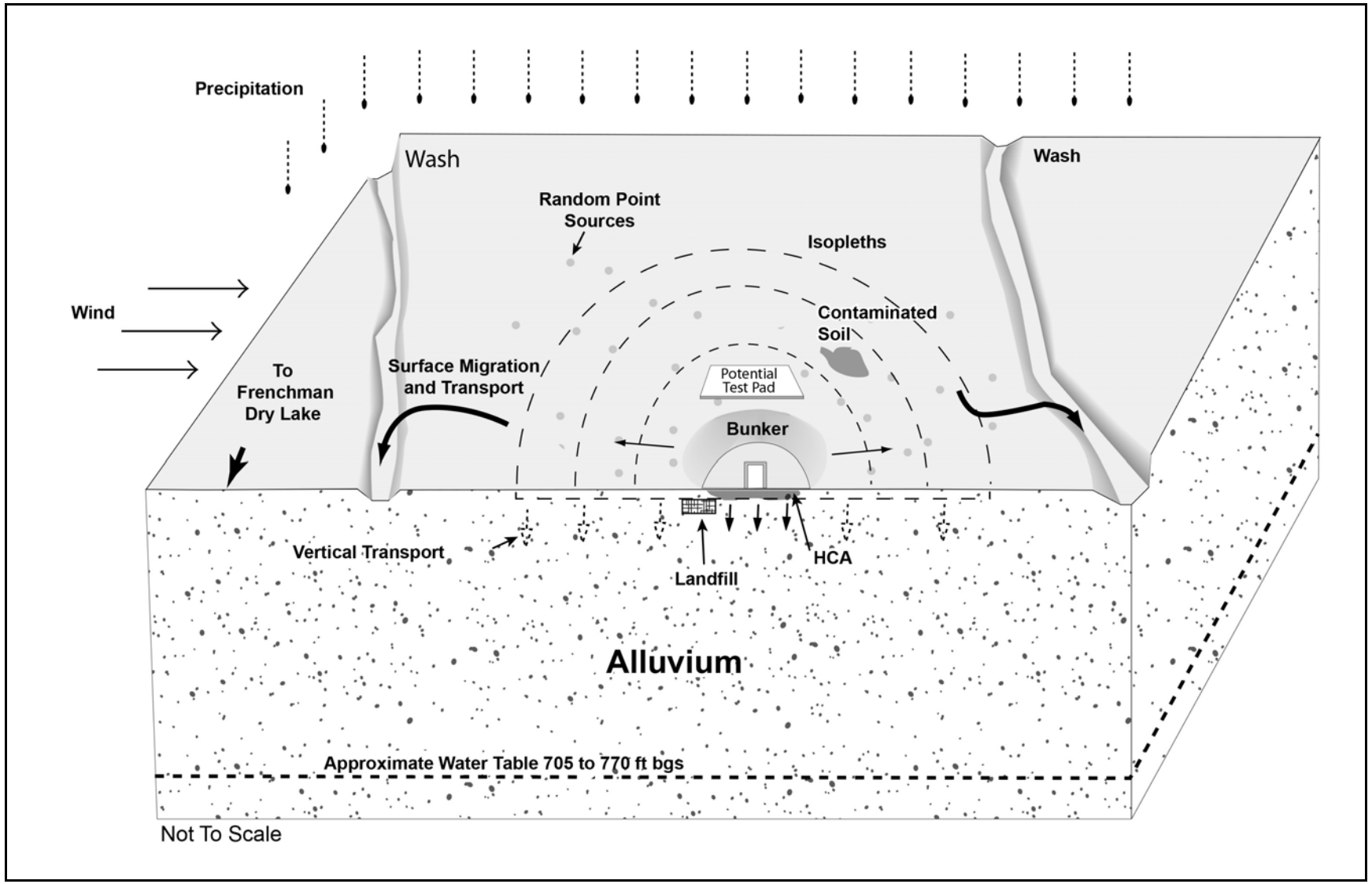

Figure A.2-2
CSM for GMX

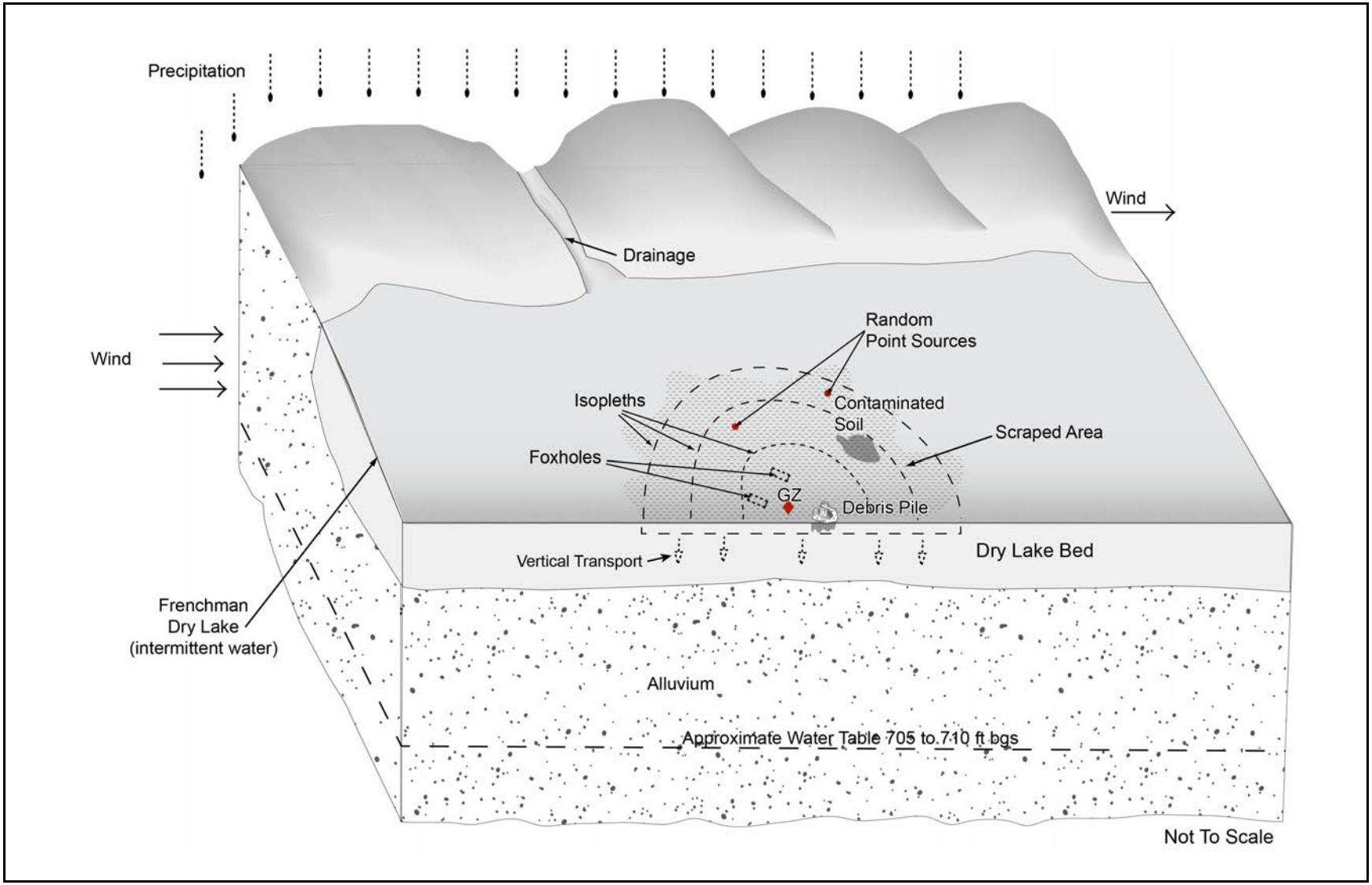

Figure A.2-3
CSM for Hamilton

easily be seen with the naked eye. According to engineering drawings, these experiments were conducted on or very near one location outside and adjacent to the bunker located within the posted HCA (Silas Mason, 1954). The initial release of radionuclides from the GMX experiments was distributed in an elongated annular pattern centered over the bunker and HCA as shown in the 2011 FIDLER TRS of the GMX area (Figure 2-6). The area inside the HCA was not included in the FIDLER TRS and was also not included in the subsequent analyses of the data. This survey detected the presence of discrete particles as well as a plume of continuous soil contamination as shown in Figure 2-7. To better define the soil contamination plume, the discrete point sources were removed from the survey data, and the remaining data were smoothed using a krieging technique. The resulting surface contamination plume is shown in Figure A.2-4. As shown in these figures, the contamination generally decreases with distance from the GZ, with the plume extending preferentially to the east and northeast.

Based on observations from an aerial photograph, the only disturbed areas of the site appear to be the access road leading to the HCA and the area within the HCA (Figure 2-1). The experiments were observed through a periscope by cameras in the bunker (Malik, 1982). Additional uses of the bunker are unknown. According to the RI/FS, decontamination of the test area began in 1956, consisting of shallow burial of Pu-contaminated clothing, scrap metals, and scrap wood near GZ (DOE/NV, 1992). The specific burial location is not stated, and no additional references were found for this information.

To facilitate site investigation and the evaluation of DQO decisions for different CSM components, the releases at GMX have been classified into one of the following study groups:

- **GMX Study Group 1 - Atmospheric Deposition**. This study group addresses the radionuclide metals that were deposited onto the soil surface as a result of the testing. The contamination associated with this type of release is limited to the top 5 cm of soil.
- **GMX Study Group 2 - Migration**. This study group addresses the radionuclide metals that were initially deposited onto the soil surface as subsequently moved by water flow.
- **GMX Study Group 3 - Spills/Debris**. This study group addresses the potential for non-test releases of COCs or PSM that may have been released onto the soil surface as well as a potential landfill located near the bunker.

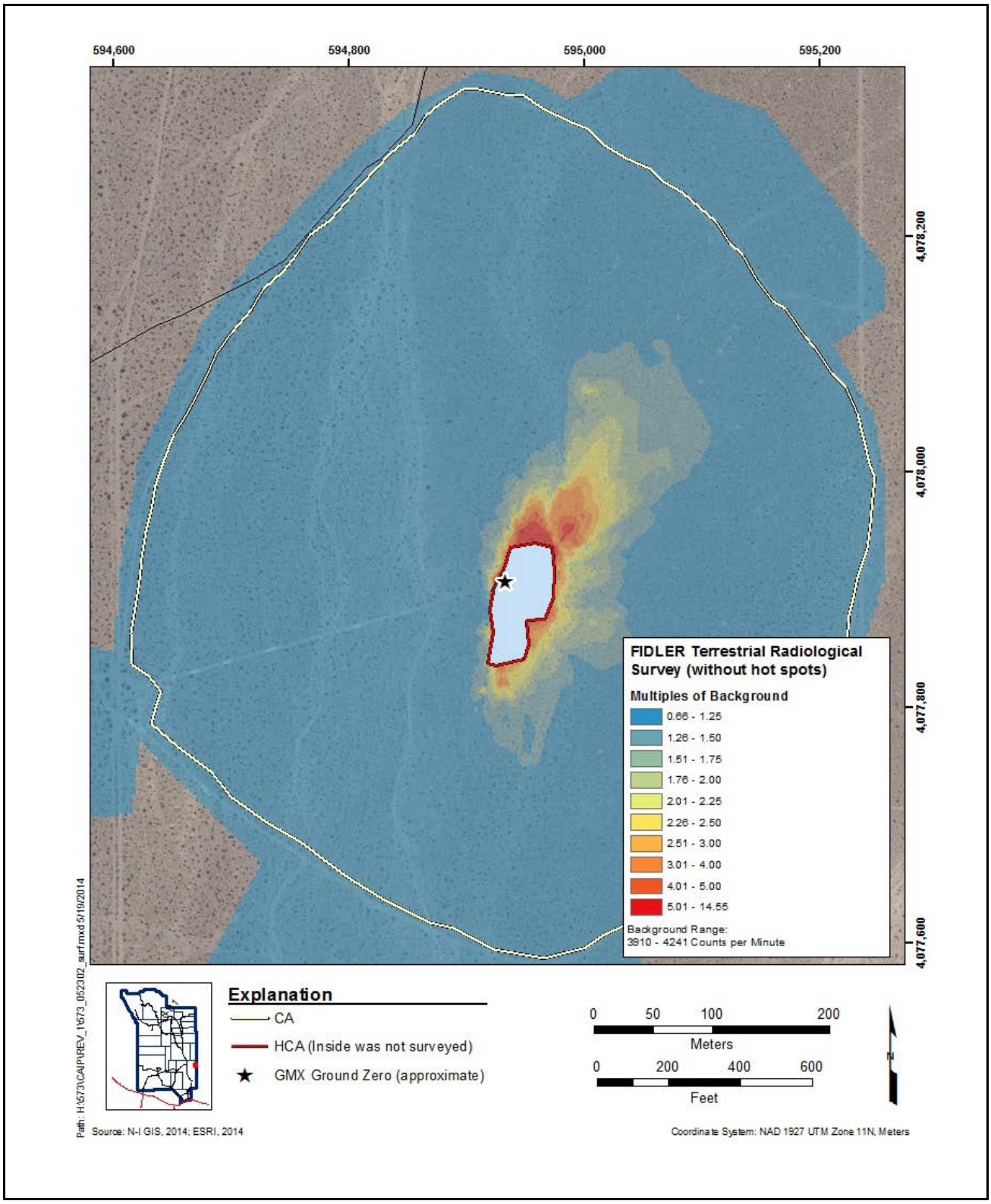

Figure A.2-4
2011 FIDLER GMX Survey Result

A.2.2.1.2 Hamilton

Hamilton is associated with the atmospheric deposition of radionuclides (e.g., fallout of fuel fragments and fission products) to the surface soil from the detonation of a weapons-related test with a 1.2-ton yield from a 50-ft tower (no longer present) (Maloney and Morgenthau, 1960; DOE/NV, 2000). Based on the radiological surveys, contamination generally appears to have an annular pattern centered over GZ and the posted CA as illustrated in a 2011 FIDLER survey of the Hamilton area (Figure A.2-5). The point source contamination outliers have been removed so their influence is not reflected in the krieging of the FIDLER measurements used to produce the smoothed surface in Figure A.2-5. Also, the debris pile (DCB) was not included in the FIDLER TRS. This general distribution pattern represents the initial surface contamination modified by the contaminated surface soil and materials that were subsequently cleaned up or excavated and relocated to the large debris pile located within the CA. It is possible that the surface soil initially impacted by the Hamilton test has subsequently been buried by lake sedimentation that occurs when the dry lake bed fills with shallow water. If so, the initially impacted soil is expected to be within the top 5 cm of soil but may be found at depths up to 30 cm because of the low sedimentation rates on dry lake beds. The most likely locations of the contamination and releases to the environment are the soils directly adjacent to GZ.

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

- **Hamilton Study Group 1 - Atmospheric Deposition**. This study group addresses the release and deposition of unconsumed nuclear fuel, fission products, and activation products onto the surface soil.

- **Hamilton Study Group 2 - Foxholes**. This study group addresses the potential for foxholes to have been filled with contaminated surface soil during site excavation.

- **Hamilton Study Group 3 - Spills/Debris**. This study group addresses the potential for non-test releases of COCs or PSM that may have been released onto the soil surface. Much of the contamination associated with Hamilton has been displaced through excavation and deposited in a debris pile at the base of a wooden pole. This study group also addresses the nature and extent of the waste pile by determining the waste type present and the volume of the debris pile.

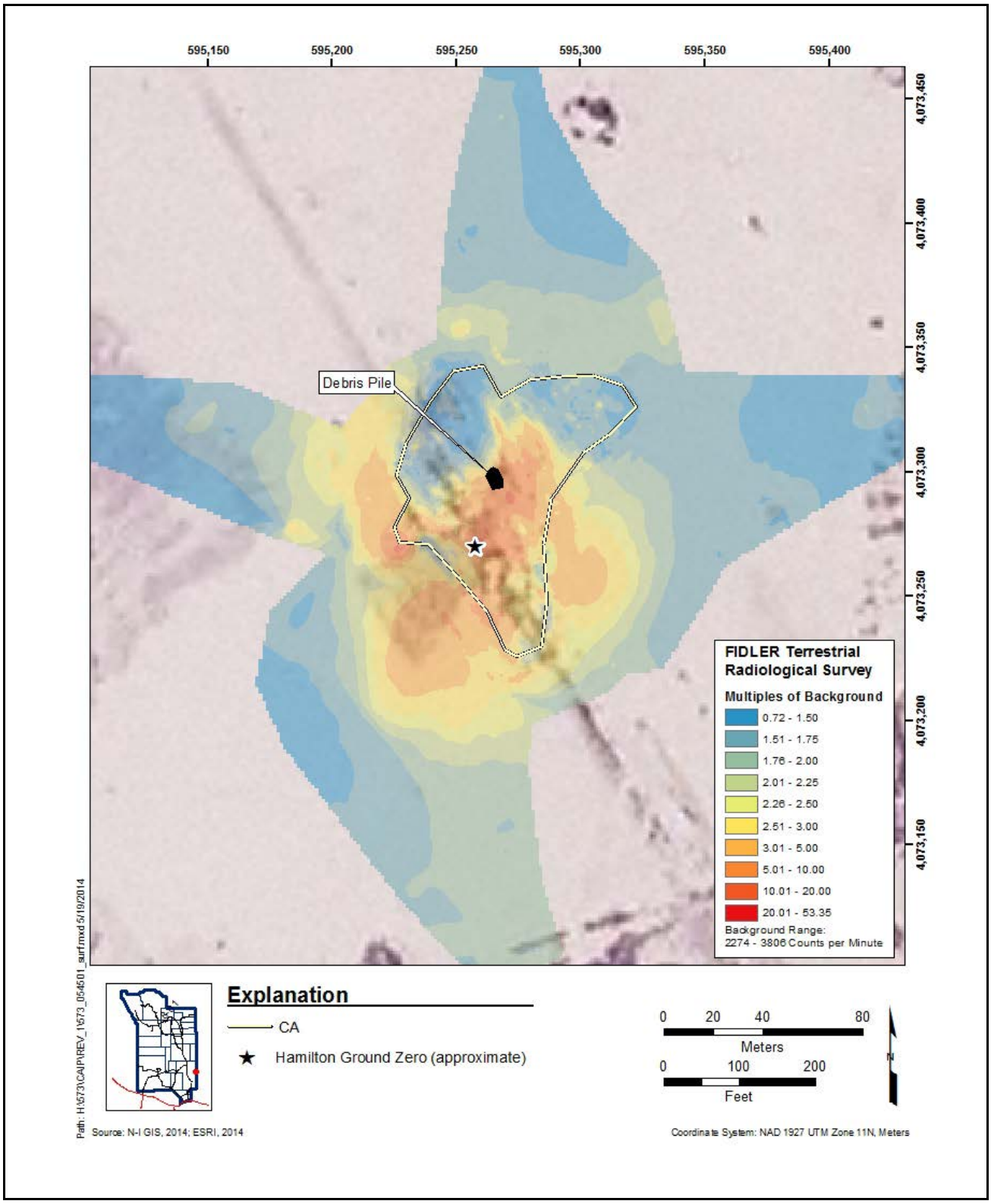

Figure A.2-5
2011 FIDLER Hamilton Survey Result

A.2.2.2 Potential Contaminants

The CAS-specific COPCs are defined as the contaminants reasonably expected at the site that could contribute to a dose or risk exceeding FALs. Based on the nature of the releases identified in Section 2.4 and previous investigation results presented in Section 2.5, the contaminants listed in Table A.2-2 could reasonably be suspected to 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 each CAS (including those that may be discovered during the investigation).

Additional COPCs for each CAS may be discovered during the investigation of debris and soil stains. Specific COPCs (and the analyses requested) will be determined for newly discovered releases based on the nature of the release (e.g., hydrocarbon stain, lead bricks).

Although not suspected to be present, analysis for additional COPCs will be performed where appropriate to evaluate the possibility of their presence due to an incomplete history of site testing operations. The site-specific possible, but not suspected, COPCs for CAU 573 are as follows:

- Co-60
- Sr-90
- Technetium (Tc)-99
- Neptunium (Np)-237
- Pu-241
- Curium (Cm)-243
- Cm-244
- Am-243
- Silver (Ag)-108m
- Aluminum (Al)-26
- Niobium (Nb)-94
- Thorium (Th)-232
- U-233

Cobalt is included on this list because it is an activation product in soil. Strontium and technetium are included in this list due to their historical presence as fission product radionuclides. Radionuclides such as Np-237, Pu-241, Cm-243, and Cm-244 are included as possible radiological COPCs based on their reported historical use as tracers and/or surrogates. The Pu ratios will be used to determine whether analysis for Cm-244 is needed. One sample (with the highest alpha FSR) will be analyzed for

Pu-241 from each Pu dispersal site. For Sr-90 analysis, one sample will be analyzed for Sr-90 from the expected location of the highest Cs-137 result. Additional sampling may be conducted based upon the 10 percent dose rule.

The COPCs applicable to Decision I environmental samples for each of the CAU 573 releases are listed in Table A.2-2. Table A.2-3 lists the analytical methods required for these COPCs, while Table A.2-4 lists the analytes that are reported by the analytical laboratory for each of the analytical methods.

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

COPCs	GMX	Hamilton
Radionuclide COPCs		
U-234	--	X
U-235/236	--	X
U-238	X	X
Pu-238	X	X
Pu-239/240	X	X
Pu-241	X	X
Am-241	X	X
Sr-90	X	X
Tc-99	X	X
Eu-152	--	X
Eu-154	--	X
Eu-155	--	X
Cs-137	--	X
Co-60	--	X

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

X = COPC associated with this CAS.
-- = COPC not associated with this CAS.

Table A.2-3
Analyses Required by Group[a]

Analyses	GMX Study Group 1	GMX Study Group 2	GMX Study Group 3[b]	Hamilton Study Group 1	Hamilton Study Group 2	Hamilton Study Group 3[b]
Inorganic COPCs						
RCRA Metals	--	--	X	--	--	X
Organic COPCs						
PCBs	--	--	X	--	--	X
VOCs	--	--	X	--	--	X
SVOCs	--	--	X	--	--	X
Radionuclide COPCs						
Gamma Spectroscopy	X	X	--	X	X	X
Isotopic U	X	X	--	X	X	X
Isotopic Pu[d]	X	X	--	X	X	X
Isotopic Am	X	X	--	X	X	X
Pu-241[e]	X	X	--	X	X	X
Sr Analysis[f]	--	--	--	X	X	X
Tc Analysis[f]	--	--	--	X	X	X

[a]The analytical method has been determined based on the site-specific COPCs. Analytical methods numbers are shown in Table A.2-4.
[b]Analyses will be determined based on the nature of the release.
[c]Results of gamma analysis will be used to determine whether further isotopic analysis is warranted.
[d]Pu ratios used to determine whether analysis for Cm-244 is needed.
[e]Collect a single confirmatory sample at each Pu dispersal site, using a sample with a higher alpha FSR. Additional sampling based upon the 10% dose rule.
[f]Collect a single confirmatory sample at the expected location of the highest Cs-137 result. Additional sample based upon the 10% dose rule.

X = Required analytical method as described in Soils QAP (NNSA/NSO, 2012)
-- = Not required

Table A.2-4
Analytes Reported Per Method

VOCs		SVOCs		Metals	Radionuclides	
Method 8260[a]		**Method 8270[a]**		**Method 6010[a]**	**Method Ga-01[b]**	**Method U-02[b]**
1,1,1,2-Tetrachloroethane	Carbon tetrachloride	1,4-Dioxane	Bis(2-ethylhexyl)phthalate	Arsenic	Ac-228	U-234
1,1,1-Trichloroethane	Chlorobenzene	2,3,4,6-Tetrachlorophenol	Butyl benzyl phthalate	Barium	Ag-108m	U-235
1,1,2,2-Tetrachloroethane	Chloroethane	2,4,5-Trichlorophenol	Carbazole	Beryllium	Al-26	U-238
1,1,2-Trichloroethane	Chloroform	2,4,6-Trichlorophenol	Chrysene	Cadmium	Am-241	
1,1-Dichloroethane	Chloromethane	2,4-Dimethylphenol	Di-n-butyl phthalate	Chromium	Cm-243	**Method Sr-02**
1,1-Dichloroethene	Chloroprene	2,4-Dinitrotoluene	Di-n-octyl phthalate	Lead	Co-60	Sr-90
1,2,4-Trichlorobenzene	cis-1,2-Dichloroethene	2-Chlorophenol	Dibenzo(a,h)anthracene	Selenium	Cs-137	
1,2,4-Trimethylbenzene	Dibromochloromethane	2-Methylnaphthalene	Dibenzofuran	Silver	Eu-152	**Lab-Specific Methods[c]**
1,2-Dibromo-3-chloropropane	Dichlorodifluoromethane	2-Methylphenol	Dimethyl phthalate		Eu-154	Pu-241
1,2-Dichlorobenzene	Ethyl methacrylate	2-Nitrophenol	Fluoranthene	**Method 7471[a]**	Eu-155	Tc-99
1,2-Dichloroethane	Ethylbenzene	3-Methylphenolc (m-cresol)	Fluorene	Mercury	K-40	
1,2-Dichloropropane	Isobutyl alcohol	4-Methylphenolc (p-cresol)	Hexachlorobenzene		Nb-94	
1,3,5-Trimethylbenzene	Isopropylbenzene	4-Chloroaniline	Hexachlorobutadiene	**Method 7196[a]**	Pa-233	
1,3-Dichlorobenzene	Methacrylonitrile	4-Nitrophenol	Hexachloroethane	Chromium VI	Pb-212	
1,4-Dichlorobenzene	Methyl methacrylate	Acenaphthene	Indeno(1,2,3-cd)pyrene		Pb-214	
2-Butanone	Methylene chloride	Acenaphthylene	n-Nitroso-di-n-propylamine		Th-229	
2-Chlorotoluene	n-Butylbenzene	Aniline	Naphthalene		Th-234	
2-Hexanone	n-Propylbenzene	Anthracene	Nitrobenzene		Tl-208	
4-Isopropyltoluene	sec-Butylbenzene	Benzo(a)anthracene	Pentachlorophenol		U-235	
4-Methyl-2-pentanone	Styrene	Benzo(a)pyrene	Phenanthrene			
Acetone	tert-Butylbenzene	Benzo(b)fluoranthene	Phenol		**Method Am-01[b]**	
Acetonitrile	Tetrachloroethene	Benzo(g,h,i)perylene	Pyrene		Am-241	
Allyl chloride	Toluene	Benzo(k)fluoranthene	Pyridine		Am-243	
Benzene	Total xylenes	Benzoic acid	Diethyl phthalate			
Bromodichloromethane	Trichloroethene	Benzyl alcohol			**Method Pu-02[b]**	
Bromoform	Trichlorofluoromethane				Pu-238	
Bromomethane	Vinyl acetate				Pu-239/240	
Carbon disulfide	Vinyl chloride					

[a] *Test Methods for Evaluating Solid Waste, Physical/Chemical Methods* (EPA, 2014b)
[b] *The Procedures Manual of the Environmental Measurements Laboratory*, which includes HASL-300 Methods (DOE, 1997)
[c] The most current EPA, DOE, or equivalent accepted analytical method may be used, including Laboratory Standard Operating Procedures approved by the contractor in accordance with industry standards and the contractor's SOW requirements.

HASL = Health and Safety Laboratory
SOW = Statement of Work

Ac = Actinium
K = Potassium
Pa = Protactinium

Pb = Lead
Tl = Thallium

A.2.2.3 Contaminant Characteristics

Contaminant characteristics include, but are not limited to, solubility, density, and adsorption potential. In general, contaminants with low solubility, high affinity for soil, 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 soil are found farther from release points or in low areas where evaporation of ponding will concentrate dissolved contaminants. Radionuclides with a low melting point (e.g., iodine) are known to travel significant distances before condensing and falling out of the plume, while those with higher melting points (e.g., cesium) tend to condense earlier and be deposited closer to respective GZs. Generally, nuclear fuel radionuclides that do not fission (e.g., U-235) have a very high melting point and are generally found very near GZ.

Residual radionuclide contaminants from nuclear weapons testing (after decay of the relatively short-lived radionuclides) are moderately to highly adsorbed on the alluvial materials present at CAU 573. An example of the inherent vertical migration potential of these contaminants through alluvium soils is presented in Table A.2-5. This table presents estimated ranges of contaminant sorption coefficients (K_d) for major radionuclide contaminants within a Yucca Flat alluvium matrix (SNJV, 2007). From these K_d values, equivalent retardation factors were calculated based on an average bulk density of 1.5 grams per cubic centimeter (Hevesi et al., 2003) and a conservative estimate of the average volumetric water content of 0.18 (based on van Genuchten model parameters in van Genuchten, 1980).

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

COC	Approximate Range of K_d Values (mL/g)	Equivalent Retardation Factor	Migration Distance in 1,000 years (m)
Uranium	0.36 – 1.7	4 – 15	12.5
Plutonium	3.4 – 102	29 – 842	1.7
Europium	832 – 3,311	6,840 – 27,228	>0.1
Strontium	66 – 575	544 – 4,733	>0.1
Cesium	2,692 – 16,218	22,132 – 133,355	>0.1
Americium	3,020 – 12,023	24,833 – 98,858	>0.1

mL/g = Milliliters per gram

Based on these properties and a maximum estimated recharge rate of 5 mm/yr (Hevesi et al., 2003), the major radionuclide contaminants at CAU 573 are estimated to migrate less than 2 m in 1,000 years except for uranium, which could migrate up to 12.5 m in 1,000 years.

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

Based on this evidence, the major radionuclide potential contaminants (plutonium and uranium) are classified as adsorbing radionuclides with low solubilities that are located within unsaturated media. Therefore, these contaminants are expected to be found relatively close to release points.

A.2.2.4 Site Characteristics

Site characteristics are defined by the interaction of physical, topographical, and meteorological attributes and properties. Topographical and meteorological properties and attributes include

precipitation frequency and amounts, precipitation runoff pathways, drainage channels and ephemeral drainages, and PET. Meteorological data are presented in Section 2.1.

Both CAU 573 CASs are located within the Frenchman Flat Hydrographic Area. Erosion of the surrounding mountains has resulted in the accumulation of more than 1,000 ft of alluvial deposits in some areas of Frenchman Flat (DOE/NV, 1996). The GMX site is located on the alluvial deposits and unconsolidated gravel of Frenchman Flat and the Hamilton test site is located on the ephemeral Frenchman Lake (dry lake bed). During the dry season, the ground surface consists of a rough hard-packed silt with a well-defined mud-crack pattern, which is a classic dessication structure of the dry lake environment. During the rainy season, the lake bed may fill with shallow water (especially during wet years), and this layer of water may be moved around by wind. The principal drainage into the dry lake bed is Nye Canyon from the north with lesser drainages from the west including Cane Spring Wash and Barren Wash. Depth to groundwater ranges between approximately 700 and 775 ft bgs (USGS and DOE, 2014).

At GMX, numerous small intermittent washes throughout the site drain south to Frenchman Lake.

A.2.2.5 Migration Pathways and Transport Mechanisms Endpoint

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 ephemeral washes are subject to much higher transport rates than contaminants present in other surface areas. These ephemeral washes are generally dry but are subject to infrequent stormwater flows. These stormwater flow events provide an intermittent mechanism for both vertical and lateral transport of contaminants. Contaminated sediments entrained by these stormwater events would be carried by the drainage channel flow to locations where the flowing water loses energy and the sediments drop out. These locations are visually identifiable as sedimentation areas.

Other migration pathways for contamination from the sites include windborne material and materials displaced via mechanical disturbance due to maintenance or construction activities at the site. Specifically, this can include activities such as site preparation and decontamination of the test site

investigation and remediation of CASs, and disassembly and removal of equipment and support structures.

Migration is influenced by the chemical characteristics of the contaminants (presented in Section A.2.2.3) and the physical characteristics of the vadose zone material (presented in Section A.2.2.4). In general, the contaminants that are reasonably expected to be present at CAU 573 (i.e., Pu, U, and Am at GMX; and Pu, Am, Cs, Eu, and Co at Hamilton) have low solubilities and high affinity for soil. The physical characteristics of the vadose zone material generally include medium and high adsorbive capacities, low moisture contents (i.e., available water-holding capacity), and relatively long distances to groundwater (e.g., over 700 ft bgs). Based on these physical and chemical factors, contamination is expected to be found relatively close to release points.

Infiltration and percolation of precipitation serve as driving forces for downward migration of contaminants. However, due to high PET (mean PET at the Area 5 RWMS has been estimated at 63.5 in. [Yucel, 2009]) and limited precipitation for this region (annual precipitation at station W5B is 4.85 in. [ARL/SORD, 2014]), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992). Although there may be standing water at times on the Frenchman Lake, percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992), but infiltration does provide a mechanism to move residual radionuclides in Frenchman Flat Playa soils downward into the subsurface (Hershey et al., 2013).

Subsurface migration pathways at CAU 573 are expected to be predominately vertical, although spills or leaks at the ground surface may also have limited lateral migration before infiltration. The depth of infiltration (shape of the subsurface contaminant plume) will be dependent upon the type, volume, and duration of the discharge as well as the presence of relatively impermeable layers that could modify vertical or lateral transport pathways, both on the ground surface (e.g., concrete) and in the subsurface (e.g., caliche layers).

A.2.2.6 Exposure Scenarios

Human receptors may be exposed to COPCs through oral ingestion or inhalation of, or dermal contact (absorption) with soil or debris due to inadvertent disturbance of these materials, or external irradiation by radioactive materials. The land-use and exposure scenarios for the CAU 573 CASs are listed in Table A.2-6. These are based on current and future land use at the NNSS (DOE/NV, 1996). Although Hamilton is located in an area where structures from past activities exist, no facilities are present that would allow these to be used as an assigned work station for NNSS site personnel. GMX is at a remote location without any site improvements and where no regular work is performed. There is still the possibility, however, that site workers could occupy these locations on an occasional and temporary basis, such as a military exercise. Therefore, the current site usage at GMX and Hamilton is conservatively represented by the Occasional Use Area exposure scenario.

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

CAS	Record of Decision Land-Use Zone	Exposure Scenario
Hamilton	**Research Test and Experiment Zone** This area is designated for small-scale research and development projects and demonstrations; pilot projects; outdoor tests; and experiments for the development, QA, or reliability of material and equipment under controlled conditions. This zone includes compatible defense and nondefense research, development, and testing projects and activities.	**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.
GMX	**Reserved 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, Federal Radiological Monitoring and Assessment Center training, and DoD exercises and training.	

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

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

A.3.1 Decision Statements

The Decision I statement is as follows: "Is any COC present in soil within the CAS?" Any contaminant present at levels exceeding the FAL will result in that contaminant 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/NFO, 2014). If a COC is detected, then corrective action is required and Decision II must be resolved.

The Decision II statement is as follows: "If corrective action is required, is sufficient information available to evaluate potential CAAs?" Sufficient information is defined to include the following:

- The lateral and vertical extent of contamination at levels exceeding the FAL
- The information needed to predict potential remediation waste types and volumes
- The information needed to evaluate the feasibility of remediation alternatives

For radiological contaminants, the presence of contamination at levels exceeding the FAL is defined as the condition where the most exposed worker has the potential to receive a TED of at least 25 mrem/yr. As presented in the Soils RBCA document, it is assumed that corrective action is required for any area exceeding HCA criteria. Therefore, a DCB was established for the GMX release that bounds the areas exceeding HCA criteria (Section 3.4 and Figure A.3-1). For Hamilton, it is assumed that the debris pile requires corrective action. Therefore, a DCB was established around the pile (Figure A.3-2). For areas outside the DCBs, Decision I samples will be submitted to analytical laboratories to determine the presence of a COC. If necessary, Decision II samples will be submitted to define the extent of a COC. In addition, samples will be submitted for analyses, as needed, to support waste management decisions.

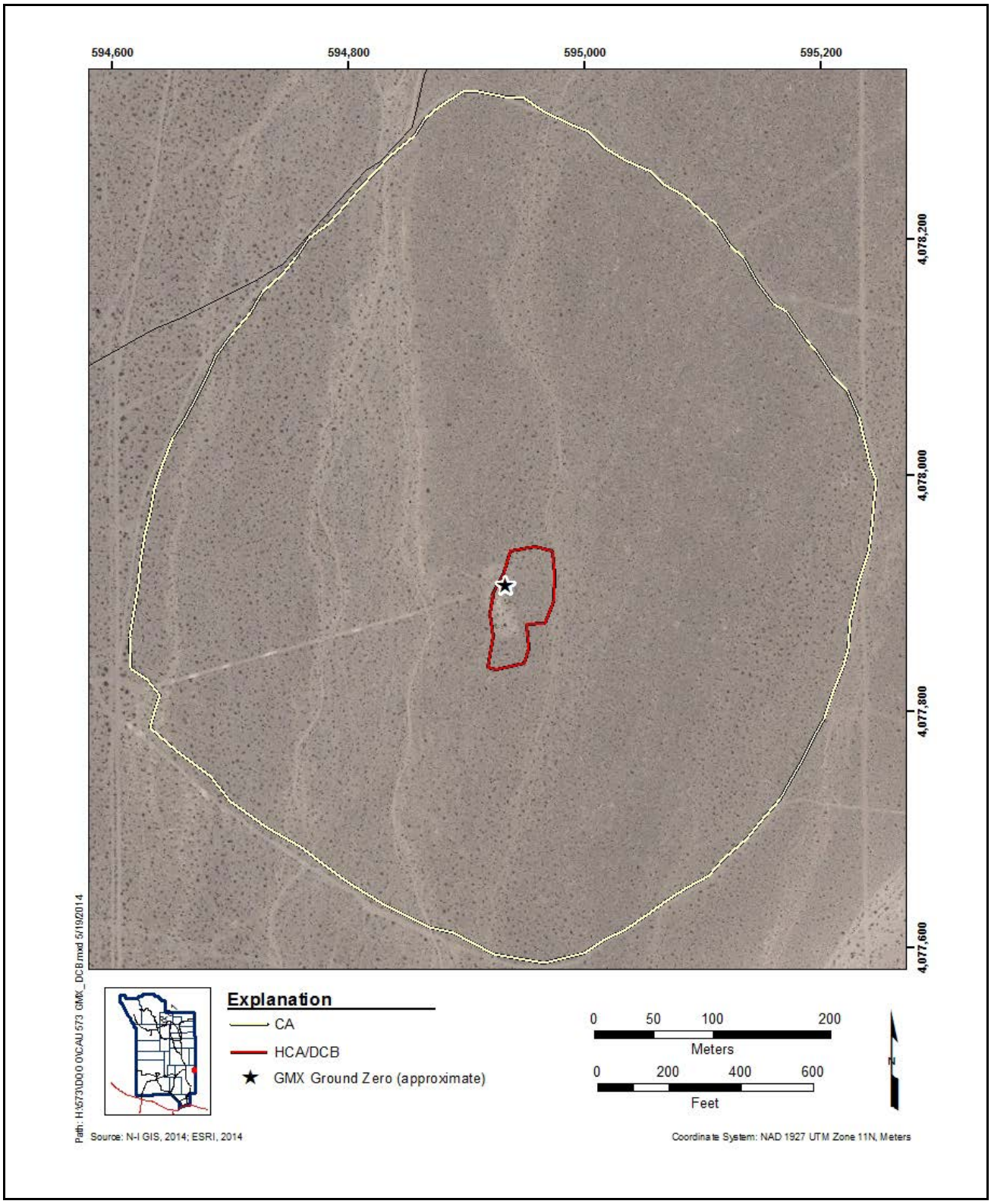

Figure A.3-1
DCB at GMX

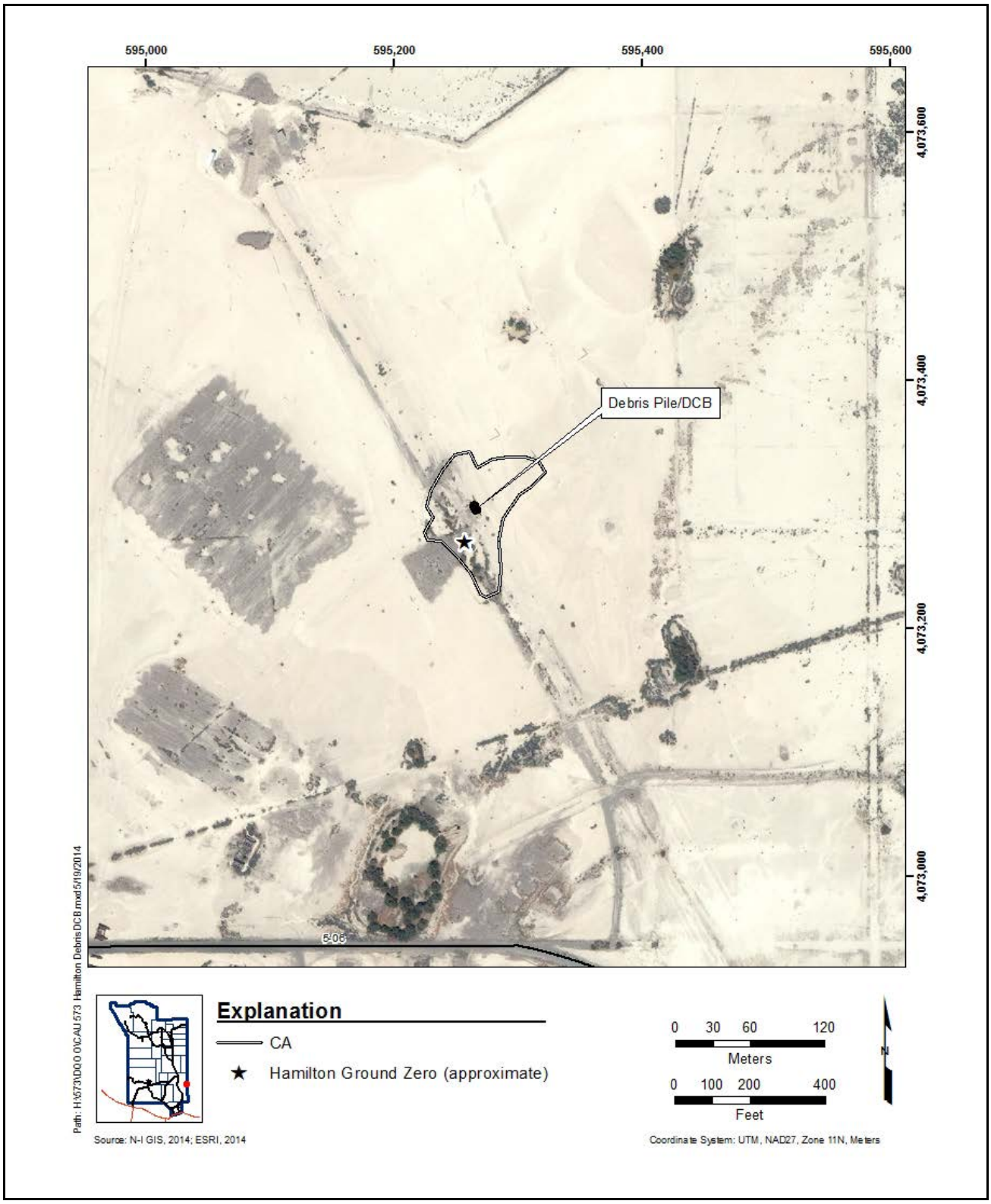

Figure A.3-2
DCB at Hamilton

The TRSs conducted at CAU 573 identified anomalous radiation values associated with discrete radioactive point sources. These items may be contaminated debris or fragments of the test material that may have also resulted in localized soil contamination. Samples will be collected, as necessary, to evaluate the potential to cause a receptor to receive a dose exceeding the FAL.

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

A.3.2 Alternative Actions to the Decisions

This section identifies actions that may be taken to resolve Decision I and Decision II issues depending on the possible outcomes of the investigation.

A.3.2.1 Alternative Actions to Decision I

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

A.3.2.2 Alternative Actions to Decision II

If the lateral and vertical extent of COC contamination have not been defined for radiological contamination, then additional samples will be collected until a coefficient of determination (or r^2) greater than 0.8 can be established between TED values and radiation survey values. If a valid correlation cannot be established using this criterion, the lateral and vertical extent of COC contamination will be defined by bounding locations where the TED is less than the FAL. If sample analytical results are not sufficient to predict potential remediation waste types, then additional waste characterization samples will be collected. If available information is not sufficient to evaluate the potential for migration of COC contamination beyond the corrective action boundary, then additional information will be collected. If sufficient information is not available to evaluate potential CAAs, then additional samples will be collected. Otherwise, collection of additional information is not required.

A.4.0 Step 3 - Identify Information Inputs

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

A.4.1 Information Needs

To resolve Decision I (determine whether contamination from the release is present at levels exceeding a FAL) for the areas outside the DCBs, 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 COC present in the samples.

The extent of COC contamination portion of Decision II will be resolved using one of the following methods:

- **Method 1.** TED rates need to be established at locations where the TED values bound the FAL dose rate and provide sufficient information to establish a coefficient of determination (or r^2) greater than 0.8 between TED values and radiation survey values. A boundary will then be determined around the radiation survey isopleth that correlates to the 25-mrem/yr FAL.
- **Method 2.** The lateral and vertical extent of COC contamination will be defined by sample results from locations contiguous to the contamination where TED or COC concentrations are less than the FAL.
- **Method 3.** The lateral and vertical extent of COC contamination will be defined by the entire lateral and vertical extent of a material with clearly identifiable physical properties that is assumed to be entirely contaminated at levels exceeding the FAL.

If additional information is needed to evaluate corrective action alternatives, samples will be collected and analyzed to meet the following criteria:

- Samples of the waste or soil must provide sufficient information to determine potential remediation waste types.
- Samples of the waste must provide sufficient information to determine whether the waste is PSM.

A.4.2 Sources of Information

Information to satisfy Decision I and Decision II will be generated by collecting environmental samples. These samples will be submitted to analytical laboratories meeting the quality criteria stipulated in the Soils QAP (NNSA/NSO, 2012). TLDs will be submitted to the Environmental Technical Services group at the NNSS, which is certified by the DOE Laboratory Accreditation Program for dosimetry. Only validated data from analytical laboratories will be used to make DQO decisions. Sample collection and handling activities will follow standard procedures.

A.4.2.1 Sample Locations

Design of the sampling approaches for the CAU 573 investigation must ensure that the data collected are sufficient for selection of the CAAs (EPA, 2002). To meet this objective, the samples collected from each site should 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. The implementation of a judgmental approach for sample location selection, and of a probabilistic sampling approach, for CAU 573 are discussed in Section A.8.0.

A.4.2.2 Analytical Methods

Analytical methods are available to provide the data needed to resolve the decision statements. The analytical methods and laboratory requirements (e.g., precision, and accuracy) for soil samples are provided in the Soils QAP (NNSA/NSO, 2012).

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

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

A.5.1 Target Populations of Interest

The population of interest to resolve Decision I ("determine whether a COC from the release is present") is TED or contaminant concentrations exceeding a FAL at any location or area within each CAS. The populations of interest to resolve Decision II (If corrective action is required, is sufficient information available to evaluate potential CAAs?) are as follows:

- The extent of CIC contamination using one of the methods described in Section A.4.1
- IDW and potential remediation waste characteristics

A.5.2 Spatial Boundaries

Spatial boundaries are the maximum vertical and lateral extent of expected contamination that can be supported by the CSM. These boundaries were agreed to in the DQO meeting with decision makers (Table A.5-1).

Table A.5-1
Spatial Boundaries

CAS	COC Type	Vertical Boundary (bgs)	Lateral Boundary
GMX	Rad Contaminant	5 cm	0.5 mi from GZ
	Non Rad Contaminant	200 cm	100 m beyond CA fence line
Hamilton	Rad Contaminant	150 cm	200 m from GZ
	Non Rad Contaminant	200 cm	200 m from GZ

Contamination found beyond these boundaries may indicate a flaw in the CSM and may require reevaluation of the CSM before the investigation can continue.

A.5.3 Practical Constraints

Practical constraints (e.g., activities by other organizations at the NNSS, utilities, threatened or endangered animals and plants, unstable or steep terrain, and/or access restrictions) may affect the ability to investigate this site. No practical constraints have been identified specific to CAU 573.

A.5.4 Define the Sampling Units

The scale of decision making refers to the smallest, most appropriate area or volume for which decisions will be made. The scale of decision making in Decision I is the study group (defined in Section A.4.2.2). The presence of a COC associated with a CAS component will cause the determination that the study group requires corrective action. The scale of decision making for Decision II is defined as a contiguous area containing a COC originating from the study group. Resolution of Decision II requires this contiguous area to be bounded laterally and vertically.

A.6.0 Step 5 - Develop the Analytic Approach

Step 5 of the DQO process specifies appropriate population parameters for making decisions, defines action levels, and generates a decision rule.

A.6.1 Population Parameters

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

A.6.1.1 Judgmental Sampling Design

The judgmental design will be implemented as described in the Soils RBCA document (NNSA/NFO, 2014). For chemical contaminants, the population parameter is the observed concentration of each contaminant from each individual analytical sample. For radiological contaminants, the population parameter is the calculated TED from each location. Each sample result will be compared to the FALs to determine the appropriate resolution to Decision I and Decision II. A single sample result for any contaminant exceeding a FAL would cause a determination that a corrective action is required (for Decision I), or that the extent of COC contamination is not bounded (for Decision II). If good prior information about the target site of interest is available, then the sampling may be designed to collect samples only from areas known to have the highest concentration levels on the target site. If the observed concentrations from these samples are below the action level, then a decision can be made that the site contains safe levels of the contaminant without the samples being truly representative of the entire area (EPA, 2006).

A.6.1.2 Probabilistic Sampling Design

For probabilistic sampling results, the population parameter is the true TED over the area of the sample plot. Resolution of DQO decisions associated with the probabilistic sampling design requires determining, with a specified degree of confidence, whether the true TED at the site in question exceeds the FAL. Because a calculated TED is an estimate of the true (unknown) TED, it is uncertain how well the calculated TED represents the true TED. If the calculated TED were significantly different than the true TED, a decision based on the calculated TED could result in a decision error.

To reduce the probability of making a false-negative decision error, a conservative estimate of the true TED is used to compare to the FAL instead of the calculated TED. This conservative estimate (overestimation) of the true TED will be calculated as the 95 percent UCL of the average TED values (Section 4.1). By definition, there will be a 95 percent probability that the true TED is less than the 95 percent UCL of the calculated TED.

The computation of appropriate UCLs will be accomplished as described in the Soils RBCA document (NNSA/NFO, 2014). For Decision I, the 95 percent UCL will be used to compare with the FAL. For Decision II, the 95 percent lower confidence limit (LCL) of the regression will be used to determine the radiological survey value that corresponds to 25 mrem/yr of TED.

A.6.2 Action Levels

The PALs presented in this section are to be used for site screening purposes. They are not necessarily intended to be used as cleanup action levels or FALs. However, they are useful in screening out contaminants that are not present in sufficient concentrations to warrant further evaluation and, therefore, streamline the consideration of remedial alternatives.

The FALs will be established using the RBCA process described in the Soils RBCA document (NNSA/NFO, 2014). This process conforms with NAC 445A.227, which lists the requirements for sites with soil contamination (NAC, 2012a). For the evaluation of corrective actions, NAC 445A.22705 (NAC, 2012b) requires the use of ASTM Method E1739 (ASTM, 1995) to “conduct an evaluation of the site, based on the risk it poses to public health and the environment, to determine the necessary remediation standards or to establish that corrective action is not necessary.” For the evaluation of corrective actions, the FALs are established as the necessary remedial standard. The RBCA process as described in the Soils RBCA document (NNSA/NFO, 2014) defines three tiers (or levels) of evaluation involving increasingly sophisticated analyses.

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.6.2.1 Chemical PALs

Except as noted herein, the chemical PALs are defined as the Region 9 Regional Screening Levels for chemical contaminants in industrial soils (EPA, 2014a). Background concentrations for RCRA metals will be used instead of screening levels when natural background concentrations exceed the screening level (e.g., arsenic on the NNSS). Background is considered the average concentration plus two standard deviations of the average concentration for sediment samples collected by the Nevada Bureau of Mines and Geology throughout the Nevada Test and Training Range (formerly the Nellis Air Force Range) (NBMG, 1998; Moore, 1999). For detected chemical COPCs without established screening levels, the protocol used by EPA Region 9 in establishing screening levels (or similar) will be used to establish PALs. If used, this process will be documented in the investigation report.

A.6.2.2 Radionuclide PALs

The PAL for radioactive contaminants is a TED of 25 mrem/yr, based upon the Industrial Area exposure scenario. The Industrial Area exposure scenario is described in Soils RBCA document (NNSA/NFO, 2014).

A.6.3 Decision Rules

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

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

The decision rules for Decision I are as follows:

- If the population parameter of any COPC in the Decision I population of interest (defined in Step 4) exceeds the corresponding FAL, then Decision II will be resolved and a corrective action will be determined, else no further action will be necessary for that COPC in that population.

- If a waste is present that, if released, has the potential to cause future soil contamination at levels exceeding a FAL, then a corrective action will be determined, else no further action will be necessary.

The decision rules for Decision II are as follows:

- If the spatial extent of any COC has not been defined, then additional samples will be collected, else no further investigation will be necessary.

- If sufficient information is not available to determine potential remediation waste types and evaluate the feasibility of remediation alternatives, additional waste characterization samples will be collected, else no further investigation will be necessary.

A.7.0 Step 6 - Specify Performance or Acceptance Criteria

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

A.7.1 Decision Hypotheses

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

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

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

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

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

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

A.7.2 False-Negative Decision Error

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

A.7.2.1 False-Negative Decision Error for Judgmental Sampling

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

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

- For Decision I, having a high degree of confidence that the sample locations selected will identify a COC 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 a COC.
- Having a high degree of confidence that analyses conducted will be sufficient to detect any COC 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 a COC (supplemented by unbiased samples where appropriate). Decision II samples must be collected in areas that represent the lateral and vertical extent of contamination (above FALs). The following characteristics must be considered to control decision errors for the first criterion:

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

These characteristics were considered during the development of the CSM and selection of sampling locations. The field-screening methods and biasing factors listed in Section A.4.2.1 will be used to further ensure that appropriate sampling locations are selected to meet these criteria. 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.5.1.

To satisfy the second criterion, Decision I soil samples will be analyzed for the chemical and radiological parameters listed in Section 3.2. Decision II soil samples will be analyzed for 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, representativeness, completeness, comparability, and sensitivity as defined in the Soils QAP (NNSA/NSO, 2012). 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.

To provide information for the assessment of the DQIs of precision and accuracy, the following QC samples will be collected (as established in the CAU 573 DQOs):

- Field duplicates (minimum of 1 per 20 environmental grab samples)
- Laboratory QC samples (1 per 20 samples)

A.7.2.2 False-Negative Decision Error for Probabilistic Sampling

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

- Sample size
- Actual variability
- Measurement error

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

- A sufficient sample size was collected (see Section 7.3.2 of the Soils RBCA document [NNSA/NFO, 2014]).
- The actual standard deviation is calculated.
- Analyses conducted were sufficient to detect contamination exceeding FALs.

A.7.3 False-Positive Decision Error

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

False-positive results are typically attributed to laboratory and/or sampling/handling errors that could cause cross contamination. To control against cross contamination, decontamination of sampling equipment will be conducted in accordance with established and approved procedures, and only clean sample containers will be used. To determine whether a false-positive analytical result may have occurred, the following QC samples will be collected (as established in the CAU 573 DQOs):

- Trip blanks (1 per sample cooler containing VOC environmental samples)
- Equipment rinsate blanks (1 per VOC decontamination event)

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

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

Step 7 of the DQO process selects and documents a design that will produce data that exceeds performance or acceptance criteria.

Judgmental sampling schemes will be implemented to select grab and sample plot locations for GMX Study Group 1 and Hamilton Study Group 1. Probabilistic sampling schemes will be implemented to select the sample locations within each of the sample plots. Judgmental sampling will also be used to investigate any newly discovered releases as described in Section A.2.2.1. Investigation results will be compared to FALs to determine the need for corrective action. PSM sample results will be evaluated against the PSM criteria listed in the Soils RBCA document (NNSS/NSO, 2014) to determine the need for corrective action. All samples will be submitted for the analyses listed in Table A.2-3.

A.8.1 GMX Study Group 1 - Atmospheric Deposition

A judgmental sampling design will be implemented for locating sample plots for GMX Study Group 1 outside the GMX DCB.

The probabilistic sampling scheme will be implemented to select sample locations within the sample plots and evaluate the analytical results. For each sample collected within the sample plot, unbiased subsample locations will be chosen based on a random start, triangular pattern (see Figure A.8-1 for an example of this sampling scheme). A TLD will be placed near the center of each sample plot to measure the external dose.

A.8.1.1 Decision I

The Decision I sample plot location will be determined with a radiological survey based on the highest results of the TRSs. This will be done in an effort to find the location where TED is the highest. Figure A.8-2 shows an example location of the Decision I sample plot based on the latest radiological surveys. This location will be refined when additional surveys are conducted during the CAI.

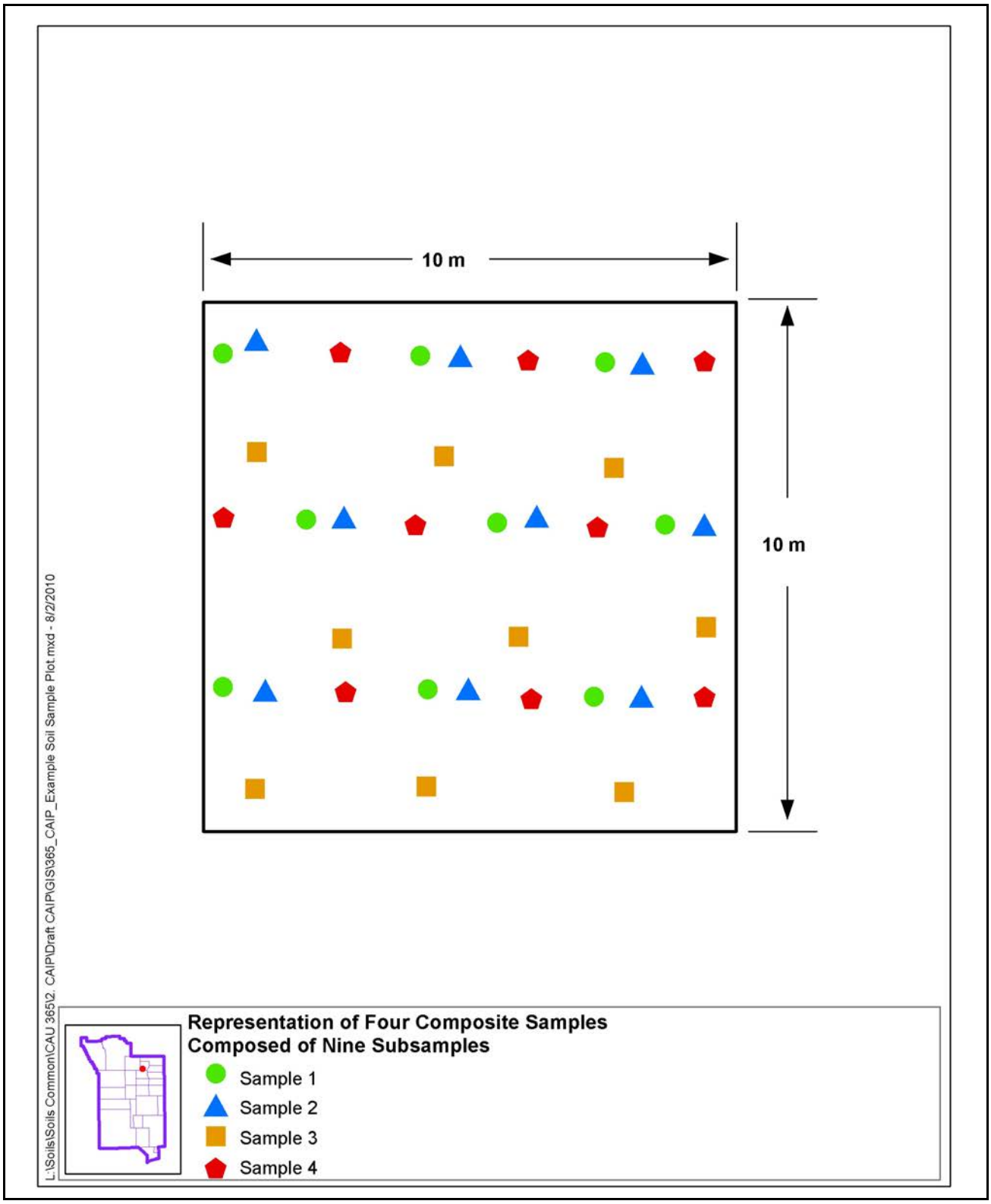

Figure A.8-1
Sample Plot Sample Collection Layout

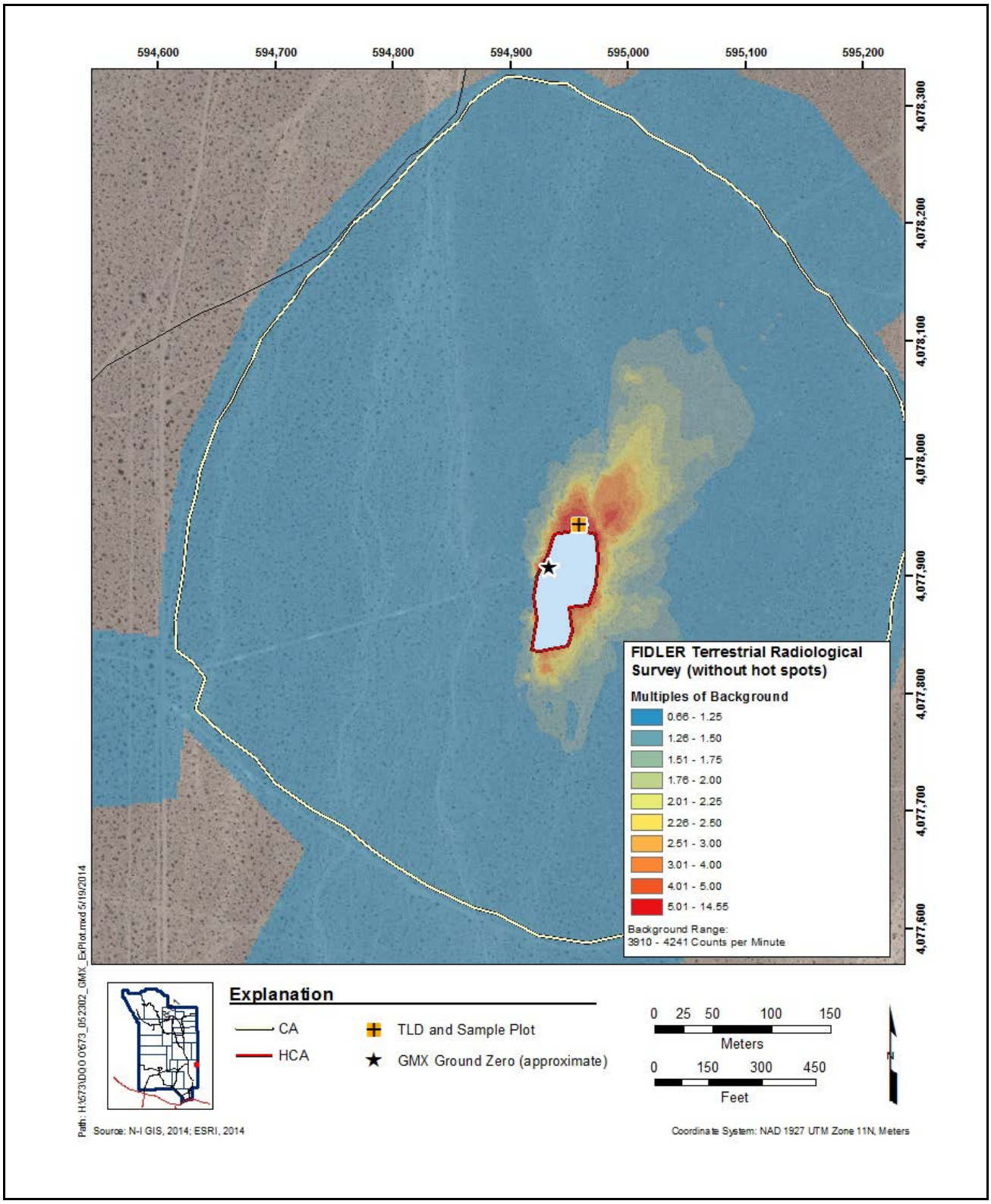

Figure A.8-2
CAU 573 Sample Plot Location for GMX

A.8.1.2 Decision II

Decision II sample plot locations, if necessary, will be selected judgmentally based on TRSs. These data will be used to establish a correlation of TED to radiation survey values. Two Decision II sample plots will be established judgmentally along a minimum of two vectors that are approximately normal to the radiation survey isopleths with the constraint that, on each vector, at least one sample plot will present a TED less than the FAL. Examples of Decision II sample plot locations are shown on Figure A.8-3.

A.8.2 GMX Study Group 2 - Migration

The migration of contamination at GMX is most likely to occur due to surface runoff in washes that run through the GMX CA. Washes that have formed as a result of precipitation events that pass near the GMX DCB and extend to Frenchman Lake will be investigated. The approximate locations of these washes are shown on Figure A.8-4. Other washes leaving the site identified during the CAI will also be investigated.

A.8.2.1 Decision I

The washes (shown in Figure A.8-4) that pass through the GMX area to Frenchman Lake will be surveyed to determine potential sample locations based on TRSs. Soil samples and TLDs will be collected at two sediment areas nearest to the DCB and at any other sedimentation areas that exhibit elevated radioactivity based on the TRS. At each sampled sedimentation area soil samples will be collected at several depth intervals.

Sample locations will be selected from the center of sediment collection areas and/or at locations of elevated radiological readings within the sedimentation accumulation areas. Judgmental samples will be collected as described in Section 4.2.3.

It will be conservatively assumed that the highest TED from either surface or subsurface samples will be used to resolve DQO decisions. A TLD-equivalent external dose will be calculated for the subsurface samples. This will be accomplished by establishing a correlation between RESRAD-calculated external dose from surface samples and the RESRAD-calculated external dose

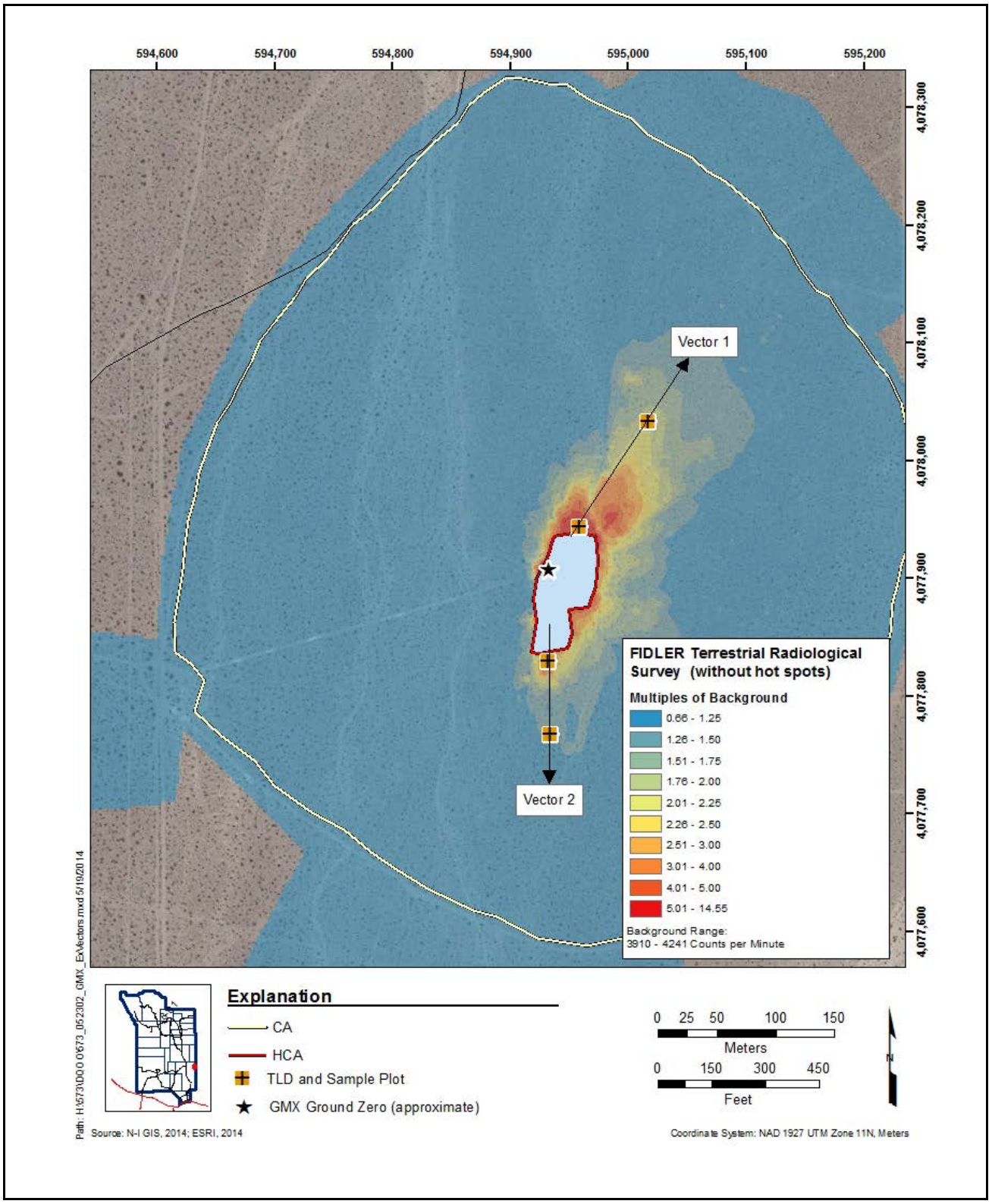

Figure A.8-3
Decision II Sample Plot Locations at GMX

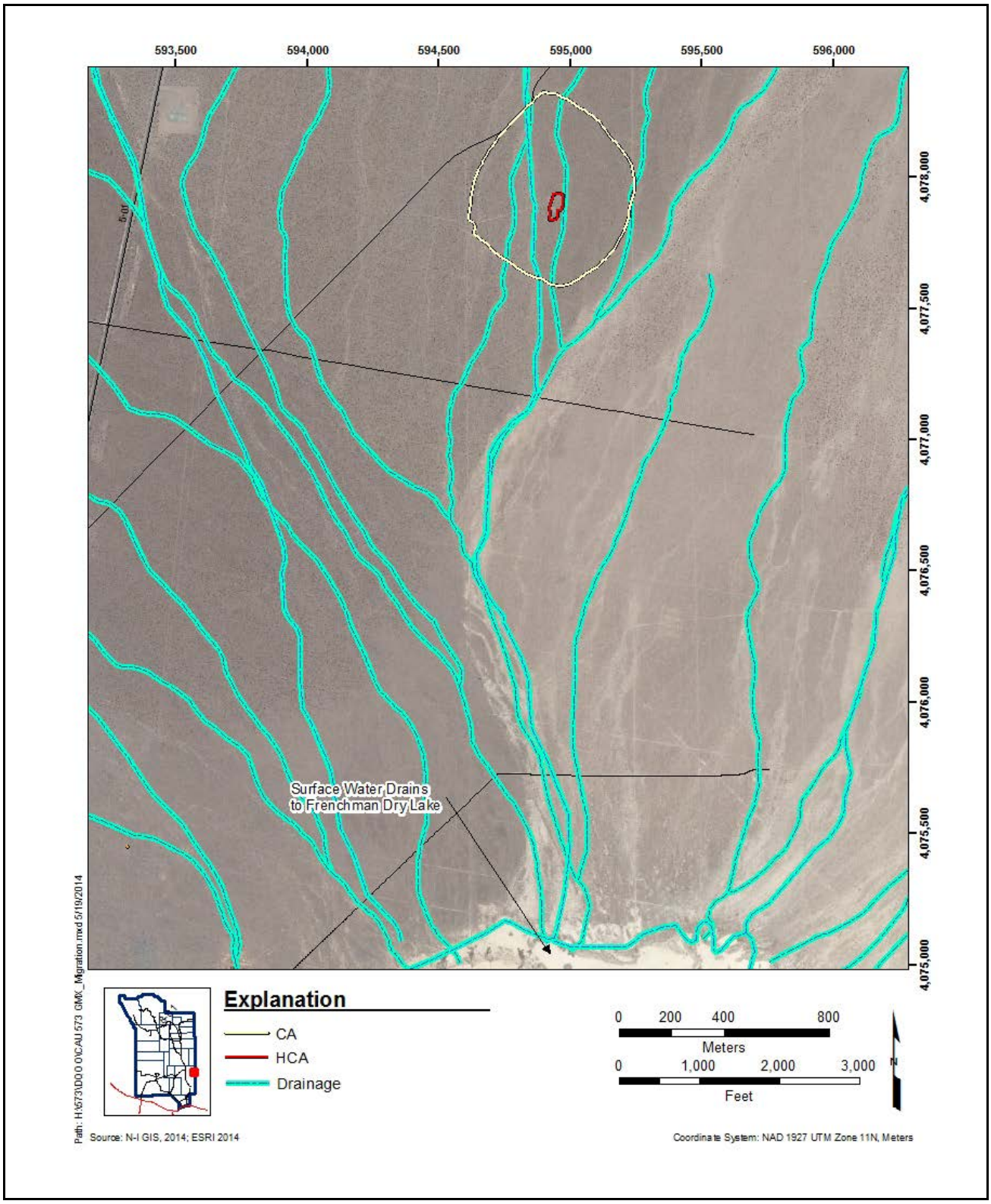

Figure A.8-4
Washes at GMX

from the subsurface samples. This surface TLD reading will be adjusted by this proportion to estimate a TLD-equivalent external dose for the subsurface soil.

Information (such as sample results and the results of the TRS) needed to assess the potential for future migration of the 25-mrem/yr boundary will be obtained during the field investigation and addressed in the investigation report. If any additional drainages are identified during the investigation that have a potential to contain a COC, they will be evaluated as necessary.

A.8.2.2 Decision II

If a contamination level exceeding a FAL is found at a sediment accumulation area sample location, additional sedimentation areas will be sampled until at least two consecutive sedimentation areas are found that do not contain contamination levels exceeding a FAL. Decision II will be resolved by the assumption that the entire volume of sediment in each sediment accumulation area where a contamination level exceeding a FAL was identified exceeds the FAL.

A.8.3 GMX Study Group 3 - Spills/Debris

Sample locations for releases identified in Study Group 3 will be determined based upon the likelihood of a contaminant release at each location. These locations will be selected based on the identification of biasing factors during the investigation. These biasing factors may include the following:

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

- *Preselected areas based on process knowledge of the site*. Locations for which evidence such as historical photographs, experience from previous investigations, or input from interviewee(s) 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.

- *Other biasing factors*. Factors not previously defined for the CAI that become evident during the CAI.

A.8.3.1 Decision I

A judgmental sampling design will be implemented for releases to establish locations and evaluate sample results. Individual sample results, rather than an average concentration, will be used to compare to FALs. Therefore, statistical methods to generate site characteristics will not be needed.

Decision I samples will be collected from soil that presents the greatest degree of the biasing factor identified (surface or subsurface). Specific analyses will be requested based on the nature of the potential release (e.g., RCRA metal analysis at a lead-acid battery PSM location).

A visual survey will also be conducted in the area of the bunker in an effort to identify a potential landfill.

A.8.3.2 Decision II

Decision II judgmental samples will be collected from locations where a COC was detected. In general, sample locations will be arranged in a triangular pattern around the area containing a COC at distances based on site conditions, process knowledge, and biasing factors. If a COC extends 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 any location within the release. A clean sample (i.e., contamination levels less than FALs) collected from each step-out direction (lateral or vertical) will define extent of contamination in that direction.

If evidence of a landfill is found, a geophysical survey will be conducted to determine the extent of the landfill.

A.8.4 Hamilton Study Group 1 - Atmospheric Deposition

A judgmental sampling design will be implemented for locating sample plots for Hamilton Study Group 1 outside the DCB at Hamilton.

The probabilistic sampling scheme will be implemented to select sample locations within the sample plots and evaluate the analytical results. For each sample collected within the sample plot, unbiased subsample locations will be chosen based on a random start, triangular pattern (see Figure A.8-1 for an example of this sampling scheme). A TLD will be placed near the center of each sample plot to measure the external dose.

A.8.4.1 Decision I

Four Decision I sample plot locations will be determined with a radiological survey based on the highest results of the TRSs. This will be done in an effort to find the location where TED is the highest. Figure A.8-5 shows example locations of the Decision I sample plots based on the latest radiological surveys. These locations will be refined when additional surveys are conducted during the CAI. Investigations for the presence of potential subsurface contamination will be implemented as described in Section 4.2.3.

A.8.4.2 Decision II

If the surface contamination is greater than the subsurface contamination in all sample plots, sample plots will be used to establish a correlation to the TRS value, which will be used to determine the area that exceeds FALs. If the subsurface contamination is greater than the surface contamination in any sample plot, subsurface samples will be used to bound the extent of subsurface contamination exceeding FALs.

A.8.5 Hamilton Study Group 2 - Foxholes

Decision I evaluation for Hamilton Study Group 2 is a judgmental sampling approach that will be based on the prior locations of foxholes to determine the presence of a COC (Figure A.8-6). The foxholes located nearest to GZ (one to the north of GZ and one to the south of GZ) will be investigated based on the CSM that contamination levels were higher near the GZ and generally

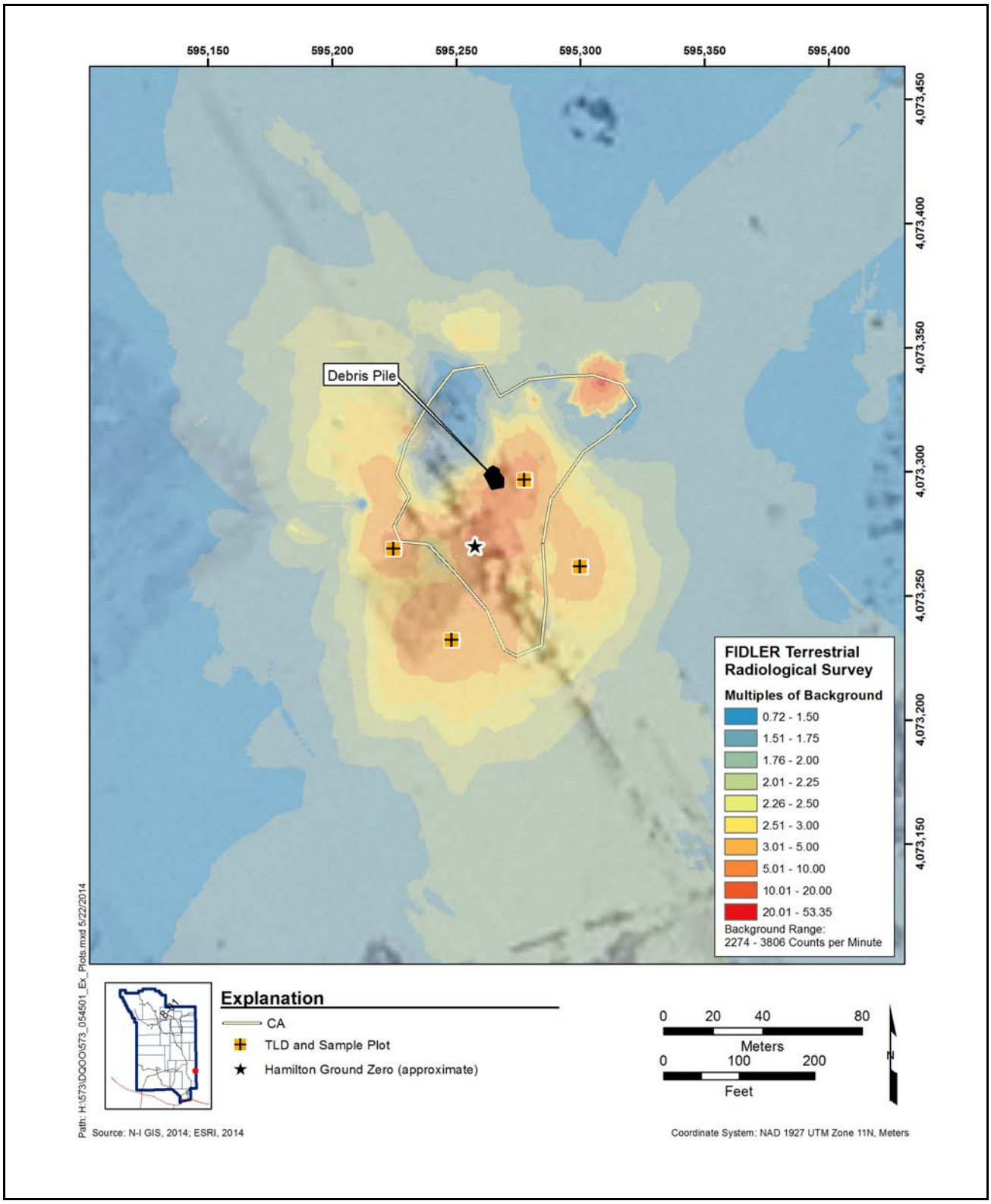

Figure A.8-5
CAU 573 Sample Locations for Hamilton Study Group 1

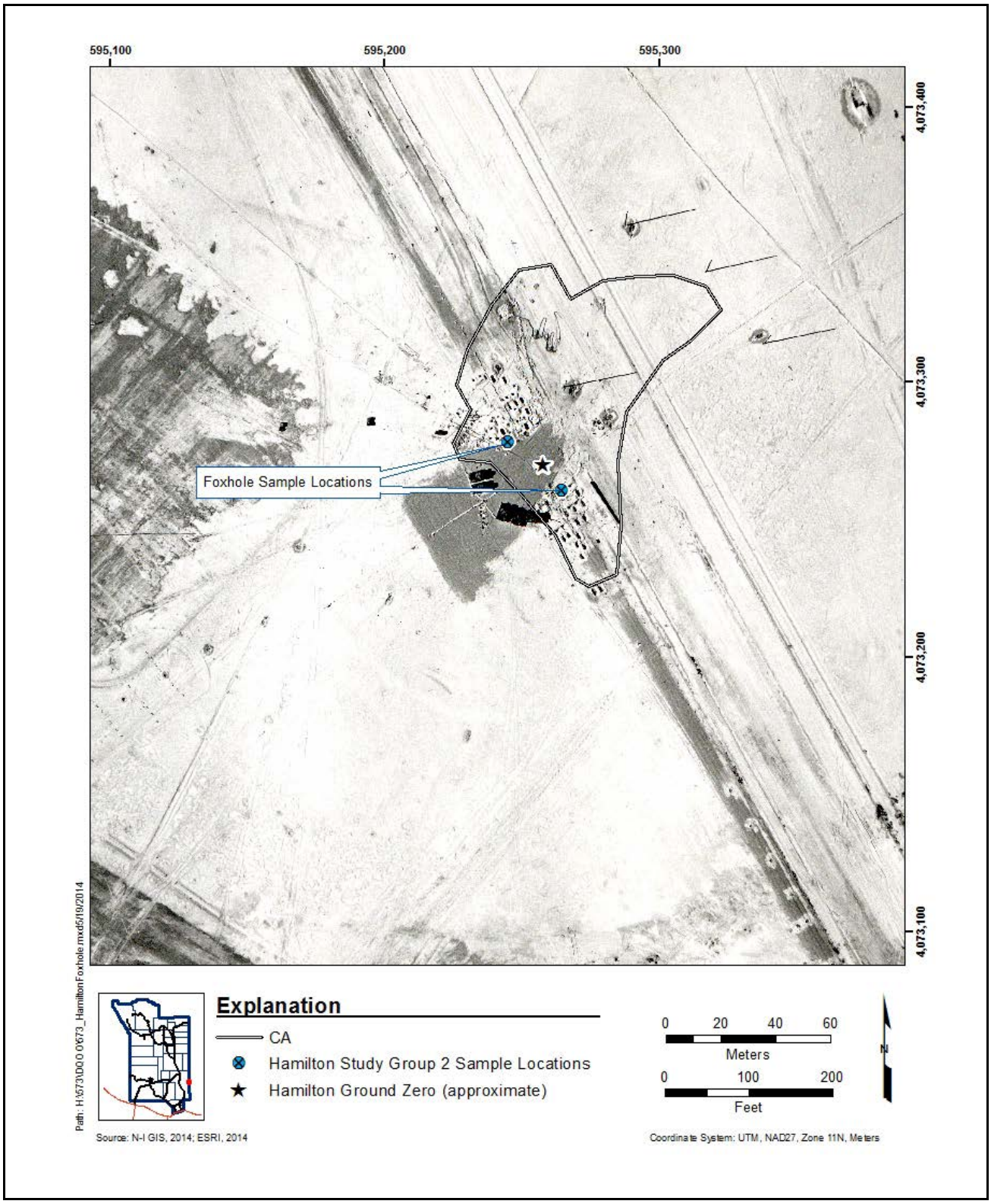

Figure A.8-6
CAU 573 Sample Locations for Hamilton Study Group 2

decreased with distance. Subsurface soil samples will be collected from 60 cm bgs and at the native soil interface. If the native soil interface cannot be determined, a final depth sample will be collected from 120 cm bgs. Where COCs have been confirmed based on validated laboratory analytical results, Decision II will assume that all foxholes are contaminated similarly to the one where the COC was found, and corrective action is necessary for all foxholes.

A.8.6 Hamilton Study Group 3 - Spills/Debris

The investigation for Hamilton Study Group 3 will be conducted as described for the GMX Spills/Debris in Section A.8.3.

Decision II judgmental samples will also be collected from and visual survey conducted of the debris pile to determine nature (waste type) and extent (volume) of the debris pile. Soil samples will be collected from locations determined to best represent the potential debris pile waste based on radiological and visual surveys of the debris pile.

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Appendix B

Activity Organization

B.1.0 Activity Organization

The NNSA/NFO Soils Activity Lead is Tiffany Lantow. She can be contacted at (702) 295-7645.

The identification of the activity 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/NFO Soils Activity Lead be contacted for further information. The Task Manager will be identified in the FFACO Monthly Activity Report prior to the start of field activities.

Appendix C

Nevada Division of Environmental Protection Comments

(8 Pages)

Nevada Environmental Management Operations Activity

DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Investigation Plan for Corrective Action Unit 573	**2. Document Date:**	
3. Revision Number:		**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Activity Lead:	Tiffany A. Lantow	**6. Date Comments Due:**	
7. Review Criteria:			
8. Reviewer/Organization/Phone No:	Jeff McDougall, NDEP,	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
1.) Page 3, Section 1.1.2, Paragraph 4, 3rd sentence		The 3rd sentence is awkward: suggest "The informational inputs and data requirements needed to resolve the problem and decision statements were generated..."	The sentence was modified to read, "The informational inputs and data required to resolve the problem and decision statements were generated as part of the DQO process for this CAU and are documented in Appendix A." Similar text in Section 3.4 was also changed.	Accept
2.) Page 9, Section 2.1.1, Paragraph 1, 1st sentence		Suggest replace "gentle" with a statement of general slope direction and average slope percent in this area.	Replaced the sentence containing "gentle" with: "The GMX site is located on the slopes of Frenchman Flat at mostly a 1 to 3 percent grade with a maximum 4 percent grade in the vicinity of the HCA, approximately 1.5 mi north of Frenchman Lake and 0.8 mi east of 5-01 Road."	Accept
3.) Page 9, Section 2.1.1, Paragraph 1, 5th sentence		Fig 2-1 shows "GMX Ground Zero" but this sentence references "bunker", therefore it seems "bunker" might be added to the Fig. Also, "GZ" implies explosion/detonation/release, but there is no clear statement of such testing, although there is a brief reference to "conventional explosive" in Sec 2.4.1.	The 2nd sentence was replaced with: "This release site is identified as the contaminated soil from the testing activities described in Section 2.4.1.According to documentation, these tests were conducted on or very near one GZ location (Lindahl, 1954). Engineering drawings indicate this location was outside and adjacent to the bunker located within the posted HCA (Silas Mason, 1954). Features associated with this site are shown in Figure 2-1." A reference was inserted to Section 2.1.4 where the nature of the tests (i.e., use of explosives) is described. Deleted other callout to Figure 2-1.	Accept
4.) Page 9, Section 2.1.2, Paragraph 1		It was stated during DQO meeting and site visit that portions of Frenchman Playa are periodically inundated; suggest introduce this fact beginning with this section, referring to recent inundation history and current inundation potential at Hamilton (see 2.4.2).	The sentence was modified to read, "Following significant rain events, it is not uncommon for standing water to be present."	Accept
5.) Page 10, Figure 2-1		Cartographic standard for this document: legend adequately defines location and extent of CA/HCA features, not necessary to replicate abbreviations of figure.	Redundant identifiers have been removed.	Accept
6.) Page 11, Figure 2-2		Cartographic standard for this document: add legend symbols to defined CA/HCA boundaries and remove "CA" from figure.	Redundant identifier was removed and the CA boundary was added to the legend.	Accept

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7.) Page 12, Section 2.2, Paragraph 1		2nd sentence, the phrase: "describe the current definition of each CAS ..." is unclear. The subsections appear to describe operational histories, not a definition.	The sentence was modified to read, "The site-specific summaries are designed to describe the releases associated with each CAS and document all significant, known activities."	Accept
8.) Page 12, Section 2.2.1, Paragraph 1, 4th sentence		"relatively small quantities...", suggest replace with an quantitative estimate based on best available information. If such an estimate can't be made, so state.	The following sentence was inserted in the response to Comment 27: "The Radionuclide Inventory and Distribution Program (RIDP) study estimated the quantity of Pu at the GMX site to be approximately 19 grams (DRI, 1989)."	Accept
9.) Page 13, Section 2.2.2., Paragraph 1, last sentence		Suggest improve discussion by interpreting the major visual details shown in this photograph, i.e., it is centered on the Hamilton GZ, Debris Pile, and CA, and shows current (recent ?) environmental conditions on the surrounding playa: gray rectangles (gravel blankets?), linear features (access roads/cable runs?), vegetation patches surrounding ponded water (south edge of photo) and along linear features, and playa sediments (bright tones throughout).	The third sentence was replaced with: "The Hamilton test area is identified by a posted CA encompassing approximately 1.5 acres. Figure 2-2 shows several site features including gravel blankets (gray rectangles), access roads and possible cable runs (linear features), patches of vegetation, and playa sediments."	Accept
10.) Page 14, Section 2.4, Paragraph 1, 2nd sentence		Grammar, change "independent" to "independently"; the phrase "... of the other" is redundant	Changed "independent of the other" to "independently".	Accept
11.) Page 14, Section 2.4.1, Paragraph 2, 1st sentence		"may be located or present" is redundant	Deleted "located or".	Accept
12.) Page 14, Section 2.4.1, Paragraph 2		Suggest replace the word "migration" when referring to sediment movement with the standard geologic nomenclature" transport".	Agree that "migration" should be used when referring to contaminants and that transport would be more appropriate when referring to the movement of sediments. As this specific text was referring to contaminant movement, the word migration was not changed.	Accept
13.) Page 15, Figure 2-3		Since there are no apparent values greater than 500 cps, remove the 500-1000 color block from legend upper left, IAW Fig 2-6	The 500-1000 color block was removed from the legend as suggested.	Accept

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14.) Page 17, Figure 2-4		Since there are no apparent values above 500 cps, remove the 500-1000 color block from legend upper left.	The 500-1000 color block was removed from the legend as suggested.	Accept
15.) Page 22, Section 2.5.1.4, Paragraphs 1,2		para 1, 2nd sentence: replace "at an elevation" with "distance above ground surface"; para 2, 1st sentence: unclear, does this refer to the "averaging" process described in 2nd bullet statement on p.11 of the DQO presentation of 3 April, 2014?; para 2, 2nd sentence: expand on purpose and results of survey outside southwest side CA boundary including hot spots shown in Fig. 2-6 (contaminated debris?), and any corrective actions taken at the time of field inspection, such as debris removal, as discussed during site visit.	Changed all instances where TRS survey referred to "at an elevation" to "with the sensor held about 12 in. above the ground surface" To address the 2nd and 3rd comment, the section was modified to read, " A three-dimensional (3-D) representation of the FIDLER survey is displayed in Figure 2-7. This figure shows the point sources present in the areas surveyed, some of which were discontinuous to the contamination plume. These point sources were not detected in the aerial survey reported in Section 2.5.1.2 due to the larger field of view. The point sources that were located outside the posted CA during the FIDLER TRS were picked up and relocated within the CA. Some of the point sources were found on the surface, while others were located as much as 4 in. bgs. These point sources ranged in size from approximately 1/8 to 1 in. in diameter. The preliminary investigation also included a visual inspection, which revealed several other pieces of debris."	Accept
16.) Page 23, Figure 2-6		If possible, increase the size for FIDLER MOB legend color circles upper left to improve readability; add the word "Survey" between "Aerial" and "Background" to Fig title.	The figure was modified as suggested. The word "background" in the title was changed to "survey."	Accept
17.) Page 25, Section 2.5.2.1, Paragraph 1, 3rd sentence		There are considerably more than "29 sample locations" shown on Fig 2-8, clarify. Explain meaning of "low" density of data points, because Fig 2-8 seems to show a relatively high density of sample locations.	The third sentence was replaced with: "Of the sample locations collected from the Frenchman Lake region, only four sample locations were located within 100 m of the Hamilton GZ. The reported Pu-239 values for these four locations ranged from 24.3 to 124.4 pCi/g."	Accept
18.) Page 25, Section 2.5.2.2, Paragraph 1		Consider presenting historical mapped data for NTS RAP (Barnes et al., 1980) as was done for historical RIDP data.	The NTS RAP maps were added as Figures 2-9 and 2-10. All subsequent figures were re-numbered.	Accept

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19.) Page 25, Section 2.5.2.3, Paragraph 1		Sentence 1; is run-on/awkward Sentence 2: suggest rewrite because the 2010 survey itself did not "modify the shapes....", but instead produced data showing survey isopleths of different size, shape, and measurement magnitude from that of the 1994 survey. It would be helpful to briefly explain why the 2010 survey produced cps measurements in some cases 3-5x higher than the 1994 survey.	Section 2.5.2.3 was replaced with: "The 1994 aerial radiological survey was flown at an elevation of 200 ft above ground surface, which provided the sensors a nominal field of view of approximately 400 ft (BN, 1999). The 2010 aerial radiological survey was flown at an elevation of 50 ft above ground surface, which provided the sensors a nominal field of view of approximately 100 ft (NSTec, 2012). Figure 2-11 displays a comparison of results from the 1994 and 2010 aerial Am surveys. The counts per second values shown for the two surveys are not directly comparable due to differences in the instrumentation used. The greater resolution provided by the 2010 aerial survey resulted in a smaller, more refined shape of the Am/Pu contaminated area than that of the 1994 aerial survey. This pattern provides information regarding the surface soil contamination as well as the influence from the large debris pile located within the CA. The radiological aerial survey results show no distinguishable gross gamma count isopleths associated with Hamilton."	Accept

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20.) Page 27, Section 2.5.2.4, Paragraph 1		2nd sentence: replace "at an elevation" with "distance above ground surface" 2nd to last sentence: unclear, does this refer to the "averaging" process described in 2nd bullet statement on p.11 of the DQO presentation of 3 April 2014?	Section 2.5.4 was replaced with: “As part of preliminary investigative work conducted at the Hamilton site in 2011, a TRS with a FIDLER was completed. The FIDLER TRS was conducted with the sensor held about 12 in. above the ground surface, which results in a nominal field of view of approximately 2 ft in diameter. The smaller field of view provides for a much greater resolution than for the aerial surveys as illustrated in Figure 2-12. The greater resolution provided by the FIDLER survey identified discrete point sources as well as more continuous contamination. A 3-D representation of the FIDLER survey is displayed in Figure 2-13. This figure shows the point sources present in the areas surveyed, some of which were discontinuous to the contamination plume. These point sources were not detected in the aerial survey reported in Section 2.5.1.2 due to the larger field of view. The point sources that were located outside the posted CA as a result of the FIDLER TRS were picked up and relocated within the CA as a best management practice (BMP). The point sources were located primarily on the surface and ranged in size from small gravel-sized pieces to pieces of twisted metal as large as 2 in. in length. The exact FIDLER reading for each point source was not recorded but in most cases exceeded the detection limit of the meter. The preliminary investigation also included a visual inspection, which revealed several pieces of debris.”	Accept
21.) Page 28, Figure 2-9		If there are no values above 500 cps, remove the 500-1000 color block from legend upper left.	The 500-1000 color block was removed from the legend as suggested.	Accept
22.) Page 29, Figure 2-10		If possible, increase the size for FIDLER MOB legend color circles upper left to improve readability.	The figure was modified as suggested.	Accept
23.) Page 35, Section 3.1.4.1, Paragraph 1, 1st sentence		the phrase, "since the original deposition" is redundant (transport of contaminated sediments could only have occurred since original deposition).	The phrase "since the original deposition" was removed from the sentence.	Accept

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24.) Page 35, Section 3.1.4.2, Paragraph 1, last sentence		after "... identified", add "although periodic playa inundation may initiate soil-water interactions that may transport radionuclides away from areas of known contamination (Hershey et al., 2013)"	The sentence was modified to read, "There are no significant migration pathways identified, although periodic playa inundation may initiate soil-water interactions that may transport radionuclides away from areas of known contamination (Hershey et al., 2013)."	Accept
25.) Page 42, Figure 3-3		What's the significance of the red border around the debris pile (DCB?)	The red line outlines the default contamination boundary.	Accept
26.) Page 47, Section 4.2.2.1, Paragraph 1, 1st sentence		Clarify the use of the 1994 AMS results and not the 2010 AMS results for TED placement measurements.	The sentence was modified to read, "Decision I at GMX Study Group 1 will be evaluated by measuring TED within a sample plot established within the area of the highest radiological values as determined from the 1994 aerial survey (BN, 1999) and/or a TRS conducted with a handheld instrument (the 2010 aerial survey did not include the GMX area)."	Accept
27.) Page A-9, Section A.2.2.1.1, Paragraph 1, 1st sentence		per DQO notes, add additional explanation of Fig A.2-4 that point source contamination outliers have been removed and the image shows averaged FIDLER measurements from adjacent locations that reflect interpolated values which produce a smoothed surface. Also clarify whether or not the area inside the HCA boundary was surveyed.	In response to this comment, Comment #8, and Comment #29, the first paragraph of Section A.2.2.1.1 and the first paragraph of Section 2.2.1 were replaced with: The GMX release is associated with the atmospheric deposition of radionuclides, primarily Pu, to the surrounding surface soil from 29 “equation of state” experiments conducted at the site. Two of the 29 tests are listed as type “U-238,” 24 are listed as type “Pu,” and 3 are listed as type “non-active” (Malik, 1982). The RIDP study estimated the quantity of Pu at the GMX site to be approximately 19 grams (DRI, 1989).These experiments were designed to examine the properties of Pu and U when subjected to forces imposed using conventional explosives. Upon detonation of the explosives, the Pu and U targets disintegrated into small particles ranging in size from microscopic to fragments that can easily be seen with the naked eye. According to engineering drawings, these experiments were conducted on or very near one location outside and adjacent to the bunker located within the posted HCA (Silas Mason, 1954). The initial release of radionuclides from the GMX experiments was	Accept

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			distributed in an elongated annular pattern centered over the bunker and HCA as shown in the 2011 FIDLER TRS of the GMX area (Figure 2-6). The area inside the HCA was not included in the FIDLER TRS and was also not included in the subsequent analyses of the data. This survey detected the presence of discrete particles as well as a plume of continuous soil contamination as shown in Figure 2-7. To better define the soil contamination plume, the discrete point sources were removed from the survey data, and the remaining data were smoothed using a krieging technique. The resulting surface contamination plume is shown in Figure A.2-4. As shown in these figures, the contamination generally decreases with distance from the GZ, with the plume extending preferentially to the east and northeast. Based on observations from an aerial photograph, the only disturbed areas of the site appear to be the access road leading to the HCA and the area within the HCA (Figure 2-1). The experiments were observed through a periscope by cameras in the bunker (Malik, 1982). Additional uses of the bunker are unknown. According to the RI/FS, decontamination of the test area began in 1956, consisting of shallow burial of Pu-contaminated clothing, scrap metals, and scrap wood near GZ (DOE/NV, 1992). The specific burial location is not stated, and no additional references were found for this information.	
28.) Page A-10, Figure A.2-4		Suggest add notation to Fig. if the area inside HCA was not surveyed.	The figure was modified to reflect this comment.	Accept
29.) Page A-5, Section A.2.2.1.1, Paragraph 1		The purpose of an "equation of state" experiment is usually NOT to measure the dispersal effects of conventional explosives on Pu, but to elucidate the material properties on an atomic level as a function of pressure, temperature and density. Consider rewriting if you decide to keep this informational lead-in.	The purpose of the experiments was clarified in the revised paragraph presented in the response to comment 27.	Accept

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30.) Page A-9, Section A.2.2.1.2, Paragraph 1, 2nd sentence		per DQO notes, add additional explanation of Fig A.2 that point source contamination outliers have been removed to reflect soil contamination and the image shows averaged FIDLER measurements from adjacent locations that reflect interpolated values which produce a smoothed surface.	The additional explanation about the point sources and the smoothed plume surface were incorporated into the revised paragraph presented in the response to Comment #27.	Accept
31.) Page A-43, Figure A.8-4		Modify Fig A.8-4 to indicate which "significant wash" Sec A.8.2 refers, since there are about 25 individual drainages shown, 4 of which traverse the CA.	The words "significant", "primary", and "secondary" were removed from the text as these terms are not needed or appropriate in the selection of sampling locations.	Accept
32.) Page A-46, Section A.8.5, Paragraph 1, 2nd sentence		Clarify the reasoning for the number and locations chosen for foxhole sampling.	The following sentences were inserted after the first sentence: "The foxholes located nearest to GZ (one to the north of GZ and one to the south of GZ) will be investigated based on the CSM that contamination levels were higher near the GZ and generally decreased with distance."	Accept
The following additional comments and subsequent needed revisions to the document were identified during the draft review:				
1.) Section 2.1.2		Change 7,000 square yards to acres so that it is consistent with Section 2.1.1.	Changed "7,000 square yards" to "1.5 acres"	Accept

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