Nevada
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Project

DOE/NV--1463

National Nuclear Security Administration

Corrective Action Decision Document/ Corrective Action Plan for Corrective Action Unit 547: Miscellaneous Contaminated Waste Sites Nevada National Security Site, Nevada

Controlled Copy No.: ___
Revision No.: 0

September 2011

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Environmental Restoration
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U.S. Department of Energy
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CORRECTIVE ACTION DECISION DOCUMENT/ CORRECTIVE ACTION PLAN FOR CORRECTIVE ACTION UNIT 547: MISCELLANEOUS CONTAMINATED WASTE SITES NEVADA NATIONAL SECURITY SITE, NEVADA

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

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CORRECTIVE ACTION DECISION DOCUMENT/CORRECTIVE ACTION PLAN FOR CORRECTIVE ACTION UNIT 547: MISCELLANEOUS CONTAMINATED WASTE SITES NEVADA NATIONAL SECURITY SITE, NEVADA

Approved by: /s/ Kevin Cabble Date: 9-14-11

Kevin J. Cabble
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Approved by: /s/ Robert F. Boehlecke Date: 9/14/11

Robert F. Boehlecke
Federal Project Director
Environmental Restoration Project

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List of Acronyms and Abbreviations

ALARA	As low as reasonably achievable
Am	Americium
bgs	Below ground surface
BJY	Buster Jangle Wye
BMP	Best management practice
CA	Contamination area
CAA	Corrective action alternative
CADD	Corrective action decision document
CAP	Corrective action 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^3	Cubic centimeter
COC	Contaminant of concern
COPC	Contaminant of potential concern
cpm	Counts per minute
CR	Closure Report
Cs	Cesium
CSM	Conceptual site model
DAC	Derived air concentration
DOE	U.S. Department of Energy
DOT	U.S. Department of Transportation
dpm/100 cm^2	Disintegrations per minute per 100 square centimeters

List of Acronyms and Abbreviations *(Continued)*

DQO	Data quality objective
EPA	U.S. Environmental Protection Agency
FAL	Final action level
FFACO	*Federal Facility Agreement and Consent Order*
FIDLER	Field Instrument for the Detection of Low-Energy Radiation
ft	Foot
g	Gram
g/ft	Grams per foot
HCA	High contamination area
ISOCS	In Situ Object Counting System
IDW	Investigation-derived waste
in.	Inch
INEL	Idaho National Engineering Laboratory
in./yr	Inches per year
mi	Mile
mrem	Millirem
mrem/yr	Millirem per year
mrem/IA-yr	Millirem per Industrial Area year
NAD	North American Datum
NDEP	Nevada Division of Environmental Protection
NDT	Non-destructive testing
NHTSA	National Highway Transit Safety Administration
NNSS	Nevada National Security Site
Np	Neptunium
ORNL	Oak Ridge National Laboratory
PCB	Polychlorinated biphenyl

List of Acronyms and Abbreviations (Continued)

pCi	Picocurie
pCi/g	Picocuries per gram
PPE	Personal protective equipment
PSM	Potential source material
Pu	Plutonium
QA	Quality assurance
QC	Quality control
REOP	Real Estate/Operations Permit
RESRAD	Residual radioactive
RRMG	Residual radioactive material guideline
RWMS	Radioactive waste management site
SCBA	Self-contained breathing apparatus
SGZ	Surface ground zero
SRS	Savannah River Site
SVOC	Semivolatile organic compound
TBD	To be determined
TRU	Transuranic
UCL	Upper confidence limit
UGTA	Underground Test Area
UR	Use restriction
UTM	Universal Transverse Mercator
VOC	Volatile organic compound
WIPP	Waste Isolation Pilot Plant
$\mu g/m^2$	Micrograms per square meter

Executive Summary

This Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP) addresses the actions needed to achieve closure for Corrective Action Unit (CAU) 547, Miscellaneous Contaminated Waste Sites, identified in the *Federal Facility Agreement and Consent Order* (FFACO). The purpose of this CADD/CAP is to present the corrective action alternatives (CAAs) evaluated for CAU 547, provide justification for selection of the recommended alternative, and describe the plan for implementing the selected alternative.

Corrective Action Unit 547 consists of the following three corrective action sites (CASs):

- CAS 02-37-02, Gas Sampling Assembly
- CAS 03-99-19, Gas Sampling Assembly
- CAS 09-99-06, Gas Sampling Assembly

The gas sampling assemblies consist of inactive process piping, equipment, and instrumentation that were left in place after completion of underground safety experiments. The purpose of these safety experiments was to confirm that a nuclear explosion would not occur in the case of an accidental detonation of the high-explosive component of the device. The gas sampling assemblies allowed for the direct sampling of the gases and particulates produced by the safety experiments. Corrective Action Site 02-37-02 is located in Area 2 of the Nevada National Security Site (NNSS) and is associated with the Mullet safety experiment conducted in emplacement borehole U2ag on October 17, 1963. Corrective Action Site 03-99-19 is located in Area 3 of the NNSS and is associated with the Tejon safety experiment conducted in emplacement borehole U3cg on May 17, 1963. Corrective Action Site 09-99-06 is located in Area 9 of the NNSS and is associated with the Player safety experiment conducted in emplacement borehole U9cc on August 27, 1964.

The CAU 547 CASs were investigated in accordance with the data quality objectives (DQOs) developed by representatives of the Nevada Division of Environmental Protection (NDEP) and the U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office. The DQO process was used to identify and define the type, amount, and quality of data needed to determine and implement appropriate corrective actions for CAU 547. Existing radiological survey data and historical knowledge of the CASs were sufficient to meet the DQOs and evaluate CAAs

without additional investigation. As a result, further investigation of the CAU 547 CASs was not required.

The following CAAs were identified for the gas sampling assemblies: (1) clean closure, (2) closure in place, (3) modified closure in place, (4) no further action (with administrative controls), and (5) no further action. Based on the CAAs evaluation, the recommended corrective action for the three CASs in CAU 547 is closure in place. This corrective action will involve construction of a soil cover on top of the gas sampling assembly components and establishment of use restrictions at each site. The closure in place alternative was selected as the best and most appropriate corrective action for the CASs at CAU 547 based on the following factors:

- Provides long-term protection of human health and the environment.
- Minimizes short-term risk to site workers in implementing corrective action.
- Is easily implemented using existing technology.
- Complies with regulatory requirements.
- Fulfills FFACO requirements for site closure.
- Does not generate transuranic waste requiring offsite disposal.
- Is consistent with anticipated future land use of the areas (i.e., testing and support activities).
- Is consistent with other NNSS site closures where contamination was left in place.

This CADD/CAP has been developed in accordance with the FFACO that was agreed to by the State of Nevada; DOE, Environmental Management; U.S. Department of Defense; and DOE, Legacy Management. Under the FFACO, this document will be submitted to NDEP for approval.

1.0 Introduction

This Corrective Action Decision Document (CADD)/Corrective Action Plan (CAP) provides the rationale and supporting information for the selection and implementation of corrective action at Corrective Action Unit (CAU) 547: Miscellaneous Contaminated Waste Sites, Nevada National Security Site (NNSS), Nevada. The document has been developed in accordance with the *Federal Facility Agreement and Consent Order* (FFACO) (1996, as amended) that was agreed to by the State of Nevada; U.S. Department of Energy (DOE), Environmental Management; U.S. Department of Defense; and DOE, Legacy Management.

Corrective Action Unit 547 comprises the following three corrective action sites (CASs):

- CAS 02-37-02, Gas Sampling Assembly – located in Area 2 of the NNSS and associated with the Mullet safety experiment. The Mullet safety experiment was conducted at borehole U2ag on October 17, 1963.
- CAS 03-99-19, Gas Sampling Assembly – located in Area 3 of the NNSS and associated with the Tejon safety experiment. The Tejon safety experiment was conducted at borehole U3cg on May 17, 1963.
- CAS 09-99-06, Gas Sampling Assembly – located in Area 9 of the NNSS and associated with the Player safety experiment. The Player safety experiment was conducted at borehole U9cc on August 27, 1964.

The gas sampling assemblies consist of inactive process piping, equipment, and instrumentation that was left in place after completion of underground safety experiments. The purpose of these safety experiments was to confirm that a nuclear explosion would not occur in the case of an accidental detonation of the high-explosive component of the device (DOE/NV, 2000). The sites are located at the NNSS (Figure 1-1), which is approximately 65 miles (mi) northwest of Las Vegas, Nevada.

Throughout this document, the names of the safety tests associated with each CAS are used extensively. These test names are considered interchangeable with the FFACO CAS number (i.e., the Mullet CAS or site refers to CAS 02-37-02; the Tejon CAS or site refers to CAS 03-99-19; and the Player CAS or site refers to CAS 09-99-06).

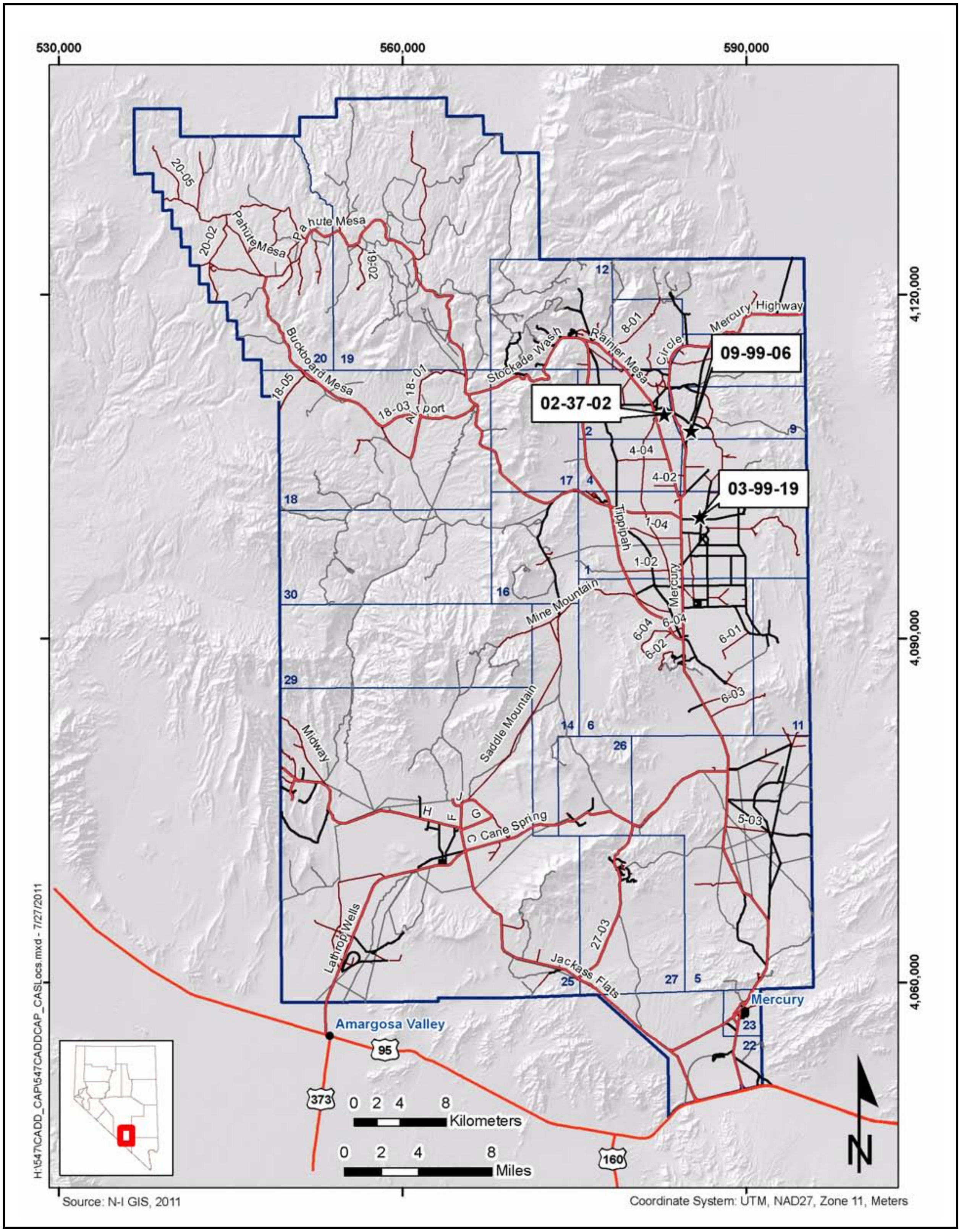

Figure 1-1
CAU 547 CAS Locations

1.1 Purpose

The purpose of this CADD/CAP is to present the evaluation of corrective action alternatives (CAAs) for the three CAU 547 gas sampling assemblies and provide the rationale for selection of the preferred corrective action. The document also provides the plan for corrective action implementation and long-term monitoring of the CASs.

1.2 Scope

The scope of this document includes the gas sampling assemblies and associated releases at the three CASs in CAU 547.

1.3 CADD/CAP Contents

This CADD/CAP includes the following sections and appendices:

Section 1.0, "Introduction," provides the document purpose, scope, and contents; and includes a detailed description of the three CASs in CAU 547.

Section 2.0, "Corrective Action Investigation Summary," provides a summary of investigation activities, results of the investigation, and the need for corrective action.

Section 3.0, "Evaluation of Alternatives," discusses the process for the evaluation of CAAs to include screening and development of alternatives, and identifies the recommended alternative.

Section 4.0, "Recommended Alternative," presents the recommended CAA and the rationale for its selection.

Section 5.0, "Detailed CAP Statement of Work," discusses the plan for implementation of the preferred CAA and the methods by which the work will be verified. Also includes a discussion of the associated quality assurance (QA)/quality control (QC) and waste management requirements and the permits required to complete the work.

Section 6.0, "Schedule," identifies the schedule for major activities.

Section 7.0, "Post-closure Plan," summarizes the requirements for post-closure inspections, maintenance, and repairs.

Section 8.0, "References," provides a list of all referenced documents used in the preparation of this CADD/CAP.

Appendix A, *Project Organization*, identifies the DOE Federal Sub-Project Director and other appropriate personnel involved with the CAU 547 characterization and closure activities.

Appendix B, *Data Quality Objectives* (DQOs), provides the corrective action DQOs.

Appendix C, *Evaluation of Risk*, presents the risk evaluation for the CAAs.

Appendix D, *Engineering Specifications and Drawings*, presents the design and specifications for the recommended corrective action. Attachment D-1 of this appendix presents the exposure model on which the soil cover design is based.

Appendix E, *Post-closure Plan*, presents the long-term monitoring plan for CAU 547.

Appendix F, *Cost Estimates*, presents the cost estimate information used in the evaluation of the CAAs.

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

Appendix H, *Corrective Action Investigation Results*, is not applicable for this document.

Appendix I, *Data Assessment*, is not applicable for this document.

Appendix J, *Sampling and Analysis Plan*, is not applicable for this document.

1.4 CAS Descriptions

The operational history for CAU 547 is summarized in this section. This information has been obtained through review of historical and current documents, engineering drawings/maps, and written accounts of site activities by former employees.

1.4.1 CAS 02-37-02, Gas Sampling Assembly

Corrective Action Site 02-37-02 consists of environmental surface and shallow subsurface releases associated with the safety experiment Mullet conducted in emplacement borehole U2ag on October 17, 1963. The emplacement hole was drilled between September 4 and 14, 1963, to a depth of 207 feet (ft) with a casing diameter of 48 inches (in.) (RSN, 1991). The Mullet experiment was part of Operation Niblick and involved a nuclear detonation that resulted in a low yield (DOE/NV, 2000). The gas sampling assembly at the Mullet site was designed to achieve prompt sampling of particulate material generated during the experiment. The system was designed to convey gas from the emplacement hole (U2ag) to a sampling assembly (Olson, 1963; H&N, 1963a). Figure 1-2 presents the engineering drawing of the Mullet gas sampling assembly. A pre-test aerial photograph taken in October 1963 shows the layout for the Mullet site (Figure 1-3).

Surface ground zero (SGZ) at the site consists of a concrete pad with a 4-in. pipe coming out of the emplacement hole. The pipe rises approximately 8 ft vertically at the emplacement hole, then turns 90 degrees and runs approximately 10 ft, then turns another 90 degrees (Figure 1-4). The pipe then runs into the ground under a berm to the east toward the U2am (Commodore test) crater. The engineering drawing (Figure 1-2) indicates the pipe continued through a series of valves to a sampling assembly housed in a subsurface trench and then to multiple sample bottles staged on the ground surface. Beyond the sampling assembly, the system had a “Y” pipe junction with each branch running to a filter unit. Unlike the other two CASs in CAU 547, the gas sampling assembly at the Mullet site did not terminate in an existing borehole, but instead terminated some distance beyond the two filter units.

According to the engineering drawing (Figure 1-2), the total system length was approximately 250 ft from SGZ at U2ag to the end of the sampling assembly. The site has been geologically disturbed, most likely from the Stanyan (U2aw) and Commodore experiments (U2am) (Figures 1-5 and 1-6). Both Stanyan and Commodore were weapons-related experiments conducted on September 26, 1974, and May 20, 1967, respectively (DOE/NV, 2000). The Commodore test area had been surveyed before the test, and alpha contamination was not identified. Furthermore, alpha contamination was not identified during the Commodore reentry survey, and routine surveys around the crater lip did not identify alpha contamination.

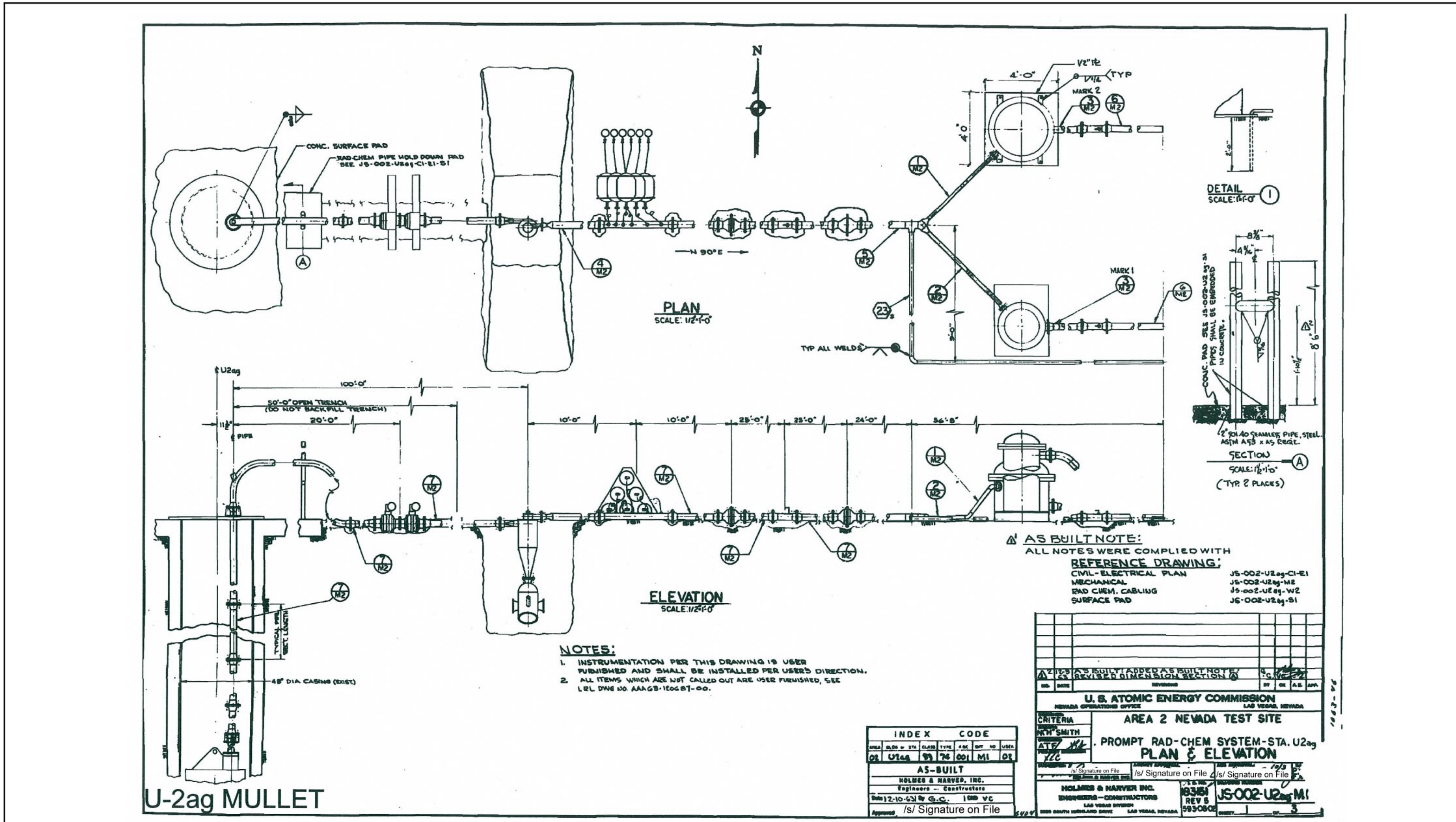

Figure 1-2
U2ag Mullet As-Built Drawing, Plan and Elevation (12/10/1963)
Source: H&N, 1963a

Figure 1-3
Mullet Safety Experiment Site Layout (October 1963)
Source: Modified from RSL, 1963

Figure 1-4
Sample Pipe System Exiting Emplacement Borehole U2ag Mullet

Some surface components of the sampling assembly were disassembled and moved after the Mullet experiment. There are open-ended, disconnected pipes near the edge of the Commodore test crater running toward the safety experiment piping (Figure 1-7). The entire length of the gas sampling assembly is currently posted as a contamination area (CA), with two smaller areas inside the fence posted as high contamination areas (HCAs). Historical information indicates the fenced areas encompass soil and buried debris contaminated after the Mullet test. Unidentified metal debris, assumed to be associated with the piping system, is visible at the surface inside one of the HCAs.

Because the gas sampling assembly was designed to vent radioactive gases from U2ag, subsurface contamination is expected in the emplacement borehole. These contaminants are included in the source term of the U2ag test, which is included in the scope of Underground Test Area (UGTA) CAS 02-57-006, U-2ag Cavity (CAU 97).

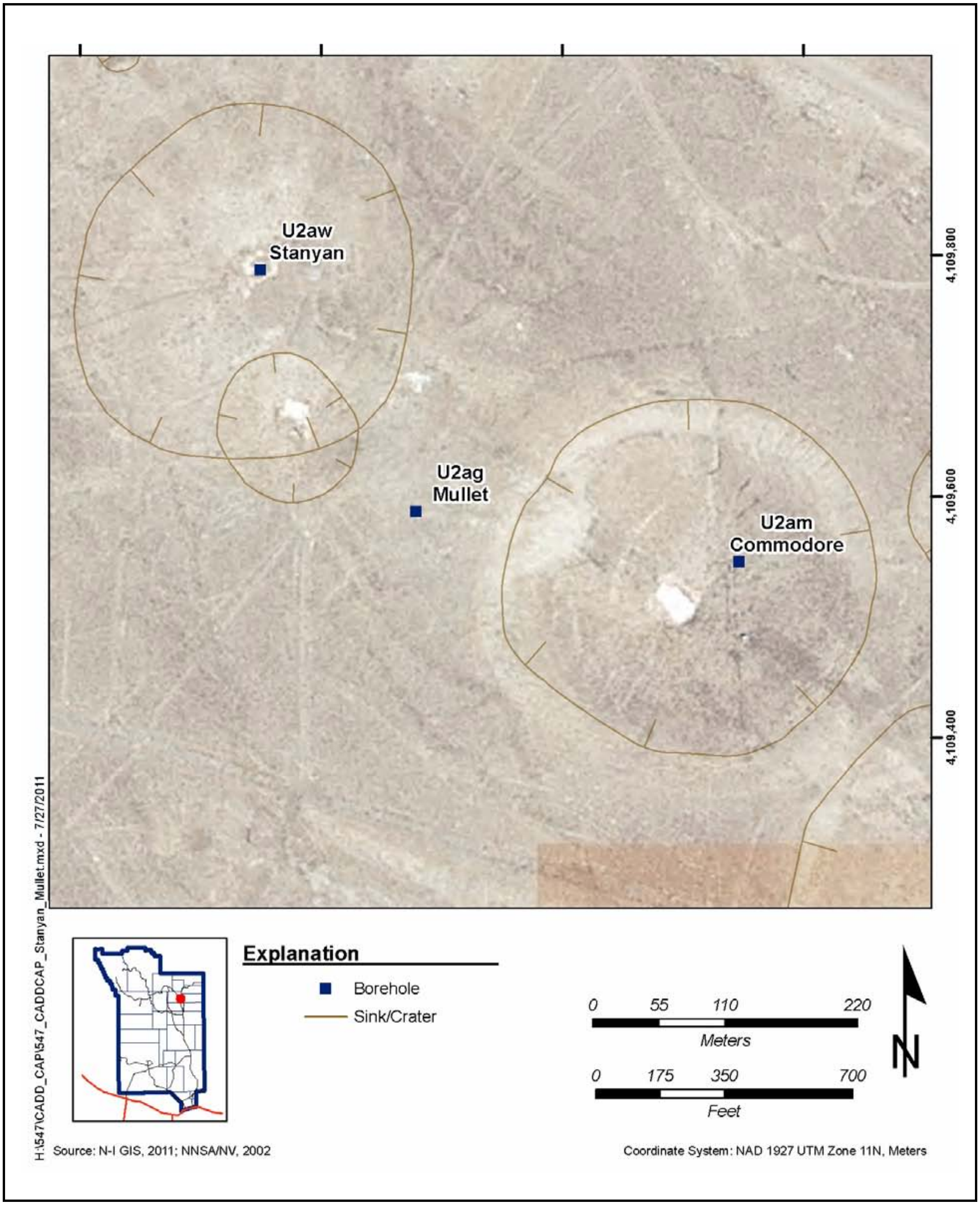

Figure 1-5
Location of Stanyan (U2aw), Commodore (U2am), and Mullet (U2ag) Sites

Figure 1-6
Area of Disturbed Soil near End of Pipe Assembly at U2ag Mullet

Figure 1-7
Open-Ended Pipe at End of Sampling Assembly at U2ag Mullet

1.4.1.1 Surface Release

Post-test radiological survey results after the Mullet safety experiment did not detect contamination outside the immediate SGZ area. However, according to available background information, retrieval of the sample material from the Mullet test caused significant plutonium (Pu) contamination limited to an area near SGZ (Author Unknown, 1963a). While removing the "sample pot," black powder was observed that spilled to the ground. The black powder was later determined to contain Pu (Author Unknown, 1963b). Winds were reportedly gusting 15 to 25 miles per hour to the south. Contamination levels ranged from more than 100,000 counts per minute (cpm) (more than 590 micrograms per square meter [$\mu g/m^2$]) around the "sample pot" area to approximately 300 cpm (1.7 $\mu g/m^2$) at the perimeter fence (approximately 500 ft away). The release contaminated soil, personnel, vehicles, and equipment in the SGZ area.

After recovery operations and decontamination of equipment, vehicles, and personnel, an oil truck was dispatched to the site to spread oil on the ground to limit the spread of contamination (Author Unknown, 1963a). Equipment that could be successfully decontaminated and had a future use was removed from the site. The contaminated equipment and temporary buildings erected to support the experiment were buried on site, potentially in the open trench that housed sampling equipment. Post-test historical photographs show what appears to be a bermed area over the trench, indicating the trench was backfilled after the test (RSL, Date Unknown [a]). The area of the trench is currently covered with a dirt berm. The exact location of the buried equipment and temporary buildings is unknown. However, there is no visible evidence of debris above the ground surface or buried debris outside the CA at the Mullet site. The lack of evidence that equipment and debris were buried outside the CA coupled with the documentation indicating that the equipment and buildings were buried on site leads to the conclusion that this material was buried under the existing soil berm within the CA. No information was found describing the disposition of the two filter units.

Background information includes several radiological surveys conducted at the site (NSTec, 2011). A survey conducted in 1970 found the radiological/chemical piping partially intact, including the "Y" junction, and shows two runs of intact piping extending past the U2am crater lip. The survey focused on the piping system itself and detected alpha contamination from 4 cpm to 900,000 cpm. The highest value was at a pipe flange between a dirt pile and a dirt berm within the current site fence line. All readings were direct, and no swipes were taken.

A 1972 survey was essentially a repeat of the 1970 survey; however, it does not show the "Y" junction nor does it show piping extending past the U2am crater lip. The survey also shows a new fence line separating the radiological/chemical piping from the U2am crater area, with all piping within the fence. Alpha contamination was detected on pipe flanges during the survey, but alpha contamination was not detected on the dirt pile or the dirt berm. All readings were direct, and no swipes were taken. Additional surveys were conducted in 1986, 1990, 1992, 1993, and 1996 (NSTec, 2011). One of the surveys focused on determining the extent of soil contamination around SGZ. An alpha contamination plume extending approximately 200 ft east of SGZ was detected in a swath approximately 100 ft wide. The maximum reading was 15,000 cpm alpha. All surveys indicated the piping is located within the fence line.

1.4.2 CAS 03-99-19, Gas Sampling Assembly

Corrective Action Site 03-99-19 consists of environmental surface and shallow subsurface releases associated with the safety experiment Tejon conducted in emplacement borehole U3cg on May 17, 1963. The U3cg emplacement hole was drilled between January 30 and February 5, 1963, to a depth of 260 ft with a casing diameter of 36 in. (RSN, 1991). The Tejon experiment was part of Operation Storax and involved a nuclear detonation that resulted in a low yield (DOE/NV, 2000). The gas sampling assembly at the Tejon site was designed to achieve prompt sampling of particulate material generated during the experiment. The system was designed to convey gas from the Tejon emplacement hole (U2cg) to the existing Bernalillo (U3n) emplacement borehole. The U3n borehole provided a convenient location to collect exhaust from the Tejon test. Figure 1-8 presents the 1963 as-built engineering drawing of the Tejon gas sampling assembly. Gases and particulates produced by the Tejon safety experiment were channeled through piping to a sampling can encased in an underground concrete block, then vented directly into the Bernalillo emplacement hole. According to the drawing, the pipe runs beneath the ground surface from the Tejon emplacement hole to approximately 135 ft from the Bernalillo emplacement hole, where the pipe surfaces and connects to the Bernalillo hole casing. The portion of pipe above the ground surface was covered by a 4-ft-high earthen mound constructed at the time of the Tejon safety experiment (visible in Figure 1-9).

The surface features at the Bernalillo site include four metal pipes and a large section of free-standing metal casing (Figure 1-10). Two pipes, a 2-in. diameter vertical pipe and a 4-in. diameter horizontal pipe with a valve, appear to originate at the emplacement borehole. The only part of the 4-in. horizontal pipe that is exposed is a short length of pipe and a valve; the rest of the pipe extends under a soil berm from the Bernalillo emplacement borehole southeast to the Tejon emplacement borehole (U3cg) (Figures 1-11 and 1-12). The third pipe is a 2-in. diameter, open-ended horizontal pipe curved at the open end that enters the site from the south and terminates in the area of the U3n emplacement borehole. The fourth pipe is a 4-in. diameter, capped horizontal pipe that enters the site from the east and terminates in the immediate vicinity of the emplacement borehole. The large metal casing piece shown in Figure 1-10 sits on the ground surface and is not connected to anything underground.

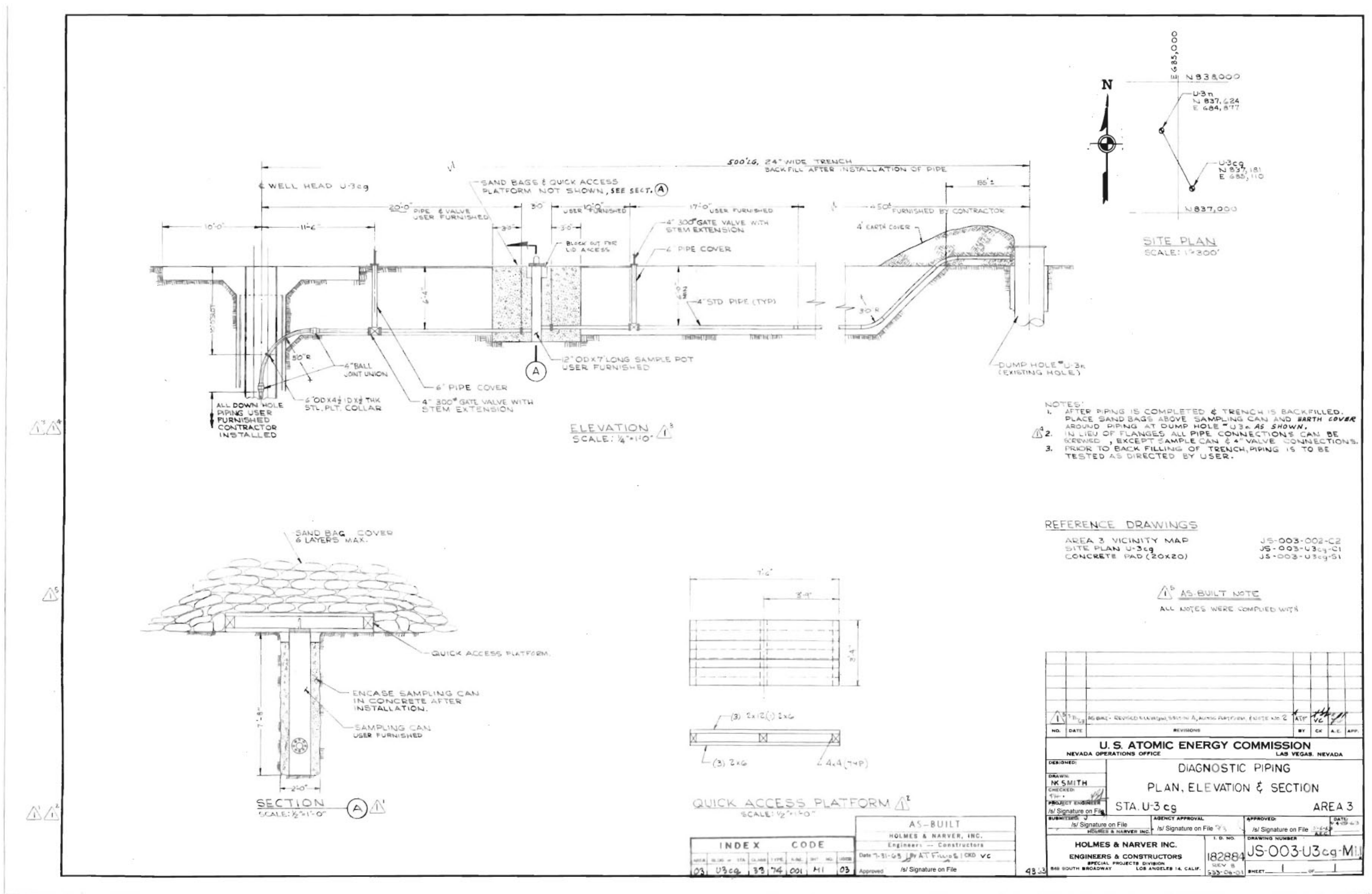

Figure 1-8
U3cg Tejon As-Built Drawing, Plan and Elevation (07/31/1963)
Source: H&N, 1963b

Figure 1-9
Aerial Photograph of U3cg (Tejon) and U3n (Bernalillo) Sites
Source: Modified from RSL, Date Unknown (b)

Figure 1-10
Surface Features at U3n Bernalillo Site

Figure 1-11
View of Horizontal and Vertical Pipe Sections at U3n Bernalillo Emplacement Borehole

Figure 1-12
Close-up View of Valve at U3n Bernalillo Emplacement Borehole

Tejon SGZ is located within a large area posted as a CA, which encompasses the locations of several other underground tests. The surface features at the Tejon site include a strongback (I-beam) with attached cables surrounded by a cracked concrete pad. Two metal T-post valves, approximately 3 ft in height, are visible adjacent to the concrete pad (Figure 1-13) and are detailed in the engineering drawing (Figure 1-8). A concrete pad flush with the ground surface is located northwest of the T-post valves. This pad, designated the "quick access platform" in the engineering drawing, is the ground surface expression of the underground concrete block in which the sampling instrumentation for the Tejon safety experiment was encased. A metal cover is located flush with the pad and is closed.

Figure 1-13
Strongback and T-Post Valve Handles at U3cg Tejon Site

Because the gas sampling assembly was designed to vent radioactive gases from U3cg to U3n, subsurface contamination is expected in both boreholes. These contaminants are included in the total source term of the U3cg test, which is in the scope of UGTA CAS 03-57-055, U-3cg Cavity (CAU 97).

1.4.3 CAS 09-99-06, Gas Sampling Assembly

Corrective Action Site 09-99-06 consists of environmental surface and shallow subsurface releases associated with the safety experiment Player conducted in emplacement borehole U9cc on August 27, 1964 (DOE/NV, 2000). The Player experiment was part of Operation Whetstone and involved a nuclear detonation that resulted in a low yield. The gas sampling assembly at the Player site was designed to achieve prompt sampling of particulate material generated during the experiment. The system was designed to convey gas from the emplacement hole (U9cc) to existing borehole

U9z PS#2. Figure 1-14 is an aerial photograph of CAS 09-99-06. The U9z PS#2 borehole, drilled two years before U9cc, provided a convenient location to collect gas and particulates generated from the U9cc test. The U9z PS#2 borehole was drilled between August 25 and 29, 1962, to a depth of 820 ft with a casing diameter of 4.5 in. (RSN, 1991). The U9cc emplacement hole was completed on July 13, 1964, to a depth of 309 ft with a casing diameter of 48 in.

Figure 1-15 presents the 1964 as-built engineering drawing of the Player gas sampling assembly. According to this and other engineering drawings, the assembly consists of 4-in. diameter schedule 40 steel pipe and various attached equipment and instrumentation (H&N, 1964a, b, c, and d; H&N, 1965). The majority of the pipe between U9cc and the U9z crater edge is covered by a 1- to 3-ft-tall soil berm (Figure 1-16). The following components are visible above the ground surface: an upright, S-shaped expansion pipe at U9cc that extends 7 ft above ground surface (Figure 1-17), a portion of a yellow metal gas sample bottle, and what may be remnants of a sample collector unit/accelerometer (Figure 1-18). Engineering drawings indicate that five other bottles were buried in the same location and were designed to connect to the pipeline (H&N, 1965).

The gas sampling assembly components outside the U9z crater are surrounded by fencing posted with “Underground Radioactive Material” signs. The pipe is uncovered at the edge of the U9z crater and extends down the crater slope to U9z PS#2 (Figure 1-19). The piping on the slope is fenced and posted with “Caution Equipment and Material Internally Radioactively Contaminated” signs. The U9z PS#2 wellhead is posted “Caution Internal Contamination” but is not fenced.

Because the gas sampling assembly was designed to vent radioactive gases from U9cc to the U9z PS#2 borehole, subsurface contamination is expected in both boreholes. These contaminants are included in the total source term of the U9cc test, which is in the scope of UGTA CAS 09-57-075, U-9cc Cavity (CAU 97). Also, the release of contaminants to the subsurface at the U9z PS#2 borehole cannot be differentiated from subsurface radiological contamination sourced from the U9z underground test, conducted at 765 ft below ground surface (bgs) and adjacent to the U9z PS#2 hole. Therefore, all subsurface radioactivity in the two boreholes will be addressed under the scope of the UGTA Project.

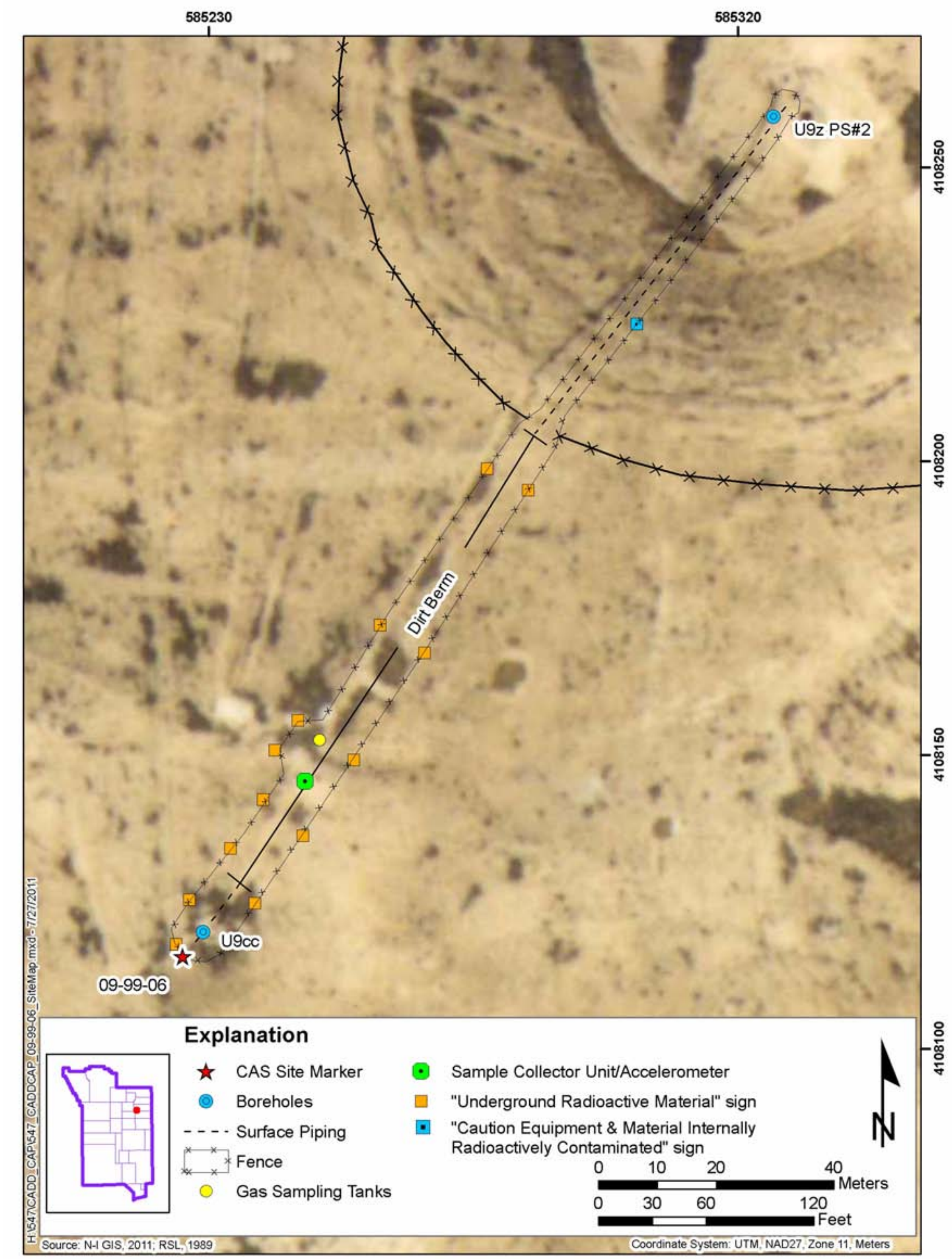

Figure 1-14
CAS 09-99-06 Features

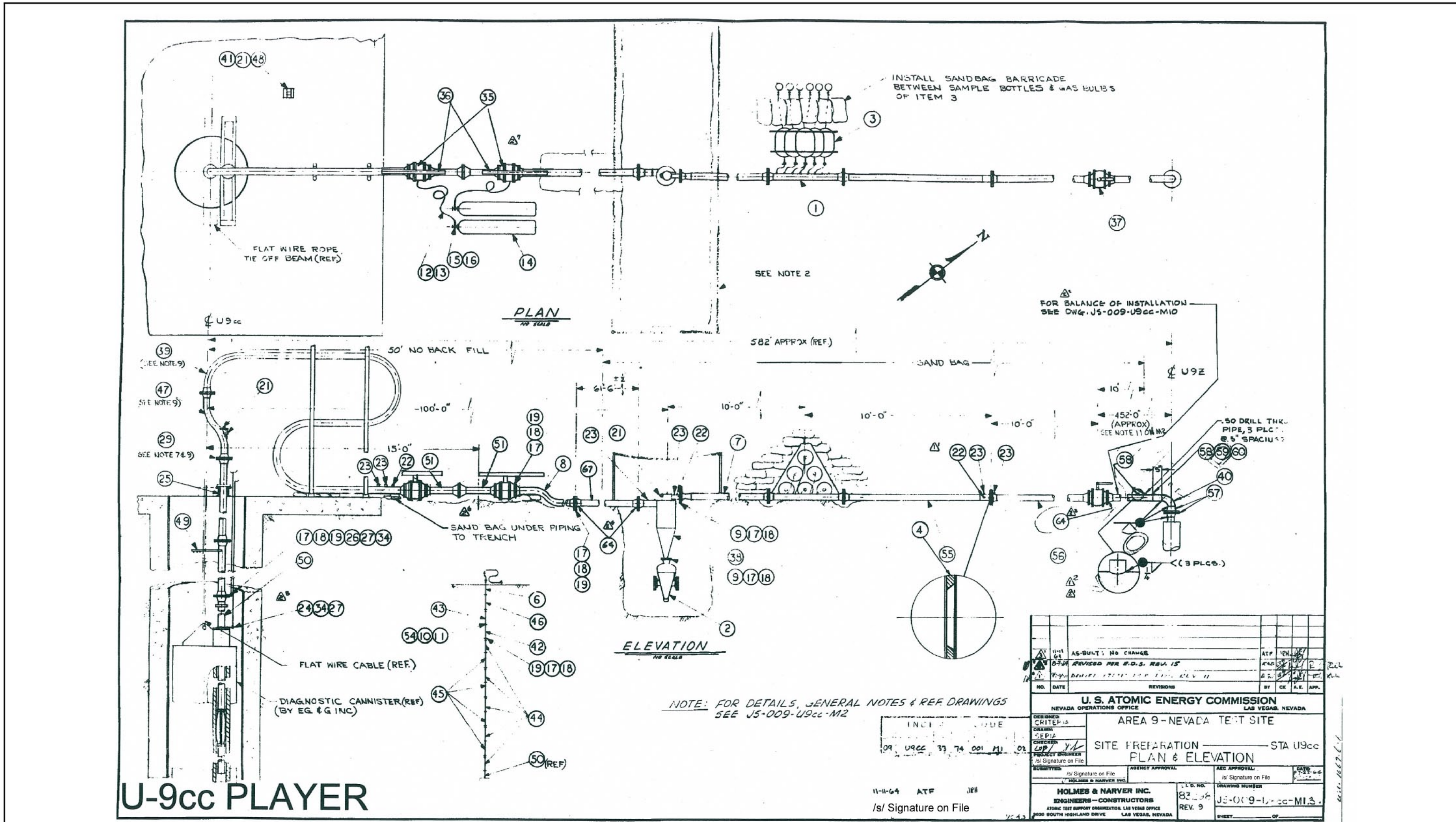

Figure 1-15
U9cc Player As-Built Drawing, Plan and Elevation (11/11/1964)
Source: H&N, 1964d

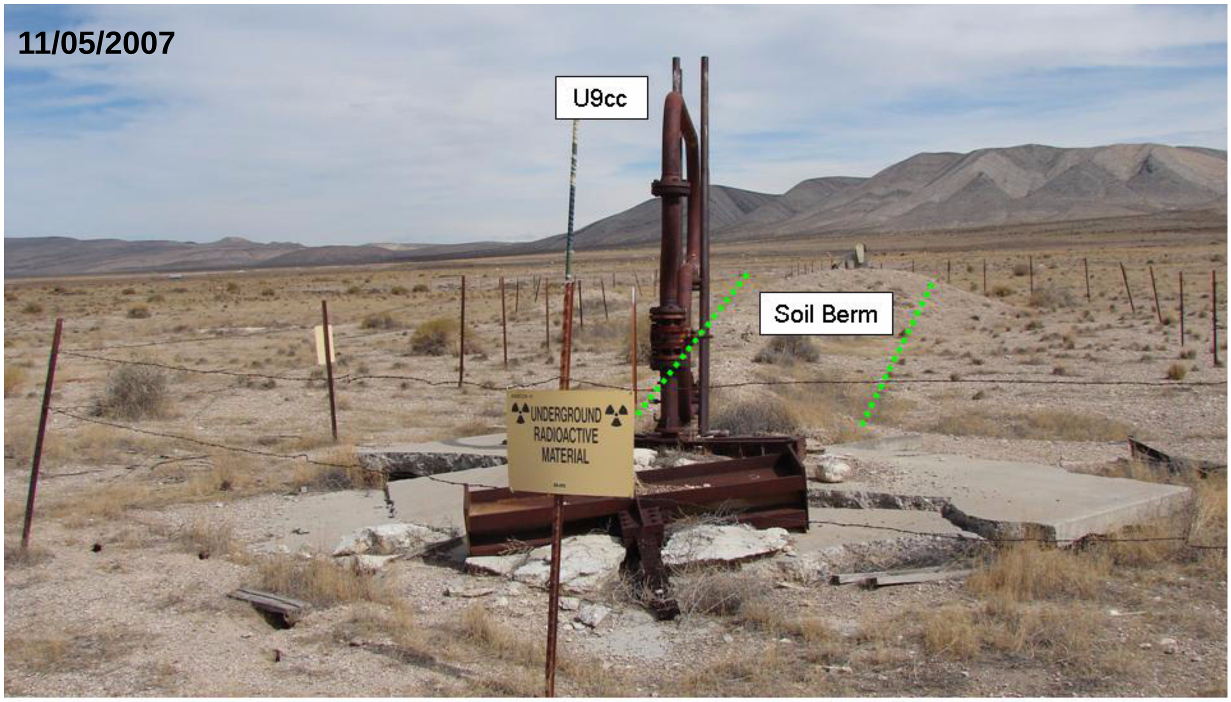

Figure 1-16
U9cc SGZ Looking North toward U9z Crater

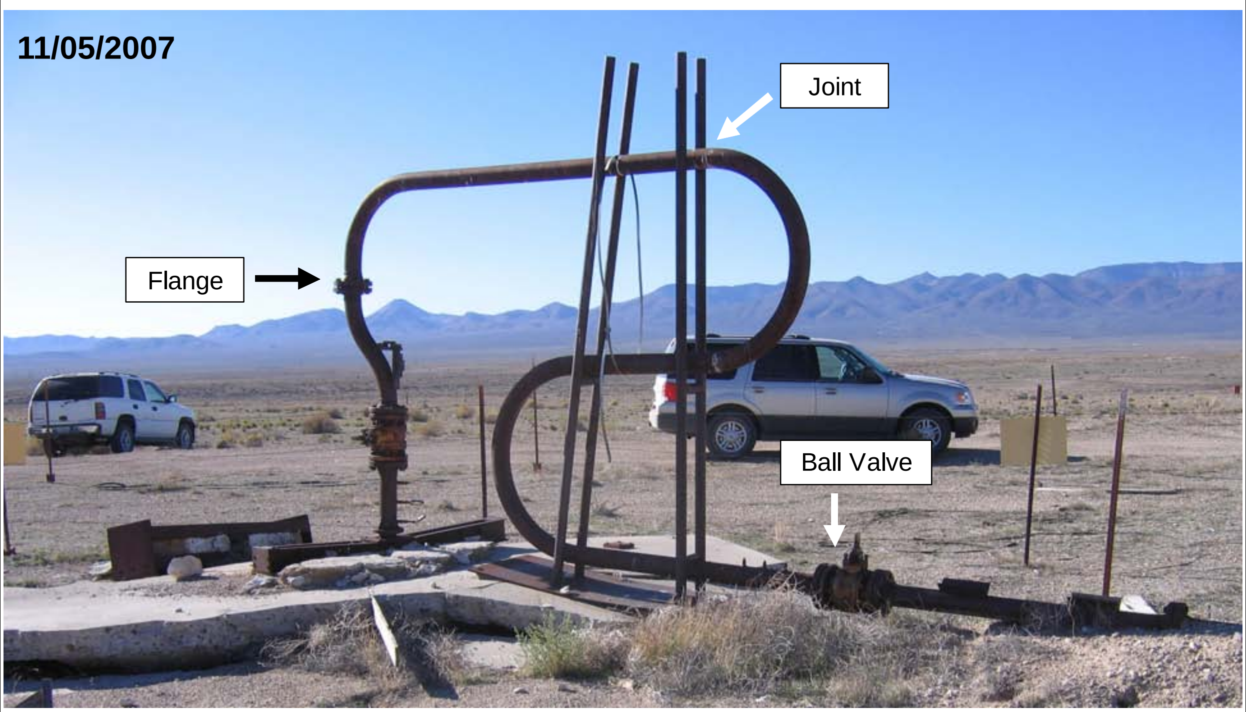

Figure 1-17
U9cc SGZ and Upright Segment of Expansion Pipe

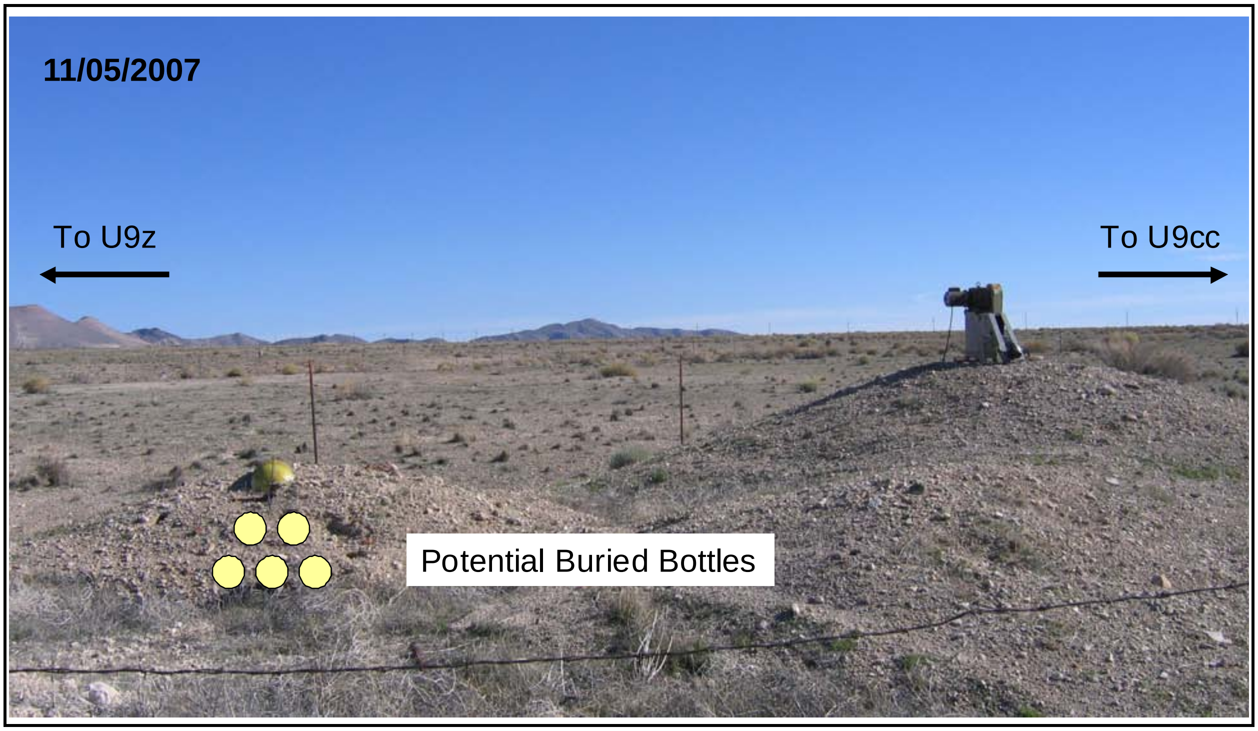

Figure 1-18
Exposed Equipment and Instrumentation between U9cc and U9z

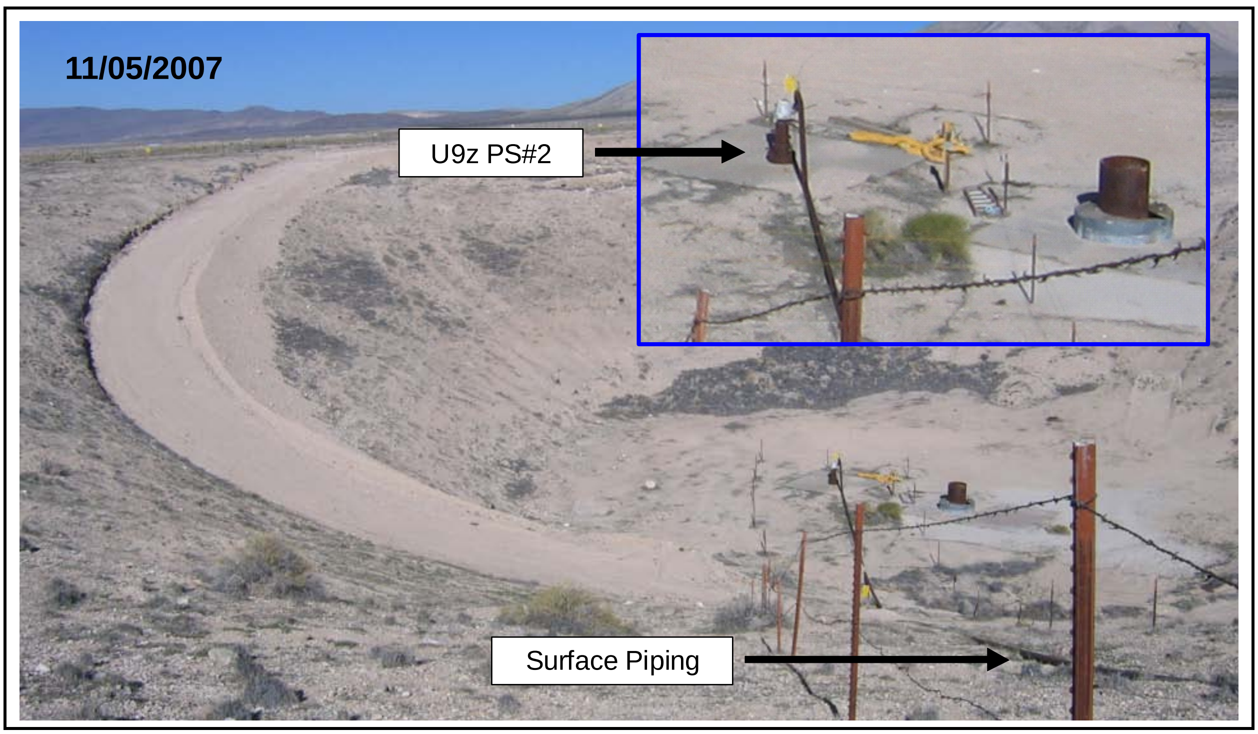

Figure 1-19
Pipe Run along U9z Crater Slope to U9z PS#2 Borehole

1.4.3.1 Surface Release

On April 30, 2007, the Borehole Management Project encountered high levels of alpha contamination after gaining access to the U9z PS#2 wellhead in preparation for borehole plugging activities (NNSA/NSO, 2007c). To gain access to the U9z PS#2 borehole, the wellhead flange was unbolted and separated to allow for the collection of swipes and direct radiological readings. The direct readings indicated alpha contamination at approximately 1.3 million disintegrations per minute per 100 square centimeters (dpm/100 cm^2) within the pipe, and a swipe collected at the same time indicated 550,000 dpm/100 cm^2 of removable contamination (NSTec, 2007). Additional isotopic results of the swipes indicated that the contamination was Pu. The release contaminated tools, personal protective equipment (PPE), and other equipment in the vicinity of the wellhead. Personnel received an internal dose during the doffing of contaminated PPE. After the release, the disconnected pipes were sealed. The borehole and surrounding area were surveyed, and no removable contamination was identified (Figure 1-20).

Figure 1-20
Current Configuration of U9z PS#2 Borehole and Fencing

2.0 Corrective Action Investigation Summary

This section summarizes the field activities completed and the data collected in support of the CAU 547 investigation, which included radiological surveys and limited soil sampling.

2.1 Investigation Activities

Corrective action investigation activities for CAU 547 included reviewing existing information and collecting additional data. The review of existing data included aerial photographs, engineering drawings, reports, correspondence, and hand-written accounts. Field activities consisted of site visits and radiological surveys. In Situ Object Counting System (ISOCS) technology was used at each CAS to measure radiation within the gas sampling assemblies and associated equipment. The ISOCS technology uses gamma spectroscopy to identify and quantify radionuclide content of containers, surfaces, and various sample matrices. At the CAU 547 sites, this allowed for the measurement of radioactive contamination within the pipes and equipment without having to breach the sampling assemblies. The ISOCS data were used to calculate the radionuclide content of each gas sampling assembly and associated equipment. The results of the ISOCS and other radiological surveys completed at CAU 547 are discussed in Section 2.2.

2.1.1 ISOCS Radiological Surveys

Radiological surveys using ISOCS were first conducted at CAU 547 in November 2007 at CAS 09-99-06 (Player) in response to the release at the U9z PS#2 borehole earlier that year (NSTec, 2008). This release also prompted a NNSS-wide assessment of all underground safety tests to determine whether sites similar to Player existed elsewhere on the NNSS (NNSA/NSO, 2011). The assessment identified seven safety test locations where further investigation was warranted based on the presence of surface features similar to those at the Player site. In October 2009, ISOCS measurements were collected at these seven sites and the Player site (Meyer, 2009). The objective of the gamma ray spectroscopy survey was to determine if the material (piping and gas sampling assembly components), exceeded transuranic (TRU) waste disposal limits (greater than 100 nanocuries per gram [nCi/g]). Based on the ISOCS results, two of these sites were later added to CAU 547: CAS 02-37-02 (Mullet) and CAS 03-99-19 (Tejon). Subsequent surveys were conducted to gather additional data for estimating the Pu loading within the gas sampling assemblies. The following subsections provide additional detail regarding each of the ISOCS field surveys.

The objective of the ISOCS surveys was to measure radioactivity inside the piping and/or equipment at the locations of highest activity in order to calculate a conservative estimate of the radionuclide inventory within the gas sampling assemblies. In preparation for the ISOCS surveys at each site, the exposed piping and/or equipment was scanned for radioactivity using a hand-held radiation instrument (i.e., sodium iodide detector). The purpose of this scan was to provide qualitative data to be used in the selection of ISOCS survey locations. That is, the hand-held instrument readings were used to locate hotspots, or locations of elevated radioactivity, along the pipe or on the piece of equipment. These areas were defined as locations at which the radioactivity measured was both greater than background and greater relative to measurements from other sections of pipe/equipment along the same gas sampling assembly. The ISOCS surveys were then conducted at these locations.

November 2007 ISOCS Survey

The November 2007 ISOCS survey was conducted using a Canberra Industries broad-energy, high-purity germanium detector. The ISOCS measurements were taken at the Player site on three sections of pipe and the accelerometer. The three sections of pipe were selected based upon their simple geometry, accessibility, and the presence of hotspots (i.e., locations at which the radioactivity as measured by hand-held radiation instruments was both greater than background and greater relative to measurements at other sections of pipe). The distribution of contamination within the pipe is not homogenous, and some sections of the pipe indicated local hotspots. Hotspots were generally identified at valves and elbows. The three sections of piping selected for ISOCS survey included the following:

- The lower section of the S-shaped expansion joint at the U9cc emplacement hole
- The pipe elbow at the edge of the U9z crater
- The lateral expansion joint located at the bottom of the U9z crater

The accelerometer was chosen based upon elevated readings using a hand-held field instrument. The counting time for each ISOCS measurement was 10 to 15 minutes. Construction drawings indicated the pipe was 4-in., schedule 40 carbon-steel pipe with a wall thickness of 0.24 in and a mass of 10.79 pounds per linear foot. The ISOCS results indicated that the piping was internally contaminated with Pu and americium (Am). The calculated activity concentration for Pu-239 at the three pipe sections was as follows:

- S-shaped expansion joint at U9cc: 4,860 nCi/g
- Pipe elbow: 1,340 nCi/g
- Lateral expansion joint in U9z crater: 1,600 nCi/g

Refer to Section 2.2.1.3 for additional detail regarding calculation of the radiological inventory within the pipe assembly at CAS 09-99-06 (Player).

October 2009 ISOCS Survey

The October 2009 ISOCS survey included four measurements at CAS 09-99-06 (Player), one measurement at CAS 02-37-02 (Mullet), and three measurements at CAS 03-99-19 (Tejon). The four measurements at CAS 09-99-06 (Player) included three sections of pipe (the same three sections measured in the November 2007 ISOCS survey) and the accelerometer. The single measurement at CAS 02-37-02 (Mullet) consisted of a section of pipe on the vertical expansion joint at the U2ag borehole. At CAS 03-99-19 (Tejon), three measurements were taken consisting of the 4-in. diameter, capped horizontal pipe that enters the site from the east, the 2-in. diameter vertical pipe, and the 4-in. valve located at the U3n emplacement borehole.

The ISOCS measurements consisted of the following:

- Scanning with a 3-by-3-in. hand-held sodium iodide detector to locate areas of elevated radioactivity (i.e., locations at which the radioactivity as measured by hand-held radiation instruments was both greater than background and greater relative to measurements at other sections of pipe). If an area of elevated radioactivity was identified, the ISOCS detector was positioned to most effectively detect gamma emissions from that area. If no area of elevated activity was found, the ISOCS detector was positioned so its field of view included either the entire item or a representative segment of the item.

- Performing high-resolution gamma spectroscopy measurements of the item or representative segment of the item with an ISOCS germanium detector system. Twenty-five millimeter thick lead shielding was used around the back and sides of the detector to reduce interferences from other potential nearby gamma sources. The counting time was 30 minutes for each item. A 30-minute background spectra was also acquired at each site.

Modeling parameters were based upon the following:

- Piping was composed of uniform steel with a wall thickness of 0.226 in. (3.5-in. nominal, schedule 40 pipe).
- It was assumed source material (e.g., internal contamination) was distributed in a thin uniform layer on the inside surface(s) of each item.
- The valve at CAS 03-99-19 was assumed to have a similar configuration as a modern gate valve with comparable dimensions.
- The accelerometer was modeled as a 16-by-16-by-6-in. steel rectangular tube with a wall thickness of 0.226 in.
- Source to detector distance varied from 2.2 to 17.25 in. depending on field conditions.

Because the October 2009 ISOCS survey was limited to one pipe section at Mullet SGZ, additional ISOCS measurements along the pipe sampling assembly at Mullet were collected in November 2009 (NSTec, 2010). Similarly, due to the limited scope of the October 2009 survey of the pipe at Bernalillo, an additional ISOCS survey was conducted at this site in June 2011 (Poderis, 2011; Primrose, 2011).

November 2009 ISOCS Survey

The November 2009 survey was similarly conducted using a broad-energy, high-purity germanium detector. This survey was limited to the Mullet site and included measurements at the same section of pipe surveyed previously, and six additional pipe sections. Two measurements were taken along the vertical expansion joint at the U2ag borehole (including the original location), and five additional measurements along the disconnected piping on the ground surface approximately 150 to 200 ft east of the U2ag emplacement hole. The sections of pipe examined with the ISOCS were selected based on their uniform geometry and accessibility.

In conjunction with the November 2009 ISOCS survey, non-destructive testing (NDT) of the piping at CAS 02-37-02 (Mullet) was performed to determine pipe wall thickness. Using an ultrasonic thickness gauge, NDT indicated a pipe wall thickness of 0.234 in. for the 4-in. pipe, and 0.21 in. for the 2-in. pipe. Modeling parameters for the November 2009 survey included the following:

- Based upon NDT, standard schedule 40 pipe specifications were used for the ISOCS model.
- While background gamma measurements were determined to be insignificant and not consistent within the area of the study, the detector was close coupled to the piping, and a 90-degree collimator was used to minimize background shine for all measurements.
- It was assumed source material (e.g., internal contamination) was distributed in a thin uniform layer on the inside surface(s) of each item.

A scan of the piping using a hand-held instrument indicated that some sections of the pipe system showed hotspots (i.e., locations at which the radioactivity as measured by hand-held radiation instruments was both greater than background and greater relative to measurements at other sections of pipe), especially near valves and elbows. Subsequent ISOCS measurements at these hotspots indicated that the piping is internally contaminated with Pu and Am, and distribution along the length of the gas sampling assembly decreases linearly along the pipe moving away from Mullet SGZ (U2ag). The highest ISOCS reading was detected at the elbow where the vertical section of the expansion joint penetrates the surface (Figure 2-1). The calculated activity concentration for Pu-239 at each of the seven ISOCS locations was as follows:

- Expansion joint at U2ag – east: 111.2 nCi/g
- Expansion joint at U2ag – west: 94.6 nCi/g
- Exposed pipe #1 – 147 ft east of U2ag: 32.1 nCi/g
- Exposed pipe #1 – 175 ft east of U2ag: 19.5 nCi/g
- Exposed pipe #2 – 205 ft east of U2ag: 4.4 nCi/g
- Exposed pipe #3 – 225 east of U2ag: 2.0 nCi/g
- Exposed pipe #4 – 225 east of U2ag: 1.1 nCi/g.

Refer to Section 2.2.1.1 for additional detail regarding calculation of the radiological inventory within the pipe assembly at CAS 02-37-02 (Mullet).

June 2011 ISOCS Survey

Because the majority of the piping and gas sampling assembly is either buried or covered with bermed soil, the June 2011 ISOCS survey at CAS 03-99-19 (Tejon) was limited to the exposed sections of pipe at the U3n (Bernalillo) emplacement borehole. Similar to the November 2009

ISOCS survey at CAS 02-37-02 (Mullet), a broad-energy, high-purity germanium detector was used to take measurements of the pipe on each side of the valve (Figure 2-2). Similar assumptions and measurement techniques were used to determine Pu loading within each pipe section. Refer to Section 2.2.1.2 for additional detail regarding calculation of the radiological inventory within the pipe assembly at CAS 03-99-19 (Tejon).

2.1.1.1 Radionuclide Inventory Estimates

Radionuclide inventories for each CAS were conservatively estimated from the ISOCS results. Inventory calculations used measurements of the radionuclides detected by ISOCS and estimated measurements, based on the isotopes found in weapons-grade Pu, for radionuclides not detected by ISOCS. The estimated mass of each item (i.e., section of piping) was calculated based on measured external dimensions. The uncertainty for each reported activity is a combination of statistical uncertainties due to counting statistics, and uncertainties in the source/attenuator distribution and configuration used in the ISOCS model. The counting uncertainty was established by using the Genie 2000 software (Canberra, 2009), which supports ISOCS analysis. The reported uncertainty is assumed to represent one sigma; therefore, an approximate 95th upper confidence level (UCL) is established by adding twice the uncertainty to the measured values.

2.1.2 Other Radiological Surveys

In addition to ISOCS surveys, radiological surveys using hand-held instruments were conducted of the area within the posted CA at CAS 02-37-02 (Mullet). Swipes were collected to measure removable contamination and a Field Instrument for the Detection of Low-Energy Radiation (FIDLER) was used to measure the activity of low-energy gamma-emitting radionuclides (e.g., Am-241).

2.2 Results

2.2.1 Data Summary

A summary of the existing information and data reviewed for each CAS is found in Section 1.4. The following sections present the results of the field investigation efforts at each CAS.

2.2.1.1 CAS 02-37-02, Gas Sampling Assembly

In October 2009, one section of the expansion joint on the 4-in. pipe exiting the U2ag emplacement hole at SGZ was surveyed to obtain preliminary data on the amount of Pu within the pipe assembly (Figure 2-1) (Meyer, 2009). Using this single measurement and assuming a uniform distribution of radionuclides along the entire length of pipe at Mullet, the initial Pu-239 inventory (95th UCL) in the gas sampling assembly was calculated at 5 grams (g).

Figure 2-1
ISOCS Survey of Pipe Assembly at U2ag Mullet

An additional ISOCS survey of the piping was conducted in November 2009 (NSTec, 2010). The survey was accomplished with a Canberra ISOCS instrument using a broad-energy, high-purity germanium detector with 50 percent detector efficiency. This survey included a total of seven ISOCS measurements: two at the expansion joint at SGZ (one of these at the same section of pipe surveyed previously) and five along the exposed piping east of SGZ. Only four of the five measurements along the exposed piping were used in the calculation of the radionuclide inventory at Mullet. The fifth measurement location (referred to as “expansion joint at U2ag - west” in Section 2.1.1, November 2009 ISOCS Survey) was eliminated due to poor geometry caused by shielding, which resulted in an underestimation of the activity at that location.

At the time of the survey, pipe length measurements were collected that estimated the entire length of pipe currently within the CA at approximately 523 ft. Although this total pipe length differs from the length of pipe in the gas sampling assembly as indicated by the engineering drawing (Section 1.4.1), the measured length of 523 ft was used to calculate the radionuclide inventory in the piping at the Mullet site. Because the piping system was partially disassembled sometime after the experiment, the original configuration of the exposed pipes east of SGZ is uncertain (i.e., how the piping was connected during the experiment). Evaluation of the ISOCS data indicated a low measured radionuclide activity in two pipes (2.0 nCi/g in exposed pipe #3 and 1.1 nCi/g in exposed pipe #4) relative to the activities at the other four ISOCS measurement locations, which ranged from 4.4 nCi/g to 111.2 nCi/g (Section 2.1.1, November 2009 ISOCS Survey). As a conservative measure, the calculation of radionuclide inventory in these two pipes used the single ISOCS measurement for each pipe and assumed a uniform distribution of radionuclides within the pipes. The ISOCS measurement from the remainder of the piping showed a linearly decreasing loading (non-uniform distribution) of Pu with increased distance from the U2ag emplacement borehole. This suggests that the initial assumption of a uniform linear distribution along the piping at Mullet applied to the October 2009 ISOCS data was overly conservative. The radionuclide inventory for this portion of the system was calculated using four ISOCS measurements and assuming a non-uniform distribution of radionuclides within the pipes. This calculated inventory, plus the inventory in the two pipes, results in a total radionuclide inventory of 2.21 g Pu-239 (95th UCL) in the 523 ft of piping at the Mullet site (Table 2-1).

In conjunction with the November 2009 ISOCS surveys, two radiological surveys were conducted within the CA at the Mullet site (NSTec, 2010). One of the surveys measured removable contamination using swipe sample methodology, and the other measured low-energy radiation using a FIDLER. The removable contamination survey identified two small areas located within the CA that met the criteria as HCAs. These areas were posted as HCAs after the survey. The determination of posting is based on the amount of removable radioactivity, as measured in dpm/100 cm^2, the type of radiation emitted and, in some cases, the radionuclide of interest. The numeric criteria for posting an area as a CA or HCA are presented in the *Nevada Test Site Radiological Control Manual*

Table 2-1
Mullet Radionuclide Inventory in Piping

Radionuclide	Nominal Activity (Ci)	Nominal Mass (g)	Uncertainty (Ci)	95th UCL Activity (Ci)	95th UCL Mass (g)
Pu-238	1.57E-03	9.21E-05	5.53E-04	2.68E-03	1.57E-04
Pu-239	7.59E-02	1.22E+00	2.67E-02	1.29E-01	2.08E+00
Pu-240	1.69E-02	7.40E-02	5.93E-03	2.88E-02	1.26E-01
Pu-241	5.83E-02	5.66E-04	2.05E-02	9.93E-02	9.65E-04
Am-241	1.63E-02	4.76E-03	6.48E-03	2.93E-02	8.54E-03
Total	1.69E-01	1.30E+00	--	2.89E-01	2.21E+00

Ci = Curie

-- = Not applicable

(NNSA/NSO, 2010). For example, an area where the activity of removable transuranic radionuclides (e.g., Pu-239) exceeds 20 dpm/100 cm^2 may be categorized as a CA; if the radioactivity in the area exceeds 2,000 dpm/100 cm^2, the area may be categorized as an HCA.

The FIDLER results provided the basis for estimating soil contamination at the Mullet site. The FIDLER was used to survey 10-by-10-ft grids covering the CA, and these results were converted into curies of activity of Am-241 per grid and summed for all the grids. An estimate of Pu-239 activity was established using a 5.3 ratio of Pu-239 to Am-241, typical of weapons-grade Pu (NSTec, 2008). This resulted in an estimate of 8.54E-3 Ci Pu-239 associated with the FIDLER results. An isotopic distribution of weapons-grade Pu was assumed to estimate the inventory of other isotopes by scaling them to Pu-239 (Table 2-2). The total inventory of radionuclides in the soil at the Mullet site was calculated at 0.731 g Pu-239 (95th UCL). The radionuclide inventories of the piping and soil were summed to derive a total radionuclide inventory for the Mullet site of 2.94 g Pu-239 (95th UCL).

As discussed in Section 1.4.1.1, a release of radionuclides to the soil near SGZ occurred shortly after completion of the Mullet test in 1963. Documented accounts state that a black powder, later determined to contain Pu, was released during retrieval of sample material from the test (Author Unknown, 1963a and b). The area impacted is described as south of SGZ, approximately 150 ft wide by 400 to 500 ft long (Author Unknown, 1963b). The historical documentation also

Table 2-2
Estimated Radionuclide Inventory in Soil, CAS 02-37-02

Radionuclide	Activity Fraction	95th UCL Activity (Ci)	95th UCL Mass (g)
Pu-238	9.42E-03	8.86E-04	5.18E-05
Pu-239	4.54E-01	4.27E-02	6.87E-01
Pu-240	1.01E-01	9.50E-03	4.17E-02
Pu-241	3.49E-01	3.28E-02	3.19E-04
Am-241	8.56E-02	8.05E-03	2.35E-03
Total	99.90%	0.094	0.731

indicates that a truck was dispatched on two occasions to spray an oil-based product onto the impacted area to limit the spread of contamination. A post-test, black and white aerial photograph of the Mullet site shows an area south of SGZ that appears distinctly darker than the surrounding area and roughly coincides with the estimated dimensions of the impacted area (RSL, Date Unknown [a]). This area is located outside the existing CA, and currently there is no visible distinction between this area and surrounding soil. In order to determine whether chemical contamination from the oil-based product is present and to confirm the absence of residual radioactive contamination from the original release, 14 soil samples were collected from this suspect area in July 2011. The sampling area of interest was biased to the suspect area of contamination based on the historical accounts and photographs. Soil sample locations within the area were selected randomly using computer-based sampling software. Soil samples were analyzed for total volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), polychlorinated biphenyls (PCBs), and isotopic Pu. No COCs were identified as a result of this sampling.

2.2.1.2 CAS 03-99-19, Gas Sampling Assembly

The ISOCS survey in October 2009 included three measurements at Bernalillo SGZ (Meyer, 2009). The measurements were collected on a section of the capped 4-in. horizontal pipe, a section of the 2-in. vertical pipe, and at the valve of the 4-in. pipe connected to the Tejon gas sampling assembly (Figure 2-2). Of the three pipe sections measured at the time, only the 4-in. steel pipe with the valve was determined to contain elevated radioactive concentrations. The initial estimate of the radionuclide inventory for the Tejon gas sampling assembly was calculated using this single measurement and a pipe length of 120 ft (the portion of pipe underneath the soil berm), assuming a uniform distribution of radionuclides along the length of pipe. The initial inventory was calculated at 795 g Pu-239.

In 2011, two additional ISOCS measurements were collected of the exposed pipe at Bernalillo SGZ. These measurements were collected on either side of the valve on the exposed portion of pipe. The 2009 and 2011 ISOCS measurements form the basis for determining the radioactive inventory in the Tejon gas sampling assembly because the only exposed portion of the assembly is at Bernalillo SGZ. The three ISOCS measurements were used to calculate the radionuclide inventory, assuming an exponentially decreasing deposition of radionuclides along the pipe away from SGZ (approximately 510 ft). Unlike the initial radionuclide inventory calculation described above, a uniform distribution of radionuclides was not assumed in this calculation because the multiple ISOCS measurements of the gas sampling assemblies at the Player and Mullet sites suggested a non-uniform distribution. Large sections of exposed piping at the Player and Mullet sites allowed for multiple ISOCS measurements, which showed a decreasing loading (non-uniform distribution) of grams of Pu per foot along the pipe moving away from the test emplacement boreholes. Because only a small portion of pipe is exposed at the Tejon site, multiple ISOCS survey locations were not possible. As a result, since the design of the Tejon safety test was similar to the Player and Mullet tests, the radionuclide distribution within the gas sampling assembly is assumed to show a similar decrease in Pu loading with increased distance from the U3cg emplacement borehole. Thus, the total radionuclide inventory for the Tejon gas sampling assembly was calculated using three ISOCS measurements and assuming an exponential distribution of radionuclides. The total inventory was calculated at 158 g Pu-239 (95th UCL) (Table 2-3).

2.2.1.3 CAS 09-99-06, Gas Sampling Assembly

In November 2007, a preliminary ISOCS survey of the Player gas sampling assembly was conducted (NSTec, 2008). Three sections of the gas sampling assembly pipe were surveyed: the lower section of the expansion joint (S-bend) at the U9cc emplacement borehole, a section of pipe at the U9z crater rim, and a section of the U-shaped horizontal expansion joint at the bottom of the crater near well U9z PS#2. Although an evaluation of the ISOCS data indicated an exponentially decreasing loading

Table 2-3
Tejon Radionuclide Inventory in Piping

Radionuclide	Nominal Activity (Ci)	Nominal Mass (g)	95th UCL Activity (Ci)	95th UCL Mass (g)
Pu-238	7.74E-02	4.53E-03	2.03E-01	1.19E-02
Pu-239	3.73E+00	6.0E+01	9.79E+00	1.57E+02
Pu-240	8.96E-02	3.93E-01	1.67E-01	7.31E-01
Pu-241	1.58E+00	1.53E-02	3.11E+00	3.02E-02
Am-241	2.85E-01	8.31E-02	5.06E-01	1.48E-01
Total	5.76E+00	6.05E+01	1.38E+01	1.58E+02

(non-uniform distribution) of grams of Pu per foot along the pipe moving away from the U9cc emplacement borehole, the total radionuclide inventory at the Player site was conservatively calculated using a uniform distribution of radionuclides along the pipe.

The total gram quantity of Pu-239 is based on calculations from three sections of pipe. The first section is the 50 ft of S-bend pipe at U9cc SGZ (Figure 2-2). The ISOCS result from the measurement location for this section of pipe is 0.38 g of Pu-239 per linear foot of pipe. Thus, the total estimate of Pu-239 is 19 g within the length of this segment. The 300 ft of pipe covered by a dirt berm was not measured by the ISOCS. For this section of pipe, the gram quantity of Pu-239 was estimated assuming a uniform distribution from the highest value in the S-bend pipe (0.38 grams per foot [g/ft]) to the value measured downgradient where the pipe emerges from the berm (0.13 g/ft). In this 300-ft section of pipe, the estimated amount of Pu-239 is 115 g. The third section was the pipe that extends from the end of the dirt berm down the U9z crater. For this section of pipe, the ISOCS result from the measurement location is 0.13 g of Pu-239 per linear foot. The total length of this section of pipe is 300 ft, giving a total of 38 g of Pu-239 for this segment. For the three sections of pipe, which comprise the Player gas sampling assembly, the total inventory of Pu-239 is 172 g (Table 2-4). The standard ratios of weapons-grade Pu were then used to calculate the activity and mass of other radionuclides expected to be present within the piping. The total inventory by radionuclide is presented in Table 2-5. Although the modeling and counting uncertainties for the calculation of total inventory for CAS 09-99-06 have not been established, the measurements and assumptions used for this analysis are conservative and reasonable for purposes of site characterization.

Figure 2-2
ISOCS Survey of Expansion Joint at U9cc Player

Table 2-4
Mass Loading of Pu-239 per Section of Gas Sampling Assembly, CAS 09-99-06

Section of Gas Sampling Assembly	Pu-239 (g/ft)	Length of Section (ft)	Total Mass Pu-239 (g)
S-bend at U9cc to berm	0.38	50	19
Pipe under berm	0.38	300	115
Exposed pipe from berm to U9z	0.13	300	38
Total	--	650	172

-- = Not applicable

Table 2-5
Player Radionuclide Inventory in Piping

Radionuclide	Nominal Activity (Ci)	Nominal Mass (g)
Am-241	2.04E+00	1.96E-02
Pu-238	2.24E-01	1.30E-02
Pu-239	1.08E+01	1.72E+02
Pu-240	2.41E+00	1.05E+01
Pu-241	8.32E+00	7.99E-02
Pu-242	2.24E-04	5.71E-02
Total	2.38E+01	1.83E+02

2.2.2 Data Assessment

This section is not applicable to the CAU 547 CADD/CAP. A data assessment was not completed because the DQOs did not result in an investigation involving the collection of data. Collection of ISOCS data was performed using well-established and calibrated instrumentation with standard operating instructions. Sufficient conservatism was used to calculate radiological inventories for each CAS.

2.3 Need for Corrective Action

The data obtained during the CAU 547 investigation indicate the presence of radionuclide contaminants of concern (COCs), including Pu, Am, and other fission products within each of the gas sampling assemblies and in the soil at the Mullet site. The radiological contamination within the gas sampling assemblies at each CAS has the potential to present an unacceptable risk to the public and/or the environment in the event of a release (see Appendix C). Although the contamination is currently contained within the assembly pipes and equipment, it is assumed that the contamination will be released to the environment over time as the assemblies deteriorate and existing soil cover erodes. Thus, the requirements of the FFACO (1996, as amended) have the potential to be violated if the assembly contents become exposed. Therefore, corrective action is necessary to protect human health and the environment in the event of a future release.

3.0 Evaluation of Alternatives

This section presents the corrective action objectives for CAU 547, describes the decision factors used to screen the various CAAs, and develops and evaluates a set of selected CAAs that will meet the corrective action objectives.

Each CAA for CAU 547 is based on the presumption that all areas within the current NNSS boundary will be controlled in perpetuity and restricted from release to the public. As such, only industrial activities are permitted, and risks to receptors under residential scenarios were not considered for CAU 547. Should the control of the NNSS change in the future to include public access or residential use, the selected CAAs may need to be reconsidered.

3.1 Corrective Action Objectives

The corrective action objective is to ensure that receptors are not subject to unacceptable risk from a future exposure to contamination within the gas sampling assemblies. As discussed in Appendix C, the only potential receptors are NNSS workers and visitors who may be exposed to contaminants through ingestion, inhalation, or direct contact. Exposures are assumed to be the result of the deterioration of the piping and equipment over time and/or the erosion of existing soil cover. Implementation of the corrective action will ensure that the contaminants remaining at each CAS will not pose an unacceptable risk to human health and the environment in the future and that site conditions will be in compliance with all applicable laws and regulations.

3.2 Screening Criteria

Evaluation of the alternatives for closure of CAU 547 was based on the U.S. Environmental Protection Agency (EPA) *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988). This guidance provides a method for evaluating each alternative against screening criteria, also referred to herein as decision factors, to determine the appropriate action. Several other criteria were also considered in the CAU 547 CAA evaluation that relate to the unique site conditions presented at each CAS and the radiological nature of the contamination. Evaluation of these criteria is designed to result in the selection of an alternative that is protective of human health and the environment, attains compliance with requirements, and is cost effective.

3.2.1 EPA Criteria

The following five criteria, selected from the full list of nine criteria provided in the EPA guidance document (EPA, 1988), have been used as the decision factors for CAU 547:

- Short-Term Effectiveness
- Reduction of Toxicity, Mobility, and/or Volume
- Long-Term Reliability and Effectiveness
- Feasibility
- Cost

Short-Term Reliability and Effectiveness

Short-term reliability and effectiveness is a qualitative measure of the impacts on human health and the environment during implementation of the CAA. The following factors were addressed for each alternative:

- Protection of the community from potential risks associated with implementation (e.g., fugitive dusts, transportation of hazardous materials)

- Protection of workers during implementation

- Adverse environmental impacts that may result from implementation

- The amount of time necessary to achieve the corrective action objectives.

Reduction of Toxicity, Mobility, and/or Volume

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

Long-Term Reliability and Effectiveness

Long-term reliability and effectiveness is a qualitative evaluation of performance after site closure and into the future. Each CAA was evaluated in terms of risk remaining at the CAU after the CAA has been implemented (see Appendix C). The primary focus of this evaluation is on the extent and effectiveness of the control that may be required to manage the risk posed by treatment of residuals and/or untreated wastes.

Feasibility

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

- Construction and Operation—The feasibility of implementing a CAA given the existing set of waste and site-specific conditions.
- Administrative Feasibility—The administrative activities needed to implement the CAA (e.g., permits, use restrictions [URs], public acceptance, rights of way, offsite approval).
- Availability of Services and Materials—The availability of adequate offsite and onsite treatment, storage capacity, disposal services, necessary technical services and materials, and prospective technologies for each CAA.

Cost

Costs for each alternative were estimated for comparison purposes only. The cost estimate for each CAA includes capital costs, and operation and maintenance costs, as applicable:

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

A scoring system was applied to each of the EPA criteria. The scoring system provides for evaluation of each alternative against the other alternatives to provide a relative ranking in the five applicable criteria. Each of the alternatives was scored as one through four in each criterion. The alternative with the highest score is the preferred alternative based on the EPA screening criteria.

3.2.2 Other Criteria

In addition to the five EPA guidance criteria (EPA, 1988), consideration was also given to other key factors with the potential to impact the evaluation, and ultimately the implementation, of the CAAs.

The CAAs, however, were not given a numerical ranking in relation to these criteria. The other criteria considered include the following:

- Nuclear Operations
- Consistency with Other DOE Complex Closures
- Regulatory Compliance
- As Low As Reasonably Achievable (ALARA)

The purpose of including these criteria in the CAA evaluation was to identify other factors not captured by the EPA screening criteria that had the potential to impact implementation of the CAA. For example, the hazard category assigned to a site under the nuclear operations program is based on the quantity of radionuclide contaminants present. Although the hazard category is independent from the corrective action considered (e.g., clean closure is not dependent upon a specific hazard category and vice versa), the site controls required as a consequence of the categorization would have an impact on CAA cost and ease of implementation.

Nuclear Operations

This criterion considers the implementation of each closure alternative with respect to 10 *Code of Federal Regulations* (CFR) 830, Subpart B, *Safety Basis Requirements* (CFR, 2011a); and DOE Standard DOE-STD-1027-92, *Hazard Categorization and Accident Analysis Techniques for Compliance with DOE Order 5480.23, Nuclear Safety Analysis Report* (DOE, 1997). A facility or activity to which these regulations and standards apply, is categorized based on radiological risk. At a minimum, work proposed at a facility designated as a Nuclear Facility (e.g., Hazard Category 3 or above) requires preparation of a Documented Safety Analysis and implementation of stringent controls. Work proposed at a facility designated as a Radiological Facility, which is a less restrictive category, requires less documentation and less restrictive controls for implementation of the work.

Consistency with Other DOE Complex Closures

This criterion considers the CAA in regard to similar projects throughout the DOE complex. The evaluation determines whether the project is consistent with currently accepted regulatory interpretations, waste disposition pathways, and similar items.

Regulatory Compliance

The regulatory compliance criterion considers regulatory impacts if the project is implemented as presented, considering all applicable compliance agreements; DOE orders; and federal, state and local regulations. The evaluation not only considers project implementation, but also disposition of wastes that may be generated during implementation of the project.

As Low As Reasonably Achievable

As Low As Reasonably Achievable is a radiation safety principle for minimizing radiation doses and releases of radioactive materials by employing all reasonable methods. This criterion considers the anticipated radiological hazards to workers, public, and the environment during implementation of the CAA.

3.3 Development of Corrective Action Alternatives

Based on the review of existing data, future use, and current operations at the NNSS, the following alternatives were identified for consideration for closure of the three CASs in CAU 547:

- Corrective Action Alternative A, Clean Closure
- Corrective Action Alternative B, Closure in Place
- Corrective Action Alternative C, Modified Closure in Place
- Corrective Action Alternative D, No Further Action (with administrative controls)
- Corrective Action Alternative E, No Further Action

3.3.1 Alternative A, Clean Closure

The corrective action of clean closure consists of cutting the gas sampling assembly piping at each CAS into small (4-ft) lengths and containerizing these sections for offsite disposal. All exposed piping and equipment would be removed at each CAS; however, piping and structures below original grade (i.e., length of piping from Tejon SGZ to start of existing soil berm) would be left in place. Piping and equipment currently underneath constructed berms would be uncovered, and the piping removed and disposed of off site. The contaminated soil currently in the CA at the Mullet site would also be removed and disposed of under this alternative. The areas at each CAS where contaminated material was left in place (e.g., subsurface emplacement boreholes) would be fenced, and UR signs would be posted. The URs would be recorded in the FFACO database and the DOE Facility Information Management System database.

This alternative assumes that the gas sampling assembly components would be disposed of as transuranic (TRU) waste and shipped to the Waste Isolation Pilot Plant (WIPP) in New Mexico. Waste determined to be low-level radioactive waste would be disposed of on the NNSS. Other contaminated materials would be disposed of at an appropriate disposal facility on the NNSS or off site. As the radioactive contamination currently contained within the gas sampling assembly pipe would be subject to release during the cutting of the pipe, engineered containment structures and PPE would be required to protect site workers. This alternative would also investigate and potentially remediate soil contamination resulting from the removal activity.

3.3.2 Alternative B, Closure in Place

The corrective action of closure in place consists of covering the existing piping assemblies with a minimum of 2 ft of soil and establishing URs. The radiological assessment model in Attachment D-1 concluded that 1 ft of soil was adequate to provide the necessary protection over the prescribed period of performance. Under this alternative, the depth of soil cover would be doubled (a total of 2 ft) to ensure that any erosion that may occur between inspections does not impact the requisite 1 ft of cover necessary to retain protectiveness. Clean soil would be placed over the entire horizontal length of each gas sampling assembly and graded into a configuration that would promote drainage away from the pipe assembly. Metal retention structures (i.e., well casings or similar) would be placed over the vertical sections of each gas sampling assembly, to include the expansion joints at Mullet and Player SGZ, the accelerometer at Player, the wellhead at U9z PS#2 in the U9z crater, and the surface location of the sampling can at Tejon. Each structure would be filled with concrete or clean fill, and welded shut with a metal cover. The area of each CAS would be completely fenced, and UR signs would be posted. The URs would be recorded in the FFACO database and the DOE Facility Information Management System database.

3.3.3 Alternative C, Modified Closure in Place

The corrective action of modified closure in place would involve the removal and onsite burial of select gas assembly features at the Mullet and Player CASs, and the establishment of URs at all three CASs. In this alternative, the expansion joints at Mullet and Player SGZ would be cut at the ground surface and buried at the bottom of the U9z crater. In addition, the entire length of pipe along the U9z crater slope would be cut into sections, moved down to the crater bottom, and buried with a minimum of 2 ft of soil cover. None of the piping at the Tejon CAS would be removed. The remaining gas sampling assembly piping and equipment at the three CASs would be closed in place with a minimum of 2 ft of soil cover. The area of each CAS, including the bottom of the crater where the removed structures would be buried, would be fenced and UR signs posted. The URs would be recorded in the FFACO database and the DOE Facility Information Management System database.

3.3.4 Alternative D, No Further Action (with administrative controls)

The corrective action of no further action (with administrative controls) would not modify the current configuration of the gas sampling assemblies but would include the establishment of URs at each CAS. The URs would be recorded in the FFACO database and the DOE Facility Information Management System database.

3.3.5 Alternative E, No Further Action

The corrective action of no further action would not modify the current configuration of the gas sampling assemblies and would not include URs. This alternative was determined not protective of human health and the environment, and was eliminated from further consideration. As a result, this alternative was not carried through the CAA evaluation process described below.

3.4 Evaluation and Comparison of Alternatives

Alternatives A, B, C, and D were selected for evaluation against the five decision factors listed in Table 3-1. For each decision factor, the CAAs were ranked relative to one another. The CAA with the least desirable impact on the remedy selection decision factor was given a ranking of one. The CAAs with increasingly desirable impacts on the remedy selection decision factor received increasing rank numbers. The CAAs that would have an equal impact on the decision factor received an equal ranking number. The “score” listed in this table represents the sum of the decision factor rankings for each CAA.

Other factors were considered in the CAA evaluation and are listed in Table 3-2. These factors generally pertain to requirements associated with the radiological contaminants at CAU 547 and have the potential to greatly impact the implementation of corrective action in terms of feasibility and cost.

Table 3-1
Evaluation of Decision Factors,
CAU 547, Miscellaneous Contaminated Waste Sites
(Page 1 of 4)

CAA A, Clean Closure		
Decision Factor	**Rank**	**Explanation**
Short-Term Reliability and Effectiveness	2	Clean closure presents the highest risk to site workers in the short term. It also presents some risk to the public in the short term because radioactive waste would be transported on public highways.
Reduction of Toxicity, Mobility, and/or Volume	4	This alternative provides no reduction in toxicity. It results in the greatest decrease in mobility of contamination because the resulting waste would be disposed of in facilities designed to limit mobility. This alternative would result in an increase in the volume of waste material through the generation of new wastes in the form of PPE, contaminated equipment, and potential contaminated soil.
Long-Term Reliability and Effectiveness	4	This alternative is reliable and effective at protecting human health and the environment in the long term because removal of most of the contaminated media would eliminate future exposure of site workers and the environment. Note: Under current assumptions, this alternative would result in leaving some contamination in place.
Feasibility	1	This alternative is considered feasible; however, it requires development of specialized processes for cutting the pipe while limiting the potential for exposure and development of processes for dealing with the pipe on the slope. It is the most difficult alternative to implement due to the technology and the large number of pipe cuts.
Cost	1	Cost to remove pipe and dispose of as TRU waste is estimated at $25 million to $35 million depending on the method used. Note: There are several potential cost savings strategies that could considerably lower overall costs. These strategies would need to go through an approval process. If all strategies are approved, clean closure costs could be as low as $5 million to $10 million.
Score	12	

Table 3-1
Evaluation of Decision Factors,
CAU 547, Miscellaneous Contaminated Waste Sites
(Page 2 of 4)

CAA B, Closure in Place		
Decision Factor	**Rank**	**Explanation**
Short-Term Reliability and Effectiveness	4	Closure in place is the most reliable and effective alternative in the short term because it minimizes risk to site workers. There are no short-term risks to the public with this alternative.
Reduction of Toxicity, Mobility, and/or Volume	3	This alternative provides no reduction in toxicity. It results in a decrease in mobility of contamination because the closure would be designed to limit mobility. This alternative is not expected to result in a significant increase in the volume of contaminated material.
Long-Term Reliability and Effectiveness	2	This alternative is considered to provide reliable and effective protection of human health and the environment; however, it would require long-term maintenance and monitoring. This option is consistent with other closures conducted on the NNSS under FFACO requirements (1996, as amended), such as CAU 370 (T-4 Atmospheric Test Site), CAU 118 (Area 27 Super Kukla Facility), and CAU 111 (Area 5 WMD Retired Mixed Waste Pits).
Feasibility	3	This alternative is considered the most feasible alternative of the three alternatives that require technology and physical activity. Placement of soil over the piping is very feasible in relation to pipe cutting and removal. This alternative requires long-term maintenance and monitoring.
Cost	3	Cost for closure in place is estimated at approximately $3 million to $4 million and would require continued costs for maintenance and monitoring. This alternative has the least project risk of the three alternatives that require technology and physical activity.
Score	15	

Table 3-1
Evaluation of Decision Factors,
CAU 547, Miscellaneous Contaminated Waste Sites
(Page 3 of 4)

CAA C, Modified Closure in Place		
Decision Factor	**Rank**	**Explanation**
Short-Term Reliability and Effectiveness	3	Modified closure in place presents risks to site workers that are similar to CAA A in the short term because it requires cutting into the pipe(s); however, under this alternative, significantly fewer cuts are required. Because waste would remain on site, there are no short-term risks to the public under this alternative.
Reduction of Toxicity, Mobility, and/or Volume	2	This alternative provides no reduction in toxicity. It results in a greater decrease in mobility of contamination over CAA B, because the potential impacts of weathering and erosion are decreased. This alternative would result in an increase in the volume of waste material through the generation of new wastes in the form of PPE, contaminated equipment, and potentially contaminated soil.
Long-Term Reliability and Effectiveness	3	This alternative is similar to CAA B; however, it is considered more effective because of the decreased potential impacts of weathering and erosion. It would require long-term maintenance and monitoring.
Feasibility	2	This alternative is considered feasible; however, it requires development of specialized processes for cutting the pipe while limiting the potential for exposure and development of processes for dealing with the pipe on the slope. This alternative also requires long-term maintenance and monitoring.
Cost	3	Cost for this alternative is estimated at approximately $12 million to $15 million, and would require continued costs for maintenance and monitoring.[a]
Score	13	

Table 3-1
Evaluation of Decision Factors,
CAU 547, Miscellaneous Contaminated Waste Sites
(Page 4 of 4)

CAA D, No Further Action (with administrative controls)		
Decision Factor	**Rank**	**Explanation**
Short-Term Reliability and Effectiveness	1	No further action (with administrative controls) presents no risk to site workers during closure as no closure would occur; however, some risk to site workers would still exist due to the potential for the piping systems to fail and release material unmitigated to the environment.
Reduction of Toxicity, Mobility, and/or Volume	1	This alternative is the least desirable, as it provides no reduction in toxicity and the least amount of reduction in mobility. The exposed pipe that would remain under the no further action alternative would allow for the highest possible mobility in the future when the pipe corrodes and material is released.
Long-Term Reliability and Effectiveness	1	No further action (with administrative controls) is the least desirable alternative for long-term reliability and effectiveness. Leaving the piping in its current configuration would result in the earliest possible release of radioactive material and present the greatest threat to human health and the environment.
Feasibility	4	This alternative requires that no technology be implemented and no physical activity at the site and is therefore the most feasible alternative.
Cost	4	The cost for the no further action alternative is minimal. The only costs would be continuous monitoring, which would also be required for the other CAAs.
Score	11	

[a] The cost estimate for this alternative was not fully developed.

RWMS = Radioactive Waste Management Site

Table 3-2
Other Criteria Considered,
CAU 547, Miscellaneous Contaminated Waste Sites
(Page 1 of 2)

CAA A, Clean Closure	
Criteria	**Explanation**
Nuclear Operations	For cost estimating purposes, it is assumed clean closure would be performed under the requirements of a Hazard Category 3 nuclear facility. However, one cost cutting strategy would be to obtain approval to clean close as a Less Than Hazard Category 3 facility.
Consistency with Other DOE Complex Closures	Clean closure of facilities that house TRU waste has been performed at other DOE facilities. Demolition and dismantling of radioactive contaminated piping is performed throughout the DOE complex.
Regulatory Compliance	Clean closure would be in compliance with FFACO requirements (1996, as amended) with an approved CADD/CAP and Closure Report (CR) describing the closure method, including disposal. Clean closure would be in compliance with DOE Orders. Disposal would be accomplished as TRU Waste at WIPP. DOE Order 435.1 (DOE, 2001) applies to removal of the piping. It is assumed that removal would be consistent with standard work procedures and controls.
As Low As Reasonably Achievable	This alternative represents the greatest human health risk due to the radiological hazards, and the benefit is not seen as commensurate with this risk.
CAA B, Closure in Place	
Criteria	**Explanation**
Nuclear Operations	It is assumed closure in place could be performed without work intrusive to the pipe systems and as a Less Than a Hazard Category 3 facility; however, the work would require relocation and placement of significant volumes of soil.
Consistency with Other DOE Complex Closures	Closure in place has been successfully implemented at DOE sites where radioactive waste disposed of before 1970 was identified (i.e., waste that would meet the current definition of TRU waste). Examples include the INEL Radioactive Waste Management Complex, SRS Old Radioactive Waste Burial Ground, and the ORNL Melton Valley site.
Regulatory Compliance	Compliance with the FFACO (1996, as amended) can be demonstrated assuming a closure in place scenario developed and proposed in a CADD/CAP is acceptable to NDEP and approved. DOE Order 435.1 (DOE, 2001) would not apply to the closure in place scenario except for any newly generated waste.
As Low As Reasonably Achievable	This alternative minimizes risk and provides added protection for future workers.

Table 3-2
Other Criteria Considered,
CAU 547, Miscellaneous Contaminated Waste Sites
(Page 2 of 2)

CAA C, Modified Closure in Place	
Criteria	**Explanation**
Nuclear Operations	It is assumed this alternative could be performed as a Less Than a Hazard Category 3 facility; however the work would require relocation and placement of significant volumes of soil, and intrusive pipe cutting activities.
Consistency with Other DOE Complex Closures	The increased benefit of reducing future risk by reducing the potential of future exposure and reduced monitoring costs may be commensurate with the short term increase in risk under this alternative.
Regulatory Compliance	This method has been proposed by NDEP and is therefore assumed to be acceptable from a regulatory compliance standpoint. However, the alternative does not comply with the current version of DOE Order 435.1 (DOE, 2001). This alternative would require specific written approval from DOE Headquarters.
As Low As Reasonably Achievable	This alternative increases risk to current workers with some benefit to future workers.
CAA D, No Further Action (with administrative controls)	
Criteria	**Explanation**
Nuclear Operations	No further action would require that some form of Documented Safety Analysis be established for the long-term storage of the material.
Consistency with Other DOE Complex Closures	No further action is implemented at some DOE sites as a remedial action, but for this type of project (legacy TRU waste storage/disposal) no further action has not been an acceptable solution.
Regulatory Compliance	No further action is not likely to be determined as an acceptable solution for FFACO compliance (1996, as amended) or for compliance with 10 CFR 835 (CFR, 2011b) requirements.
As Low As Reasonably Achievable	This alternative minimizes risk to current workers, but increases risk to future workers.

INEL = Idaho National Engineering Laboratory
ORNL = Oak Ridge National Laboratory
SRS = Savannah River Site

3.4.1 Alternative A, Clean Closure

Of the alternatives evaluated, the clean closure alternative was the most desirable option for the reduction of toxicity, mobility, and/or volume; and long-term reliability and effectiveness. By removing the exposed sections of the gas sampling assemblies, the volume of COCs available for future release is greatly reduced. However, this alternative involves increased, short-term exposure of site workers to radiological contamination during pipe cutting and removal activities. In addition, this alternative would present a short-term exposure potential to the public because the removed assembly components (i.e., pipe, equipment) would require transport off the NNSS for disposal as TRU waste. None of the other alternatives considered require the shipment of TRU waste off site. The clean closure alternative received the least desirable ranking for both feasibility and cost. Although the alternative is feasible, it would require substantial construction, operation, and administrative action. The potential cost for this alternative was the highest of those evaluated at up to $35 million.

Other, non-ranked considerations for this alternative are presented in Table 3-2. From a Nuclear Operations perspective, the clean closure alternative would likely require the implementation of controls for working in a nuclear facility (i.e., Hazard Category 3 or above), unless approval was obtained to operate in a less restrictive category. The requirements for work in a nuclear facility are extensive and involve administrative and engineering controls designed to minimize the potential for an incident involving nuclear material. The clean closure alternative would be consistent with similar site closures in the DOE complex and would be in compliance with applicable regulations and agreements. However, by presenting the greatest risk to site workers, this alternative would not satisfy ALARA principles because the benefit of clean closure at these remote sites was determined not commensurate with the short-term exposure risk to site workers and the public.

As defined in Section 3.3.1, this alternative would result in removal of the exposed portions of each gas sampling assembly but would require the establishment of URs at each site to address the subsurface portions of the systems that were left in place. Thus, only the surface at each CAS would be remediated under the clean closure alternative. Considering the expected future land use in these areas on the NNSS, the existence of surface contamination at nearby locations, and the presence of subsidence craters, the clean closure alternative would result in an uncontaminated area in the vicinity of each CAS, surrounded by surface-contaminated areas and/or limited-use land.

3.4.2 Alternative B, Closure in Place

Of the alternatives evaluated, the closure in place alternative was the most desirable option for short-term reliability and effectiveness. In contrast to clean closure and modified closure in place, it minimizes risk to site workers during corrective action implementation. In addition, this alternative would not generate TRU waste that would require shipment off the NNSS, and therefore would not present a risk to the public in transportation. Although this alternative does not reduce the toxicity or volume of COCs, establishment of a soil cover would physically limit contaminant mobility. Closure in place also provides long-term reliability and effectiveness, but is contingent on the maintenance and effectiveness of URs in preventing inadvertent exposure. This alternative was ranked the most feasible and least costly option among those alternatives involving more than administrative controls (i.e., CAAs A, B, and C). The estimated cost for this alternative is $3 million to $4 million.

Because the piping systems would not be cut as part of this CAA, this alternative would be implemented in accordance with the requirements of a radiological facility (as opposed to a nuclear facility as with CAAs A and C). The requirements for working in a radiological facility are more easily implemented than the nuclear facility requirements. The closure in place alternative would be consistent with similar site closures in the DOE complex and NNSS and would be in compliance with applicable regulations and agreements. Although this alternative presents some short-term risk to site workers during construction of the soil cover and installation of UR signs, it would achieve ALARA objectives in keeping radiological exposure risk to a minimum, commensurate with the long-term benefit of human health protection.

3.4.3 Alternative C, Modified Closure in Place

This alternative represents a combination of elements of CAAs A and B by proposing removal of some piping, while leaving some piping in place, covering, and installing URs. In general, the rankings for this alternative are in between those of CAAs A and B. This alternative was desirable in terms of short-term reliability and effectiveness because although it would involve potential risk to site workers in cutting the pipe, fewer total cuts would be required. In addition, because the cut sections of pipe would be disposed of on site, there is no risk to the public through transportation of TRU waste to WIPP. This alternative is considered more effective and received a higher score than closure in place for long-term reliability and effectiveness because by cutting and burying the vertical sections of the pipe and the pipe on the crater slope at Player, the impact of weathering and erosion on the most vulnerable sections of the gas sampling assemblies is minimized. The estimated cost for this alternative was $12 million to $15 million.

As with CAA A, this alternative would require compliance with the extensive requirements for working in a nuclear facility (i.e., Hazard Category 3 or above). Another consideration is that this alternative would not meet existing DOE requirements for the management and disposal of the removed sections of piping with internal radioactive contamination, which would meet the definition of TRU waste. In essence, this alternative could not be implemented without obtaining an exception and would not be consistent with waste management practices at the majority of facilities across the DOE complex. Although this alternative presents similar short-term risks to site workers as CAA A, the potential exposure time for site workers and the number of pipe cuts would be greatly reduced. Thus, from an ALARA perspective, this alternative would pose less radiological risk than the clean closure alternative but greater risk than the closure in place alternative.

3.4.4 Alternative D, No Further Action (with administrative controls)

This alternative is a variant of CAA B in that it includes the establishment of URs at each site, but would not involve the construction and maintenance of a soil cover over the gas sampling assemblies. Because this alternative is limited to the establishment of administrative controls only, this alternative was ranked the least desirable option in the short-term effectiveness; reduction of toxicity, mobility, and/or volume; and long-term reliability and effectiveness categories. While this alternative presents a minimal short-term risk to site workers during the installation and maintenance of UR signs at each site, it does not provide long-term effectiveness in preventing worker exposure in the future should the assembly contents be released. This alternative does not reduce the toxicity, mobility, and/or volume of the contaminants. Due to the limited action proposed in this alternative, this option ranked the best overall in feasibility and cost. The costs inherent to this alternative include the initial placement and continuing maintenance of the UR signs at each CAS, which is a cost required for all the alternatives considered in the ranked evaluation.

From the Nuclear Operations perspective, this alternative would require some form of nuclear safety documentation that addresses the radioactive material left in place. Alternatives that include only administrative controls have been implemented at other DOE sites but are not generally accepted as an industry standard for site closure. This alternative would be considered compliant with the FFACO (1996, as amended) for as long as site conditions remain unchanged. It is assumed, however, that eventually the gas sampling assemblies will deteriorate, resulting in the release of COCs to the environment, which would not meet the FFACO criteria for site closure. This alternative would comply with ALARA principles because the physical activities associated with the corrective action would be limited to the installation of signs, thus keeping site worker exposure to a minimum.

3.5 Land Use

Existing and future land use at each of the CASs was another important consideration in the CAA evaluation for CAU 547. The NNSS is a secure, access-controlled government facility that is expected to remain under government control for the foreseeable future. All three CASs in CAU 547 are in a region of the NNSS known as the Yucca Flat weapons test basin. The region of Yucca Flat was used extensively in the past for atmospheric and underground nuclear testing activities and currently houses the Area 3 RWMS, a low-level radioactive waste disposal unit.

The CAU 547 CASs are located in Areas 2, 3, and 9 on Yucca Flat. These areas are within the Nuclear Test Zone, which is the land use designation for land areas reserved for nuclear testing and experiments (DOE, 1996). As shown in Figures 3-1 through 3-3, each CAS is surrounded by numerous subsidence craters associated with underground nuclear testing activities. The Tejon and Player sites (Figures 3-2 and 3-3) are also surrounded by surface-contaminated areas currently posted for radiological control (CAs, HCAs, Radioactive Material Areas, and Underground Radioactive Material Areas).

There are six CASs in the area surrounding the Tejon and Bernalillo sites. These CASs—which are within CAU 568, Area 3 Plutonium Dispersion Sites—are CAS 03-23-17, S-3I Contamination Area; CAS 03-23-19, T-3U Contamination Area; CAS 03-23-20, Otero Contamination Area; CAS 03-23-22, Platypus Contamination Area; CAS 03-23-23, San Juan Contamination Area; and CAS 03-23-26, Shrew/Wolverine Contamination Area. The CASs are currently fenced and posted as CAs, and will be investigated under the NNSS Soils Project. Southeast of the Tejon site is the RWMS, which is an active low-level radioactive waste disposal unit. The Player site is surrounded by several fenced CAs to the north and west. The surface soil within the controlled areas near Player is estimated to contain a total of approximately 1,000 g of Pu (McArthur and Kordas, 1985). The areas of land that are in close proximity to each of the three CASs have been used in a way that has resulted in either extensive radioactive contamination to the ground surface or in the formation of large craters as a result of weapons testing. As a result, the land that surrounds each of the three CASs is not suitable for future activities other than testing and experiments due to the extent of contamination and cratered topography.

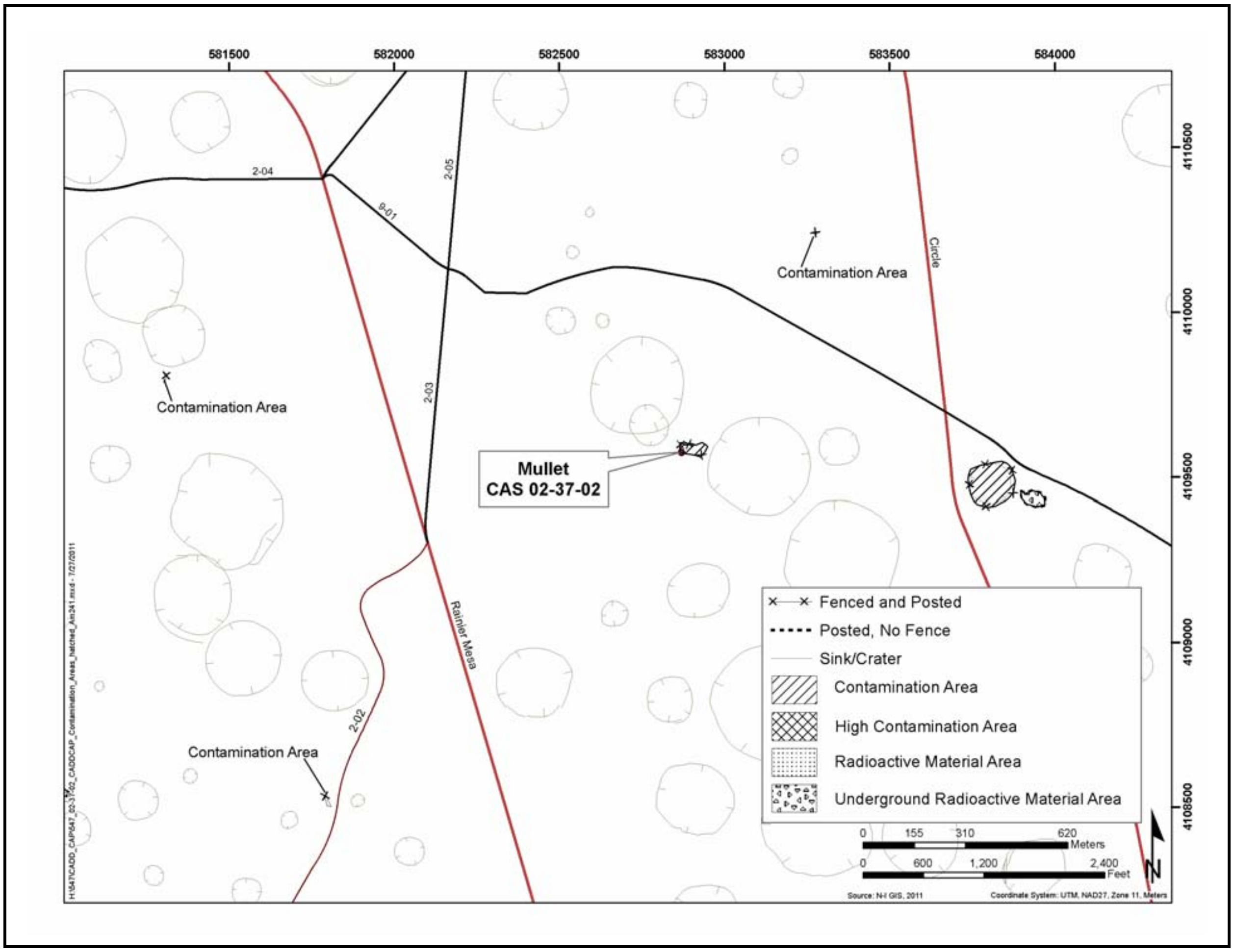

Figure 3-1
Radiological Control Areas near CAS 02-37-02 (Mullet)

For the CAA evaluation, it was assumed that the federal government would maintain control of the NNSS for the foreseeable future. Thus, residential use scenarios were not considered in the evaluation. As indicated above, the current and expected future land use at each CAS location is limited to testing and experiment activities. Based on the assumption that the current land use will not change in the future to allow a more intensive use of the land (e.g., permanent buildings for full-time work assignments), each of the CAAs evaluated would be consistent with future land use at the three CASs. Under the clean closure alternative, however, significant resources would be expended to remediate surface contamination at each CAS, even though surface contamination on the surrounding lands may be left in place. Although surface contamination is not present on the land surrounding the Mullet site, the site is located between two large subsidence craters whose presence would limit future use of the area. Thus, implementation of clean closure would result in a relatively

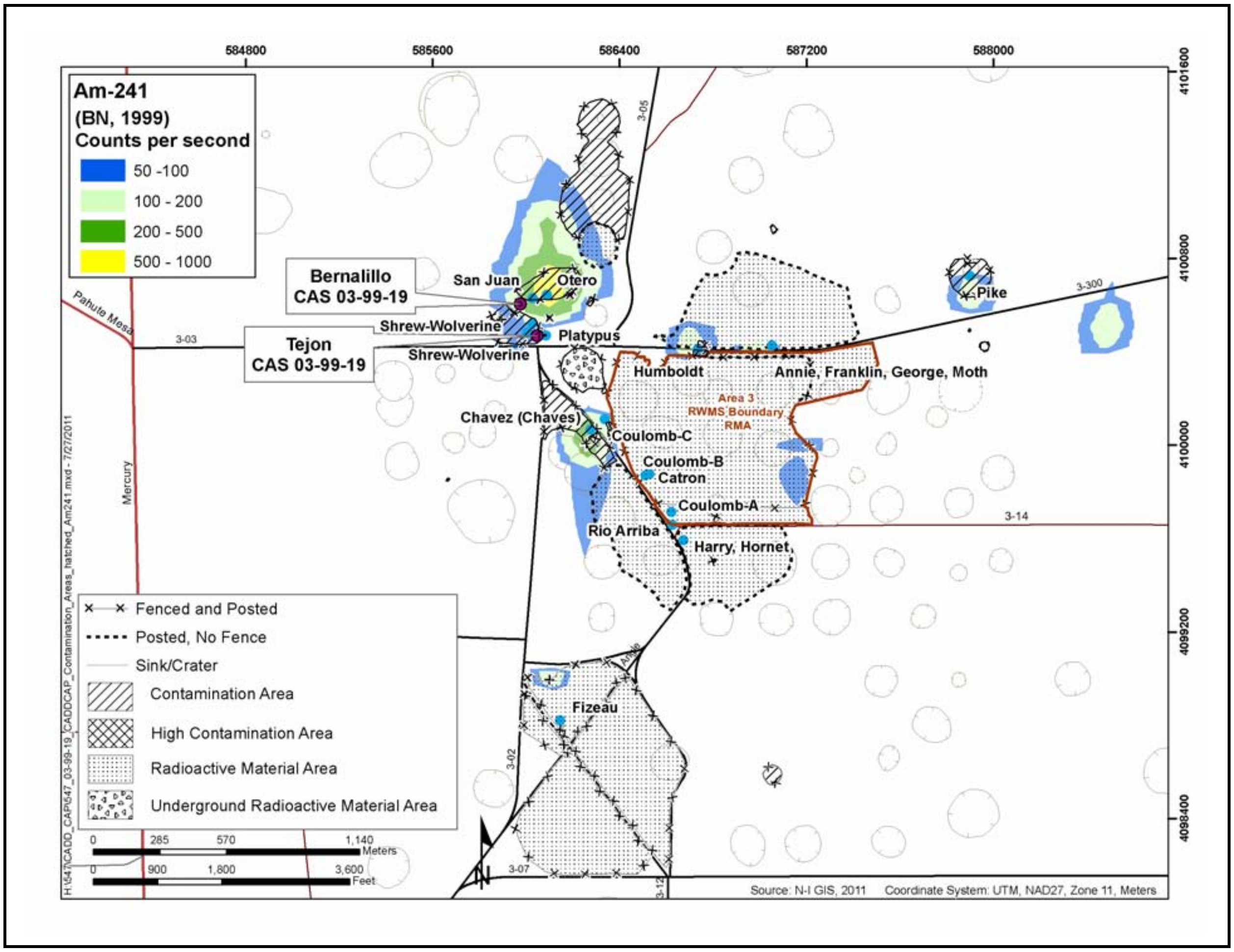

Figure 3-2
Radiological Control Areas near CAS 03-99-19 (Tejon)

small "clean" area amidst a larger surface-contaminated and/or otherwise limited use area (due to the presence of craters). Implementation of the modified closure in place, closure in place, and no further action (with administrative controls) CAAs would be consistent with future land use at each CAS.

3.6 Closure in Place at Other NNSS Sites

In addition to the specific screening criteria discussed in Section 3.2, consistency with other NNSS site closure actions was also considered during the CAA evaluation. This section provides a summary of closure at select sites on the NNSS at which contaminated material and/or media was left in place. These examples demonstrate that the risk-informed closure strategy and the corrective action of closure in place with URs has been effectively applied to sites throughout the NNSS.

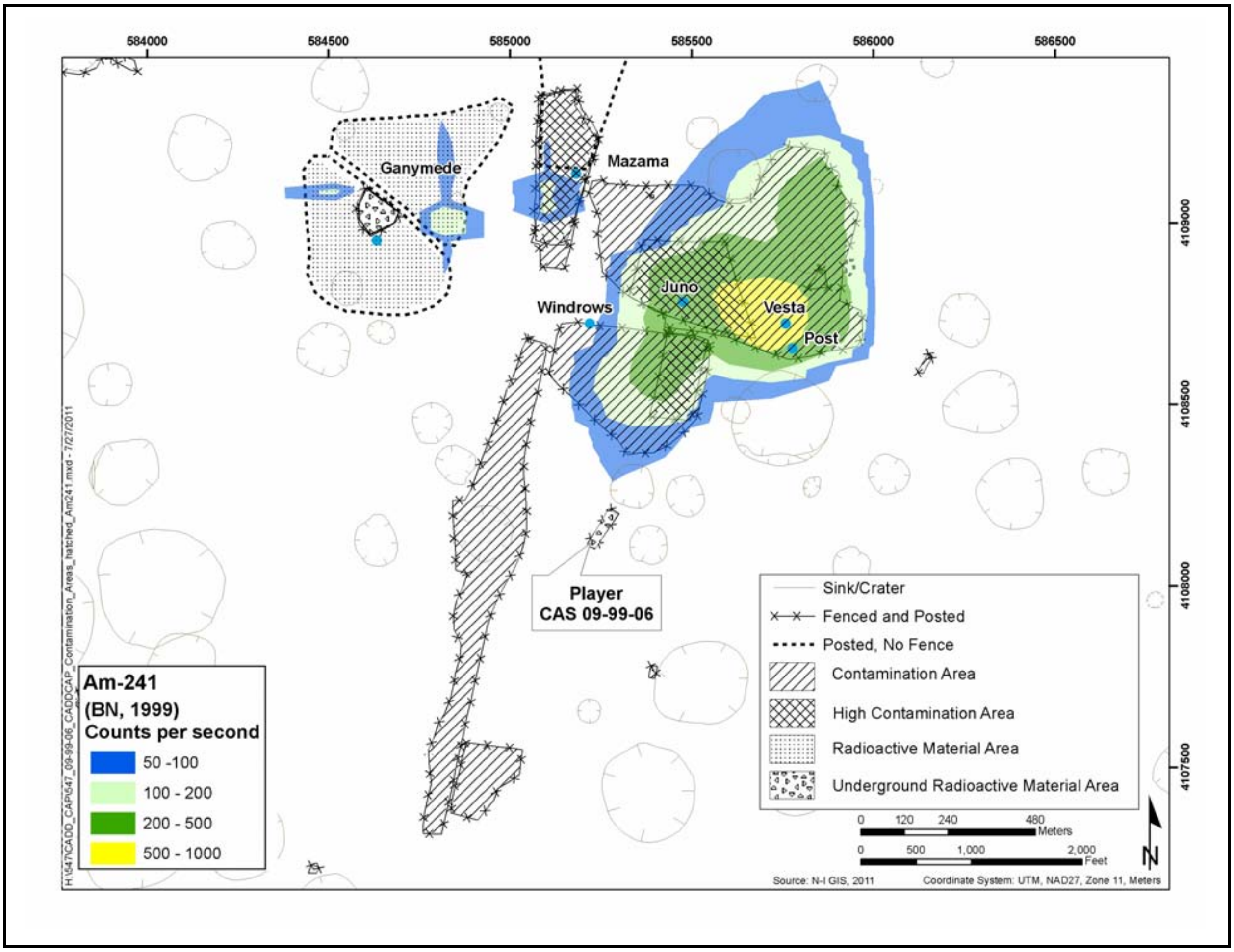

Figure 3-3
Radiological Control Areas near CAS 09-99-06 (Player)

3.6.1 92-Acre Area and CAU 111, Area 5 WMD Retired Mixed Waste Pits

The 92-acre area constitutes the southeast quadrant of the RWMS in Area 5 of the NNSS. This area encompasses CAU 111, Area 5 WMD Retired Mixed Waste Pits, which is a land disposal facility used for the shallow burial of mixed low-level radioactive waste before the mid-1970s. The 92-acre area also includes other land-based disposal units used to dispose of low-level radioactive waste and TRU waste. The selected corrective action for the 92-acre area was closure in place with a soil cover and URs (NNSA/NSO, 2009a).

3.6.2 CAU 118, Area 27 Super Kukla Facility

Corrective Action Unit 118, Area 27 Super Kukla Facility, was closed using the risk-informed process for evaluation of various source materials in the facility, including lead shielding and small amounts of chemicals and radionuclides present in paint (NNSA/NSO, 2007a). The final closure of the CAU included both administrative and physical barriers. The administrative barriers included URs to control site access and prevent exposure of workers to site contamination. The UR is for radionuclides and lead debris entombed within the facility and for chemical contamination in the subsurface soil. The physical barriers included entombment of residual contamination to prevent migration and reduce potential exposure pathways. Based on evaluation of several CAAs, it was determined that closure in place was the most effective option for controlling risk.

3.6.3 CAU 168, Area 25 and 26 Contaminated Materials and Waste Dumps

Corrective Action Unit 168, Area 25 and 26 Contaminated Materials and Waste Dumps (CAS 25-23-02, Radioactive Storage RR Cars), was closed by employing a risk assessment that demonstrated that the residual radioactivity within and on the railroad cars did not present an unacceptable risk to human health and the environment (NNSA/NSO, 2007b). The CAU was closed by establishing a UR to limit worker exposure to radionuclides. The closure in place alternative with institutional controls was chosen as the corrective action because there was less risk involved to site workers and future receptors than the clean closure alternative. Clean closure would result in physical safety hazards and radiological risks during the disassembly of the cars and removal of the contamination that outweighs the risk to future receptors if left in place. In addition, the cost of the clean closure alternative was very high, and the resulting reduction in long-term risk did not support the expenditure of this level of resources.

3.6.4 CAU 370, T-4 Atmospheric Test Site

Corrective Action Unit 370, T-4 Atmospheric Test Site, was closed in place using a risk-informed approach to determine the area of the site that would present an annual dose to site workers that exceeds the 25-millirem-per-year (mrem/yr) final action level (FAL) (NNSA/NSO, 2009b). The area was posted, and a UR was included in the closure documentation. Use restrictions were implemented as part of the closure in place corrective action to control use and limit access to the site to prevent exposure of workers to chemical and radiological contamination.

3.6.5 CAU 357, Mud Pits and Waste Dump

Corrective Action Unit 357, Mud Pits and Waste Dump (CAS 04-26-03, Lead Bricks), was closed administratively after a risk assessment was conducted to determine whether the bricks and residual lead in the soil presented an unacceptable risk to human health or the environment (NNSA/NSO, 2005). The lead bricks were in a posted Radioactive Material Area. Approximately 1,000 lead bricks were removed and placed into B-25 boxes, along with soil under the bricks, for offsite disposal. A risk assessment was then used to establish the FAL for lead for low-occupancy industrial land-use scenario. The results of the risk assessment determined that for the low-occupancy scenario the remaining lead did not pose an unacceptable risk to human health or the environment. However, because the risk scenario differed from the established industrial reuse it was necessary to establish a UR. Use restrictions were implemented as part of the closure in place corrective action as a best management practice (BMP) based on the elevated concentrations of lead in the surface soil within the lead brick “high-density area.”

3.6.6 CAU 529, Area 25 Contaminated Materials

Corrective Action Unit 529, Area 25 Contaminated Materials, used a risk assessment to demonstrate that the radioactive inventory present in the Topopah Wash next to Test Cell C would not present an unacceptable risk to residential ranchers if the entire inventory were transported to the installation boundary (NNSA/NSO, 2004). Because the radioactivity would not present an unacceptable risk, there was no need to use restrict the wash. The only areas that were use restricted were those at which cesium-contaminated soil had been buried.

4.0 Recommended Alternative

Based on available process knowledge and existing radiological survey data, the gas sampling assembly at each CAS is known to be internally contaminated with radionuclides. The CAA evaluation assumed that the containment (i.e., pipe) will eventually fail, releasing contamination to the surrounding soil. Therefore, the contents of the assemblies are considered potential source material (PSM) consisting of COCs that have the potential to be released in the future.

Based on the CAA evaluation, the recommended corrective action for the three CASs in CAU 547 is closure in place, which involves covering the gas sampling assembly components at each CAS. The closure in place alternative is the best and most appropriate corrective action for the CASs at CAU 547 for the following reasons:

- Is preferable over alternatives that requires intrusive work (i.e., cutting pipe) because the potential short-term risk to site workers is commensurate with the long-term benefits provided by the soil cover and URs.
- Provides long-term protection of human health and the environment.
- Minimizes short-term risk to site workers in implementing corrective action.
- Is easily implemented using existing technology.
- Complies with regulatory requirements.
- Fulfills FFACO requirements for site closure.
- Does not generate TRU waste requiring offsite disposal.
- Is consistent with other NNSS site closures where contamination was left in place.
- Is consistent with future land use in the CAS areas.

5.0 Detailed CAP Statement of Work

This section presents the detailed statement of work for implementation of the recommended CAA of closure in place at CAU 547. Included are a summary of site preparation activities, soil cover design, QC requirements, and waste management activities.

5.1 Preferred Corrective Action Alternative

The preferred CAA for CAU 547 is closure in place, which includes the following:

- Covering all exposed sections of the gas sampling assembly components with soil.
- Installing physical barriers and UR signs at each site.
- Performing long-term maintenance of the soil covering and signage.

Although the planned physical end state for each CAS in CAU 547 is closure in place, some restoration activities may occur independent of FFACO closure. Certain BMPs completed during the corrective action implementation to mitigate health and safety hazards or facilitate closure may occur outside the FFACO scope of the CAU 547 CADD/CAP. For example, debris located at the CAS but not directly associated with the gas sampling assemblies may be removed and disposed of as a BMP. Any such BMPs will be documented in the CR for CAU 547.

5.1.1 Site Preparation

Site preparation activities at the CASs include the following:

- Repair and level the concrete pads at the Mullet and Player SGZ. Cracks in the existing concrete will be filled, and the pads will be leveled to accommodate placement of the retention structures (i.e., metal casing).

- Repair the existing concrete pad at Tejon SGZ. Cracks in the existing concrete will be filled.

- Remove T-posts near Tejon SGZ and non-contaminated piping at Bernalillo SGZ. The two T-posts that straddle the sampling can location near Tejon SGZ will be cut at the ground surface and grouted. The exposed portions of the three non-contaminated pipes at Bernalillo SGZ will be cut at the ground surface and capped. These include the 2-in. vertical pipe, the open 2-in. curved horizontal pipe, and the capped 4-in. pipe that enters the site from the east.

- None of the safety tests associated with the three CASs resulted in the collapse of soil at the ground surface; therefore, a crater stability study was not completed for these locations. In 2007, a crater stability study was performed for the U9z crater, which contains a large portion of the Player gas sampling assembly. This study concluded “the current configuration is stable” (Roberts et al., 2007). The drilling of two post-test holes within the crater further demonstrates that the ground surface at the bottom of the crater is stable and it is safe to perform work.

5.1.2 Engineered Cover Construction

The soil cover is designed to perform the following:

- Provide long-term minimization of migration of liquid through the cover.
- Provide function with minimal maintenance.
- Promote drainage and minimize erosion of the cover.
- Accommodate settling and subsidence to maintain cover integrity.

5.1.2.1 Soil Cover Model

In order to optimize soil cover design, evaluate the potential for release of radiological contamination to environmental media, and demonstrate compliance with federal regulations and DOE requirements, an optimization of the cover design was performed and tested using GoldSim software (Shott and Yucel, 2011). The optimization included a quantitative analysis of closure cover thickness with respect to protection of human health and the environment. The model for CAU 547 uses the same conceptual and mathematical model as the Area 3 RWMS Performance Assessment Model (see Attachment D-1). The Area 3 RWMS is a land disposal unit used for the disposal of low-level radioactive waste.

The following conservative assumptions are accounted for in the model:

- The critical group is a site visitor who may be present at the CASs for up to 80 hours per year. This assumption is conservative due to the remote location of the CASs, arid climate, marginal agricultural soil, lack of resources such as surface water or shallow groundwater, presence of nearby craters resulting from nuclear testing activities, and posted soil CAs that are likely to warn potential visitors of the presence of radioactive contamination. In addition, public access to the NNSS is restricted, and UR signs and postings installed as part of the corrective action will warn visitors of the potential contamination.

- All radionuclides are assumed to be immediately available for release and transport (i.e., the pipe assembly and components have failed, and the contents have been released directly into the cover soil). Rodent burrowing is expected to mix contamination throughout the soil profile. Contamination is available for plant uptake, gaseous diffusion, and upward liquid advection. This assumption is conservative because the pipe assembly and components are likely to delay the release of radionuclides for decades if not hundreds of years.

- The model assumes a 1-ft-thick cover. This assumption is conservative because the preferred corrective action was designed with a minimum 2-ft-thick cover to be placed over the pipe assembly and components at each CAS.

Based on the model, using a 1-ft-thick cover, the expected dose for a transient visitor is less than 25 millirem (mrem) over a 1,000-year period. A 2-ft-thick native soil cover is more conservative, is protective of personnel and the environment, and maintains radionuclide releases ALARA (Shott and Yucel, 2011). Figure 4.3 in Attachment D-1 illustrates that increasing the cover thickness above 2 ft provides no significant increase in protection of human health or the environment. Increasing cover thickness beyond this optimum value would increase the risk to the workers who construct the cover due to unnecessary exposure to standard industrial risks associated with heavy equipment operation during soil excavation, transportation, and placement.

5.1.2.2 Soil Cover Design

As part of the soil cover design process, geophysical surveys were performed at CAS 03-99-19 (Tejon) and CAS 09-99-06 (Player) to estimate the burial depth of the gas sampling assembly piping (Thiele, 2011). A survey was not performed at CAS 02-37-02 (Mullet) because the majority of the gas sampling assembly is exposed. With the exception of a small section of pipe at Bernalillo SGZ, all of the gas sampling assembly components at CAS 03-99-19 are currently covered, either below existing grade or under a soil berm constructed at the time of the safety test. The piping below grade was not detected by the survey instruments, which indicates the pipe is buried greater than 4 ft below the surface. This is consistent with the Tejon engineering drawing (Figure 1-8), which indicates a burial depth of 6 ft for this section of pipe. The pipe under the soil berm is at a depth of 3.7 to 4 ft, as measured by the survey.

In consultation with NDEP, in order to maximize reuse of material at the NNSS and reduce project costs, it was determined that the metal retaining structures to be used in the closure in place corrective action at CAU 547 sites would be taken from the existing inventory. The largest casing diameter currently available at NNSS is 12 ft. The width of the upright pipe sections at Mullet and Player SGZ measure approximately 10 ft 9 in. and 11 ft 3 in., respectively. The use of the 12 ft casing would not meet the general design criteria of at least 2 ft of soil cover over the piping. As the design was developed, however, it was determined that the metal retaining structures will be filled with concrete rather than soil, effectively encasing the piping in a stable medium. After discussions with NDEP, it was determined that the concrete and metal casing would provide protection comparable to a 2-ft soil cover.

This section provides a summary of the soil cover design for each of the three CASs. Design details are presented in Appendix D, which contains the engineering drawings, basis of design, and construction specifications.

CAS 02-37-02 Mullet

- Cover the gas sampling assembly and loose pipes with a minimum of 2 ft of soil cover from the U2ag emplacement hole to the end of the pipe assembly at the lip of the U2am (Commodore) crater. Potential buried debris associated with the safety test will be included under the soil cover as a consequence of covering the piping.

- Install a metal retaining structure around the upright section of pipe (i.e., expansion joint) at Mullet SGZ, fill void spaces with concrete, and secure with a welded lid.

- Figure 5-1 illustrates the closure in place concept for CAS 02-37-02 (Mullet).

Soil contaminated in the release that occurred shortly after the Mullet safety test will be left in place, as will contaminated debris (e.g., wooden structure) that was buried after the release. The only visible debris at the site is contained within the existing CA and HCAs and will be buried under the soil cover as a result of implementation of the corrective action at the site. Because the primary function of the soil cover is to provide protection from the gas sampling assembly components (i.e., piping), some contaminated soil currently within the CA may be left uncovered. The baseline radiological survey at the completion of soil cover construction will ensure that the UR boundary at the Mullet site encompasses all contaminated soil currently within the CA (see Section 7.2). As discussed in Section 5.1.4, the UR boundary will be fenced and posted to warn site workers and visitors.

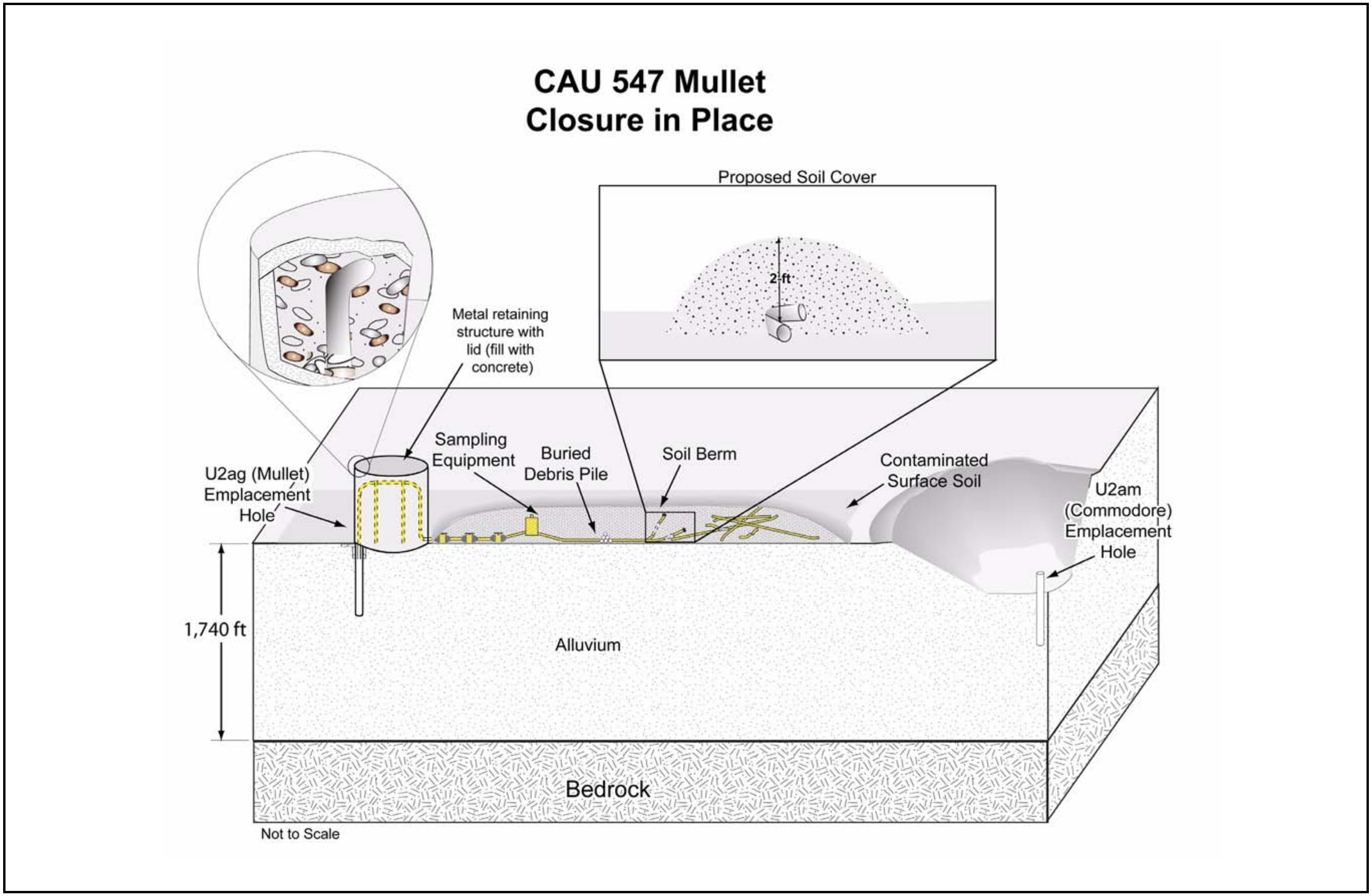

Figure 5-1
Closure in Place Concept for CAU 547, CAS 02-37-02 (Mullet)

CAS 03-99-19 Tejon

- Cover the exposed piping at the U3n emplacement hole (Bernalillo) SGZ with a minimum of 2 ft of soil cover.

- Install a metal retaining structure at the surface location of the sampling can north of the U3cg emplacement hole (Tejon), fill void spaces with clean fill (e.g., soil or sand), and secure with a welded lid.

- Figure 5-2 illustrates the closure in place concept for CAS 03-99-19 (Tejon).

According to the engineering drawing (Figure 1-8), the gas sampling assembly for the Tejon safety test included a subsurface sampling can, located north of Tejon SGZ. The drawing indicates the can was encased in concrete. The surface expression at this location is a cracked concrete pad flush with the ground surface and a metal cover with lifting ring (Figures 5-3 and 5-4). The metal cover is bolted down. Based on the engineering drawing, the sampling can appears to be an integral part of the gas sampling assembly. As such, it is presumed to be contaminated with radionuclides in similar concentrations as found in the pipe at Bernalillo SGZ. Due to the potential for worker exposure and the limited benefit of investigating the sampling can structure, the metal cover was not removed. The soil cover at this location was designed based on the potential for existence of a void in the subsurface that could cause soil subsidence over time. A metal retention structure will be placed at the location of the sampling can, filled with clean fill, and secured with a welded lid. This structure will contain enough clean material (e.g., soil or sand) to completely fill any void space that may be created by future subsidence.

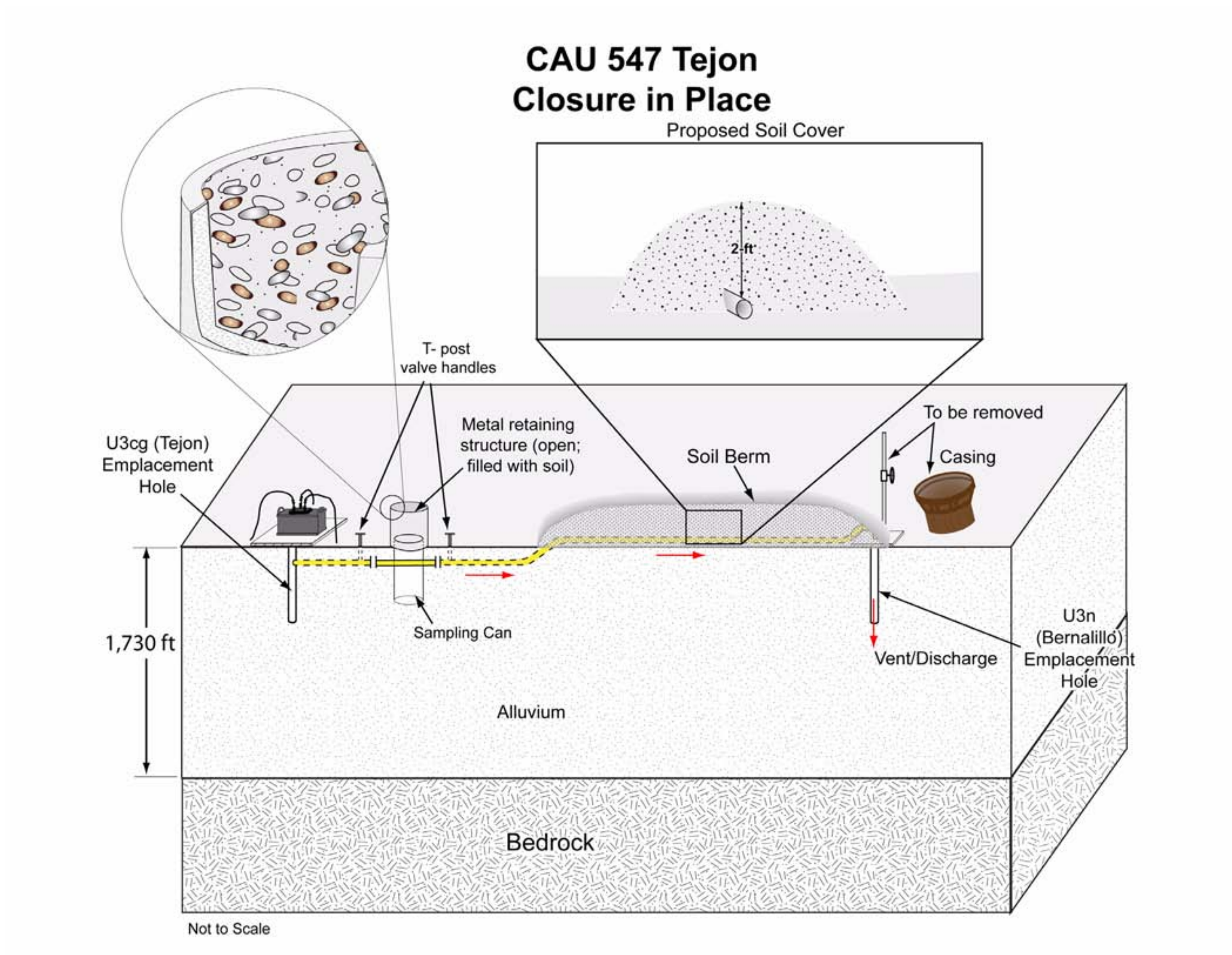

Figure 5-2
Closure in Place Concept for CAU 547, CAS 03-99-19 (Tejon)

Figure 5-3
Sampling Can Surface Location near Tejon SGZ

Figure 5-4
Close-up of Sampling Can Location

CAS 09-99-06 Player

- Cover the gas sampling assembly and components with a minimum of 2 ft of soil cover from the U9cc (Player) emplacement hole to the U9z PS#2 wellhead hole at the bottom of the U9z (York) crater.

- Place concrete pipe anchors at select locations on the U9z crater slope to prevent movement of the pipe during corrective action implementation. The anchors will also serve to stabilize the pipe once the soil cover has been constructed.

- Install metal retaining structures around the upright section of pipe (i.e., expansion joint) at Player SGZ, around the accelerometer, and at the U9z PS#2 wellhead in the U9z crater. Void spaces in each structure will be filled with concrete, and the top of each structure will be secured with a lid.

- Figure 5-5 illustrates the closure in place concept for CAS 09-99-06 (Player).

The impact of surface water and wind erosion on the soil cover on the U9z slope was carefully considered in the development of the soil cover design. Of particular interest was the point at the crater rim where the pipe begins its descent into the crater. The U9z crater intercepts surface water run-on to the Player site from the north. Erosion rills are evident on the north face of the crater, however are not visible at the crater rim where the pipe is located. Existing drainage courses in the area of the Player site drain away from the west edge of the U9z crater. Historical site photographs also indicate minimal erosion over the years since the test, suggesting that water erosion is not a concern (RSL, 1964, 1973, and 1989; NNSA/NV, 2002). As part of the design process, geotechnical samples of the fill soil to be used in the soil cover were collected. Wind erosion calculations performed using the fill soil properties yielded a wind erosion rate of 0.7 inches per year (in./yr). The erosion calculations also indicate that after 3.1 in. of erosion, desert "pavement" will form, and erosion will cease. Based on the visible surface water erosion patterns and the wind erosion calculations, erosion on the pipeline edge of the U9z crater is expected to be minor. Thus, installation of additional measures to protect against soil cover erosion (e.g., geomembrane material) along the U9z slope and at the crater rim are not necessary.

Another design consideration along the crater slope at the Player CAS, where the pipe is unsupported, was the potential for incidental movement or collapse of the pipe during soil cover construction. The weight of the soil and the process of soil compaction could create conditions in which the integrity of the pipe is compromised and the pipe contents are released. Some sections of the pipe along the slope

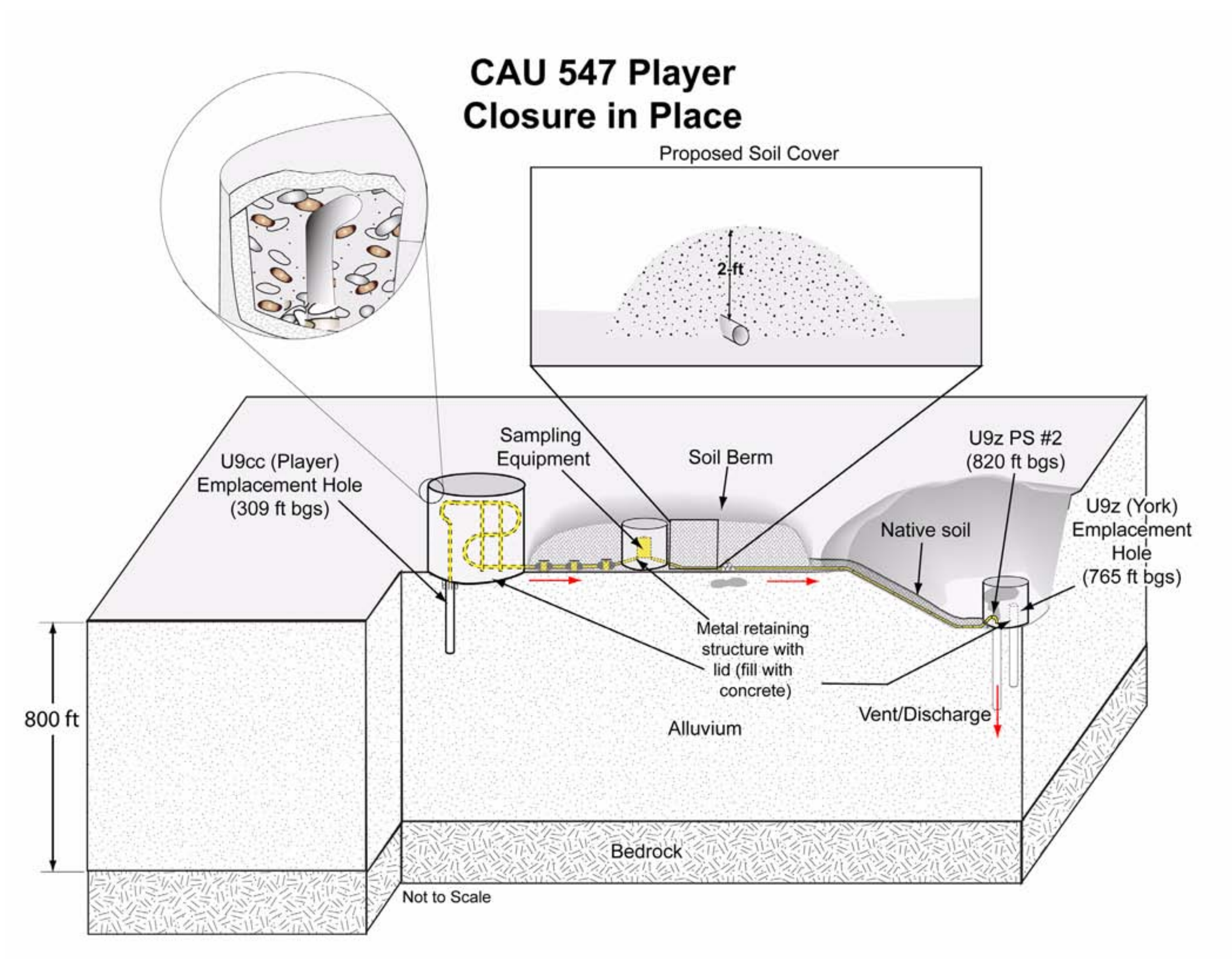

Figure 5-5
Closure in Place Concept for CAU 547, CAS 09-99-06 (Player)

are lying directly on the ground surface, while other sections are completely unsupported. The soil cover design for the unsupported sections of pipe includes the installation of concrete anchors directly underneath the pipe (see Appendix D). These anchors are intended to stabilize and support the pipe during soil cover installation and compaction. Anchors will not be installed at locations where the pipe is currently supported by the ground surface.

5.1.3 Fencing, Monuments, and Vehicle Access Controls

The soil design includes the establishment of a fence around the gas sampling assemblies at each CAS. Existing fencing will be used to fulfill this requirement where possible. New, three-strand wire fencing will be installed where necessary. In addition, concrete barriers will be installed around the retention structures (i.e., metal casings) to prevent vehicle access. A minimum of four upright concrete monuments will be installed at each CAS along the fence line in conspicuous locations. The fencing, concrete barriers, and monuments, together with the UR signs, serve to warn site workers and potential trespassers of the presence of radioactive contamination at the CASs. The existing road into the U9z (York) crater at the Player CAS will be permanently closed with concrete barriers to prevent vehicle access to the soil cover along the crater slope. A separate access road will be cleared to enable long-term monitoring of the soil cover and retention structure within the crater, as required by the post-closure plan (see Appendix E).

5.1.4 Use Restrictions Implementation

Because contamination will be left in place, URs will be established for the protection of site workers and visitors. The fences at each CAS will serve as the UR boundary and will be posted with UR signs at a minimum of every 200 ft. Use restrictions will be entered into the FFACO database and the DOE Facility Information Management System database.

5.2 Construction Quality Assurance/Quality Control

Construction QA and QC activities will be completed in accordance with the soil cover design specifications as detailed in Appendix D.

5.2.1 Sample Collection

Bulk and grab samples of the fill material to be used in construction of the soil cover at CAU 547 were collected and analyzed for geotechnical parameters. Laboratory testing consisted of obtaining index properties and grain size analyses to assist in soil classification and soil corrosivity and strength. The following parameters were analyzed:

- Gradation
- Atterberg Limits
- Corrosivity Suite (pH, chloride, minimum resistivity, sulfate)
- Remolded Direct Shear
- Modified Proctor

5.2.2 Field Testing

Field activities will include in-place density testing and the determination of compliance with soil compaction standards. One in-place density test will be performed for every 250 linear ft of fill placed. The soil cover will be compacted to a minimum of 90 percent relative compaction in accordance with construction specifications (see Appendix D).

5.3 Waste Management

Disposable PPE (coveralls, respirators) is the only anticipated waste stream to be generated during corrective action and closure activities. Management of investigation-derived waste (IDW) will be based on regulatory requirements, field observations, process knowledge, and analytical results, where available. All waste will be managed and disposed of in accordance with applicable DOE orders, U.S. Department of Transportation (DOT) regulations, state and federal waste regulations, and agreements and permits between DOE and NDEP.

The onsite management and ultimate disposition of wastes will be determined based on a determination of the waste type (e.g., industrial, low-level, hazardous, mixed), or the combination of waste types. A determination of the waste type will be guided by several factors, including, but not limited to, the analytical results of samples either directly or indirectly associated with the waste, historical site knowledge, knowledge of the waste generation process, field observations, field-monitoring/screening results, ISOCS results, and/or radiological survey/swipe results.

5.3.1 Waste Minimization

Closure activities are planned to minimize IDW generation. Hazardous material used at the CASs will be controlled to limit unnecessary generation of hazardous or mixed waste. Administrative controls, including decontamination procedures and waste characterization strategies, will minimize waste generated during site closure.

5.4 Confirmation of Corrective Action

The confirmation of corrective action implementation serves to (1) verify that the chosen corrective action is appropriate and effective, (2) assure that corrective actions minimize the potential for future exposures, and (3) confirm that the corrective actions have been completed.

The following activities will be completed before closure of the site Real Estate/Operations Permit (REOP) at each CAU 547 CAS:

- Placing soil cover over existing gas sampling piping and components in accordance with design (see Appendix D).
- Installing soil retaining structures around upright sections of piping (expansion joints) and components of pipe, filling void spaces with concrete and securing with lids.
- Performing a baseline radiological survey at each CAS after construction is complete.
- Removing all temporary signage and fencing.
- Placing UR signs.
- Placing concrete monuments and barriers.
- Removing all equipment, wastes, debris, and materials associated with the closure activity
- Inspecting the site and verifying that restoration activities have been completed.
- Preparing and certifying (via a professional land surveyor) a final survey plat, including monument locations at each CAS.

Note: Although the Data Quality Indicators (e.g., precision, accuracy) are typically assessed to confirm corrective actions, these indicators are not applicable to this CADD/CAP (Section 2.2.2).

5.5 Permits

No state and/or federal permits will be required for implementation of the closure in place corrective action at CAU 547.

6.0 Schedule

Table 6-1 is a tentative duration of activities (in calendar days) associated with closure of the gas sampling assemblies. The estimated number of days are per CAS, and activities may overlap.

Table 6-1
Field Activities

Duration (days)	Activity
30	Site Preparation
180	Fieldwork
180	Closure Report
180	Waste Management and Disposition

Reports generated during ongoing field activities will be provided to NDEP upon request. Historical information and documents referenced in this plan are retained in the NNSA/NSO project files in Las Vegas, Nevada, and can be obtained through written request to the NNSA/NSO Federal Sub-Project Director. This document is available in the DOE public reading facilities located in Las Vegas and Carson City, Nevada, or by contacting the appropriate DOE Federal Sub-Project Director.

7.0 Post-closure Plan

The post-closure plan for the three CASs in CAU 547 consists of a program for long-term monitoring of the soil cover and URs. The plan outlines a progressive monitoring approach that provides a protective and cost effective method to monitor the CAU 547 sites and address potential contaminant migration in the future. The details of the post-closure plan are presented in Appendix E.

7.1 Inspections

In order to verify the integrity and effectiveness of the soil cover and URs at each CAS, visual inspections will be conducted quarterly for the first two years after completion of the corrective action. After this two-year period, the inspection frequency will change to annual. In addition, non-scheduled inspections will be conducted after precipitation events that involve over 1 in. of rainfall in a 24-hour period as measured at the nearest rain gauge to each CAS.

7.2 Monitoring

A radiological survey will be completed at each CAS to document radiological conditions after installation of the soil cover. This survey will be used as a baseline for site conditions. These survey data can be used to identify changing radiological conditions in the future (e.g., as a result of cover erosion, animal disturbance) and confirm restoration of baseline conditions after periodic repairs or maintenance.

The post-closure plan outlines a progressive monitoring approach based on the extent and source of contamination that may be identified during inspections. This progressive approach presents a range of monitoring responses specific to the circumstances presented. These responses include the conduct of additional radiological survey for small areas of contamination, air sampling for larger areas of contamination, and evaluation of design effectiveness and recommended changes in the case of design failure. The plan details the provisions and circumstances for each progressive monitoring step (see Appendix E).

7.3 Maintenance and Repair

Animal burrows greater than 6 in. deep or erosion/subsidence greater than 6 in. deep and 3 ft long will require NDEP notification. These impacted areas will be surveyed for radiation and repaired within 90 days of discovery. The UR signs and concrete barriers will be replaced or repaired as necessary.

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Appendix A

Project Organization

A.1.0 Project Organization

The NNSA/NSO Federal Sub-Project Director and Task Manager for CAU 547 is Kevin Cabble, who can be reached at (702) 295-5000.

The identification of the project Health and Safety Officer and the Quality Assurance Officer can be found in the appropriate plan. However, personnel are subject to change and it is suggested that the NNSA/NSO Federal Sub-Project Director be contacted for further information.

Appendix B

Data Quality Objectives

B.1.0 Introduction

This appendix details the DQO process for CAU 547. The DQO process is a strategic planning approach based on the scientific method that is designed to ensure that existing data and/or data collected provide sufficient and reliable information to identify, evaluate, and technically defend the recommendation of viable CAAs (e.g., no further action, clean closure, or closure in place). The DQOs were developed in accordance with the *Guidance on Systematic Planning Using the Data Quality Objectives Process* (EPA, 2006).

Corrective Action Unit 547 comprises the following three CASs:

- CAS 02-37-02, Gas Sampling Assembly – located in Area 2 of the NNSS and associated with the Mullet safety experiment in emplacement hole U2ag.
- CAS 03-99-19, Gas Sampling Assembly – located in Area 3 of the NNSS and associated with the Tejon safety experiment in emplacement hole U3cg.
- CAS 09-99-06, Gas Sampling Assembly – located in Area 9 of the NNSS and associated with the Player safety experiment in emplacement hole U9cc.

The gas sampling assembly at each CAS consists of the piping, valves, equipment, and associated instrumentation.

B.1.1 Summary of DQO Analysis

Based on historical knowledge of the three safety experiments and existing radiological survey data, there is sufficient data to resolve the problem statement defined in the DQOs without additional investigation. The gas sampling assemblies at CASs 02-37-02 (Mullet), 03-99-19 (Tejon), and 09-99-06 (Player) contain PSM (i.e., the pipes are known to be internally contaminated with Pu) that may cause the future release of COCs; therefore, a corrective action is recommended. Based on the evaluation of CAAs presented in Section 3.0, the preferred corrective action at each of the CAU 547 CASs is closure in place with a soil cover and URs.

B.2.0 Step 1 - State the Problem

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

B.2.1 Problem Statement

The problem statement for CAU 547 is: "Is the preferred CAA of closure in place the most protective based on risk and future land use?"

B.2.2 Planning Team Members

The DQO planning team consisted of representatives from NDEP; NNSA/NSO; Navarro-Intera, LLC; and National Security Technologies, LLC. The initial DQO meeting for CAS 09-99-06 (Player) was held on January 9, 2008; the meeting for CAS 02-37-02 (Mullet) and CAS 03-99-19 (Tejon) was held on July 20, 2011. The primary decision-makers are the NDEP and NNSA/NSO representatives.

B.2.3 Conceptual Site Model

The conceptual site model (CSM) is used to organize and communicate information about site characteristics. It reflects the best interpretation of available information at any point in time. The CSM is the 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 the impacts of such movement. It is the basis for assessing how contaminants could reach receptors both in the present and future.

The CSM consists of the following:

- Potential contaminant releases associated with the gas sampling assemblies and debris components, including affected media.
- Release mechanisms (the conditions associated with the release).

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

The CSM was developed for the gas sampling assemblies of CAU 547 using information from the physical setting, potential contaminant sources, release information, historical background information, knowledge from similar sites, modeling, monitoring data, and physical and chemical properties of the potentially affected media and COCs.

Based on available process knowledge and existing data, the assemblies are known to be internally contaminated with radionuclides. Therefore, the gas sampling assemblies contain PSM with the potential to cause the future release of COCs. Although the contamination is currently contained within the piping systems, with the exception of the release to the soil at CAS 02-37-02 (Mullet), the CSM for each CAS assumes the future release of COCs adjacent to and beneath the assembly piping/equipment.

A graphical representation of the CSM for CAS 02-37-02 (Mullet) is presented in Figure B.3-1; for CAS 03-99-19 (Tejon) in Figure B.3-2; and for CAS 09-99-06 (Player) in Figure B.3-3. Site characteristics (e.g., geography, geology, groundwater, surface water), modeling, and monitoring data have been evaluated to support the CSM. The CSMs for all three CASs at CAU 547 demonstrate that migration of contaminants is not occurring and that the preferred CAA of closure in place with a 2-ft soil cover is protective of human health and the environment.

B.2.4 Site Contaminants

The COCs were identified during the planning process through the review of site history, process knowledge, personal interviews, past investigation efforts (where available), and inferred activities associated with the CASs. Based on radiological swipes and ISOCS data, Pu, Am, and other fission

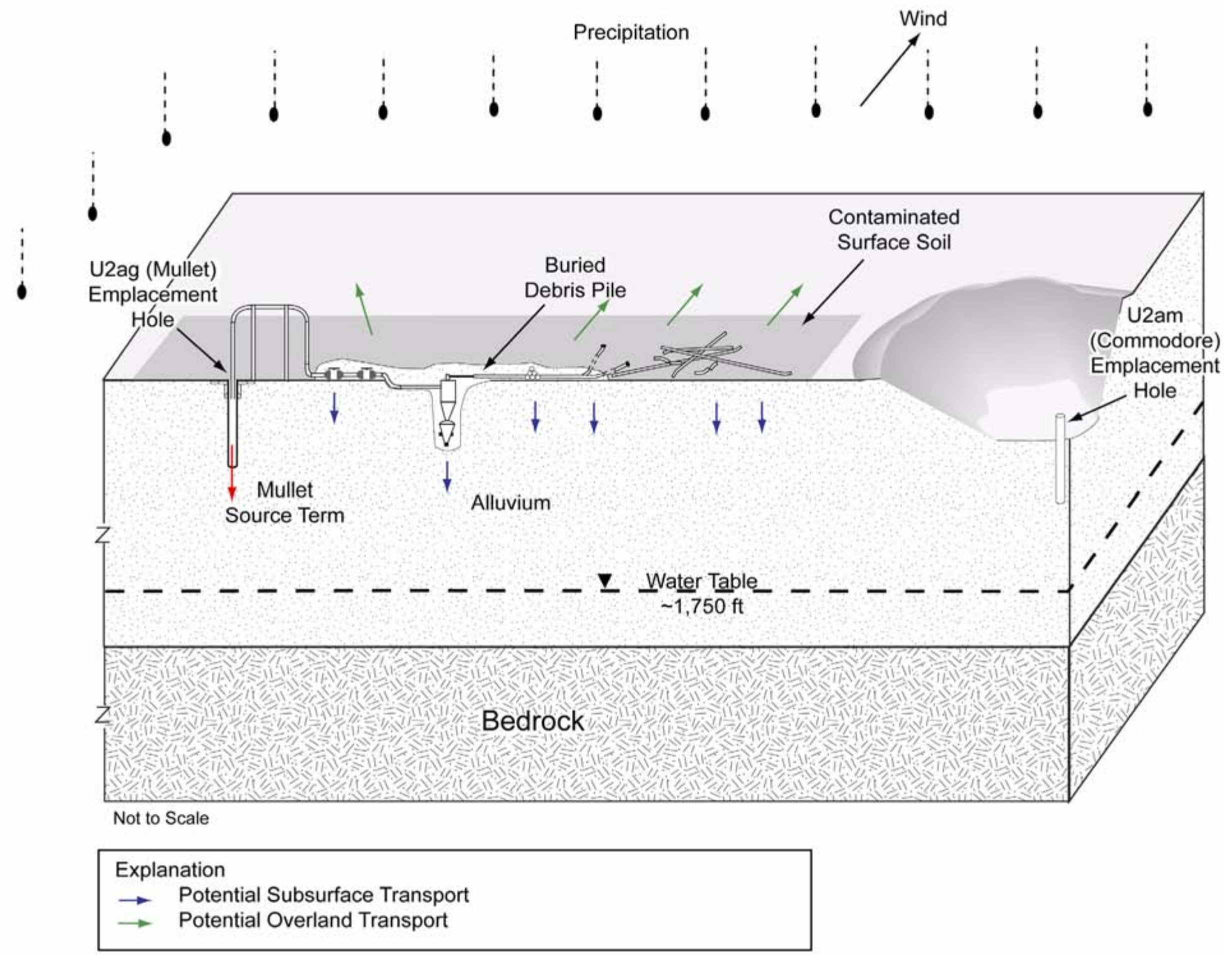

Figure B.3-1
Conceptual Site Model for CAU 547, CAS 02-37-02 (Mullet)

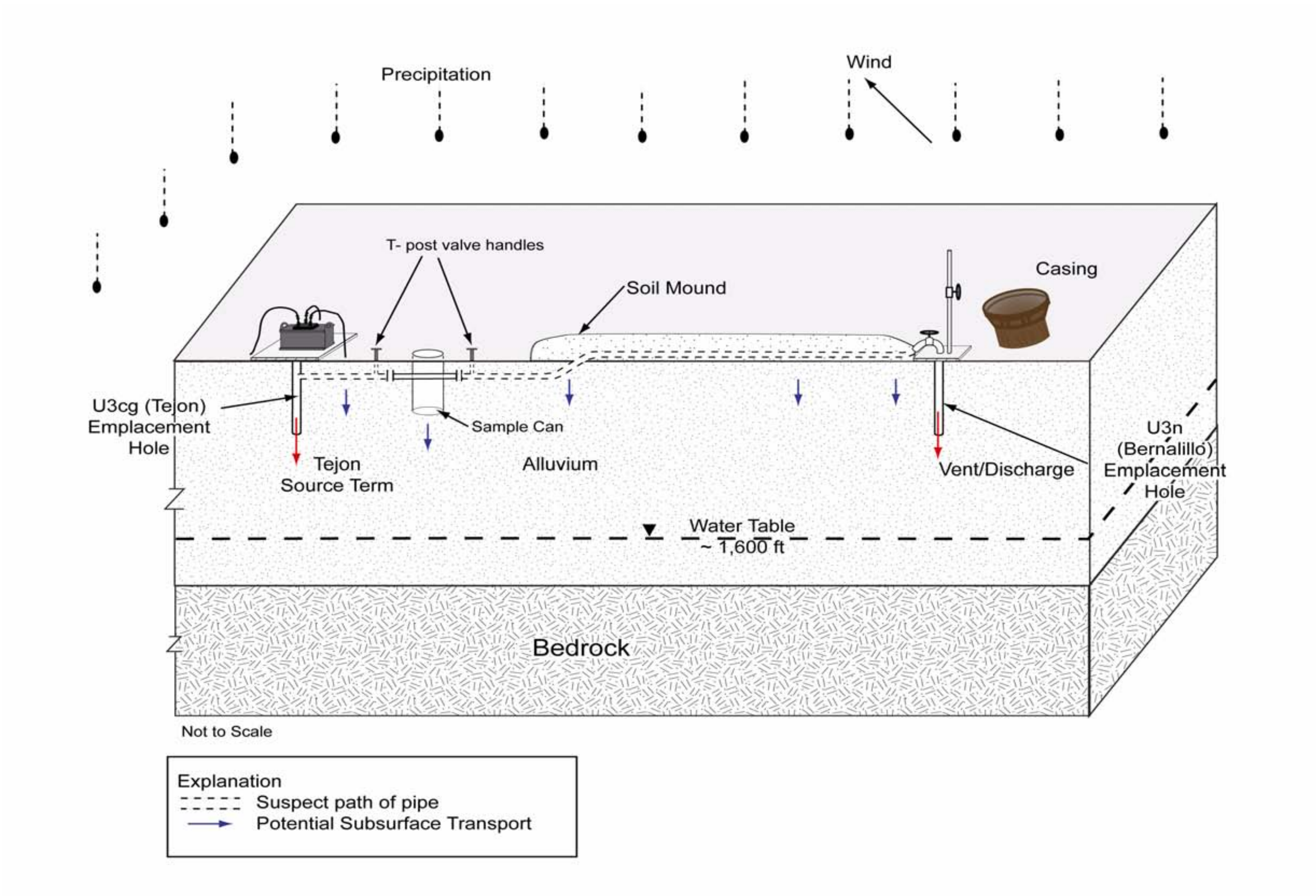

Figure B.3-2
Conceptual Site Model for CAU 547, CAS 03-99-19 (Tejon)

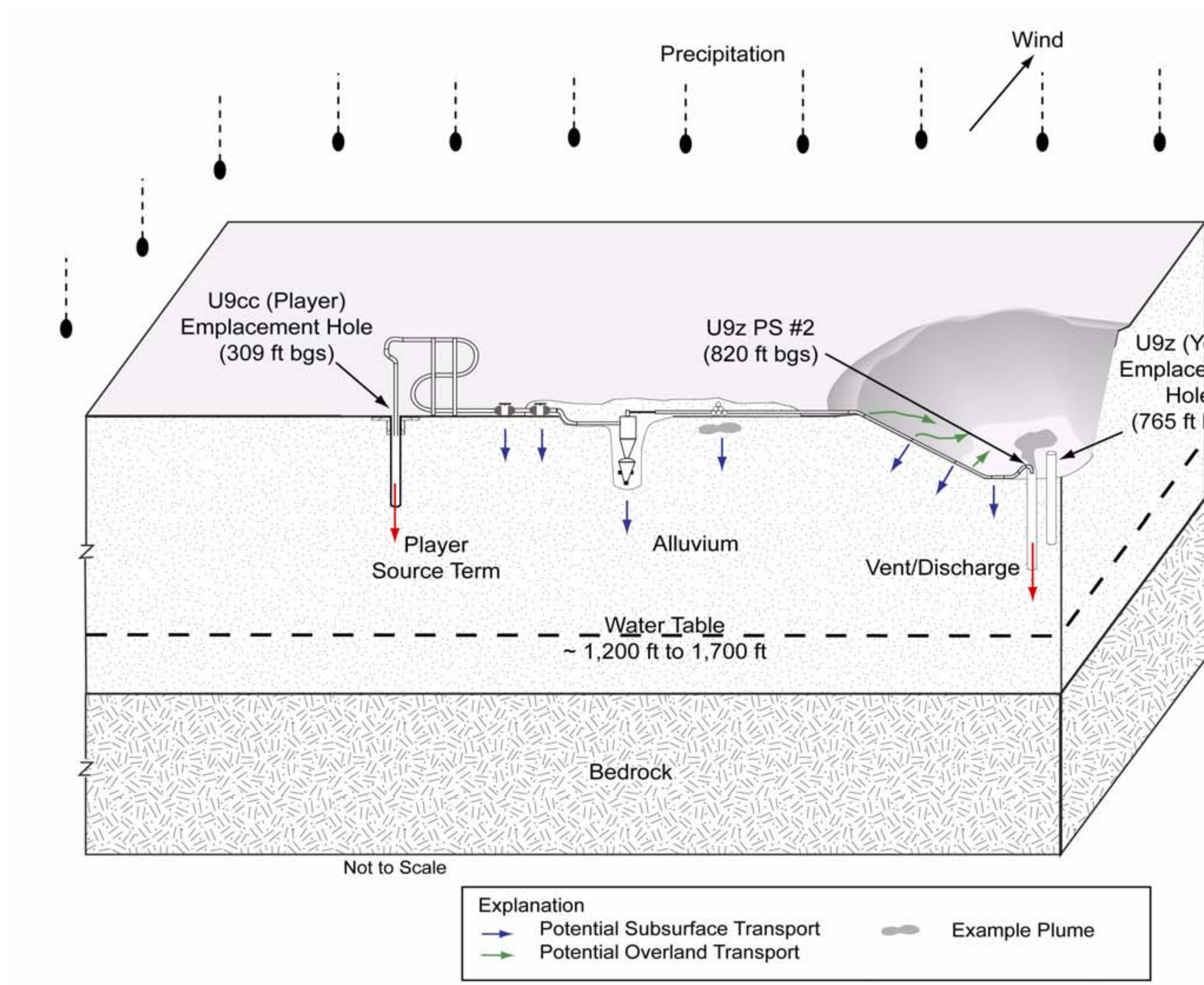

Figure B.3-3
Conceptual Site Model for CAU 547, CAS 09-99-06 (Player)

products inside the gas sampling assemblies at all three CASs are confirmed COCs. Because of the potential for future release, these radionuclides are also considered PSM.

B.2.5 Contaminant Characteristics

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

The major contaminants (Pu and Am) identified in the gas sampling assemblies strongly adsorb to soil particles and would generally only be translocated as soils are translocated through erosion or with soil colloids as they are moved downward through the soil profile with infiltrating stormwater.

B.2.6 Site Characteristics

Site characteristics are defined by the interaction of physical, topographical, and meteorological attributes and properties. Physical properties include permeability, porosity, hydraulic conductivity, degree of saturation, sorting, chemical composition, and organic content. Topographical and meteorological properties and attributes include slope stability, precipitation frequency and amounts, precipitation runoff pathways, drainage channels and ephemeral streams, and evapotranspiration potential. The site characteristics as they apply to the CASs in CAU 547 are discussed below.

B.2.6.1 CAS 02-37-02 (Mullet)

Corrective Action Site 02-37-02 is located in north-central Yucca Flat, a hydrographically closed basin that is bounded on all sides by low hills and ranges of volcanic and sedimentary rocks (Laczniak et al., 1996). The subsurface geology of Yucca Flat is dominated by volcanic rocks, consisting mainly of ashflow tuffs with interbedded nonwelded and bedded tuffs. The tuffs are overlain by younger alluvial sediment eroded from the surrounding mountains.

Groundwater depth measurements were collected recently at two wells located within 0.5 mi of CAS 02-37-02. The depth to groundwater at these wells was recorded on March 17, 2011, as follows: 1,775 ft bgs (U2gk southwest of site) and 1,725 ft bgs (ER-2-1 southeast of site) (USGS and DOE, 2011).

The average annual precipitation at the closest rain gauge station, Buster Jangle Wye (BJY), is 6.34 in. for the observation period of 1960 to 2010 (ARL/SORD, 2011). This station is located in Yucca Flat approximately 4.8 mi southeast of CAS 02-37-02, near the intersection of Mercury Highway and Rainier Mesa Road.

B.2.6.2 CAS 03-99-19 (Tejon)

Corrective Action Site 03-99-19 lies within the Yucca Flat Hydrographic Area of the NNSS (Laczniak et al., 1996). Uplift and erosion of the surrounding mountains has resulted in the accumulation of more than 1,000 ft of alluvial deposits in some areas of Yucca Flat. Carbonate rocks primarily underlie the alluvium in parts of Yucca Flat and form much of the surrounding mountains in this area. The surrounding soil is typical desert alluvium composed of mostly fine soil and rock particles and includes loose rocks measuring up to 3 in. diameter.

Groundwater occurs in Yucca Flat within alluvial and volcanic aquifers that overlie a carbonate aquifer. This carbonate aquifer underlies large areas of the NNSS and is part of a regional groundwater flow system. Within the overlying alluvial and volcanic aquifers in Yucca Flat, lateral groundwater flow occurs from the margins to the center of the basin. Groundwater flows downward from these aquifers into the carbonate aquifer (Laczniak et al., 1996). The direction of groundwater flow in this region of the carbonate aquifer is generally from the northeast to southwest.

Groundwater depth measurements were collected recently at three wells located within 1 mi of CAS 03-99-19. The depth to groundwater at these wells was recorded on March 17, 2011 as follows: 1,599 ft bgs (Water Well-A south of site), 1,645 ft bgs (Test Well-7 north of site), and 1,619 ft bgs (U3cn#5 northeast of site) (USGS and DOE, 2011).

The average annual precipitation at the closest rain gauge station, BJY, is 6.34 in. for the observation period of 1960 to 2010 (ARL/SORD, 2011). This station is located in Yucca Flat approximately

1.5 mi northwest of CAS 03-99-19, near the intersection of Mercury Highway and Rainier Mesa Road.

B.2.6.3 CAS 09-99-06 (Player)

Corrective Action Site 09-99-06 is located in the southwest region of Area 9 in the Yucca Flat Hydrographic Area, where the estimated recharge is 0.043 in./yr (Rush, 1971). The CAS is located within the Aqueduct Mesa drainage basin, approximately 1,400 ft east of the nearest wash, which drains south to the Yucca Flat dry lake bed.

The soil at CAS 09-99-06 is native and consists of silt to cobble-sized alluvium of various lithologies. Soil thickness is estimated to be more than 10 ft in Yucca Flat (Hevesi et al., 2003). The depth of the alluvium is approximately 750 ft (BN, 2006) as measured from the nearest borehole, U9aw, drilled 525 ft east of CAS 09-99-06. The topography from the U9cc SGZ to the edge of the U9z crater is relatively flat, with no nearby drainages. The walls of the U9z crater are steep, and soil erosion into the crater is expected, especially during storm events.

Groundwater depth measurements were collected recently at three wells located within 2 mi of CAS 09-99-06. The depth to groundwater at these wells was recorded on March 17, 2011, as follows: 1,775 ft bgs (U2gk west of site), 1,725 ft bgs (ER-2-1 northwest of site), and 1,240 ft bgs (UE-4t#2 south of site) (USGS and DOE, 2011).

The average annual precipitation at the closest rain gauge station, BJY, is 6.34 in. for the observation period of 1960 to 2010 (ARL/SORD, 2011). This station is located in Yucca Flat approximately 3.8 mi from CAS 09-99-06, near the intersection of Mercury Highway and Rainier Mesa Road.

B.2.7 Migration Pathways and Transport Mechanisms

An important element of the CSM is the expected fate and transport of contaminants (i.e., how contaminants migrate through media and where they can be expected in the environment). Fate and transport of contaminants are presented in the CSM as the migration pathways and transport mechanisms that could potentially move the contaminants laterally and vertically through the various media. The pathways include air, surface water, and groundwater, and are the routes through which contamination could migrate from the site(s) to locations where a receptor might receive an exposure.

Fate and transport are influenced by physical and chemical characteristics of the contaminants and media described in Section B.2.5.

B.2.8 Air Pathway

Releases to the air may result from resuspension of contaminated surface soil particles from strong winds, or evaporation of the volatile components of contaminants potentially released from soil or debris.

At the Mullet site, wind is a potential transport mechanism for the surface contaminated soil in the posted CAs and HCAs. According to historical documents, oil was sprayed on the contaminated soil to limit airborne distribution of contamination after the release, and may currently provide some level of protection against windborne migration. It is not known whether the oil contained PCBs. Contaminated debris was buried at the Mullet site after completion of the test. Some of this debris is exposed (i.e., sticking out of or on top of the soil mounds), which may be the result of wind, soil erosion, or the settling of buried debris over time. Except for whatever protection the oil affords, there is currently no protection against the windborne migration of surface soil contamination or contamination on exposed debris at the Mullet site. In addition, there are several open-ended pipes lying exposed on the ground surface at the Mullet site in which the presence of Pu and Am contamination has been confirmed. The contents of these pipes is potentially subject to migration via the air pathway.

At the Tejon site, wind is not expected to be a transport mechanism for releases from the gas sampling assembly because the majority of the assembly is underground or currently covered by a soil mound.

At the Player site, wind is not expected to be a transport mechanism for releases along the exposed segment of piping within the U9z crater due to the presence of steep crater walls. A release of contaminants to the air is not considered to be a transport mechanism along the piping from the U9cc borehole to the U9z crater edge because this segment is covered by a dirt berm. The only areas potentially subject to windborne migration are the exposed portions of the assembly (i.e., sample bottles, piping at SGZ).

B.2.9 Surface Water Pathway

As Pu and Am are essentially immobile in soil, the migration of these contaminants is limited to the movement of the soil. Therefore, migration pathways include the lateral and vertical migration of potential contaminants with surface soils. Potential receptors could be exposed to contamination at the soil surface through the surface exposure pathway.

At the Mullet site, the earth was disturbed by neighboring underground tests, including the Commodore test (U2am). This resulted in the creation of uneven terrain in the form of hills and troughs that run roughly parallel to the gas sampling assembly near the edge of the U2am crater. Cracks or fissures in the earth created by the neighboring tests present a potential vertical migration pathway for contamination; however, the extent of such migration cannot be predicted because the depths of the cracks are unknown. The ground surface at the Mullet site slopes from the U2ag emplacement borehole toward the U2am crater, presenting a pathway for surface migration of contamination to the crater.

The Tejon site is relatively flat with the existing soil mound near the Bernalillo emplacement hole (U3n), the only surface feature presenting a potential for soil erosion. Based on the engineering drawing (Figure 1-8), the majority of the gas sampling assembly is underground. Therefore, a potential release of contamination from underground piping would not result in a surface exposure but could result in an exposure if the area were excavated.

The Player site is relatively flat from the U9cc emplacement borehole to the edge of the U9z crater. The crater slope presents the potential for soil erosion and lateral surface migration of contamination into the U9z crater. The surface soil within the U9z crater is gradually increasing in depth through windborne deposition and soil erosion, which tends to bury current surface materials (soil containing radiological or chemical contamination) with additional layers of surface soil over time. If contaminated soil from the slope of the crater migrates to the bottom of the crater, with time, it will be buried as the crater bottom slowly fills with additional uncontaminated soil.

B.2.10 Groundwater Pathway

At the CAU 547 CASs, infiltration and percolation of precipitation serve as a driving forces for the downward vertical migration of contaminants through soil. Due to the high evaporative demand (annual potential evapotranspiration at the Area 3 RWMS has been estimated at 62.6 in. [Shott et al., 1997]) and limited precipitation for this region (6.4 in./yr [Winograd and Thordarson, 1975]), percolation of infiltrated precipitation at the NNSS does not provide a significant mechanism for vertical migration of contaminants to groundwater (DOE/NV, 1992). Also, the radiological contaminants are strongly attached to soil particles and would only be subject to vertical migration through the soil profile with soil colloids that may be translocated with infiltrating stormwater. Migration of these colloids would be sufficiently slow to preclude consideration of this pathway to groundwater through the 1,200 to 1,700 ft of overlying material.

There is also the potential for vertical migration at the Mullet and Player sites through surface cracks or fissures created by nearby ground disturbances.

B.2.11 Land-Use and Exposure Scenarios

Human receptors may be exposed to contaminants of potential concern (COPCs) through oral ingestion, inhalation, dermal contact (absorption) of soil or debris due to inadvertent disturbance of these materials, or irradiation by radioactive materials.

The land-use and exposure scenarios for CAU 547 are based on NNSS current and future land use (DOE/NV, 1998). The three CASs are located within the Nuclear Test Zone land-use category. This category is reserved for dynamic experiments, hydrodynamic tests, and underground nuclear weapons and weapons-effects tests. This zone includes compatible defense and nondefense research, development, and testing activities. Based on the identified future land use, an Occasional Use Area exposure scenario is appropriate. The criteria for this exposure scenario is that it is a remote area with no active site improvements and where no regular work is performed. However, there is a possibility that site workers could occupy these locations on an occasional and temporary basis such as a military exercise. A site worker under this scenario is assumed to be exposed to the site for an equivalent of 80 hours per year for 5 years (NNSA/NSO, 2006).

B.2.12 Conclusions

Corrective Action Unit 547 is well suited for isolation and closure in place of the gas sampling assemblies at the following locations:

- CAS 02-37-02 (Mullet)
- CAS 03-99-19 (Tejon)
- CAS 09-99-06 (Player)

The sites are located on an access-controlled government facility, many miles from residential populations. Land use is restricted to industrial or occasional use. The sites have a windy, arid climate.

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

Step 2 of the DQO process indicates how environmental data will be used in meeting objectives and solving the problem, and identifies the questions or decision statement(s) the study will attempt to resolve.

B.3.1 Decision Statements

The Decision I question is: "Do historical information and existing data allow for the development and evaluation of CAAs?" If yes, then develop and evaluate CAAs, and identify the risks and costs associated with each. If no, proceed with Decision II.

The Decision II question is: "If historical information and data are not sufficient to allow for the development and evaluation of CAAs, then an investigation strategy to obtain the necessary information will be developed."

Sufficient information is defined to include the following:

- Identification of sites where safety experiments were conducted and prompt gas sampling assemblies were used for the collection and sampling of post-test gases and particulates.
- Quantity and nature of COCs at each site.
- Extent of contamination at each site.
- Information required to characterize wastes resulting from corrective action implementation for disposal.
- Information required to evaluate the feasibility of potential CAAs.

B.4.0 Step 3 - Identify Information Inputs

Step 3 of the DQO process identifies the information, and determines sources for information needed to address the goals of the study.

B.4.1 Information Needs

To resolve Decision I, information sources, historical information and other pertinent data need to be collected and analyzed. Data collected in association with various studies, preliminary investigations, historical information and modeling have been compiled to support the development of a closure strategy. The information needed to develop and evaluate CAAs is summarized below.

- Closure in place data needs:
  - CSM developed in sufficient detail to allow for all pathways modeling to be completed.
  - Sufficient information to estimate and develop design for soil cover, estimate costs for installation of the cover, worker dose, and dose to the public.
  - Understanding of operational history.
  - Sources of potential contamination and inventories.
- Clean closure data needs:
  - Sufficient information regarding waste volumes and inventory to estimate cost, worker dose, transportation risk, and dose to the public.
  - Identification of disposal capacity sufficient for the projected waste streams that will be generated in the event of a clean closure option.

To resolve Decision II, additional data must be collected and/or additional investigations performed.

B.4.2 Sources of Information

Information to satisfy Decision I and Decision II will be generated by review of historical information, personnel interviews, site process knowledge, photographs, and previous field investigations and analytical results.

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

Step 4 of the DQO process defines the target population of interest and its relevant spatial boundaries, and specifies temporal and other practical constraints associated with data collection.

B.5.1 Target Populations of Interest

The population of interest for which corrective actions will be developed include the following three CAS locations:

- CAS 02-37-02, Gas Sampling Assembly (Mullet)
- CAS 03-99-19, Gas Sampling Assembly (Tejon)
- CAS 09-99-06, Gas Sampling Assembly (Player)

B.5.2 Spatial Boundaries

Spatial boundaries are the maximum lateral and vertical extent of expected contamination at each site based on the CAS-specific CSM. The lateral boundary is 50 ft from any component, and the vertical boundary is 15 ft bgs. Contamination found beyond these boundaries may indicate a flaw in the CSM and may require reevaluation of the CSM before the investigation could continue. Each CAS is considered geographically independent, and intrusive activities are not intended to extend into the boundaries of neighboring CASs.

B.5.3 Practical Constraints

Common practical constraints—such as military activities at the NNSS, the presence of utilities, and unstable or steep terrain—may affect the ability to implement corrective actions at CAU 547.

B.5.4 Time Constraints

The time necessary to evaluate the study data, develop appropriate CAAs, and obtain concurrence from the NDEP on the selection of a CAA must be considered. The time required to prepare the CADD/CAP and develop field implementation documents (e.g., engineering designs, construction specifications) must also be considered.

B.6.0 Step 5 - Develop the Analytic Approach

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

B.6.1 Decision Rules

Decision I:

- If closure in place is the most feasible closure option, then a closure design will be developed ensuring that the corrective action is protective of human health and the environment.

Decision II:

- If clean closure is the most feasible closure option, then a closure plan will be prepared outlining the remediation plans.

B.7.0 Step 6 - Specify Performance or Acceptance Criteria

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

B.7.1 Decision Errors

The bounding CAAs have been identified as clean closure and closure in place. In order to facilitate discussion of decision errors, closure in place will be defined as the baseline condition.

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 will be established qualitatively by performing the following:

- Developing and gaining concurrence of CSMs (based on process knowledge) by stakeholder participants during the DQO process.
- Testing the validity of CSMs based on investigation results.

B.7.1.1 False Negative Decision Error

The false negative decision error would mean deciding that the baseline condition is false when, in fact, it is true. This error means deciding that clean closure is the most advantageous option, when closure in place is actually the best alternative. The possible consequences of this decision error are increased worker dose during removal, packaging, and transportation of waste; increased short-term risk to the public during transportation of waste; and increased cost. This error will be controlled by having a high degree of confidence in the data, such as waste inventory, contamination levels, and the CSM.

B.7.1.2 False Positive Decision Error

The false positive decision error would mean deciding that the baseline condition is true when, in fact, it is false. This error means deciding that closure in place is the most advantageous option, when clean closure is actually the best alternative. The potential consequence is an increased risk to human health and the environment due to leaving the gas sampling assemblies in place. This error will be controlled by having a high degree of confidence in the data such as waste inventory, contamination levels, and the CSM. Additionally, as all sites within CAU 547 are currently controlled for radiological purposes, and there is no proximal public receptor, the impact of this error is minimized.

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

Step 7 of the DQO process selects and documents a design that will yield data that will best achieve performance or acceptance criteria. Historical information, and other pertinent data collected to date will be used to resolve the decisions outlined in the previous sections.

B.8.1 Process Knowledge

Historical operations, drawings, and photographs associated with CAU 547 are well documented through multiple sources.

B.8.2 Radiological Inventory

Information regarding the radiological inventory within the gas sampling assemblies was collected between 2007 and 2011. The ISOCS sampling of the gas sampling assemblies at each CAS has been redundant, and sample locations were biased at locations presumed to contain the highest activities.

B.8.3 Conceptual Site Model

Historical information, modeling data, and other information have been collected to accurately describe the CSM, and to identify the risks and benefits associated with each of the proposed CAAs.

B.9.0 References

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Appendix C

Evaluation of Risk

C.1.0 Background

Corrective Action Unit 547 comprises the following three CASs:

- CAS 02-37-02, Gas Sampling Assembly (Mullet) – located in Area 2 of the NNSS and associated with the Mullet safety experiment. The Mullet safety experiment was conducted at borehole U2ag on October 17, 1963.
- CAS 03-99-19, Gas Sampling Assembly (Tejon) – located in Area 3 of the NNSS and associated with the Tejon safety experiment. The Tejon safety experiment was conducted at borehole U3cg on May 17, 1963.
- CAS 09-99-06, Gas Sampling Assembly (Player) – located in Area 9 of the NNSS and associated with the Player safety experiment. The Player safety experiment was conducted at borehole U9cc on August 27, 1964.

The operational history, photographs, and characterization information for each CAS is presented in detail in Section 1.4. Data particularly relevant to this risk evaluation are included below.

C.1.1 CAS 02-37-02 (Mullet)

According to the engineering drawing (Figure 1-2), the total length of the gas sampling assembly at CAS 02-37-02 from the emplacement borehole U2ag to the end of the system was approximately 250 ft. Actual pipe measurements collected in November 2010 indicate the length of pipe within the Mullet CA is approximately 523 ft. The entire length of the gas sampling assembly is currently posted as a CA, with two smaller areas inside the fence posted as HCAs. Historical information indicates the fenced areas encompass contaminated soil and buried radioactive material. Soil samples from each HCA were collected and submitted for gamma spectroscopy and isotopic Pu analyses. Based on these results, the maximum potential dose was estimated using the maximum values for each radionuclide and the Residual Radiation (RESRAD) computer code (Yu et al., 2001). Additional background information on CAS 02-37-02 is presented in Section 1.4.1.

C.1.2 CAS 03-99-19 (Tejon)

The total length of the gas sampling assembly at CAS 03-99-19 from the Tejon emplacement borehole (U2cg) to the Bernalillo (U3n) emplacement borehole is approximately 500 ft. The pipe runs beneath the ground surface from the Tejon emplacement hole to approximately 135 ft from the Bernalillo emplacement borehole, where the pipe is covered with a berm. This 4-ft-high earthen mound was constructed at the time of the Tejon safety experiment. Additional background information on CAS 03-99-19 is presented in Section 1.4.2.

C.1.3 CAS 09-99-06 (Player)

The total length of the gas sampling assembly at CAS 09-99-06 from the Player emplacement borehole (U9cc) to the U9z PS#2 borehole is approximately 650 ft. Approximately 300 ft of pipe is covered by soil from near the U9cc SGZ to the U9z crater edge. The approximately 350 ft of remaining pipe is exposed on the ground surface along the U9z crater slope to the U9z PS#2 borehole. The gas sampling assembly components outside the U9z crater are surrounded by fencing posted with "Underground Radioactive Material" signs. The piping on the slope is fenced and posted with "Caution Equipment and Material Internally Radioactively Contaminated" signs. The U9z PS#2 wellhead is posted "Caution Internal Contamination" but is not fenced. Additional background information on CAS 09-99-06 is presented in Section 1.4.3.

C.2.0 Closure Strategy

A corrective action for the gas sampling assembly at each CAS will be necessary because the radioactive contamination present inside the gas sampling assembly, if released to surface soil, could result in a dose to a worker in the area exceeding the 25-mrem/yr action level. The following CAAs were considered:

- Corrective Action Alternative A, Clean Closure
- Corrective Action Alternative B, Closure in Place
- Corrective Action Alternative C, Modified Closure in Place
- Corrective Action Alternative D, No Further Action (with administrative controls)
- Corrective Action Alternative E, No Further Action

C.2.1 Corrective Action Alternative A, Clean Closure

Clean closure would require workers to remove and dispose of the gas sampling assemblies and components above existing grade. As the radioactive contamination currently contained within the gas sampling assemblies would be subject to release during the cutting of the pipe, engineered containment structures and PPE would need to be used to protect site workers. This corrective action would also investigate and potentially remediate soil contamination released during the removal activity.

This corrective action of clean closure would involve the removal of the gas sampling assemblies and components that would cause these materials to become newly generated waste, and the removed components would be subject to current waste regulations. The covered portions of the gas sampling assemblies would be uncovered while monitoring for potential releases. Ancillary equipment and assembly components other than the pipe would be disassembled and packaged as waste. Based on the potential estimated mass of Pu-239 contained within the gas sampling assemblies, the resulting waste would require handling and disposal as TRU waste. To fit into TRU waste containers, the pipe would need to be cut into approximately 4-ft sections. The cut sections would be transported to a waste management area where they would be placed into waste containers. The voids in the containers would be filled with inert material, sealed, and labeled.

Clean closure activities at the Mullet site would involve disassembly, size reduction, and removal of all existing pipe. Before disassembly, site workers would uncover the covered portions of the pipe assembly using hand tools (e.g., shovels). Size reduction of the 4-in. steel pipe assembly and components would require approximately 63 manual cuts. Contaminated soil within the CA and HCAs at the Mullet site would also be remediated and packaged. This soil would likely be dispositioned as radioactive low-level waste.

Clean closure of the Tejon site would require disassembly, size reduction, and disposition of approximately 135 ft of 4-in. steel pipe. The remaining buried portions of the pipe assembly from the end of the berm to the U3cg borehole would remain in place. This section of the pipe assembly is a minimum of 4 ft below grade. The covered portion of the pipe assembly at the U3n borehole and running to the southeast under the soil berm would require 34 manual cuts. Before disassembly and size reduction, the pipe assembly under the existing berm would require site workers to manually uncover the pipe.

Clean closure activities at the Player site would involve disassembly, size reduction, removal, and disposition of the entire approximately 650 ft of pipe assembly and components. Covered portions of the pipe assembly would be manually uncovered. Size reduction of the pipe assembly would require approximately 163 manual cuts. Size reduction and removal of the pipe assembly on the crater slope would require additional safety controls to mitigate hazards associated with personnel working on the slope.

After removal of the gas sampling assembly components, the soil surface would be screened for radioactivity, sampled, analyses performed, and results evaluated. Soil contamination exceeding action levels would also be removed and packaged as waste. Excavated areas would be returned to surface conditions compatible with the intended future use of the site.

Waste containers would be prepared for transport and loaded on trucks for delivery to the WIPP for disposal. This corrective action would involve the use of tools, heavy equipment, physical disassembly, material handling, waste management, loading, transportation, and work along the steep crater slope (at the Player site only).

C.2.2 Corrective Action Alternative B, Closure in Place

The corrective action of closure in place would require site workers to cover all exposed sections of the gas sampling assembly with a minimum of 2 ft of soil, install new fencing around each site where required, and maintain the soil covering, fencing, and signage. Use restrictions would be entered into the FFACO database and the DOE Facility Information Management System database.

The primary risk associated with Pu and Am contamination is from the internal exposure pathway due to ingestion or inhalation of alpha-emitting particles. Due to the nature of alpha particles, any cover (regardless of the depth or type of cover) would be effective in preventing an external dose and would preclude ingestion or inhalation of these radionuclides. The placement of additional depths of soil over the pipe would not provide additional protection but would provide additional assurance that the piping would not become uncovered. Therefore, soil would be placed around the pipe in a manner that would minimize any resulting slope and provide a stable surface upon which soil building could continue.

Closure in place of the Mullet site would involve placement of a minimum of 2 ft of fill over the entire length of the pipe assembly. While some of the steel pipe assembly at Mullet has an existing soil cover, the depth of burial was not determined due to the HCAs. Fill would be added to create a berm that meets the minimum cover requirements. The soil berm would have typical 2:1 (horizontal: vertical) compacted side slopes. The berm would be widened in areas where exposed piping lying parallel to the main pipe alignment remains to ensure all piping is covered with a 2-ft minimum soil cover. The wellhead and vertical expansion joint at Mullet would be encased in a 12-ft-diameter metal casing and backfilled with concrete. The casing would then be capped with a thick, welded steel plate. Before placement of the steel casing, the existing concrete foundation would require additional concrete to level and repair cracks and gaps. Pre-cast concrete and wire fencing would be installed to restrict access to the site from nearby roads. Existing fencing surrounding the CAS would be retained when possible.

The pipe assembly and components at the Tejon site are currently covered for most of the approximate 500-ft pipe length between the U3cg and U3n boreholes. Recent field survey at the site confirmed that a minimum 2 ft of soil cover is present along most of the pipe alignment. A short section of pipe at the U3n Bernalillo borehole and a subsurface sample can located near the U3cg borehole require covering to achieve minimum cover requirements. A soil berm with typical 2:1 (horizontal: vertical) compacted side slopes would be placed over the borehole at U3n. A 6-ft-diameter casing would be placed over the sample can near the U3cg borehole. The casing would be backfilled with clean fill and capped with a welded cover. Pre-cast barriers and wire fencing would be installed to restrict access from nearby roads. Existing wire fencing surrounding the CAS would be retained when possible.

The Player site has approximately 400 ft of exposed steel piping, of which approximately 350 ft runs down the U9z (York) crater at an approximate 3:1 (horizontal: vertical) side slope. A 2-ft engineered soil cover would be placed to cover the piping and components to include valves, sampling equipment, and other miscellaneous debris. The installed soil berm would have typical 2:1 compacted side slopes. Concrete pipe anchors would be constructed on the crater slope to stabilize the pipe for soil cover placement.

Metal retention structures (i.e., casing) would be placed over the U9z PS#2 wellhead, vertical expansion joint at U9cc, and the accelerometer. The vertical expansion joint requires a 12-ft-diameter casing that would be backfilled with concrete. The casing would be capped with a welded-on steel plate. The existing concrete pad around the expansion joint is badly damaged and would be repaired before placement of the casing. A 6-ft-diameter casing would be placed over the accelerometer and then backfilled with concrete. In the U9z (York) crater, the piping rises up at a 45-degree angle and is approximately 4 ft above ground next to the wellhead. The piping would be strapped to the wellhead before encasement. A 12-ft-diameter casing would be used to encase the pipe and wellhead and then backfilled with concrete. Barriers in the form of Type F Barrier (Jersey Wall) would be placed to block access from nearby roads and into the U9z (York) crater. Existing fence would be used where able or replaced/repaired as necessary with standard three-strand wire fence.

Care would be taken to not open or cut the gas sampling assemblies or components. Clean fill material from Borrow Area #3 would be used as earth fill material. The soil cover would be placed in lifts of 6-ft maximum thickness using heavy equipment. Each lift would be graded and compacted to a minimum of 90 percent relative compaction.

C.2.3 Corrective Action Alternative C, Modified Closure in Place

The corrective action of modified closure in place would involve the removal and onsite burial of select gas assembly features and the establishment of URs. In this alternative, the expansion joints at Mullet and Player SGZ would be cut at the ground surface and buried at the bottom of the U9z crater. In addition, the entire length of pipe along the U9z crater slope would be cut into sections, moved down to the crater bottom, and buried with a minimum of 2 ft of soil cover. The remaining gas sampling assembly components would be closed in place with a minimum of 2 ft of soil cover. The area of each CAS, including the bottom of the crater where the removed structures would be buried, would be fenced, and UR signs would be posted. The URs would be recorded in the FFACO database and the DOE Facility Information Management System database.

C.2.4 Corrective Action Alternative D, No Further Action (with administrative controls)

The corrective action of no further action (with administrative controls) would require a fence around the site with warning signs. No modification of the gas sampling assembly systems would be required.

It is assumed that the existing fence would be used for the UR boundary. This corrective action would require site workers to maintain the fencing and signage. A UR would be entered into the FFACO database and the DOE Facility Information Management System database.

C.2.5 Corrective Action Alternative E, No Further Action

The corrective action of no further action would not modify the current configuration of the gas sampling assembly and would not implement any URs.

C.3.0 Risks Associated with Implementation of the CAAs

Risk to site workers was evaluated as (1) potential radiological dose and (2) environmental and occupational safety risk associated with the implementation of each CAA. For the purposes of comparison to FFACO FALs, standard radiological FALs are based on a dose equivalent of 25 mrem/yr. Identified risks to the public were also evaluated, including the potential risk associated with physical damage during the transportation of radioactive wastes over public highways for the CAA of clean closure. Except for CAA E, no further action, all of the CAAs, will require a UR for the remaining contamination. In the short term, this will require site workers to install signage and either install or repair fencing. In the long term, this will require workers to repair and maintain the fencing and signage. For CAA A, clean closure, the use restricted areas will be limited to the locations of subsurface contamination (i.e., the boreholes and below-grade piping at Tejon). For the other CAAs with URs, the URs will encompass all contamination left in place. The radiological dose impacts are evaluated in Section C.3.1. Safety risks to workers and the general public as well as environmental impacts are evaluated in Section C.3.2.

C.3.1 Potential Radiological Dose

This section presents general information about the contaminants present at the site and the site physical characteristics that, together, form the CSM. This CSM is used in the evaluation of potential radiological doses for the various CAAs in Sections C.3.1.3 through C.3.1.6. These potential radiological dose evaluations include estimated doses for both the short term (defined as the time interval for implementation of the corrective action) and the long term (defined as the next 1,000 years). The short-term scenario assumes that the pipe will provide containment of the contamination unless it is breached as part of a corrective action. The long-term scenario assumes that the pipe has deteriorated and no longer provides any containment of the contaminants, thus releasing all of the contamination to the adjoining soil. The potential radiological dose evaluations in this section assume that planned exposure controls are in place with additional consideration of the doses that may be incurred if controls fail.

C.3.1.1 Conceptual Site Model

This section presents a summary of the CSM. Additional detail regarding the CSM, as well as figures, may be found in Section B.2.3.

The CSM includes radiological contamination present within the piping that has not been released to the environment, radiological contamination that was released to the atmosphere and deposited on the soil surface (at the Mullet site only), and oil applied to surface soil (at the Mullet site only). It is assumed that eventually the containment afforded by the piping will fail, and the contamination will be released to the adjacent soil. Without any corrective actions, it is presumed that the contamination would then be located in the surface and near-surface soil at those locations where the pipe is exposed and in the subsurface soil at those locations where the pipe is covered with soil. Some of the subsurface contamination may be brought to the surface by burrowing animals.

Potential receptors would be exposed to radiological contamination present at the soil surface through the surface exposure pathway including ingestion, inhalation, and irradiation. Except for nearby craters, the surface topography at each site is relatively flat with only a slight slope and no discernible stormwater collection features. The nearby craters provide significant slope and redirect surface stormwater flow into the craters. Therefore, no significant soil erosion is expected other than on or near crater slopes that accumulate in the bottom of the craters. Any contaminated soil eroding into the craters will be mixed with other uncontaminated soil that is also eroding and subsequently buried as the crater slowly fills with additional soil. Surface soils outside the craters are gradually increasing in depth through windborne deposition of airborne soil, which will continually cover surface soil over time.

The migration of the surface contamination to groundwater is also a potential exposure pathway. However, the major contaminants (Pu and Am) strongly adsorb onto soil particles, and their vertical migration through the soil profile would primarily be limited to the movement of soil colloids that are translocated with infiltrating stormwater. Migration of these colloids is sufficiently slow to preclude consideration of this pathway to groundwater through 1,200 to 1,700 ft of overlying alluvium.
Due to the high evaporative demand (annual potential evapotranspiration at the Area 3 RWMS has been estimated at 62.6 in. [Shott et al., 1997]) and limited precipitation for this region (6.4 in./yr

[Winograd and Thordarson, 1975]), percolation of infiltrated precipitation at the NNSS does not provide a significant driver for vertical migration of contaminants to groundwater (DOE/NV, 1992).

All three sites are located in Yucca Flat, where numerous underground tests have been conducted resulting in the release of subsurface radiological contaminants. The entire radionuclide inventories from the Player, Mullet, and Tejon tests are included in the evaluation of UGTA CASs. Therefore, if the entire radionuclide inventory in the piping and on the surface at these three sites were to migrate to groundwater, it would not change the UGTA groundwater evaluations. Also, the activity of the combined surface radionuclide inventory from these three tests (28.3 Ci based on the conservative estimate of Pu-239 presented in Section 2.0) is insignificant compared to the total mass of contamination released by the underground tests conducted in this area (estimated to be more than 12,000 Ci of Pu-239 in the Yucca Flat basin [Bowen et al., 2001]).

C.3.1.2 Dose Calculation Assumptions

The long-term maximum added annual radiological dose (excluding doses received from non-CAU 547 related sources) estimated to be received by an industrial site worker who would be assigned to work at each location was calculated based on the ISOCS measurements and the RESRAD computer code. This maximum added annual radiological dose was conservatively estimated based on the assumption that the release of the contamination to soil after the eventual failure of the pipe (i.e., post-release) is along the entire length of the piping with a width of 20 centimeters (cm) (estimate of dispersion based on twice the 4-in. diameter of the pipe).

The maximum potential activities of the radiological contaminants in soil (presented in Table C.3-1) were calculated using the input data listed in Table C.3-2 as follows:

<u>Total contamination area volume</u>

Length (cm) * 20 cm width * 5 cm depth = contaminated volume (cubic centimeters [cm^3])

<u>Total contamination area mass</u>

Soil density of 1.5 g/cm^3 * contaminated volume (cm^3) = contaminated mass (g)

<u>Radionuclide activity per gram of soil</u>

Activity (picocuries [pCi]) / contaminated mass (g) = Pu activity in soil
(picocuries per gram [pCi/g])

Table C.3-1
Maximum Long-Term Potential Annual Dose Rates and Exposure Durations

	RRMG	Mullet	Tejon	Player
Am-241 activity in soil (pCi/g)	1,503	25,634	221,347	1,112,739
Pu-238 activity in soil (pCi/g)	2,416	2,345	88,801	121,706
Pu-239 activity in soil (pCi/g)	2,207	112,861	4,282,590	5,911,427
Pu-240 activity in soil (pCi/g)	2,207	25,197	73,053	1,309,787
Pu-241 activity in soil (pCi/g)	--	86,877	1,360,455	4,526,298
Maximum dose (mrem/IA-yr)	--	2,015	53,940	101,567
Exposure duration to receive a 25-mrem dose (hours)	--	27.9	1.0	0.6

mrem/IA-yr = Millirem per Industrial Area year

-- = Not applicable

Table C.3-2
Piping Lengths and Calculated Soil Volumes

Site	Piping Length (ft)	Piping Length (cm)	Soil Volume (cm^3)	Soil Mass (g)
Mullet	500	15,240	1,524,000	2,286,000
Tejon	250	7,620	762,000	1,143,000
Player	650	19,812	1,981,200	2,971,800

The long-term maximum potential dose rate at each CAS was estimated (using RESRAD) based on the conservative assumptions that the entire mass of radionuclide inventory is on the soil surface and an industrial worker is directly exposed to this contaminated soil with no respiratory protection. Total effective dose was determined by comparing analytical results from soil samples to residual radioactive material guidelines (RRMGs) for TED that were established using the Residual Radioactive (RESRAD) computer code (Yu et al., 2001). The RRMGs presented in Table C.3-1 are radionuclide-specific values for radioactivity in surface soils. The RRMG is the value, in picocuries per gram of surface soil, for a particular radionuclide that would result in an internal dose of 25 mrem/yr to a receptor (under the appropriate exposure scenario) independent of any other radionuclide (assumes that no other radionuclides contribute dose). The internal dose associated with any specific radionuclide would be established using the following equation:

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

As more than one radionuclide is present, the TED was calculated as the sum of the internal doses for each radionuclide.

These direct exposure maximum potential dose rates are presented in Table C.3-1 and are used in the following subsections for all long-term exposure scenarios and for short-term exposure scenarios where the corrective actions involve breaching the containment of the piping.

For the calculation of the short-term maximum potential dose to an industrial worker, the total dose is calculated as the sum of external dose and internal dose. External dose is determined directly from TLD measurements. The TLDs were obtained from, and measured by, the Environmental Technical Services group at the NNSS. The TLDs were analyzed using automated TLD readers that are calibrated and maintained by the National Security Technologies, LLC, Radiological Control Department in accordance with existing QC procedures for TLD processing. A summary of the TLD QC efforts and results can be found in Section 5.2.1 of the *Nevada Test Site Environmental Report 2006*. Certification is maintained through the DOE Laboratory Accreditation Program for dosimetry.

The determination of the external dose component of the TED by TLDs was determined to be the most accurate method because the use of a TLD to determine an individual’s external dose is the standard in radiation safety and serves as the “legal dose of record” when other measurements are available. Specifically, 10 CFR Part 835.402 (CFR, 2011a) indicates that personal dosimeters shall be provided to monitor individual exposures and that the monitoring program that uses the dosimeters shall be accredited in accordance with a DOE Laboratory Accreditation Program.

As the radionuclides associated with the Player and Tejon sites is currently contained within the piping, these radionuclides are not available for uptake and do not present a potential for internal dose. Therefore, the external dose results were used as the TED for the Player and Tejon sites and internal dose was calculated only for the Mullet site release. Internal dose for the Mullet site was determined by comparing analytical results from soil samples to RRMGs for internal dose in the same manner as described previously for the calculation of long-term TED. The soil samples were collected in July 2011 from the locations of the highest radiological survey values at each HCA and submitted for gamma spectroscopy and isotopic Pu analyses.

The maximum potential short-term dose to an industrial worker and the exposure time to receive a 25-mrem dose at each site is presented in Table C.3-3.

Table C.3-3
Maximum Short-Term Potential Annual Dose Rates and Exposure Durations

	Current Mullet	Current Tejon	Current Player
Maximum dose (mrem/IA-yr)	542	42	17
Exposure duration to receive a 25-mrem dose (8-hour workdays)	13	169	423

C.3.1.3 Corrective Action Alternative A, Clean Closure

In the short term, the corrective action of clean closure would require workers to remove and dispose of all aboveground piping and associated equipment. The installation of fencing and the implementation of URs around the remaining boreholes would also be required. As the contamination currently contained within the piping would be subject to release during the cutting of the pipe, any soil contaminated during implementation of the corrective action would also need to be removed and managed as waste.

Considerations in the evaluation of radiological exposure to site workers include the following:

- As evidenced by the April 30, 2007, release described in Section 1.4.3.1, contamination contained within the pipe would be released when the pipe is cut.
- Contaminated pipe waste would need to be containerized for shipping, requiring the pipe to be manually cut into approximately 260 pieces.
- The number of cuts required and the number of waste items generated would require significant manual manipulation of the waste items resulting in significant potential exposure time.
- Dose to workers cutting pipe will be based on Player Pu inventory.
- Intrusive work would require the use of glove bags/boxes, tents, and Level C personal PPE with a self-contained breathing apparatus (SCBA).
- Pipe cutting would be via low-speed portable band saw to minimize the creation of airborne radioactivity.

- Double-protective clothing would be worn due to the potential for an HCA.
- The protection factor for an SCBA in the pressure demand mode is 10,000 (i.e., would reduce the contaminant concentration by a factor of 10,000).
- At least 24 site workers would be present during the implementation of this corrective action due to the use of multiple shifts and the need for relief staff.

Some contamination would be released during each cut. Based on the April 30, 2007, release (Section 1.4.3.1), contamination levels of 1.3 million dpm/100cm^2 of alpha particles and 11,623 derived air concentration (DAC) at each pipe were used in this estimate. The use of these assumed contamination values for each cut is conservative but reasonable given that the April 30, 2007, release was at the lower-contamination end of the pipe run and contamination levels within the remainder of the pipe are expected to be higher (see ISOCS results in Section 2.2.1.3).

During the implementation of this corrective action, controls would be implemented to protect site workers from exposure to the contaminants. However, this would not preclude site workers from receiving an added potential radiological dose. During each cut of the pipe, the estimated dose to a single worker (assuming all controls are in place and effective) would be about 1.5 mrem for a single cut. This dose estimate is based on the worker spending one-half hour in the area of the cut and an SCBA protection factor of 10,000. If this worker were involved in all 260 cuts, the estimated maximum potential dose received by this worker would be approximately 390 mrem. This dose would be less than the permissible administrative control dose for a radiological worker of 500 mrem/yr.

A failure of short-term controls could occur at any time during the implementation of this corrective action that could result in significant doses to site workers. For example, should an intake occur to personnel while removing the SCBA and the double set of PPE, the potential intake could result in a significant internal dose. If site controls were to fail and an unprotected worker (assuming no SCBA or respirator) were to approach within 6 ft from a cut, the estimated dose would be about 1,000 mrem.

Therefore, the implementation of this CAA could result in significant added short-term radiological dose even if short-term controls are effective, and potentially very large doses if short-term controls were to fail.

While many site workers would be present during the implementation of this corrective action, it is assumed that the most exposed individual would be a laborer involved with all phases of clean closure at each of the CASs as listed in Table C.3-4.

Table C.3-4
Exposure Times for the Most Exposed Individual by Phase of Work for the Clean Closure Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Site Setup	70	70	70
Excavation/Uncover Piping	20	80	80
Cut and Package Piping	75	486	2,120
Cut and Package Expansion Joint/Other Debris at Wellhead	160	80	200
Decontamination	120	120	120
Demobilization	60	60	60
Total for the most exposed individual	**505**	**896**	**2,650**

The estimated man hours of exposure for the various phases of this corrective action in which a failure of controls could lead to a significant radiological dose are listed in Table C.3-5.

Table C.3-5
Exposure Times for All Workers by Phase of Work for the Clean Closure Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Site Setup	1,918	1,957	1,737
Excavation/Uncover Piping	440	1,640	1,760
Cut and Package Piping	2,250	15,000	63,866
Cut and Package Expansion Joint/Other Debris at Wellhead	5,280	2,565	6,025
Hotline Support/Decontamination	1,955	2,730	3,370
Demobilization	1,403	1,393	1,393
Total	**13,246**	**25,285**	**78,151**

A potential radiological exposure to the public is also possible should a traffic accident compromise the waste containment during shipment to an offsite disposal facility over public highways. However, this potential dose cannot be quantified and will not be included in the total potential dose estimates.

In the long term, the corrective action of clean closure would provide protection from exposure to a radiological dose as the surface radiological contamination would no longer be present at the site. The implementation of this CAA would, therefore, not result in any added long-term radiological dose to a potential receptor. As no long-term controls would be put in place, there is no added long-term risk should controls fail.

The UR would provide protection from exposure to remaining contamination in the boreholes and beneath the surface by preventing excavating activities. After the corrective actions, surface contamination would be removed, and added risk to workers (other than potential excavation workers) would not be significant. The installation or maintenance of UR signage and fencing would not result in any significant added short-term or long-term radiological dose to site workers. If this control were to fail, it could result in significant doses to potential excavation workers.

C.3.1.4 Corrective Action Alternative B, Closure in Place

In the short term, the corrective action of closure in place with a soil covering would involve site workers in the covering of exposed portions of piping with soil. Workers who install or maintain the signage and fencing would not enter the fenced area and, therefore, would not receive an added dose. During covering of the piping with soil at the Player and Tejon sites, workers would be present in the vicinity of the piping but would not be directly exposed to the radiological contamination that is contained within the pipe (as this planned activity would not involve opening or cutting the pipe). Workers covering the piping with soil at the Mullet site would be exposed to the surface contamination previously released at the site.

While many site workers would be present during the implementation of this corrective action, it is assumed that the most exposed individual would be a laborer involved with all of the phases of covering the piping with soil at each of the CASs as listed in Table C.3-6.

Table C.3-6
Exposure Times for the Most Exposed Individual by Phase of Work for the Closure in Place Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Mark Utilities	40	40	40
Mobilize	20	10	10
Excavate & Deliver Soil	0	20	50
Setup	30	20	30
Concrete Work	20	10	20
Cover Pipes	40	10	150
Cover Expansion Joint/Equipment	30	20	80
Fencing	40	20	40
Decontamination	40	20	40
Demobilize/Site Restoration	20	20	40
Total for most exposed individual	**280**	**190**	**500**

Based on the dose rates for indirect exposure to the radionuclide contamination at each site, the added dose to the most exposed individual is conservatively estimated to be 67.4, 3.5, and 3.7 mrem, respectively, for the Mullet, Tejon, and Player sites for a total of 75 mrem. A worker at the Player or Tejon site would not receive any significant added short-term radiological dose because all contamination is contained within the pipe. However, a worker could receive significant added short-term radiological dose during implementation of the corrective actions at the Mullet site. This assumes that no controls are in place and there is no accidental breach of the pipe with subsequent release and exposure. The potential for such an accident is low, and the risk associated with such an event cannot be estimated. Therefore, it is not included in this evaluation.

Also of concern is the total added radiation exposure to workers needed to complete this corrective action. The cumulative exposure time to all workers is listed in Table C.3-7. Based on the dose rate for indirect exposure to the radionuclide contamination at each site, the added cumulative dose to all workers is conservatively estimated to be 899, 81, and 55 mrem, respectively, for the Mullet, Tejon, and Player sites. Assuming no accidental release and that controls are not implemented or controls are not effective, the total added short-term radiological dose for this corrective action alternative is conservatively estimated to be 1,034 mrem.

Table C.3-7
Exposure Times for All Workers by Phase of Work
for the Closure in Place Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Mark Utilities	107	151	151
Mobilize	453	135	235
Excavate & Deliver Soil	0	2,437	690
Setup	630	420	630
Concrete Work	268	135	268
Cover Pipes	350	135	2,400
Cover Expansion Joint/Equipment	592	215	1,282
Fencing	565	270	565
Decontamination	615	295	615
Demobilize/Site Restoration	153	162	598
Total	**3,733**	**4,355**	**7,434**

In the long term, the corrective action of closure in place would provide protection from exposure to the contamination released to the surface soil by preventing access to the site through the UR. The implementation of this CAA would, therefore, not result in any added long-term radiological dose to a potential receptor. If the long-term control of the UR were to fail, the contamination would be covered by soil, and any person present at this site would not receive any significant added dose unless the soil covering were removed or excavated.

C.3.1.5 Corrective Action Alternative C, Modified Closure in Place

In the short term, the corrective action of modified closure in place would require workers to remove and dispose of the expansion joints at Mullet and Player SGZ as well as the pipe along the U9z crater slope, and then establish a soil cover over all remaining piping. Installation of fencing and the implementation of URs around the remaining piping and boreholes would also be required. Workers who install or maintain the signage and fencing would not enter the fenced area and, therefore, would not receive an added dose. During covering of the piping with soil at the Player and Tejon sites, workers would be present in the vicinity of the piping but would not be directly exposed to the radiological contamination that is contained within the pipe (as this planned activity would not involve opening or cutting the pipe). Workers covering the piping with soil at the Mullet site would be exposed to the surface contamination previously released at the site.

During the removal and disposal phases of this corrective action, the contamination currently contained within the piping would be subject to release. Any soil contaminated during implementation of the corrective action would also need to be removed and managed as waste.

Considerations in the evaluation of radiological exposure to site workers include the following:

- As evidenced by the April 30, 2007, release described in Section 1.4.3.1, contamination contained within the pipe would be released when the pipe is cut.
- Contaminated pipe waste would need to be containerized for shipping requiring the pipe to be manually cut into approximately 110 pieces.
- The number of cuts required and the number of waste items generated would require significant manual manipulation of the waste items resulting in significant potential exposure time.
- Intrusive work would require the use of glove bags/boxes, tents, and Level C PPE with an SCBA.
- Pipe cutting would be via low-speed portable band saw to minimize the creation of airborne radioactivity.
- Double-protective clothing would be worn due to the potential for an HCA.
- The protection factor for an SCBA in the pressure demand mode is 10,000 (i.e., would reduce the contaminant concentration by a factor of 10,000).
- At least 22 site workers would be present during the implementation of this corrective action due to the use of multiple shifts and the need for relief staff.

Some contamination would be released during each cut. Based on the April 30, 2007, release (Section 1.4.3.1) contamination levels of 1.3 million dpm/100cm^2 of alpha particles and 11,623 DAC at each pipe were used in this estimate. The use of these assumed contamination values for each cut is conservative but reasonable given that the April 30, 2007, release was at the lower-contamination end of the pipe run and contamination levels within the remainder of the pipe are expected to be higher (see ISOCS results in Section 2.2.1.3).

During the implementation of this corrective action, controls would be implemented to protect site workers from exposure to the contaminants. However, this would not preclude site workers from receiving an added potential radiological dose. During each cut of the pipe, the estimated dose to a single worker (assuming all controls are in place and effective) would be about 1.5 mrem for a single cut. This dose estimate is based on the worker spending one-half hour in the area of the cut and an SCBA protection factor of 10,000. If this worker were involved in all 110 cuts, the estimated maximum potential dose received by this worker would be approximately 165 mrem. This dose would be approximately one-third of the permissible administrative control dose for a radiological worker of 500 mrem/yr.

A failure of short-term controls could occur at any time during the implementation of this corrective action that could result in significant doses to site workers. For example, should an intake occur to personnel while removing the SCBA and the double set of PPE, the potential intake could result in a significant internal dose. If site controls were to fail and an unprotected worker (assuming no SCBA or respirator) were to approach within 6 ft from a cut, the estimated dose would be about 1,000 mrem.

Therefore, the implementation of this CAA could result in significant added short-term radiological dose even if short-term controls are effective, and potentially very large doses if short-term controls were to fail.

While many site workers would be present during the implementation of this corrective action, it is assumed that the most exposed individual would be a laborer involved with all of the phases of covering the piping with soil at each of the CASs as listed in Table C.3-8.

Based on the dose rates for indirect exposure to the radionuclide contamination at each site, the added dose to the most exposed individual is conservatively estimated to be 79.5, 3.5, and 10 mrem, respectively, for the Mullet, Tejon, and Player sites for a total of 93 mrem. A worker at the Player or Tejon site would not receive significant added short-term radiological dose because all contamination is contained within the pipe. However, a worker could receive significant added short-term radiological dose during implementation of the corrective actions at the Mullet site. This assumes that no controls are in place and there is no accidental breach of the pipe with subsequent release and exposure. The potential for such an accident is low, and the risk associated with such an event cannot be estimated. Therefore, it is not included in this evaluation.

Table C.3-8
Exposure Times for the Most Exposed Individual by Phase of Work for the Modified Closure in Place Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Mark Utilities	40	40	40
Mobilize	20	10	10
Excavate & Deliver Soil	0	20	50
Setup	30	20	30
Concrete Work	20	10	20
Cover Pipes	40	10	960
Cover Expansion Joint/Equipment	80	20	130
Fencing	40	20	40
Decontamination	40	20	40
Demobilize/Site Restoration	20	20	40
Total for most exposed individual	**330**	**190**	**1,360**

Also of concern is the total added radiation exposure to workers needed to complete this corrective action. The cumulative exposure time to all workers is listed in Table C.3-9. Based on the dose rate for indirect exposure to the radionuclide contamination at each site, the added cumulative dose to all workers is conservatively estimated to be 1,334, 81, and 261 mrem, respectively, for the Mullet, Tejon, and Player sites. Assuming no accidental release and that controls are not implemented or controls are not effective, the total added short-term radiological dose for this corrective action alternative is conservatively estimated to be 1,676 mrem.

In the long term, the corrective action of modified closure in place would provide protection from exposure to the contamination released to the surface soil by preventing access to the site through the UR. The implementation of this CAA would, therefore, not result in any added long-term radiological dose to a potential receptor. If the long-term control of the UR were to fail, the contamination would be covered by soil, and any person present at this site would not receive any significant added dose unless the soil covering were removed or excavated.

Table C.3-9
Exposure Times for All Workers by Phase of Work
for the Modified Closure in Place Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Mark Utilities	107	151	151
Mobilize	453	135	235
Excavate & Deliver Soil	0	2,437	690
Setup	630	420	630
Concrete Work	268	135	268
Cover Pipes	350	135	28,496
Cover Expansion Joint/Equipment	2,400	215	3,100
Fencing	565	270	565
Decontamination	615	295	615
Demobilize/Site Restoration	153	162	598
Total	**5,541**	**4,355**	**35,348**

C.3.1.6 Corrective Action Alternative D, No Further Action (with administrative controls)

In the short term, the corrective action of no further action (with administrative controls) would involve site workers in the installation of signage on the fence surrounding the site. Workers who install or maintain the signage and fencing would not need to enter the fenced and use restricted area. The implementation of this CAA would, therefore, not result in any significant added short-term radiological dose to a potential receptor. If the controls provided by the UR were to fail at the Mullet site, a worker at the site could receive a dose exceeding the 25-mrem/yr action level within 104 hours (based on the estimated direct exposure dose rate to existing maximum radiological contamination). If radiation protection controls were to fail at the Player or Tejon sites, a worker would not receive any significant added dose because all the radiological contamination is contained within the pipe or covered by soil. If radiation protection controls were to fail during the implementation of the corrective actions at the Mullet site, a worker could a significant added short-term radiological dose.

While many site workers would be present during the implementation of this corrective action, it is assumed that the most exposed individual would be a laborer involved with all of the phases of covering the piping with soil at each of the CASs as listed in Table C.3-10.

Table C.3-10
Exposure Times for the Most Exposed Individual by Phase of Work for the No Further Action (with administrative controls) Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Mark Utilities	40	40	40
Fencing	40	20	40
Survey	10	10	10
Total for most exposed individual	**90**	**70**	**90**

Based on the dose rates for indirect exposure to the radionuclide contamination at each site, the added dose to the most exposed individual is conservatively estimated to be 21.7, 1.3, and 0.7 mrem, respectively, for the Mullet, Tejon, and Player sites for a total of 24 mrem. A worker at the Player or Tejon site would not receive significant added short-term radiological dose because all contamination is contained within the pipe. However, a worker could receive significant added short-term radiological dose during implementation of the corrective actions at the Mullet site. This assumes that no controls are in place and there is no accidental breach of the pipe with subsequent release and exposure. The potential for such an accident is low, and the risk associated with such an event cannot be estimated. Therefore, it is not included in this evaluation.

Also of concern is the total added radiation exposure to workers needed to complete this corrective action. The cumulative exposure time to all workers is listed in Table C.3-11. Based on the dose rate for indirect exposure to the radionuclide contamination at each site, the added cumulative dose to all workers is conservatively estimated to be 172, 8, and 6 mrem, respectively, for the Mullet, Tejon, and Player sites. Assuming no accidental release and that controls are not implemented or controls are not effective, the total added short-term radiological dose for this corrective action alternative is conservatively estimated to be 187 mrem.

In the long term, the corrective action of no further action (with administrative controls) would provide protection from exposure to the contamination released to the surface soil by preventing

Table C.3-11
Exposure Times for All Workers by Phase of Work
for the No Further Action (with administrative controls) Alternative

Phase	Mullet	Tejon	Player
	Exposure Time (hours)		
Mark Utilities	107	151	151
Fencing	565	270	565
Survey	43	52	43
Total	**715**	**473**	**759**

access to the sites through the URs. The implementation of this CAA would, therefore, not result in any significant added long-term radiological dose to a potential receptor. If this control were to fail, a worker present at these sites could receive a dose exceeding the 25-mrem/yr action level in the exposure durations presented in Table C.3-1 (based on the dose rates for direct exposure to the radionuclide contamination at each CAS). The implementation of this CAA would, therefore, result in significant added long-term radiological dose if controls were to fail.

C.3.1.7 Corrective Action Alternative E, No Further Action

In the short term, the corrective action of no further action would not include any corrective action activities and would not subject potential receptors to any added short-term radiological dose. As no short-term controls would be put in place, there is no added risk should the controls fail. However, the corrective action of no further action at the Mullet site would not provide any protection from exposure to contamination that has already been released to the surface soil. Based on the estimated direct exposure dose rate to existing maximum radiological contamination at Mullet of approximately 542 mrem/yr, any person present at this site would receive a dose exceeding the 25-mrem/yr action level within 104 hours.

In the long term, the corrective action of no further action would not provide any protection from exposure to contamination released to the surface soil. The exposure durations for a person present at these sites to receive a dose exceeding the 25-mrem/yr action level are presented in Table C.3-1 (based on the dose rates for direct exposure to the radionuclide contamination at each CAS). The implementation of this CAA would, therefore, present significant added long-term radiological dose to any potential receptor present at the site. As no controls would be put in place, there is no added risk should the controls fail.

C.3.2 Safety Risks and Environmental Impacts

The safety risks will be evaluated for only the time needed to implement the various corrective actions (short term). The relative risk to workers will be evaluated for the CAAs where site workers will implement a corrective action (excludes the CAA of no further action). The baseline for this comparison will be the CAA of closure in place with UR. The other CAAs will compare the types of physical hazards to the hazards for the closure in place with UR alternative based on the total number of hours required to complete each alternative. Environmental impacts will be evaluated for both short- and long-term effects.

C.3.2.1 Corrective Action Alternative A, Clean Closure

The safety-related hazards and related risks associated with this CAA would include general safety risks associated with the following:

- Risks to workers from hazards associated with the construction-related tasks such as working on and around heavy equipment; using hand tools, power tools, and equipment; wearing PPE such as an SCBA and Tyvek coveralls; working on uneven surfaces; working in extreme heat or cold temperatures; rigging, hoisting, and material handling; and loading and unloading pipe.

- Risks to vehicle operators, the general public, and the environment from hazards associated with transportation of the waste materials over public roads (e.g., injuries and environmental damage due to traffic accidents during the vehicular transport of the pipe to a disposal location).

Construction related hazards associated with the clean closure alternative include the following:

- Using hand and power tools.
- Material handling, rigging, and hoisting.
- Working on uneven ground surfaces.
- Working on crater slopes.

- Working on and around heavy equipment (haul trucks for cover material in one case, and trucks for transporting the contaminated waste materials in the other).

- Working while wearing PPE, which restricts movement and vision and increases the likelihood of injuries due to slips, trips and falls.

- Using double PPE coveralls, which poses a significant heat stress potential hazard.

- Working while wearing SCBA, which extends the time required to complete the task, requires the implementation of heat stress monitoring protocols during hot weather periods, and increases the likelihood of heat stress injuries.

- Conducting cutting and burning activities, which add to the physical hazards on the site and introduce workers to potential airborne contaminants from the pipe contents and the metals in the pipe.

The type of activities involved in implementing this CAA would pose greater extent and severity of the physical risks than for the other CAAs. The level of occupational risk is directly related to the total number of hours worked at the site, including loading and certifying the waste shipment, which have been estimated at 116,682 hours.

Short-term risks to vehicle operators, the general public, and the environment from hazards associated with transportation of the waste materials over public roads can be estimated by applying documented traffic accident rates to the estimated miles to be traveled by the waste transport trucks. There would be six loads of waste, each traveling approximately 2,000 mi to Idaho for waste certification, then to the WIPP site, for a total of 12,000 mi. The National Highway Transit Safety Administration (NHTSA) records and evaluates risks for vehicle operating on highways in the United States. Data from 2006 (NHTSA, 2006) indicate fatality and injury rates for large truck occupants of 0.36 and 10, respectively, per 100 million vehicle miles traveled by large trucks. Thus, the likelihood of a transportation fatality or injury involving the waste shipments for this alternative would be approximately 0.006 percent, and 0.17 percent, respectively. It is assumed that any accident that results in an injury to a large truck occupant may also release the contents of the vehicle to the environment. Therefore, a 0.14 percent factor for the risk of impact to a member of the general public or to the environment would apply. Short-term environmental impacts in the case of an accident on public highways could include the release of radioactivity on private properties.

Long-term environmental impacts associated with this corrective action would be minimal as the contamination would be stabilized in a long-term storage facility.

C.3.2.2 Corrective Action Alternative B, Closure in Place

The corrective action of closure in place would involve site workers covering exposed sections of the gas sampling assembly, installing a fence and signs around the site, and maintaining the fencing and signage. This CAA would include all the safety risks associated with the CAA of no further action (with administrative controls) for installing fencing around the site (see Section C.3.2.4). Additionally, site workers would be exposed to the physical hazards associated with transporting soil to the site and covering the pipe with soil during the construction phase of the corrective action. Covering the exposed sections of the pipe with soil would require the use of heavy equipment to haul in fill material, place and grade the fill material over the pipe, and install soil retention structures (e.g., large-diameter pipe) around the vertical portions of the assembly at the boreholes and at the accelerometer.

The physical risks associated with installing a soil retention structure around the vertical portions of the assembly would involve hazards normally associated with the operation of a crane (rigging and hoisting of the retention structure), use of hand and power tools, use of heavy equipment and vehicles, cutting and welding, and soil excavation.

Physical risks to workers under this corrective action would be associated with routine construction activities and heavy equipment operation. The level of risk would be greater during the installation of the soil cover on piping located on the crater slope at the Player site than for the installation of the soil cover on piping at other locations. The risk is directly related to the number of hours that would be worked at the site (which have been estimated at 15,522 hours). The type of activities involved in implementing this CAA would pose greater physical risks than for routine occupational activities. Installation of the soil covering along the crater slope would involve additional physical risks associated with workers installing the soil cover on the slope and operating equipment on the slope.

Short-term environmental impacts at the site during the work activities would arise from the vehicle traffic and heavy equipment operation on the site roads, and would primarily include surface soil erosion and dust generation. Long-term environmental impacts would be reduced due to the soil covering over the pipe, which would eliminate surface migration of contaminants. As the contamination would be buried beneath 2 ft of soil cover, the long-term environmental impacts associated with the release of contamination to the soil would not be more than the long-term environmental impacts from other radiological contamination in the area. As discussed in Section 3.5, the areas where the CASs are located encompass a number of nuclear test sites that are controlled due to the presence of radioactivity. As Pu and Am contamination is very immobile, there would be no offsite environmental impacts.

C.3.2.3 Corrective Action Alternative C, Modified Closure in Place

This CAA would include all the safety risks associated with the CAA of closure in place (Section C.3.2.2) for installing a soil cover over piping. Additionally, site workers would be exposed to the safety-related hazards and related risks associated with the CAA of clean closure (Section C.3.2.1) for the parts of the piping and equipment to be removed (Section C.2.2).

Except for the CAA of clean closure, the type of activities involved in implementing this CAA would pose greater extent and severity of the physical risks than for the other CAAs. The level of occupational risk is directly related to the total number of hours worked at the site, including loading and certifying the waste shipment, which have been estimated at 45,244 hours.

Short-term environmental impacts at the site during the work activities would arise from the vehicle traffic and heavy equipment operation on the site roads, and would primarily include surface soil erosion and dust generation. Long-term environmental impacts would be reduced due to the soil covering over the pipe, which would eliminate surface migration of contaminants. As the contamination would be buried beneath 2 ft of soil cover, the long-term environmental impacts associated with the release of contamination to the soil would not be more than the long-term environmental impacts from other radiological contamination in the area. As discussed in Section 3.5, the areas where the CASs are located encompass a number of nuclear test sites that are controlled due to the presence of radioactivity. As Pu and Am contamination is very immobile, there would be no offsite environmental impacts.

C.3.2.4 Corrective Action Alternative D, No Further Action (with administrative controls)

The corrective action of no further action (with administrative controls) would involve site workers installing a fence and signs around the site, and maintaining the fencing and signage. Site workers would be exposed to the physical hazards associated with installing fencing and signs around the site. The risks associated with these physical hazards would not be significantly greater than risks posed by routine occupational activities, with the exception of additional physical risks associated with working on the sloped crater surfaces. The risk of injury from slip, trip, and fall hazards would be higher for tasks performed on the crater surface than for work on level ground surfaces.

The level of risk is directly related to the number of hours worked at the site (estimated at 1,947 hours).

There would be no short-term environmental impacts as the contamination is contained within the pipe. In the long term, the contamination in the exposed portions of the piping would be released to the surface soil and subject to migration. However, Pu and Am contaminants are not mobile; soil is accumulating in this area (covering surface contamination); and surface gradients are relatively flat in the area (low erosion potential) except for within the crater where eroding contaminated soil would end up in the bottom of the crater, where it would be covered as the crater continues to fill. The long-term, environmental impacts associated with the release of the contamination to the soil would be similar to the long-term environmental impacts from other surface radiological contamination in the immediate area of the CASs. As discussed in Section 3.5, the areas where the CASs are located encompass a number of nuclear test sites that are controlled due to the presence of radioactivity. As Pu and Am contamination is very immobile, there would be no offsite environmental impacts.

C.3.2.5 Corrective Action Alternative E, No Further Action

The corrective action of no further action would not require the presence of workers at the site. The implementation of this CAA would, therefore, not result in any increased safety risk to site workers or the public. There would be no short-term environmental impacts as the contamination is contained within the pipe. In the long term, the contamination contained in the pipe would be released to the surface soil where the pipe is exposed and to the subsurface soil where the pipe is covered with soil. The long-term environmental impacts associated with the release of the contamination to the soil would be similar to the long-term environmental impacts from other surface radiological contamination in the immediate area of the CASs. As discussed in Section 3.5, the areas where the CASs are located encompass a number of nuclear test sites that are controlled due to the presence of radioactivity. As Pu and Am contamination is very immobile, there would be no offsite environmental impacts.

C.4.0 Summary

Based on the number of manhours required, the physical risks for the CAA of clean closure would be at least 7 times greater than the physical risks for the CAA of closure in place, at least 2 times greater than the physical risks for the CAA of modified closure in place, and at least 60 times greater than the physical risks for the CAA of no further action (with administrative controls). As this comparison is based only on the total number of manhours, it considers that activities associated with cutting and removal of piping are inherently higher-risk activities.

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Appendix D

Engineering Specifications and Drawings

(142 Pages)

FINAL

Final Basis of Design and Engineering Design Report of CAU 547 (TEJON, MULLET and PLAYER), Nevada National Security Site, Nevada

Prepared for

National Security Technologies, LLC

July 2011

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6 Hutton Centre Drive, Suite 700
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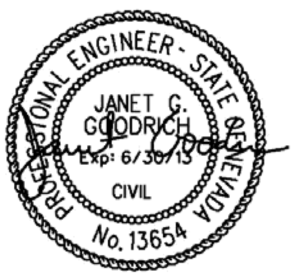
Basis of Design and Engineering Design Report of CAU 547 (TEJON, MULLET, and PLAYER) Nevada National Security Site, Nevada

This Basis of Design and Engineering Design Report of CAU 547 (TEJON, MULLET, and PLAYER) has been prepared under the supervision of Janet G. Goodrich, P.E. (Registered Civil Engineer Civil 13654), whose seal as a Registered Professional Engineer in the State of Nevada is affixed below.



Janet G. Goodrich, P.E., Civil 13654	07/18/11 Date

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Contents

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Acronyms and Abbreviations

BoD	Basis of Design
CA	Contamination Area
CAS	Corrective Action Site
CAU	Corrective Action Unit
HCA	High Contamination Area
NNSS	Nevada National Security Site
NSTec	National Security Technologies, LLC

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SECTION 1

Introduction

This Basis of Design (BoD) and Engineering Design report summarizes and presents the design for a corrective action to close in place Corrective Action Unit (CAU) 547, Miscellaneous Contaminated Waste Sites. CAU 547 consists of three Corrective Action Sites (CAS), 03-99-19 (TEJON), 02-37-02 (MULLET), and 09-99-06 (PLAYER), each located at the Nevada National Security Site (NNSS), Nevada. All elements of the design criteria and outstanding design issues are presented herein.

1.1 Project Background

The NNSS is located in southern Nevada, approximately 105 kilometers (km) (65 miles [mi]) northwest of Las Vegas. The NNSS is subdivided into administrative areas. The CASs addressed within this report lie within three of the administrative areas, Area 9 (PLAYER Site; CAS 09-99-06), Area 2 (MULLET Site; CAS 02-37-02), and Area 3 (TEJON Site; CAS 03-99-19).

The TEJON safety test was conducted in emplacement borehole U3cg on May 17, 1963. Gases from the test were piped to the BERNALILLO test borehole U3n. The surface features at the BERNALILLO borehole include four metal pipes and a large section of metal casing. The area immediately surrounding the U3n emplacement borehole is posted as a Contamination Area (CA). However, due to the presence of metal piping at the ground surface, a radiological survey of the piping was completed in 2009. The survey indicated that the 4-inch pipe with the valve contained transuranic radionuclides, including plutonium. For the purposes of this BoD and Engineering Design Report, the composite TEJON/BERNALILLO CAS is referred to as TEJON.

The MULLET safety test was conducted on October 17, 1963. The test design included a gas sampling assembly with a piping system to convey gas and particulates from the emplacement hole (U2ag) to a sampling assembly. The gas assembly consisted of a pipe leading from the emplacement borehole, a cyclone separator, six gas sampling tanks/cylinders, and a "Y" pipe junction with one branch running to a filter unit and the other to a scrubber unit. The total system length is approximately 250 ft. The piping system at the MULLET site was partially disassembled shortly following the test and open-ended pipes were left lying on the ground surface. The entire area surrounding the piping system and emplacement hole is posted as a CA; two small areas within the CA are posted as High Contamination Areas (HCAs). Radiological surveys of the pipes at the MULLET site completed in 2009 indicate the presence of transuranic radionuclides, including plutonium, within the pipes.

The PLAYER safety test was conducted on August 27, 1964 in Area 9 of the NNSS. The test design included a metal gas sampling assembly and piping system that was used to convey gas and particulates from the emplacement hole (U9cc) through various sampling instruments to the U9z PS#2 borehole. The U9z PS#2 borehole is at the bottom of a subsidence crater, approximately 650 ft away from the U9cc hole. The gas assembly system outside the crater is posted as an Underground Radioactive Material Area. Portions of the gas assembly system inside the crater are posted as Radioactive Material Areas. Radiological surveys of the pipes at the PLAYER site completed in 2009 indicate the presence of transuranic radionuclides, including plutonium, within the pipes.

1.2 Site Setting

The NNSS occupies approximately 1,360 square miles of land in southern Nevada. The NNSS is surrounded by the U.S. Air Force Nevada Test and Training Range, the Desert National Wildlife Refuge and is in close proximity to Creech Air Force Base and Nellis Air Force Base. The area is remote and desolate with minimal access to the public. The climate is an arid desert environment. Daily weather conditions on the NNSS exhibit the classic desert environment characteristics, such as large average diurnal temperature ranges, rapid heating and cooling at sunrise and sunset respectively, and large annual changes in temperature between winter and summer. The absolute ranges in surface temperature on the NNSS are from -20°F in the winter to 115°F in the summer, which occur mainly in the basins on the NNSS. Diurnal ranges in temperature can be 60°F or more in the basins (Climatology of the Nevada Test Site, 2006).

Surface drainage at the east side of NNSS consists of closed basin systems that drain onto the dry lake beds in each valley (Yucca and Frenchman Flats). The surface drainage for the west side of the NNSS drains through natural channels and dry stream beds that only carry water during intense or persistent precipitation. There are no continuously flowing streams on the NNSS.

Topography throughout the specific project areas is generally flat with the exception of some craters and modest surface undulations. Existing grades slope at approximately 1 percent, with the exception of the PLAYER site, where a portion of the piping system extends into a crater approximately 65-feet deep and the MULLET site located on the rim of the COMMODORE subsidence crater. Soil characteristics indicate unconsolidated to moderately cemented alluvial sediments throughout the project site consisting of alluvial fan material, slope wash, and eolian deposits. The thickness of the alluvial sediments varies to more than 1,000-feet within the project boundaries (Istok et al., 1994). Existing vegetation varies from desert scrub and cactus in the lowest elevations to woodlands on the mesas.

1.3 Purpose

The purpose of the corrective action is to provide protection to human health and environment from radiation exposure by closing in place each site within the CAU with a soil cover. In addition, the vertical expansion joints at the PLAYER and MULLET sites will be secured with steel pipe casings filled with concrete. A below-grade sample can at TEJON will also be secured with a casing filled with earthfill. Soil covers will be protected and maintained through long term controls such as periodic inspections, erosion repairs, radiological surveys, and barriers. Barriers are also addressed in this conceptual design.

1.4 Scope

The project scope of work consists of the basis of design/conceptual design, draft and final design documents for closure of CAU 547, TEJON, MULLET, and PLAYER sites. The scope of this design report includes the following key elements:

- Earthwork limit lines and topographic grades;
- Installation of casings for aboveground piping and expansion joints including repairing and extending concrete foundations;
- Erosion control/slope stabilization as needed;
- Compaction requirements for the berm and adjacent areas;
- Gradation requirements (i.e. screening of oversize material);
- Compaction control; and
- Barriers and signage around the bermed areas.

The purpose of this BoD and Engineering Design Report is to complete a design for approval by National Security Technologies, LLC (NSTec), U.S. Department of Energy, and the Nevada Division of Environmental Protection.

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CAU 547 Final Closure Basis of Design

2.1 General

The basis of design for the CAU 547 final closure involves construction of a 2-foot-thick engineered cover over the existing 4-inch diameter carbon steel schedule 40 pipe and associated appurtenances such as elbows, valves, sampling equipment, and other miscellaneous debris. Selection of this proposed remedy was guided by a Corrective Action Alternative evaluation using the following corrective action standards.

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

After determining compliance of the proposed remedy with these standards, the remedy was evaluated further against multiple other alternatives, using the following five decision factors:

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

This process led to the selection of the 2-foot-thick engineered cover as the preferred alternative. The conceptual design also indicated that the existing interim cover is a minimum of 2-feet in many areas. Several above-grade piping and equipment structures will require encasement in readily-available steel pipe casings. The pipe casing with concrete backfill will serve as an equivalent to the 2-foot engineered cover for the vertical expansion joints at MULLET and PLAYER, the wellhead in the PLAYER crater, and the accelerometer at PLAYER. The casings at MULLET and PLAYER will be completely backfilled with concrete. The concrete backfill will be capped with a welded-on steel plate. At the TEJON sample can, the casing will be backfilled with soil and peaked at the top to allow for drainage. New designs for foundations for the casings are not proposed. Existing foundations will be repaired and extended prior to casing installation.

An important part of optimizing cover thickness is to determine the top of piping. A field survey was completed in early May 2011 (Site Survey 5-12-11) that included the surface features, topography, and data to estimate the existing thickness of pipe cover, where applicable. Site personnel used utility location instruments to determine the minimum cover thickness where survey could not determine cover thickness. This information was used to determine the thickness of berm cover needed in areas with some existing soil cover over the piping. Soil samples were taken from the Area 3 Borrow Pit and edge of the YORK crater at the PLAYER site and were analyzed for geotechnical properties. All earthfill material will come from the Area 3 Borrow Pit. The results from the geotechnical analysis of the borrow material and the site were used to determine the optimal berm slope for stability. Based on these results, the design slopes vary from 3:1 (horizontal: vertical) and existing grade. The majority of the berms are at 2:1 with some 3:1 slopes around the accelerometer casing to minimize cut areas. Soil from the Area 3 Borrow Pit will be used to construct the berms. Field photos and site reconnaissance indicate that there is existing cover over much of the piping at the TEJON and MULLET sites. The PLAYER site has an approximate 250-foot section of exposed piping within the existing YORK crater.

The design approach for the 3 sites is similar. The goals are to:

- Use existing berms to maintain a minimum 2-foot cover over above ground steel piping
- Engineer additional fill to meet minimum cover and compaction requirements-90% compaction per ASTM D1557
- Ensure berms as designed do not cause significant drainage ponding or block existing natural water courses
- Reduce the potential for inadvertent intrusion with access control/barriers
- Minimize the potential for erosion
- Minimize cost and complexity of design

2.2 TEJON Site

The TEJON site currently has an existing soil cover over most of the approximate 128-foot pipe alignment near the BERNALILLO (U3n) borehole. There is an existing 8-foot vertical pipe and a pipe casing that will be removed prior to berm construction. In addition, several pipe segments on the ground near the elbow will also be removed prior to construction. The May 5, 2011 field survey confirmed top of the existing ground cover and the surrounding topography. Site personnel confirmed that the minimum 2-foot soil cover is present along the entire pipe alignment. The pipe will have 2-foot minimum soil cover around the pipe and associated appurtenances such as elbows, valves, sampling equipment, and other miscellaneous debris. The soil berm will be trapezoidal in shape and have typical 2:1 (horizontal: vertical) compacted side slopes. This site has an exposed pipe elbow which will also require the minimum 2-foot soil cover. A sample can near the U3cg borehole will require a minimum 3-foot diameter casing. This casing will be backfilled with soil and peaked at the top at a grade of 2 percent to allow for drainage. Soil backfill is used at this location to allow visual monitoring of the casing. Any subsidence within the casing can be repaired with additional soil backfill. Barriers and three-strand plastic-coated smooth wire fencing will be required to block access from nearby roads. These barriers will be in the form of precast concrete barriers (also known as Type F Barriers or Jersey Walls). In addition, concrete boundary monuments will be field-located at the corners and at appropriate intervals along the fence. Design drawings, specifications, and calculations are provided in Appendices 1, 2, and 3, respectively.

2.3 MULLET Site

The MULLET site also has an existing soil cover over most of the approximate 197 feet of steel piping. The field survey confirmed top of the existing ground cover and the surrounding topography. Site personnel could not verify that the minimum 2-foot soil cover is present along the entire pipe alignment due to the high contamination areas. An additional 2 feet of fill will be added to create a berm that meets the minimum cover requirements. The soil berm will be trapezoidal in shape and have typical 2:1 (horizontal: vertical) compacted side slopes. There are several exposed pipes laying parallel to the main pipe alignment. These pipes will require the 2-foot minimum cover. The berm will be widened to accommodate these pipes. The cabling that is also next to the exposed loose piping will not be covered by the berm unless it happens to lay within the berm alignment.

The MULLET site is in a CA and part of it is an HCA. The wellhead and expansion joint will be encased in a 12-foot owner-furnished pipe casing and backfilled with concrete. The concrete backfill will be capped with a ½-inch thick welded steel plate. The existing concrete foundation will also require additional concrete since the pipe hole is offset from the expansion joint. The foundation will be extended to provide a flat stable surface prior to construction. This site will require barriers in the form of Type F Barrier (Jersey Wall) or equivalent, as well as boundary monuments, and will block access from nearby roads. Existing fence will be used where able or replaced/repaired as necessary with standard three-strand wire fencing. Design drawings, specifications, and calculations are provided in Appendices 1, 2, and 3, respectively.

2.4 PLAYER Site

The PLAYER site has approximately 330 feet of exposed steel piping, of which approximately 250 feet runs down the YORK crater at an approximate 3:1 (horizontal: vertical) side slope. A 2-foot engineered soil berm will cover the piping. The field survey confirmed top of the existing ground cover and the surrounding topography. Site personnel verified that the minimum 2-foot soil cover is not present along the entire pipe alignment. Additional fill will be added to create a berm that meets the minimum cover requirements. The pipe will have 2-feet minimum cover around the pipe and associated appurtenances such as elbows, valves, sampling equipment, and other miscellaneous debris. The soil berm will be trapezoidal in shape and have typical 2:1 (horizontal: vertical) compacted side slopes. Concrete pipe anchors will be constructed in place on the crater slope and field located to stabilize the pipe for berm placement. At a minimum, pipe anchors will be constructed down the YORK crater slope for unsupported pipe lengths of 10-feet or more.

The PLAYER site will require steel casings to cover the wellhead, expansion joint, and accelerometer. The existing concrete pad around the expansion joint is badly damaged and requires repair before a casing can be installed. The new pad would be constructed prior to casing construction. The expansion joint will require an owner-furnished 12-foot diameter casing backfilled with concrete. The casing will be capped with a ½-inch thick welded-on steel plate. A 6-foot diameter or larger owner-furnished casing will be required for the accelerometer. In the YORK crater, the steel piping rises up at a 45-degree angle and is approximately 4-feet above ground next to the wellhead. The piping will be strapped to the wellhead prior to encasement. A 12-foot diameter owner-furnished casing will be used to encase the pipe and wellhead and then backfilled with concrete. Barriers in the form of Type F Barrier (Jersey Wall) will block access from nearby roads and into the YORK crater. Existing fence will be used where able or replaced/repaired as necessary with standard three-strand wire fence. Concrete boundary monuments will be field-located along the fence line. Design drawings, specifications, and calculations are provided in Appendices 1, 2, and 3, respectively.

Erosion on the pipeline edge (southern edge) of the YORK crater is expected to be minor, thus installation of Geoweb on the hinge is unnecessary. The YORK crater intercepts run-on to the PLAYER site from the north. Erosion rills are evident on the north face of the YORK crater. During CH2M HILL's site visit, rills were not observed in the crest area where the pipeline is located. Existing drainage courses in this area drain away from the YORK crater and the crest area. Historical site photos also indicate minimal erosion over the years. This indicates that water erosion has not been a concern. Wind erosion calculations performed with Area 3 borrow area soil properties yielded annual erosion of less than 0.7 inches. The erosion calculations also indicate that after 3.1 inches of erosion, desert pavement will form and erosion will cease. Furthermore, pipe anchors will be installed on the pipeline along the crater slope to increase stability during construction. The pipe anchors will be field-located as needed. It is recommended that a pipe anchor be placed at a minimum when the unsupported pipe length exceeds 10 feet.

The voids under the cracked PLAYER wellhead slab will be filled prior to this project.

2.5 Resolved Design Issues

The pipe cover survey occurred June 1, 2011. Where the survey could not verify depth of cover, a minimum 2-foot high berm will be designed on top of the existing soil cover. This occurs at the MULLET site due to the HCA.

Several appurtenant structures in the project cannot be practically covered with 2-feet of soil cover. The expansion joints at MULLET and PLAYER, the sample can at TEJON, the accelerometer at PLAYER, and the well casing in the YORK crater at PLAYER will all have steel pipe casings filled with concrete or earthfill. The sample can at TEJON will be the only site with earthfill. The pipe casing and the backfill will act as an equivalent or greater protective barrier than the 2-foot berm over the rest of the facilities in the project. Wind erosion in the pipe casings will be significantly less than around the berm areas. The approved remediation plan allows for the substitution of steel and concrete (or earthfill) in place of the 2-foot berm to minimize the risk of accidental release. The cover thickness of the pipe casing and backfill can be less than the 2-feet thick berm.

The steel pipe casings at MULLET and PLAYER (in the crater) will have an inside diameter of 12-feet. These casings will be capped with a ½-inch thick welded steel plate with a minimum 2-inch overhang. The steel casing at PLAYER for the accelerometer will have a 6-foot inside diameter or an equivalent larger diameter from available stock onsite. This casing will also be capped with a ½-inch thick welded steel plate with a minimum 2-inch overhang. The expansion joint at PLAYER is approximately 11.8-feet wide. There is potential for damage to the expansion joint should the casing hit the piping during installation. The contractor has indicated that a 12-foot inside diameter casing can be installed without damage over the PLAYER expansion joint. This casing will be capped with a ½-inch thick welded steel plate with a minimum 2-inch overhang. An additional 3-foot minimum diameter casing will be installed at TEJON over a sample can. This casing will be backfilled with earthfill and peaked at 2 percent grade for drainage. Additional earthfill will be placed as needed to maintain the drainage slope during maintenance inspections. The justification for the backfill is to allow monitoring and maintenance of the borehole for subsidence.

The backfill material for the pipe casing will be Type II Neat Portland Cement per NSTec standard specifications.

Boundary monuments are available onsite and locations will be field-located. Signage details will be similar to standard use restrictions at the NNSS.

Concrete anchors will be used to secure the piping descending the PLAYER crater side slope. The anchors will be field-located. At a minimum, anchors will be placed on unsupported pipe lengths in excess of 10-feet in length. The concrete mix will be Type II Neat Portland Cement with a compressive strength of 4,000 pounds per square inch per NSTec standard specifications.

Three-strand plastic coated wire fencing will be used to extend and/or repair existing fencing at TEJON, MULLET, and PLAYER. Chain-link fence was considered as an option. However, the wire fencing is preferred as it is used at the majority of closed sites at the NNSS, it is more cost efficient in installation as well as repair, and will allow easy access to any point at the site in the event that cover repair is required.

The wind erosion calculations were updated to reflect Area 3 Borrow Pit soil characteristics for all sites. Area 3 will be the only source of fill material. The 90% and final calculations also reflect a change in slope length to 250-feet at the YORK crater. The total soil degradation before armoring occurs is now 3.1 inches versus 1.5 inches in the 60% submittal. The annual erosion based on the calculation is approximately 0.7 inches per year. In 5 years, the soil cover should degrade sufficiently for armoring to occur. These changes are acceptable to the overall design.

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SECTION 3

References

"Climatology of the Nevada Test Site". Soule, David. National Oceanic Atmospheric Administration, Special Operations and Research Division. Silver Springs, Maryland. April 2006.

Istok, J.D., D.O. Blout, L. Barker, K.R. Johnejack, and D.P. Hammermeister. 1994. Spatial Variability in Alluvium Properties at a Low-Level Nuclear Waste Site. Soil Science Society of America Journal, Volume 58, No. 4, July-August 1994: 1040-1051.

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Appendix 1
Design Drawings

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NATIONAL NUCLEAR SECURITY ADMINISTRATION

NEVADA SITE OFFICE — LAS VEGAS, NEVADA

CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES TEJON, MULLET, AND PLAYER

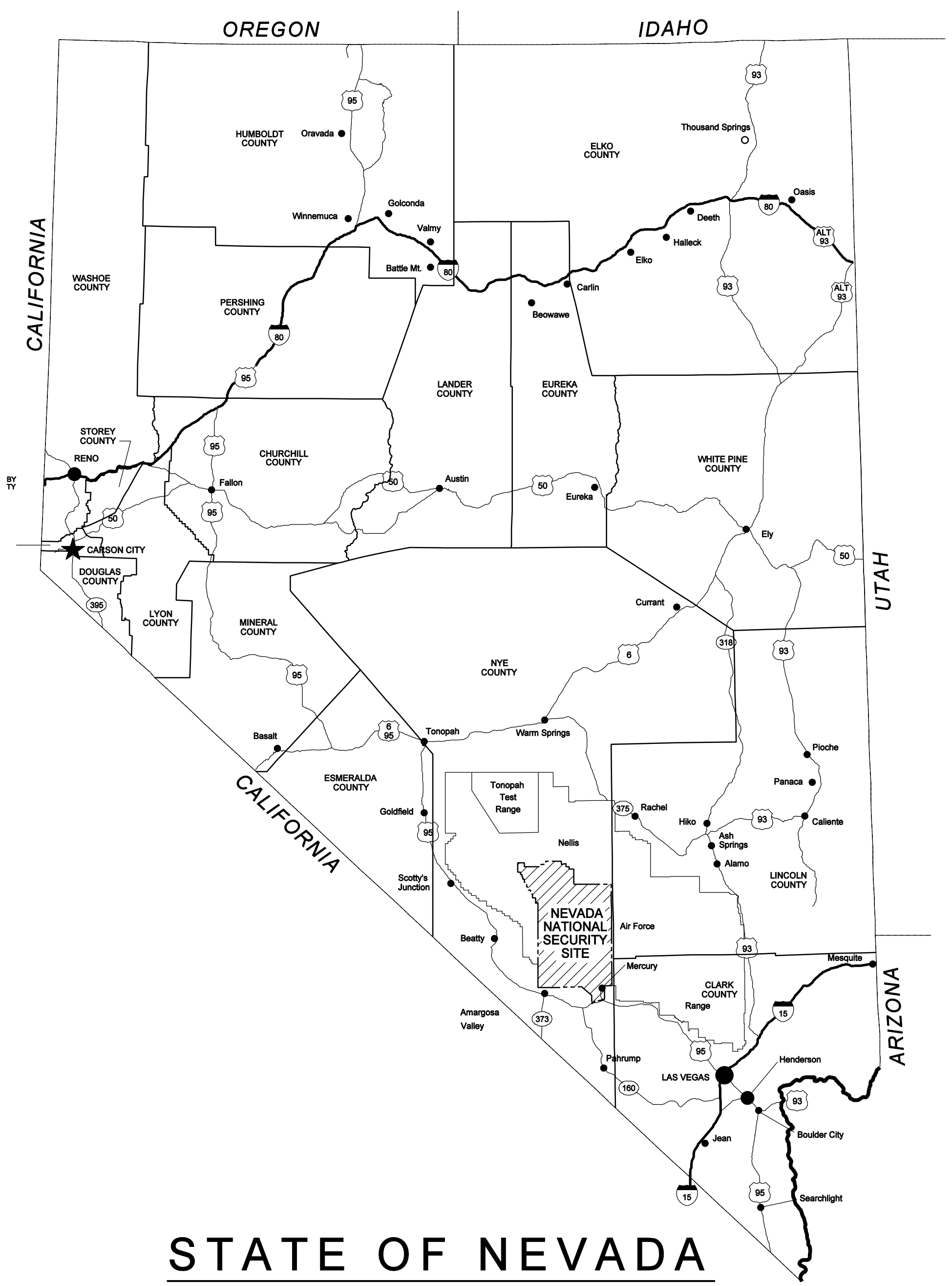
SCOPE OF WORK

GRADE NEW BERMS (FILL) OR PROVIDE ADDITIONAL FILL ON TOP OF EXISTING BERMS TO PROVIDE MINIMUM SPACE, OR 2.0-FOOT COVER OVER EXISTING PIPING AND OR PIPE APPURTENANCES.

INSTALL PIPE CASINGS AS NOTED ON PLANS.

PROVIDE TYPE F CONCRETE BARRIERS AND SIGNAGE AROUND BERMED AREAS, AS DIRECTED.

REPAIR/EXTEND EXISTING CONCRETE PADS WHERE SHOWN.



STATE OF NEVADA

SCALE: NONE

DRAWING INDEX

DRAWING NUMBER	*DRAWING TITLE*
TITLE	
00424-G-0001	TITLE SHEET \ VICINITY MAP
00424-G-0002	STANDARD ABBREVIATIONS
00424-G-0003	TYPICAL CIVIL SYMBOLS, NOTES & LEGEND
CIVIL	
00424-C-1001	OVERALL PROJECT SITE PLAN
00424-C-1002	TEJON SITE GRADING PLAN
00424-C-1003	MULLET SITE GRADING PLAN
00424-C-1004	PLAYER SITE GRADING PLAN
00424-C-3001	TEJON SITE (STA 0+00.00 TO STA 0+75.00) & MULLET SITE (STA 0+11.50 TO STA 2+07.12) BERM PROFILE
00424-C-3002	PLAYER SITE BERM PROFILE - STA 0+97.20 TO STA 4+90.00
00424-C-3003	PLAYER SITE BERM PROFILE - STA 4+90.00 TO STA 6+84.41
00424-C-3004	TYPICAL BERM SECTIONS
00424-C-5001	PIPE CASING DETAILS
00424-C-5002	DETAILS

CAUTION NOTE:

INFORMATION SHOWN ON THESE DRAWINGS MIGHT NOT REFLECT CURRENT CONDITIONS OF FACILITY OR STRUCTURE. PERSONNEL SHALL USE CAUTION WHEN PERFORMING WORK BASED ON THE EXISTING INFORMATION SHOWN ON THE DRAWINGS.

GS

PROFESSIONAL ENGINEER - STATE OF NEVADA
GINO V. NGUYEN
CIVIL
NO 20062
7-20-11

ISSUED FOR CONSTRUCTION

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER/ USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

TITLE SHEET \ VICINITY MAP

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

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STANDARD ABBREVIATIONS

GENERAL

ABBREVIATION	ABBR
ABOVE FINISH FLOOR	AFF
ABOVE FINISH GRADE	AFG
ADMINISTRATION	ADMIN
AGGREGATE	AGGR
AIR CONDITIONING	A/C
ALTERNATE	ALT
ALUMINUM	AL
AMERICAN NATIONAL STANDARDS INSTITUTE	ANSI
AMERICAN SOCIETY FOR TESTING AND MATERIALS	ASTM
AMERICAN SOCIETY OF SANITARY ENGINEERS	ASSE
AMERICAN WATER WORKS ASSOCIATION	AWWA
ANCHOR BOLT	AB
AND	&
APPROVED	APVD
APPROXIMATE	APPROX
ARCHITECT/ENGINEER	A/E
ASBESTOS CEMENT PIPE	ACP
ASPHALT	ASPH
ASPHALT CEMENT	AC
AT	@
AUTOMATIC	AUTO
AUXILIARY	AUX
AVERAGE	AVG
BEAM	BM
BELOW FINISH GRADE	BFG
BITUMINOUS	BITMUM
BLOCK	BLK
BLOCKING	BLKG
BOREHOLE	BH
BOTTOM	BOT
BRACING	BRCG
BRACKET	BRKT
BREAKLINE	BRKLN
BUILDING	BLDG
BURIED CABLE	BC
CAST IRON	CI
CARBON STEEL	CS
CATALOG	CAT
CAULKING	CLKG
CEILING	CLG
CEMENT	CEM
CENTER	CTR
CENTER LINE	℄
CENTER TO CENTER	℄ TO C
CHAIN LINK FENCE	CH LN
CIRCULAR	CIRC
CLEAR	CLR
CODE OF FEDERAL REGULATORS	CFR
COLUMN	COL
COMBINATION	COMB
COMMUNICATIONS	COMM/C
COMPARTMENT	COMPT
CONCRETE	CONC
CONCRETE MASONRY UNITS	CMU
CONNECTION	CONN
CONSTRUCTION	CONSTR
CONSTRUCTION JOINT	CJ
CONSTRUCTION SPECIFICATION	CON SPEC
CONTAMINATED AREA	CA
CONTINUATION/CONTINUOUS	CONT
CONTROL JOINT	CLJ
COPPER	CU
CORNER	COR
CORPORATION	CORP
COUNTERSUNK	CTSK
COUNCIL OF AMERICAN BUILDING OFFICIALS	CABO
CROSSING	XING
CUBIC FOOT	CFT
CUBIC METER	CM
CUBIC YARD	CY
DATED	DTD
DETAIL	DET
DEGREE	DEG
DEPARTMENT OF ENERGY	DOE
DIAGONAL	DIAG
DIAMETER	DIA ∅
DIMENSION	DIM

DOUBLE	DBL
DOWN	DN
DRAWING	DWG
DUCTILE IRON	DI
EACH	EA
EAST	E
ELECTRIC/ELECTRICAL	ELEC
ELECTRIC HEATER	EH
ELECTRIC WATER COOLER	EWC
ELECTRIC WATER HEATER	EWH
ELECTRIC UNIT HEATER	EUH
ELEVATION	EL
EMERGENCY	EMER
ENCLOSURE	ENCL
ENGINEER	ENGR
ENTRANCE	ENTR
EQUAL	EQL
EQUIPMENT	EQPT
EXHAUST	EXH
EXISTING	EXIST
EXPANSION	EXP
EXPANSION JOINT	EXP JT
EXPOSED	EXP
EXTERIOR	EXT
FACILITY	FACIL
FACTORY MUTUAL	FM
FEET	FT
FIBER OPTICS	FO
FIELD	FLD
FINISH	FNSH
FINISH FLOOR	FF
FINISH GRADE	FG
FIRE	F
FIRE ALARM CONTROL PANEL	FACP
FIRE HYDRANT	FHY
FIRE PROTECTION	FP
FIRST	1ST
FITTING	FTG
FIXTURE	FXTR
FLANGE	FLG
FLANGED END	FE
FLOOR	FL
FOOT	FT
FOOTING	FTG
FOUNDATION	FDN
FUTURE	FUT
GAGE OR GAUGE	GA
GALLONS/HOUR	GPH
GALLONS/MINUTE	GPM
GALVANIZED	GALV
GALVANIZED IRON	GALVI
GATE VALVE	GTV
GENERAL	GENL
GOVERNMENT	GOVT
GOVERNMENT FURNISHED EQUIPMENT	GFE
GRADE	GR
GRATING	GRTG
HAND RAIL	HNDRL
HAZARDOUS WASTE	HAZ W
HEATING, VENTILATING AND AIR CONDITIONING	HVAC
HEIGHT	HGT
HELICOPTER LANDING PAD	HELO
HIGH POINT	HPT
HORIZONTAL	HORIZ
HORSEPOWER	HP
HOUR	HR
INCH	IN
INTERNATIONAL BUILDING CODE	IBC
INSIDE DIAMETER	ID
INSULATION	INSUL
INVERT	INVT
JOINT	JT
LAVATORY	LAV

LEFT	LT
LENGTH	LG
LIGHTING	LTG
LINEAR FOOT	LF
LINEAR METER	LM
LIQUEFIED PETROLEUM GAS	LPG
LONG	LG
LOW POINT	LP
MACHINE	MACH
MAGNETIC	MAG
MAINTENANCE	MAINT
MANHOLE	MH
MANUFACTURER	MFR
MANUFACTURING	MFG
MATERIAL	MATL
MAXIMUM	MAX
MECHANICAL	MECH
MECHANICAL JOINT	MJ
MEMBRANE	MEMB
METAL	MET
METER/METRIC	M
METRIC TON	MTON
MEZZANINE	MEZZ
MILE	MI
MILIMETER	MM
MILLION GALLONS PER DAY	MGD
MINIMUM	MIN
MISCELLANEOUS	MISC
MOUNT(ING) (ED)	MT(G)(D)
NATIONAL FIRE PROTECTION ASSOCIATION	NFPA
NATIONAL PIPE THREAD	NPT
NATIONAL SANITATION FOUNDATION	NSF
NEVADA	NV
NEVADA ADMINISTRATIVE CODE	NAC
NEVADA NATIONAL SECURITY SITE	NNSS
NON RISING STEM	NRS
NOMINAL	NOM
NORMAL	NORM
NORTH	N
NOT IN CONTRACT	NICS
NOT TO SCALE	NTS
NUMBER	NO #
OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION	OSHA
ON CENTER	OC
OPENING	OPNG
OPPOSITE	OPP
OUTSIDE DIAMETER	OD
OUTSIDE STEM & YOKE	OS & Y
OVERHEAD	OVHD
PAIR	PR
PAVEMENT	PVMT
PLAIN END	PE
PLATE	PL
POINT	PT
POLE	P
POLYVINYL CHLORIDE (PIPE)	PVC
POUNDS	LBS
POUNDS/SQUARE FOOT	PSF
POUND/SQUARE INCH	PSI
POWER	P
POWER POLE	PP
POWER OVERHEAD	POH
POWER UNDERGROUND	PUG
PREFABRICATED	PREFAB
PRESSURE	PRESS
PRESSURE INDICATOR	PI
PRESSURE REDUCING VALVE	PRV
PRESSURE REDUCING VALVE STATION	PRVS
PROJECT ENGINEER	PE
QUANTITY	QTY
RADIUS	RAD/R
RADIOACTIVE WASTE MANAGEMENT SITE	RWMS
REFERENCE	REF
REGIONAL TRANSPORTATION COMMISSION	RTC
REINFORCED CONCRETE BOX	RCB
REINFORCING	REINF
REQUIRED	REQD
REVISIONS/REVERSE	REV
RIGHT	R
RIGID STEEL	RS
ROAD	RD

ROOF	RF
ROOF DRAIN	RD
ROOF DRAIN OVERFLOW	RDOF
ROOM	RM
ROUGH	RGH
ROUGH OPENING	RO
ROUND	RND
SANITARY SEWER	SS
SCHEDULE	SCH
SECOND	2ND SEC
SECTION	SECT
SHEET METAL	SH MET
SIMILAR	SIM
SOUTH/SEWER	S
SPACE	SPA
SPARE	SPR
SPECIFICATION	SPEC
SPIGOT	SP
SQUARE	SQ
STANDARD	STD
STATION	STA
STEAM	ST
STEEL	STL
SUBGRADE	SG
SUBSTATION	SUBSTA
SYMMETRICAL	SYMM
TANGENT/TELEPHONE	T
THICK	THK
TEMPORARY	TEMP
TOP OF CONCRETE	TOC
TYPICAL	(TYP)
UNDERGROUND	UG
UNDERWRITERS LABORATORIES	UL
UNFINISHED	UNFIN
UNIFORM BUILDING CODE	UBC
UNIFORM PLUMBING CODE	UPC
UNITED STATES	US
UNLESS OTHERWISE NOTED	UON
UNLESS OTHERWISE SPECIFIED	UOS
URINAL	UR
VACUUM	VAC
VENTILATOR	VENT
VERTICAL	VERT
VITRIFIED CLAY PIPE	VCP
VOLUME	VOL
WATER CLOSET	WC
WATERPROOF	WTRPRF
WEATHERPROOF	WP
WEIGHT	WT
WEST/WATER/WASTE	W
WIDTH	WD
WITH	W/
WITHOUT	W/O
YARD	YD

CIVIL

CONTROL POINT	CONT PT
CORRUGATED METAL PIPE	CMP
CORRUGATED METAL PIPE ARCH	CMPA
GALVANIZED IRON PIPE	GIP
HIGH POINT OF VERTICAL CURVE	HI
HIGHWAY	HWY
MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES	MUTCD
MIDDLE ORDINATE OF CURVE	MO
NATIONAL SECURITY TECHNOLOGIES	NSTec
NEVADA DEPARTMENT OF TRANSPORTATION	NDOT
POINT OF CURVE	PC
POINT OF INTERSECTION	PI
POINT OF REVERSE CURVE	PRC
POINT OF TANGENCY	PT
POINT OF VERTICAL CURVE	PVC
POINT OF VERTICAL INTERSECTION	PVI
POINT OF VERTICAL REVERSE CURVE	PVRC
POINT OF VERTICAL TANGENCY	PVT
SLOPE	S
SHOULDER	SHLDR
VERTICAL CURVE	VC

GENERAL NOTES

1. CONTACT THE ENGINEER FOR ABBREVIATIONS NOT LISTED.
2. THIS IS A STANDARD ABBREVIATION SHEET. THEREFORE, SOME ABBREVIATIONS MAY APPEAR ON THIS SHEET AND MAY NOT BE UTILIZED ON THIS PROJECT.

GS

PROFESSIONAL ENGINEER - STATE OF NEVADA
GINO V. NGUYEN
CIVIL
NO 20062
7-20-11

ISSUED FOR CONSTRUCTION

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER/USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

STANDARD ABBREVIATIONS

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER/USER
/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 00424
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER: 00424-G-0002
REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001

TYPICAL CIVIL SYMBOLS, NOTES & LEGEND

CIVIL SYMBOLS

DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL
EXISTING MINOR CONTOUR		SURFACE DRAINAGE FLOW DIRECTION	SLOPE%
EXISTING MAJOR CONTOUR	(3934)	EXISTING WING TYPE HEADWALL	
NEW MINOR CONTOUR	34	NEW WING TYPE HEADWALL	
NEW MAJOR CONTOUR	35	EXISTING CURB INLET/CATCH BASIN	CB
EXISTING SPOT ELEVATION	(3934.00)	EXITING STORM DRAIN MANHOLE	D
FINISH GRADE ELEVATION	3935.00 FG	EXISTING SURFACE GRATE INLET	
EXISTING CENTER LINE	5+00 6+00	NEW CURB INLET/ CATCH BASIN	CB
NEW CENTER LINE W/STATIONS	5+00 6+00	NEW STORM DRAIN MANHOLE	D
AREA BOUNDARY LINE		NEW SURFACE GRATE INLET	
FUTURE LIMITS OF CONSTRUCTION		EXISTING ROADWAY GUARDRAIL	
LIMITS OF GRADING		NEW ROADWAY GUARDRAIL	
EXISTING UNPAVED ROAD		EXISTING 4' HIGH FENCE 2 STRAND SMOOTH WIRE	
NEW UNPAVED ROAD		NEW 4' HIGH FENCE 2 STRAND SMOOTH WIRE	
EDGE OF EXISTING PAVING		EXISTING 4' HIGH FENCE 3 STRAND SMOOTH WIRE	
LIMITS OF NEW PAVING		NEW 4' HIGH FENCE 3 STRAND SMOOTH WIRE	
EDGE EXISTING CONCRETE SIDEWALK		EXISTING 4' HIGH FENCE 3 STRAND SMOOTH WIRE WITH PLASTIC MESH	XO
EDGE NEW CONCRETE SIDEWALK		NEW 4' HIGH FENCE 3 STRAND SMOOTH WIRE WITH PLASTIC MESH	XO
EXISTING EARTH		EXISTING 4' HIGH FENCE CHAIN LINK	XX
COMPACTED EARTH		NEW 4' HIGH FENCE CHAIN LINK	XX
AGGREGATE BASE COURSE		EXISTING 8' HIGH FENCE CHAIN LINK	X
CONCRETE PAD		NEW 8' HIGH FENCE CHAIN LINK	X
EXISTING FLOW LINE		EXISTING 4' HIGH FENCE W/BARBED WIRE	
NEW FLOW LINE		NEW 4' HIGH FENCE W/BARBED WIRE	
EXIST TOP OF SLOPE OR EXISTING HACETURE TOP OF SIDE SLOPE		NEVADA STATE COORDINATE SYSTEM	N 710,000 E 700,000
EXIST TOE OF SLOPE		CENTER LINE BEARING	N01°30'30"E
NEW TOP OF SLOPE OR NEW HACETURE TOP OF SIDE SLOPE		SURVEY CONTROL MONUMENT (BM)	
NEW TOE OF SLOPE	TOE	SURVEY TEMPORARY BENCHMARK (TBM)	
RIPRAP		SURVEY DELTA (CENTRAL ANGLE)	
EXISTING BUILDING OR STRUCTURE		EXISTING COMMUNICATIONS POLE (NO.& TYPE)	CP
NEW BUILDING OR STRUCTURE		NEW COMMUNICATIONS POLE (NO.& TYPE)	CP
EXISTING MOBILE/ TEMPORARY FACILITY		EXISTING COMMUNICATIONS UNDERGROUND	CUG
BUFFER ZONE AREA BOUNDARY		NEW COMMUNICATIONS UNDERGROUND	CUG
AREA BOUNDARY LINE - RWMS		EXISTING COMMUNICATIONS UNDERGROUND FIBER	CUG (F)
OPEN WASTE DISPOSAL CELL/PIT/TRENCH (IN PLAN VIEW)		NEW COMMUNICATIONS UNDERGROUND FIBER	CUG (F)
COVERED WASTE DISPOSAL CELL/PIT/TRENCH (IN PLAN VIEW)		EXISTING COMMUNICATIONS SURFACE LAID	C (SL)
APPROX EXTENTS OF BURIED WASTE MATERIAL (IN PROFILE VIEW)		NEW COMMUNICATIONS SURFACE LAID	C (SL)
EXISTING OPEN AREA OF PIT FOR WASTE MATERIAL (IN PROFILE VIEWO		EXISTING COMMUNICATION VAULT/MANHOLE	C
EXISTING STORM DRAIN PIPE W/SIZE	18" SD	NEW COMMUNICATION VAULT/MANHOLE	C
NEW STORM DRAIN LINE W/SIZE	30" SD	EXISTING COMMUNICATIONS PEDESTAL	T
EXISTING CULVERT SIZE & TYPE	8" RCP	NEW COMMUNICATIONS PEDESTAL	T
NEW CULVERT SIZE & TYPE	12" RCP		

DESCRIPTION	SYMBOL	DESCRIPTION	SYMBOL
EXISTING (JOINT) COMM / POWER POLE (NO.& TYPE)	JP	EXISTING WATER TAPPING SLEEVE	
NEW (JOINT) COMM / POWER POLE (NO.& TYPE)	JP	NEW WATER TAPPING SLEEVE	
EXISTING COMMUNICATION OVERHEAD	COH	EXISTING FIRE HYDRANT	
NEW COMMUNICATION OVERHEAD	COH	NEW FIRE HYDRANT	
EXISTING POWER OVERHEAD	POH	EXISTING POST INDICATOR VALVE	
NEW POWER OVERHEAD	POH	NEW POST INDICATOR VALVE	
EXISTING POWER POLE (NO.& TYPE)	PP	EXISTING SANITARY SEWER LINE W/SIZE	4" SS
NEW POWER POLE (NO.& TYPE)	PP	NEW SANITARY SEWER LINE W/SIZE	4" SS
POLE WITH GUY ANCHOR		EXISTING SANITARY SEWER VAULT/ MANHOLE	S
EXISTING ELECTRICAL TRANSFORMER ON POLE (NO.& SIZE)		NEW SANITARY SEWER VAULT/ MANHOLE	S
NEW ELECTRICAL TRANSFORMER ON POLE (NO.& SIZE)		EXISTING SEWER CLEANOUT	CO
EXISTING PAD MTD TRANSFORMER (NO.& SIZE)	T	NEW SEWER CLEANOUT	CO
NEW PAD MTD TRANSFORMER (NO.& SIZE)	T	EXISTING GAS MAIN W/SIZE	2" G
EXISTING CONDUIT PULL BOX	PBOX	NEW GAS MAIN W/SIZE	2" G
NEW CONDUIT PULL BOX	PBOX	EXISTING GAS METER	GM
EXISTING AREA LIGHTING POLE	LP	NEW GAS METER	GM
NEW AREA LIGHTING POLE (SGL ARM)	LP	EXISTING SIGN (TRAFFIC OR INFORMATION)	
NEW AREA LIGHTING POLE (DBL ARM)	LP	NEW SIGN (TRAFFIC OR INFORMATION)	
EXISTING ELECTRICAL VAULT/MANHOLE	E	PIPE BOLLARDS	
NEW ELECTRICAL VAULT/MANHOLE	E	EXISTING PARKING BUMPER OR WHEEL STOP	
EXISTING POWER UNDERGROUND	PUG 3-2"C	NEW PARKING BUMPER OR WHEEL STOP	
NEW POWER UNDERGROUND	PUG 1-2"C	EXISTING CONCRETE SECURITY WALL (JERSEY BARRIER)	
EXISTING POWER SURFACE LAID	P (SL)	NEW CONCRETE SECURITY WALL (JERSEY BARRIER)	
NEW POWER SURFACE LAID	P (SL)	AIRFIELD WIND SOCK, COMMUNICATIONS TOWER OR ANTENNA W/GUY WIRES	WEATHER STATION
EXISTING WATER LINE W/SIZE	8" W	LYSIMETER OR METEOROLOGY TOWER W/STRUCTURAL ANCHOR PADS	(TYPE) TOWER
NEW WATER LINE W/SIZE	8" W	CONCRETE (BOUNDARY) CONTROL MONUMENT	NORTH, EAST ELEV, ID *
EXISTING FIRE PROTECTION MAIN W/SIZE	6" FP	EXISTING ENVIRONMENTAL MONITORING TUBE (ID#)	AP1 RP2
NEW FIRE PROTECTION MAIN W/SIZE	6" FP	EXISTING ENVIRONMENTAL MONITORING TUBE (ID#)	NE1
EXISTING WATER VALVE & CAP	WV	EXISTING TDR ENVIRONMENTAL MONITORING TUBE	
NEW WATER VALVE & CAP	WV	EXISTING VADOSE STA (ID#) TDR ARRAY	VADOSE STA (ID #)
EXISTING WATER CHECK VALVE	CV	EXISTING GREATER CONFINEMENT DISPOSAL BOREHOLE (GCD #)	GCD
NEW WATER CHECK VALVE	CV	EXISTING COMPRESSED AIR LINE	3" A
EXISTING BACK FLOW PREVENTER		BREAKLINE	
NEW BACK FLOW PREVENTER		DRAINAGE	
EXISTING WATER FLOW METER	FM	BOUNDARY MONUMENT	
NEW WATER FLOW METER	FM		
EXISTING WATER METER	WM		
NEW WATER METER	WM		
EXISTING WATER VAULT/MANHOLE	W		
NEW WATER VAULT/MANHOLE	W		

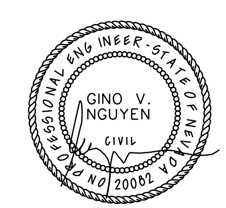
CIVIL NOTES

GENERAL CIVIL NOTES

1. DO NOT USE ANY SCALE FOR OBTAINING FORMAL DIMENSIONS. THE DIMENSIONS SHOWN ON THE DRAWINGS SHALL TAKE PRECEDENCE.
2. WHERE CONFLICTS EXIST BETWEEN THE REFERENCED SPECIFICATIONS 00424-SPC-01 AND THE DRAWINGS, THE PROJECT DRAWINGS SHALL TAKE PRECEDENCE.
3. CONSTRUCTOR SHALL CONFIRM ALL EXISTING DIMENSIONS AND ELEVATIONS PRIOR TO COMMENCING WORK AND SHALL REPORT ALL DISCREPANCIES TO THE PROJECT ENGINEER OR DESIGNATED REPRESENTATIVE.
4. CONTACT THE ENGINEER FOR ABBREVIATIONS NOT LISTED.
5. THIS IS A STANDARD SYMBOL AND LEGEND SHEET, THEREFORE, SOME SYMBOLS OR LEGENDS MAY APPEAR ON THIS SHEET AND MAY NOT BE UTILIZED ON THIS PROJECT.

GENERAL CONSTRUCTION NOTES

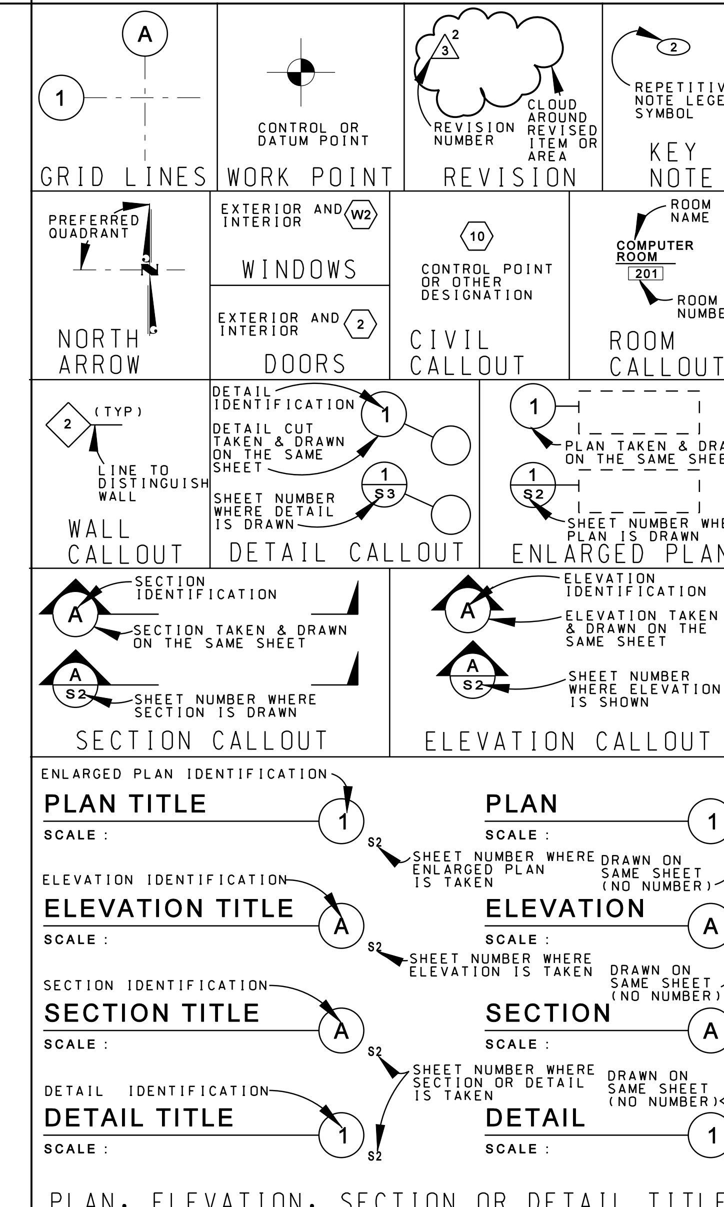
1. BASIS FOR HORIZONTAL CONTROL: NORTH AMERICAN DATUM 1927, NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE. BASIS FOR VERTICAL CONTROL: NORTH AMERICAN VERTICAL DATUM 1929, NEVADA STATE COORDINATE SYSTEM, CENTRAL ZONE.
2. SURVEY DATA SHALL BE SUBMITTED TO NSTec ENGINEERING IN ASCII FILE FORMAT ALONG WITH COPIES OF FIELD SURVEY SKETCHES. DATA FILES SHALL CONTAIN SUFFICIENT DATA POINTS TO FACILITATE AS-BUILT DRAWINGS.
3. REFER TO CONSTRUCTION SPECIFICATION 00424-SPC-01.



7-20-11

ISSUED FOR CONSTRUCTION

DRAFTING LEGEND



GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER/ USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

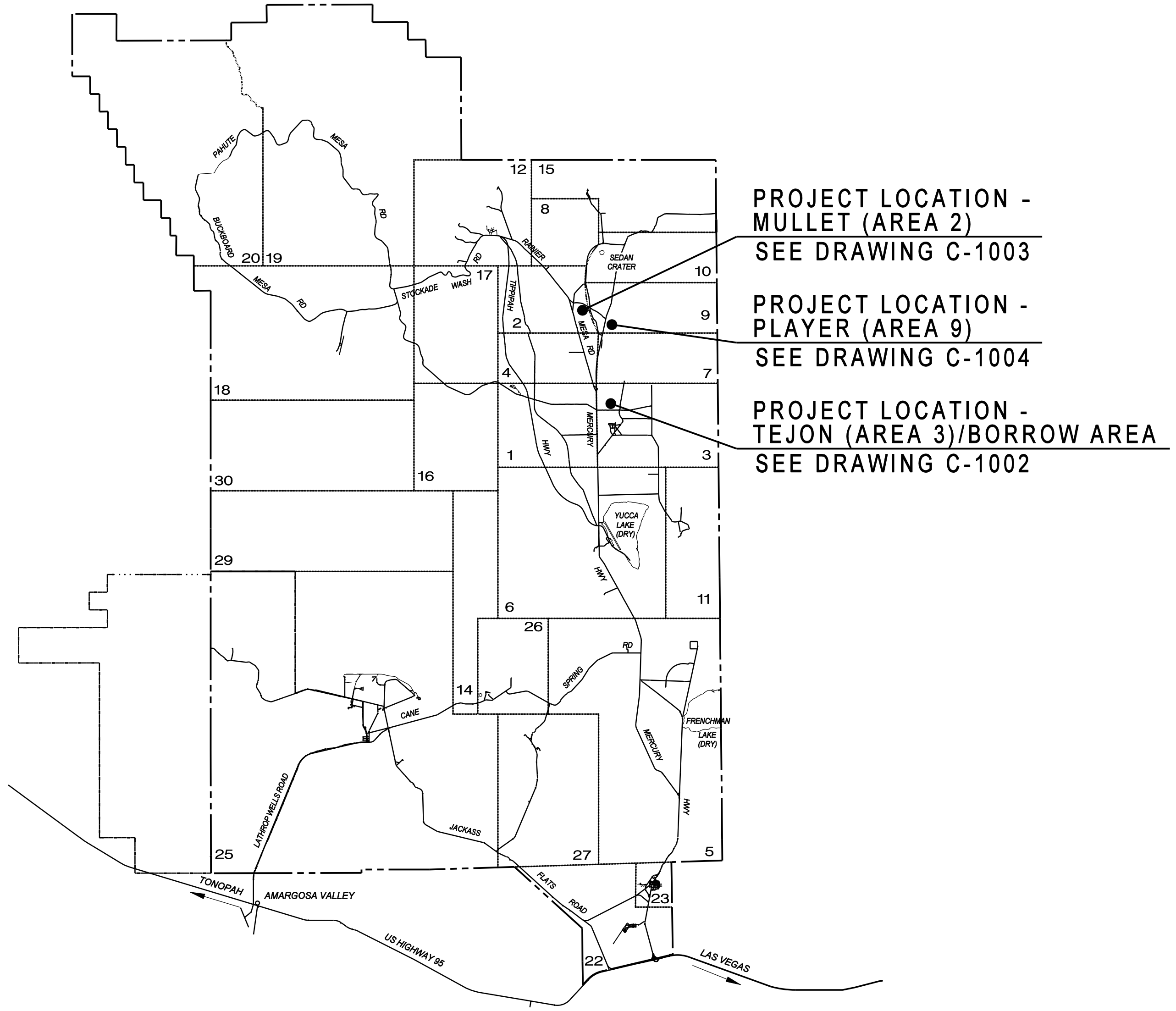
TYPICAL CIVIL SYMBOLS, NOTES & LEGEND

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 00424
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER 00424-G-0003
REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001



NEVADA NATIONAL SECURITY SITE

SCALE: NONE

GINO V. NGUYEN
CIVIL
No. 20082
PROFESSIONAL ENGINEER - STATE OF NEVADA
7-20-11

ISSUED FOR CONSTRUCTION

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER/ USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

OVERALL PROJECT SITE PLAN

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 00424
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER 00424-C-1001
REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001

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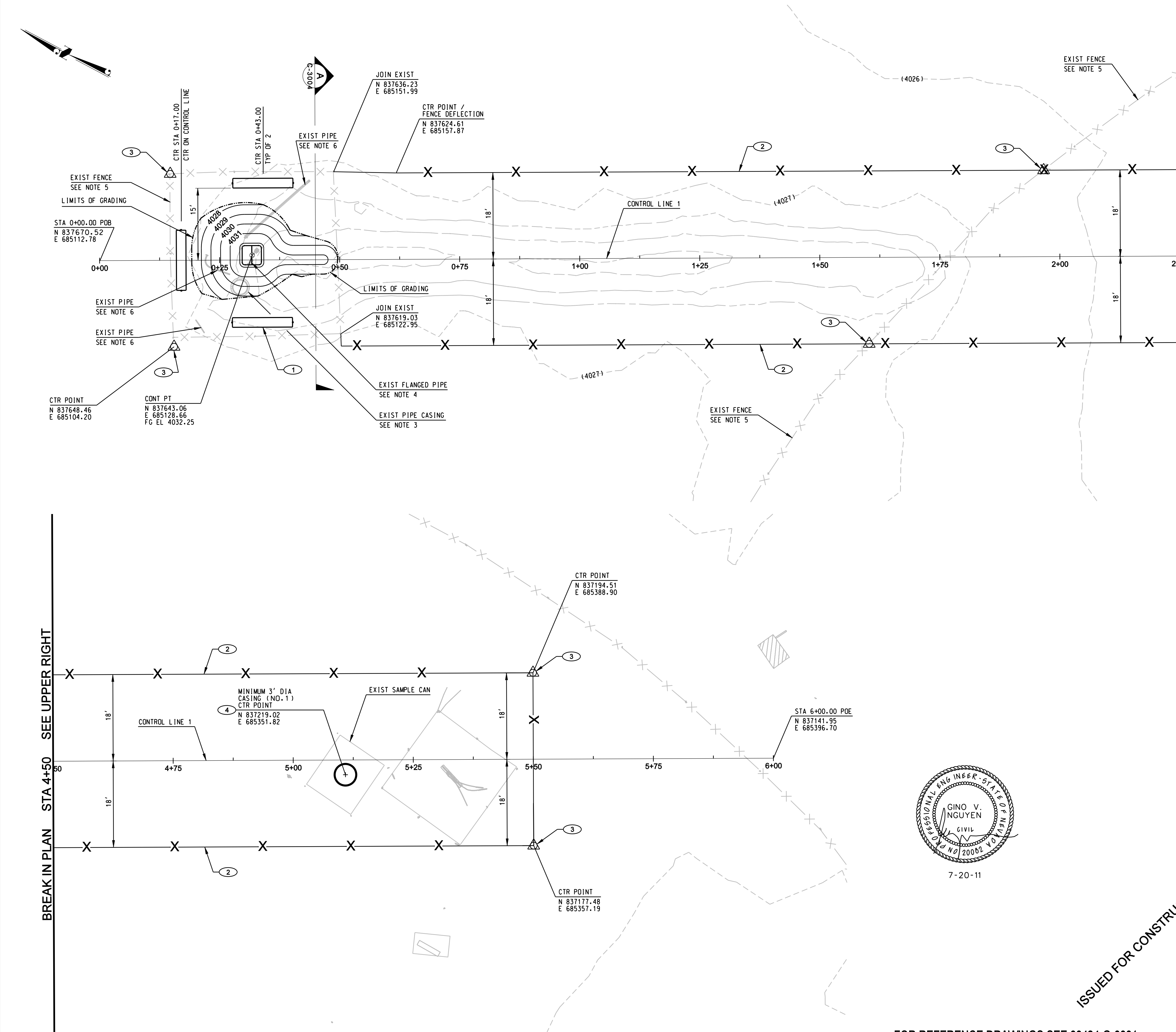

GENERAL NOTES

1. THE TYPICAL BERM SURFACE SIDE SLOPE VARIES BETWEEN 3:1 AND EXISTING GRADE. TYPICAL SLOPE IS 2:1.
2. CONTOURS SHOWN ARE TO FINAL GRADES.
3. REMOVE EXIST PIPE CASING.
4. EXIST VERTICAL PIPE TO BE REMOVED AT FLANGE PRIOR TO CONSTRUCTION.
5. EXIST FENCING TO BE TEMPORARILY REMOVED PRIOR TO COMMENCEMENT OF CONSTRUCTION ACTIVITIES. FENCING TO BE RE-ESTABLISHED AFTER CONSTRUCTION.
6. EXIST PIPES NOT RELATED TO CAU 547 WILL BE REMOVED PRIOR TO CONSTRUCTION.

CONSTRUCTION NOTES

(1) INSTALL TYPE F CONCRETE BARRIER PER NEVADA DEPARTMENT OF TRANSPORTATION (NDOT) OR EQUIVALENT. FIELD LOCATE.

(2) INSTALL 3-STRAND PLASTIC COATED WIRE FENCING WITH T-POSTS PER DETAIL 1 SHEET C-5002.

(3) PLACE BOUNDARY MONUMENTS. FIELD LOCATE.

(4) INSTALL CASING PER DETAIL E ON DRAWING C-5001.

ESTIMATED QUANTITIES

TOTAL NET FILL = 23.5 CY (INCLUDES CASING NO. 1 FILL OF 2.4 CY)

GRAPHIC SCALE 0 5 10 20 30 FEET 1" = 10'

GS

GINO V. NGUYEN CIVIL No 20082 PROFESSIONAL ENGINEER - STATE OF NEVADA

7-20-11

ISSUED FOR CONSTRUCTION

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION

NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9

CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES

TEJON, MULLET AND PLAYER

TEJON SITE GRADING PLAN

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 00424 — ORIGINAL SIGNATURES ON FILE

DRAWING NUMBER / WORK ORDER NUMBER: 00424-C-1002

REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001

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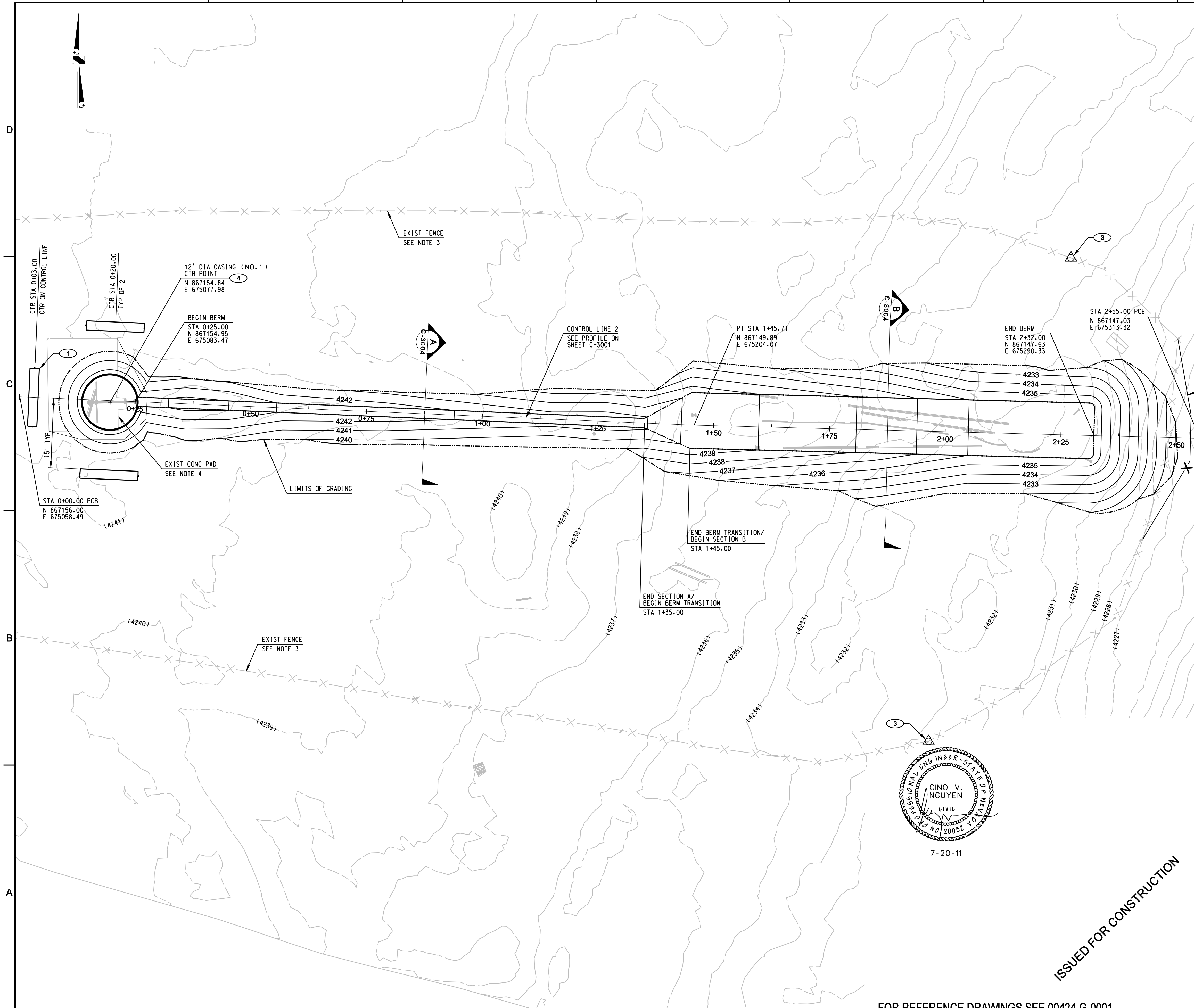

GINO V. NGUYEN
CIVIL
NO 20082
PROFESSIONAL ENGINEER - STATE OF NEVADA
7-20-11

ISSUED FOR CONSTRUCTION

GENERAL NOTES

1. THE TYPICAL BERM SURFACE SIDE SLOPE VARIES BETWEEN 2:1 AND EXIST GRADE.
2. CONTOURS SHOWN ARE TO FINAL GRADES.
3. EXIST FENCING TO BE TEMPORARILY REMOVED PRIOR TO COMMENCEMENT OF CONSTRUCTION ACTIVITIES. FENCING TO BE RE-ESTABLISHED AFTER CONSTRUCTION.
4. EXIST CONC PAD WILL BE REPAIRED AND EXTENDED PRIOR TO INSTALLATION OF PIPE CASING.

CONSTRUCTION NOTES

(1) INSTALL TYPE F CONCRETE BARRIER PER NEVADA DEPARTMENT OF TRANSPORTATION (NDOT) OR EQUIVALENT. FIELD LOCATE.

(2) INSTALL 3-STRAND PLASTIC COATED WIRE FENCING WITH T-POSTS PER DETAIL 1 SHEET C-5002.

(3) PLACE BOUNDARY MONUMENT. FIELD LOCATE.

(4) INSTALL CASING PER DETAIL D ON DRAWING C-5001.

ESTIMATED QUANTITIES

TOTAL NET FILL = 283.9 CY

GRAPHIC SCALE
0 5 10 20 30 FEET
1" = 10'

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

MULLET SITE GRADING PLAN

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

National Security Technologies LLC
Vision • Service • Partnership
NEVADA OPERATIONS
P.O. BOX 98521 LAS VEGAS, NV 89193-8521

ENGINEERING NO. 00424
ORIGINAL SIGNATURES ON FILE
DRAWING NUMBER / WORK ORDER NUMBER: 00424-C-1003
REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001

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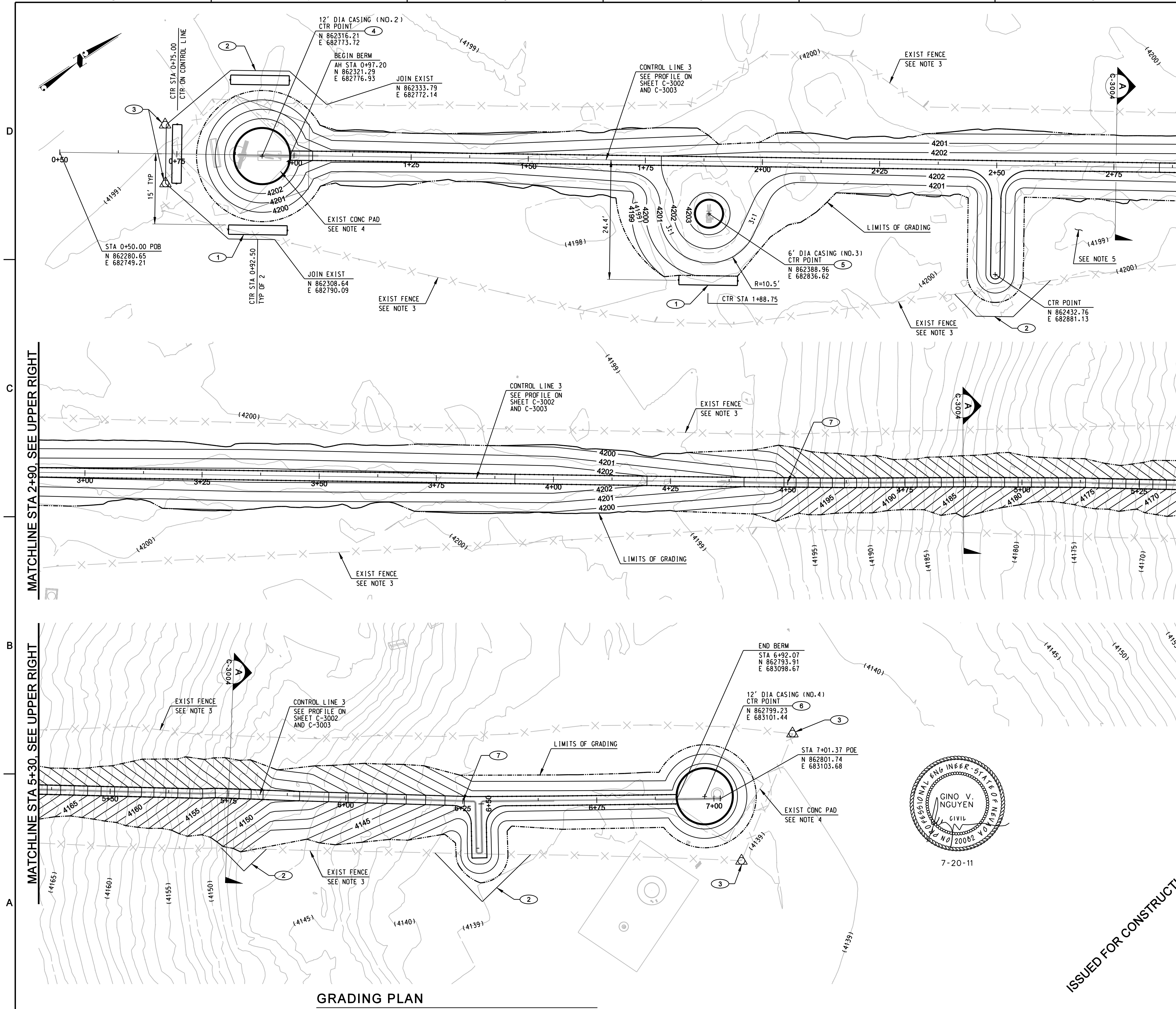

GRADING PLAN

SCALE : 1"=10'

GENERAL NOTES

1. THE TYPICAL BERM SURFACE SIDE SLOPE VARIES BETWEEN 2:1 AND EXIST GRADE.
2. CONTOURS SHOWN ARE TO FINAL GRADES.
3. EXIST FENCING TO BE TEMPORARILY REMOVED PRIOR TO COMMENCEMENT OF CONSTRUCTION ACTIVITIES. FENCING TO BE RE-ESTABLISHED AFTER CONSTRUCTION.
4. EXIST CONC PAD WILL BE REPAIRED AND EXTENDED PRIOR TO INSTALLATION OF PIPE CASING.
5. ENSURE SOIL COVER/BERM DOES NOT CREATE LOW AREAS WHERE SURFACE WATER CAN ACCUMULATE AND POND.

CONSTRUCTION NOTES

1. INSTALL TYPE F CONCRETE BARRIER PER NEVADA DEPARTMENT OF TRANSPORTATION (NDOT) OR EQUIVALENT. ADDITIONAL BARRIER (NOT SHOWN) WILL BE USED TO BLOCK ACCESS ROADS.
2. INSTALL 3-STRAND PLASTIC COATED WIRE FENCING WITH T-POSTS PER DETAIL 1 SHEET C-5002.
3. PLACE BOUNDARY MONUMENT. FIELD LOCATE.
4. INSTALL CASING PER DETAIL A ON DRAWING C-5001.
5. INSTALL CASING PER DETAIL B ON DRAWING C-5001.
6. INSTALL CASING PER DETAIL C ON DRAWING C-5001.
7. CONSTRUCT PIPE ANCHOR PER DETAIL 2 ON C-5002. FIELD LOCATE. SEE DRAWING C-3002 & C-3003 FOR SPACING REQUIREMENTS.

ESTIMATED QUANTITIES

TOTAL NET FILL = 396.0 CY

GRAPHIC SCALE 0 5 10 20 30 FEET 1" = 10'

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER/USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

PLAYER SITE GRADING PLAN

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

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ENGINEERING NO. 00424 — ORIGINAL SIGNATURES ON FILE

DRAWING NUMBER / WORK ORDER NUMBER: 00424-C-1004

REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001

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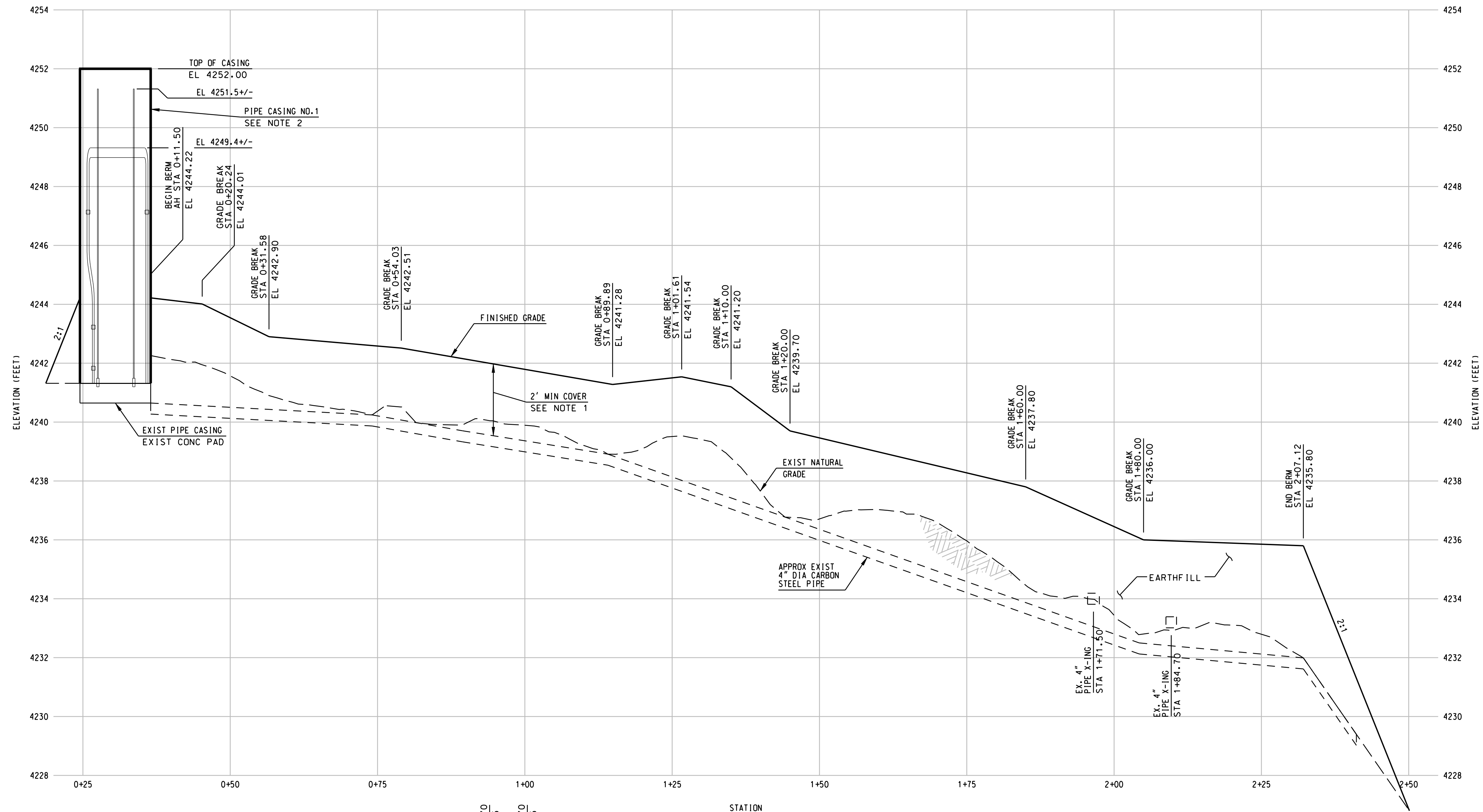


BERM PROFILE ALONG CONTROL LINE 2 (1) C-1003

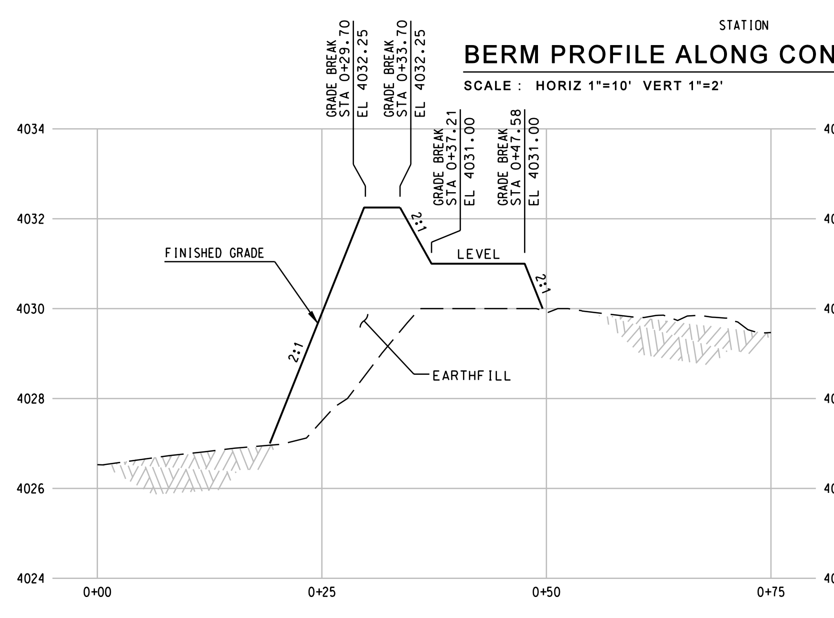
SCALE : HORIZ 1"=10' VERT 1"=2'

NOTES

1. A 2 FOOT HIGH BERM WILL BE CONSTRUCTED OVER THE EXISTING GROUND. DUE TO THE HIGH CONTAMINATION AREA THE DEPTH OF EXISTING COVER COULD NOT BE DETERMINED.
2. INSTALL PIPE CASING PER DETAIL D ON SHEET C-5001.

VERTICAL GRAPHIC SCALE 0 1 2 4 6 FEET 1" = 2'

HORIZONTAL GRAPHIC SCALE 0 5 10 20 30 FEET 1" = 10'



BERM PROFILE ALONG CONTROL LINE 1
STA 0+00.00 TO STA 0+75.00 (2) C-1002

SCALE : HORIZ 1"=10' VERT 1"=2'

GINO V. NGUYEN CIVIL No 20062 PROFESSIONAL ENGINEER STATE OF NEVADA

7-20-11

ISSUED FOR CONSTRUCTION

GS

NO	DATE	REVISIONS	DRAWN	PREPARER	CHECKER	PROJ ENGR	APPROVER USER

NATIONAL NUCLEAR SECURITY ADMINISTRATION
NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

TEJON SITE & MULLET SITE BERM PROFILE

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/s/ Signature on File 6/6 DATE	/s/ Signature on File 6/6 DATE	/s/ Signature on File 7/19 DATE	/s/ Signature on File 6/6 DATE	DATE

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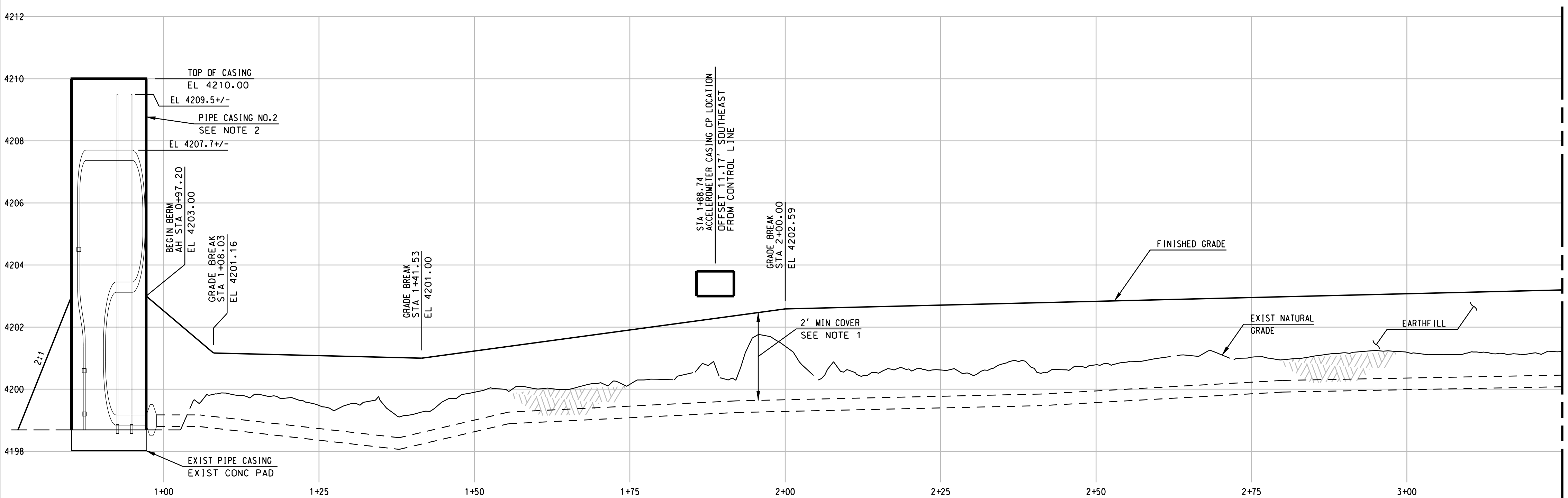
ENGINEERING NO. 00424 — ORIGINAL SIGNATURES ON FILE

DRAWING NUMBER / WORK ORDER NUMBER: 00424-C-3001 — REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001



BERM PROFILE ALONG CONTROL LINE 3 (1 / C-1004)

SCALE : HORIZ 1"=10' VERT 1"=2'

NOTES

1. A 2-FOOT HIGH BERM WILL BE CONSTRUCTED OVER THE PIPELINE OR APPURTENANT STRUCTURES. THE BERM HEIGHT MAY EXCEED 2 FEET WHERE THE TOPOGRAPHY HAS GULLIES AND MOUNDS.
2. INSTALL PIPE CASING PER DETAIL A ON SHEET C-5001.
3. CONSTRUCT PIPE ANCHOR PER DETAIL 2 ON SHEET C-5002. FIELD LOCATE. AT A MINIMUM PLACE ANCHORS 10 FEET ON CENTER WHERE UNSUPPORTED LENGTH EXCEEDS 10 FEET.
4. PIPE IS GENERALLY EXPOSED ALONG CRATER SLOPE. EXISTING NATURAL GRADE LINE REFLECTS VEGETATION ON SURFACE.

VERTICAL GRAPHIC SCALE: 0 1 2 4 6 FEET, 1" = 2'

HORIZONTAL GRAPHIC SCALE: 0 5 10 20 30 FEET, 1" = 10'

GS

GINO V. NGUYEN, CIVIL, NO 20082 — PROFESSIONAL ENGINEER, STATE OF NEVADA

7-20-11

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CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

PLAYER SITE BERM PROFILE AH STA 0+97.20 TO STA 4+90.00

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DRAWING NUMBER / WORK ORDER NUMBER 00424-C-3002
REVISION 0

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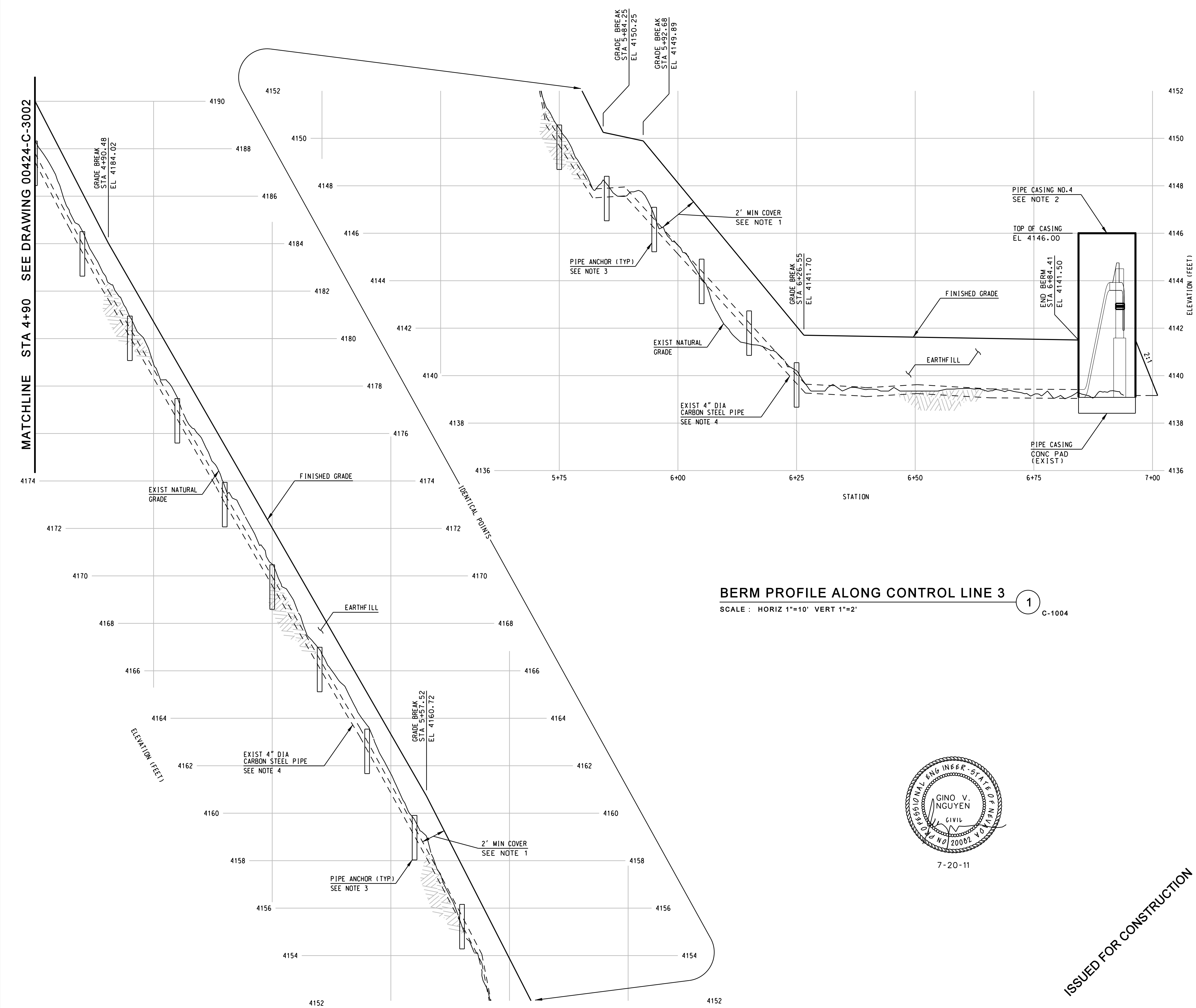

BERM PROFILE ALONG CONTROL LINE 3 (1) C-1004

SCALE : HORIZ 1"=10' VERT 1"=2'

NOTES

1. A 2-FOOT HIGH BERM WILL BE CONSTRUCTED OVER THE PIPELINE OR APPURTENANT STRUCTURES. THE BERM HEIGHT MAY EXCEED 2 FEET WHERE THE TOPOGRAPHY CONTAINS GULLIES AND MOUNDS.
2. INSTALL PIPE CASING PER DETAIL C ON SHEET C-5001.
3. CONSTRUCT PIPE ANCHOR 10 FEET ON CENTER PER DETAIL 2 ON SHEET C-5002. FIELD LOCATE. AT A MINIMUM PLACE ANCHORS 10-FEET ON CENTER WHERE UNSUPPORTED LENGTH EXCEEDS 10-FEET.
4. PIPE IS GENERALLY EXPOSED ALONG CRATER SLOPE. EXISTING NATURAL GRADE LINE REFLECTS VEGETATION ON SURFACE.

VERTICAL GRAPHIC SCALE 0 1 2 4 6 FEET 1" = 2'

HORIZONTAL GRAPHIC SCALE 0 5 10 20 30 FEET 1" = 10'

GS

GINO V. NGUYEN CIVIL No 20082 PROFESSIONAL ENGINEER STATE OF NEVADA

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CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES

TEJON, MULLET AND PLAYER

PLAYER SITE BERM PROFILE

STA 4+90.00 TO STA 6+84.41

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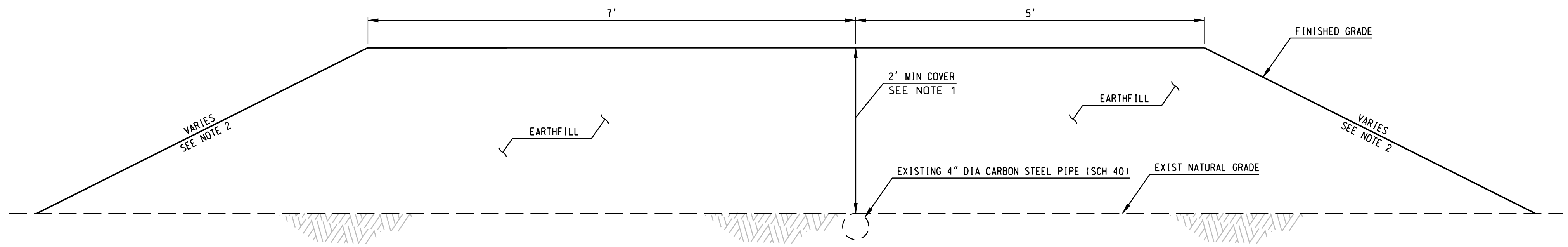
DRAWING NUMBER / WORK ORDER NUMBER: 00424-C-3003 — REVISION 0

FOR REFERENCE DRAWINGS SEE 00424-G-0001

NOTES

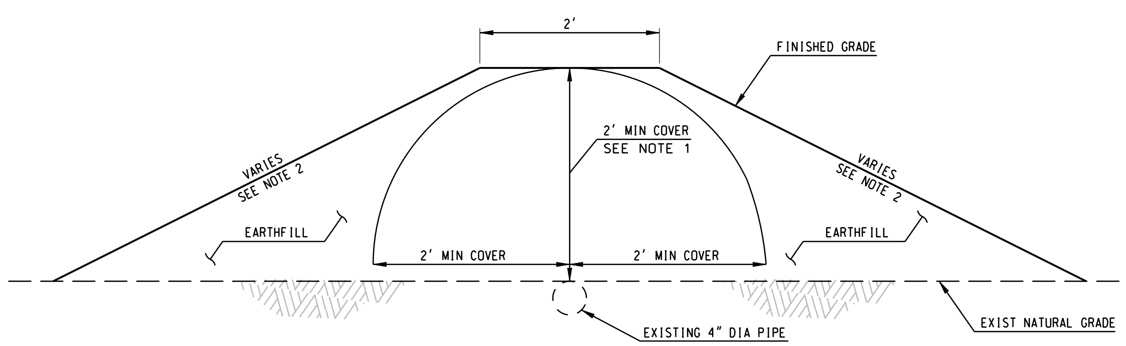
1. A 2-FOOT HIGH BERM WILL BE CONSTRUCTED OVER THE PIPELINE OR APPURTENANT STRUCTURES. THE BERM HEIGHT MAY EXCEED 2 FEET WHERE THE TOPOGRAPHY HAS GULLIES AND MOUNDS.

2. BERM SLOPE VARIES BETWEEN 3:1 AND EXISTING GRADE. TYPICAL SLOPE IS 2:1.



TYPICAL SECTION (MULLET ONLY) (B) C-1003

SCALE : HORIZ 1"=1' VERT 1"=1'



TYPICAL SECTION (A) C-1002 C-1003 C-1004

SCALE : HORIZ 1"=1' VERT 1"=1'

VERTICAL GRAPHIC SCALE 0 0.5 1 2 3 FEET — 1" = 1'

HORIZONTAL GRAPHIC SCALE 0 0.5 1 2 3 FEET — 1" = 1'

GS

PROFESSIONAL ENGINEER - STATE OF NEVADA — GINO V. NGUYEN — CIVIL — No 20082

7-20-11

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CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES

TEJON, MULLET AND PLAYER

TYPICAL BERM SECTIONS

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
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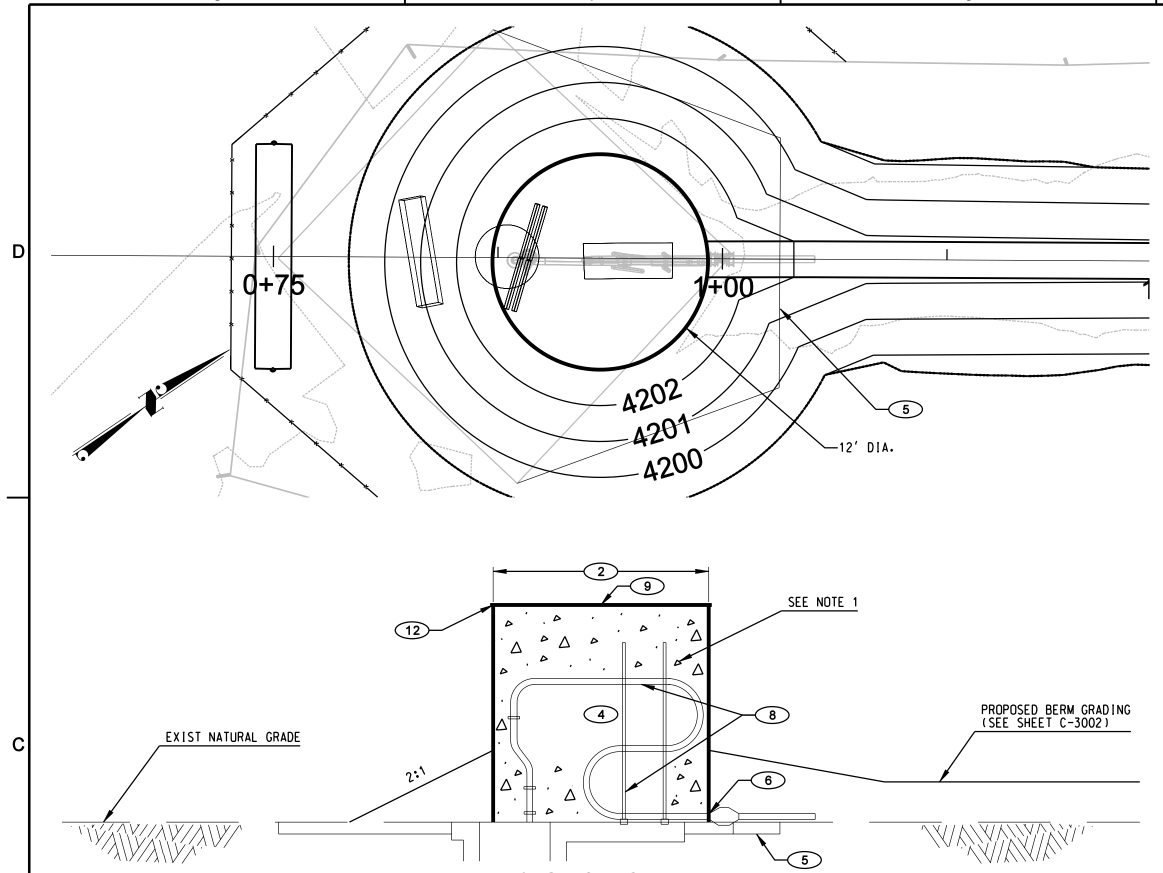
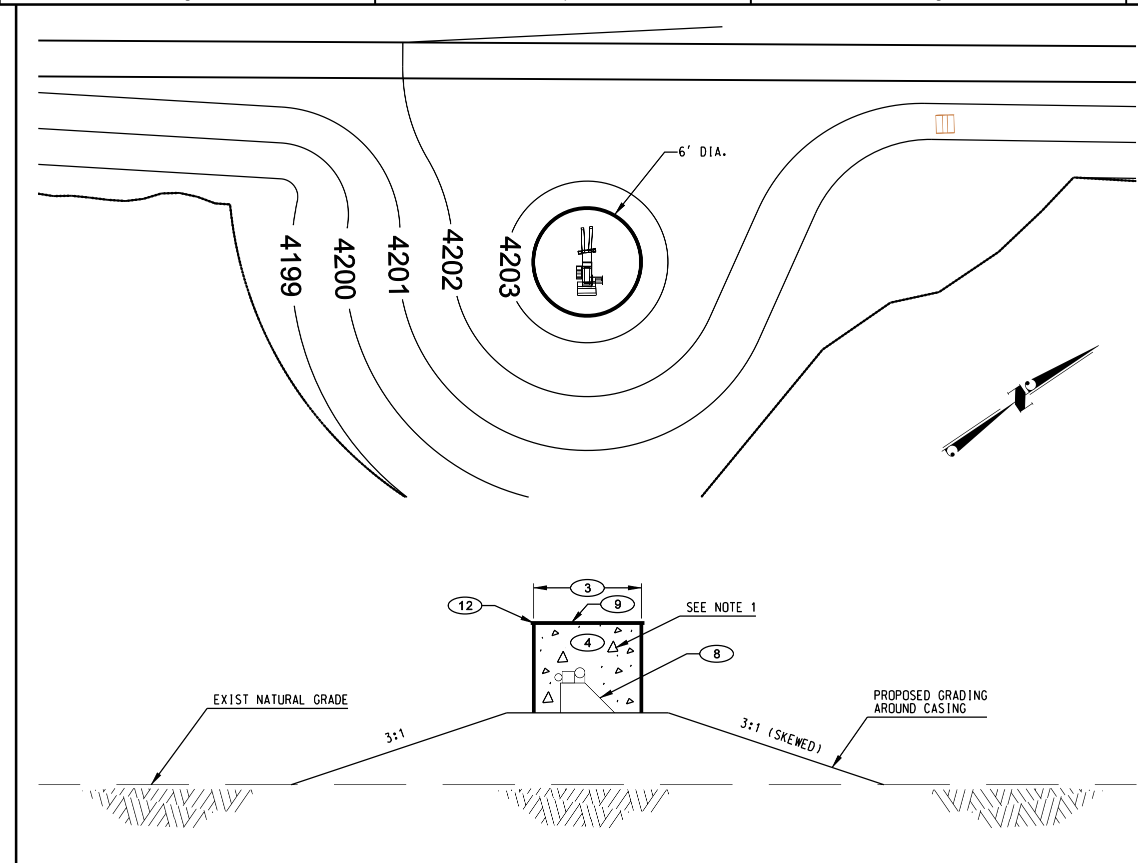


PLAN DETAIL & SECTION
PLAYER SITE CASING NO. 2 (A) C-3002
SCALE : 1"=5'



PLAN DETAIL & SECTION
PLAYER SITE CASING NO. 3 (B) C-1004
SCALE : 1"=5'

GENERAL NOTES

1. CONC BACKFILL TYPE II NEAT PORTLAND CEMENT. NSTEC SPECIFICATIONS.
2. LIFTING EYES WILL BE INSTALLED TO MOVE AND INSTALL CASINGS.

CONSTRUCTION NOTES

(1) NOT USED

(2) INSTALL MIN 12' DIA x 12' HIGH x 1/2" THICK WELDED STEEL PIPE CASING.

(3) INSTALL MIN 6' DIA x 5' HIGH x 1/2" THICK WELDED STEEL PIPE CASING.

(4) CONC BACKFILL SHALL BE PLACED IN CASING IN MAXIMUM LIFT DEPTHS OF 6 FEET. ALLOW 24 HOURS BETWEEN LIFTS.

(5) EXIST CONC PAD TO BE REPAIRED AND EXTENDED PRIOR TO INSTALLATION OF PIPE CASING.

(6) NOTCH CASING TO ALLOW ROOM FOR EXISTING 4" HORIZONTAL PIPE. PROVIDE MINIMUM 6" CLEARANCE ON EACH SIDE OF OPENING. NOTCH SHALL BE SMOOTH AND FREE OF LARGE BURRS OR GOUGES.

(7) SECURE EXISTING PIPE WITH PERFORATED GALVANIZED STEEL STRAP.

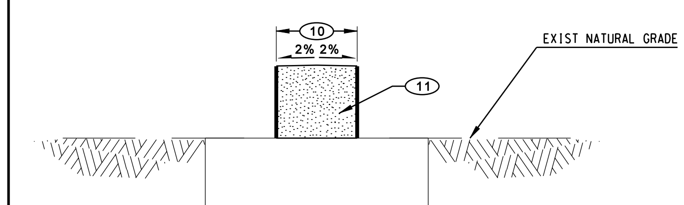
(8) EXISTING PIPE AND APPURTENANCES TO BE PROTECTED IN PLACE DURING CONSTRUCTION.

(9) INSTALL 1/2" THICK STEEL COVER WITH MINIMUM 2" OVERHANG. WELD CONTINUOUSLY AROUND CASING.

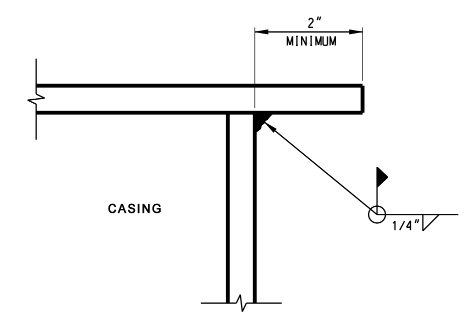
(10) INSTALL MIN 3' DIA x 4' HIGH x 1/2" THICK WELDED STEEL PIPE CASING.

(11) EARTHFILL, NO COMPACTION.

(12) WELD CAP TO CASING AS FOLLOWS:
1. WELDS SHALL CONFORM TO AWS D1.1/D1.1M STRUCTURAL WELDING CODE STEEL (LATEST EDITION).
2. REPAIR WELDS FOUND DEFECTIVE IN ACCORDANCE WITH AWS D1.1.5.26.
3. WHERE CONTINUOUS WELDS ARE SHOWN ON DRAWINGS, USE INTERMITTMENT WELDS PRIOR TO CONTINUOUS WELD TO AVOID WARPING.
4. SEE DETAIL BELOW FOR WELD INSTRUCTIONS.



SECTION
TEJON SITE CASING NO. 1 (E) C-1002
SCALE : 1"=5'



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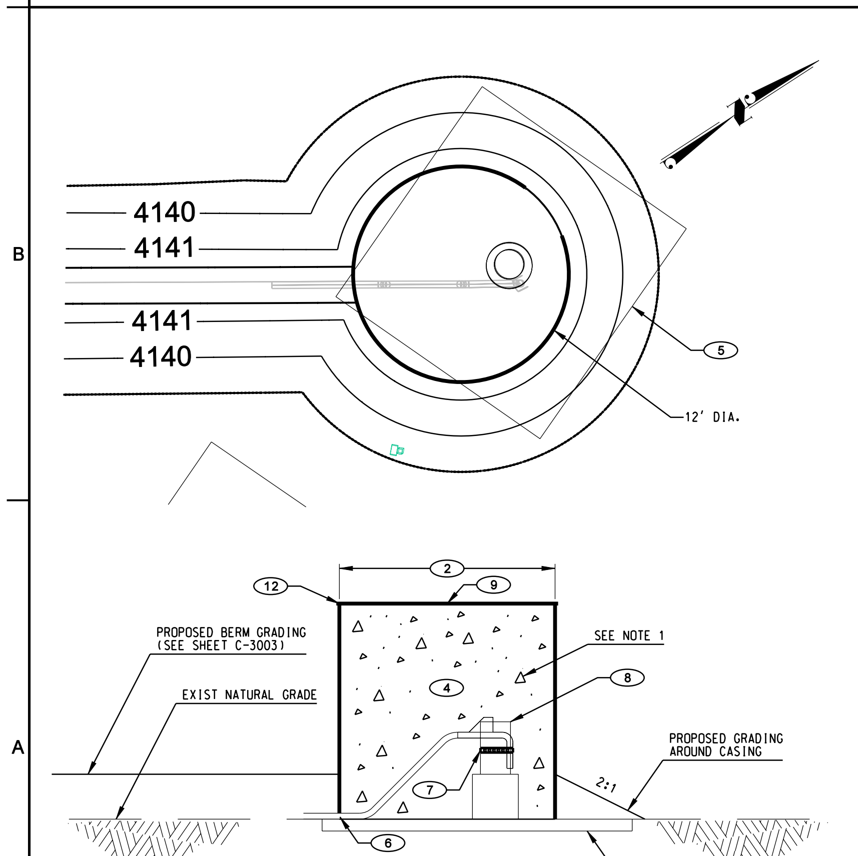
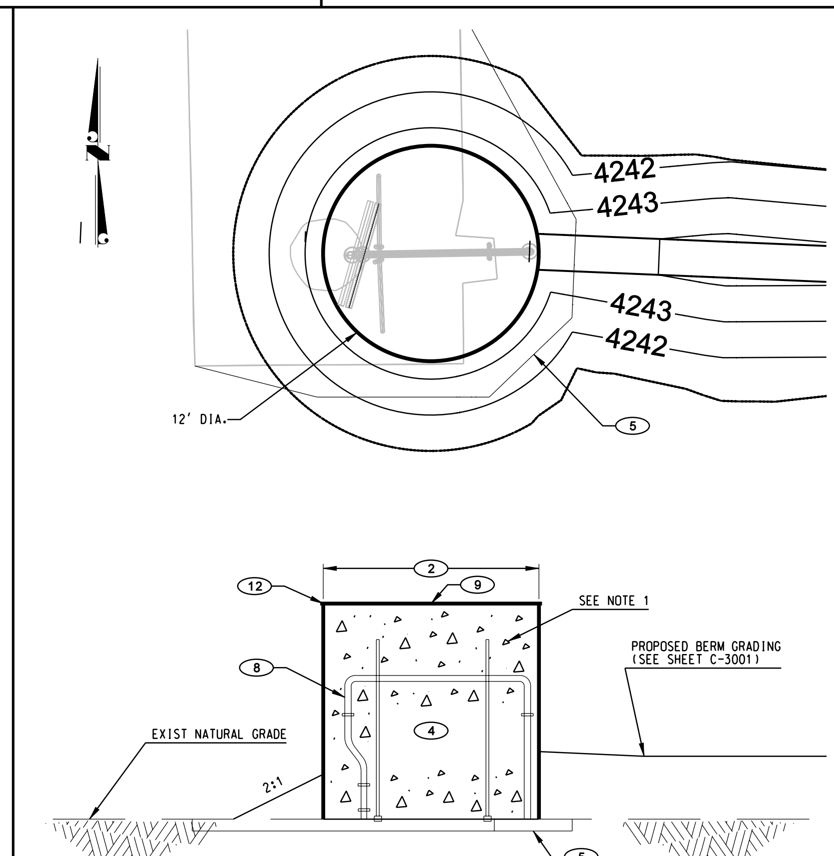


PLAN DETAIL & SECTION
PLAYER SITE CASING NO. 4 (C) C-3003
SCALE : 1"=5'



PLAN DETAIL & SECTION
MULLET SITE CASING NO. 1 (D) C-3001
SCALE : 1"=5'

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GINO V. NGUYEN
CIVIL
NO 20062
7-20-11

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NEVADA NATIONAL SECURITY SITE — AREA 2,3,9
CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES
TEJON, MULLET AND PLAYER

PIPE CASING DETAILS

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
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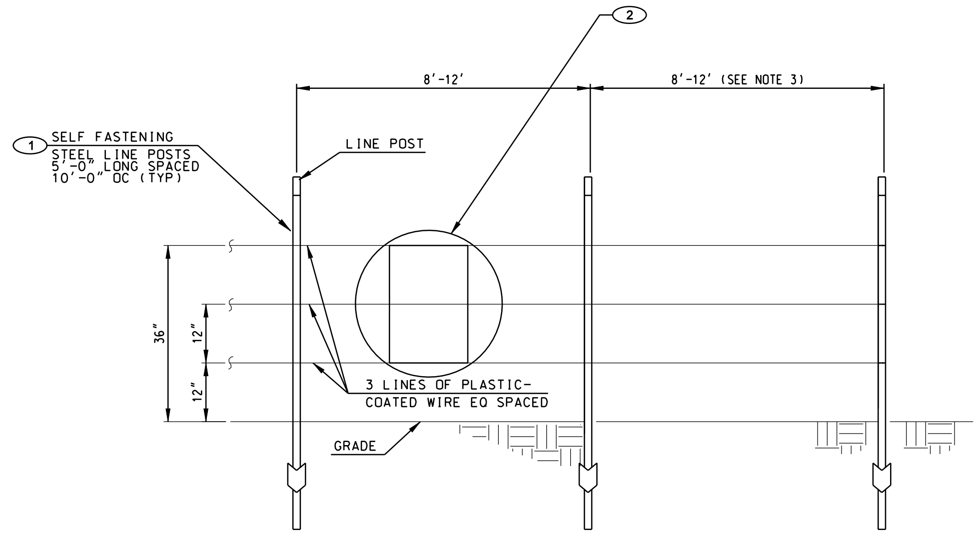
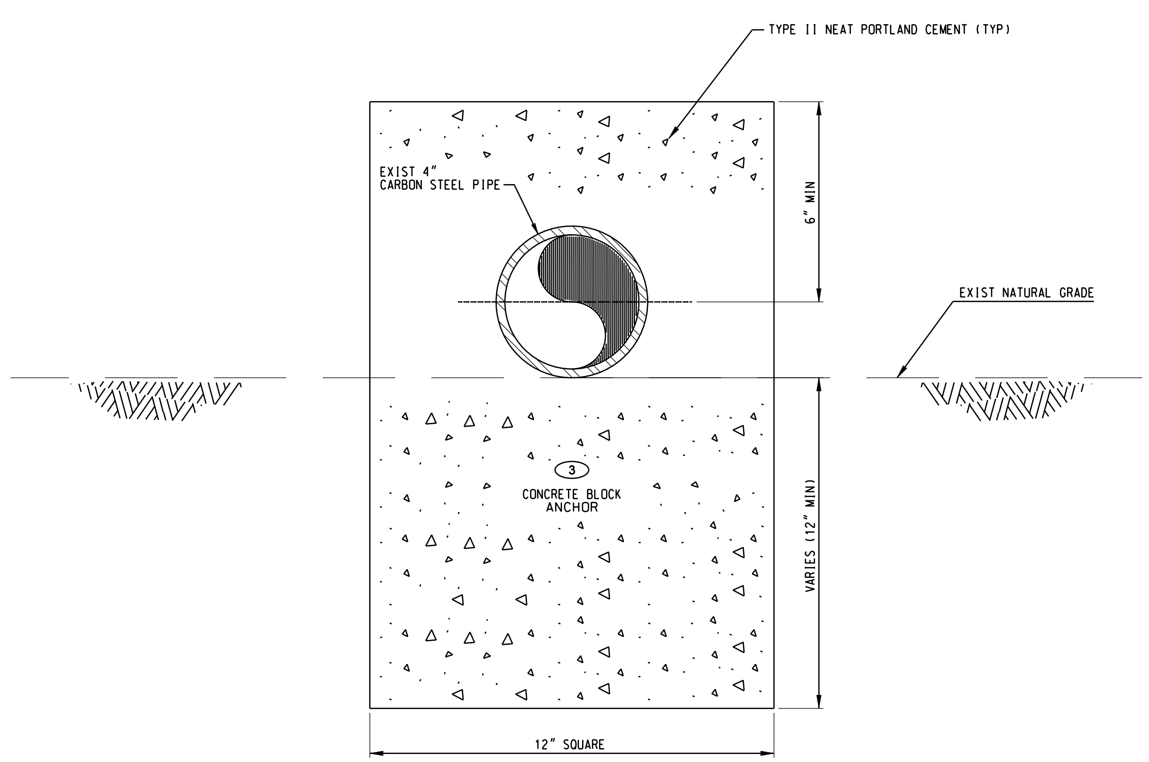


3 STRAND PLASTIC COATED SMOOTH WIRE FENCE (1)

SCALE : NTS

C-1002
C-1003
C-1004



PIPE ANCHOR DETAIL (2)

SCALE : NTS

C-1004
C-3002
C-3003

GENERAL NOTES

1. FENCING SHALL MEET THE REQUIREMENTS OF THIS DRAWING.
2. ALL FENCING COMPONENTS SHOWN ARE NOMINAL.
3. T-POST SPACING TO BE NO LESS THEN 8' BUT NO MORE THAN 12'.
4. SECURE WIRE TO T-POSTS AND PULL AROUND CORNER POST WITH ENOUGH TENSION TO AVOID SAGGING.
5. SECURE SIGN TO WIRE WITH #9 WIRE.

CONSTRUCTION NOTES

(1) FENCING WIRE SHALL BE VINYL COATED COMMERCIAL GRADE, 7 x 7 STRAND CORE, 3/32 INCH (GAGE), 3/16 GALVANIZED STEEL WIRE ROPE WITH A MINIMUM OF 920 LBS BREAKING STRENGTH.

(2) SIGNS TO BE FIELD LOCATED.

(3) CONSTRUCT CONCRETE PIPE ANCHORS. FIELD LOCATE. EMBED ANCHOR A MINIMUM 12" INTO GROUND. SPACE ANCHORS 10-FEET MINIMUM OVER UNSUPPORTED PIPE AT LEAST 10-FEET IN LENGTH.

PROFESSIONAL ENGINEER - STATE OF NEVADA - GINO V. NGUYEN - CIVIL - NO 20082

7-20-11

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NATIONAL NUCLEAR SECURITY ADMINISTRATION

NEVADA SITE OFFICE — LAS VEGAS, NEVADA

NEVADA NATIONAL SECURITY SITE — AREA 2,3,9

CORRECTIVE ACTION UNIT 547 CONTAMINATED WASTE SITES

TEJON, MULLET AND PLAYER

DETAILS

DRAWN	PREPARER	CHECKER	PROJECT ENGINEER	APPROVER / USER
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Appendix 2
Construction Specifications

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NEVADA NATIONAL SECURITY SITE

NNSS CAU 547

CONSTRUCTION SPECIFICATION

Document No. **00424-SPC-01**

Revision **0**

100% Submittal

QG-3

Preparer: /s/ Robert M. Henderson Date: 7/18/11 Checker: /s/ Janet Goodrich Date: 07/18/11
Robert M. Henderson, P.E. Janet Goodrich, P.E.

Project Engineer: /s/ Gino Nguyen Date: 07/18/11
Gino Nguyen, P.E.

Approver: ______ Date: ______
Julie Sorola, P.E.

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TABLE OF CONTENTS

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SECTION 31 23 23
FILL AND BACKFILL

PART 1 GENERAL

1.01 REFERENCES

A. The following is a list of standards which may be referenced in this section:

1. ASTM International (ASTM):
    a. C117, Standard Test Method for Materials Finer Than 75-Micrometers (No. 200) Sieve in Mineral Aggregates by Washing.
    b. C136, Standard Method for Sieve Analysis of Fine and Coarse Aggregates.
    c. D75, Standard Practice for Sampling Aggregates.
    d. D1556, Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method.
    e. D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3)).
    f. D6938, Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.02 DEFINITIONS

A. Optimum Moisture Content:

1. Determined in accordance with ASTM Standard specified to determine maximum dry density for relative compaction.
2. Determine field moisture content on basis of fraction passing 3/4-inch sieve.

B. Prepared Ground Surface: Ground surface after completion of required demolition, clearing and grubbing, scalping of sod, stripping of topsoil, excavation to grade, and subgrade preparation.

C. Completed Course: A course or layer that is ready for next layer or next phase of Work.

D. Lift: Loose (uncompacted) layer of material.

E. Well-Graded:

1. A mixture of particle sizes with no specific concentration or lack thereof of one or more sizes.
2. Does not define numerical value that must be placed on coefficient of uniformity, coefficient of curvature, or other specific grain size distribution parameters.
3. Used to define material type that, when compacted, produces a strong and relatively incompressible soil mass free from detrimental voids.

F. Influence Area: Area within planes sloped downward and outward at 60-degree angle from horizontal measured from:

1. 1 foot outside outermost edge at base of foundations or slabs.
2. 1 foot outside outermost edge at surface of roadways or shoulder.
3. 0.5 foot outside exterior at spring line of pipes or culverts.

G. Borrow Material: Material from required excavations or from designated borrow areas on or near Site.

1.03 SUBMITTALS

A. Test results of In-Place Density tests.

B. Results from all compaction tests.

C. As-built surveys and drawings showing final lines and grades.

1.04 QUALITY ASSURANCE

A. Notify Engineer when:

1. Structure is ready for backfilling, and whenever backfilling operations are resumed after a period of inactivity.
2. Soft or loose subgrade materials are encountered wherever embankment or site fill is to be placed.
3. Fill material appears to be deviating from Specifications.

PART 2 PRODUCTS

2.01 EARTHFILL

A. Excavated material from Borrow Area 3, free from rocks larger than 3 inches, from roots and other organic matter, ashes, cinders, trash, debris, and other deleterious materials.

B. Well-graded from coarse to fine and containing sufficient fines to bind material when compacted, but with maximum 65 percent by weight passing the No. 10 sieve and maximum 15 percent by weight passing No. 200 sieve.

2.02 CONCRETE BACKFILL FOR STEEL PIPE CASING

A. Mix: ASTM C94/C94M, Option A.

1. Cement: ASTM C150, Portland Type II NEAT.
2. Coarse Aggregate Size: 3/4 inch.
3. Design for Minimum Compressive Strength at 28 Days: 4,000 psi.

2.03 WATER FOR MOISTURE CONDITIONING

A. Free of hazardous or toxic contaminates, or contaminants deleterious to proper compaction.

PART 3 EXECUTION

3.01 GENERAL

A. Keep placement surfaces free of water, debris, and foreign material during placement and compaction of fill and backfill materials.

B. Place and spread fill and backfill materials in horizontal lifts of uniform thickness, in a manner that avoids segregation, and compact each lift to specified densities prior to placing succeeding lifts. Slope lifts only where necessary to conform to final grades or as necessary to keep placement surfaces drained of water.

C. Do not place fill or backfill, if fill or backfill material is frozen, or if surface upon which fill or backfill is to be placed is frozen.

D. Tolerances:

1. Final Lines and Grades: Provide fill and backfill to dimensions and grades as shown in the plans, adequate to achieve minimum of 2.0 feet of cover above the existing ground or the exposed top of pipe.
2. Grade to establish and maintain slopes and drainage as shown. Reverse slopes are not permitted.

E. Settlement: Correct and repair any subsequent damage to structures, pavements, curbs, slabs, piping, and other facilities, caused by settlement of fill or backfill material.

F. Backfill with earthfill to lines and grades shown. Place in lifts of 6-inch maximum thickness and compact each lift to minimum 90 percent relative compaction as determined in accordance with ASTM D1557.

G. Use only hand operated compaction equipment or other equipment that will not damage existing carbon steel pipe and appurtenances.

3.02 BERM EMBANKMENT FILL

A. Outside Influence Areas beneath Structures, Piping, and Other Facilities: Unless otherwise shown, place earthfill as follows:

1. Place and compact fill across full width of embankment.
2. Compact to minimum 90 percent relative compaction as determined in accordance with ASTM D1557.

B. Concrete Backfill in Pipe Casing:

1. Do not allow dirt or foreign material to become mixed with concrete during placement.
2. Allow sufficient time for concrete to reach initial set before additional concrete is placed in pipe casing.
3. Prevent flotation of pipe.

C. Concrete Pipe Anchors:

1. Allow 7 days of cure time for anchors to achieve 80 percent of its compressive strength prior to berm construction activities.

3.03 SITE TESTING

A. Gradation:

1. Remove material placed in Work that does not meet Specification requirements based on visual inspection at the Borrow Area.

B. In-Place Density Tests: In accordance with ASTM D6938. During placement of materials, test as follows:

1. Earth Fill.
2. Frequency. One in-place density test shall be performed for every 250 linear feet of fill placed.
3. Compaction: Minimum compaction shall be 90% relative compaction in accordance with ASTM D1557.

END OF SECTION

Appendix 3
Calculations

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Site-Specific Erosion Calculations

Wind Erosion Calculations

This section includes wind erosion calculations for the TEJON, MULLET, and PLAYER sites of Corrective Action Unit (CAU) 547, Nevada National Security Site, Nevada. Calculations were based off of design criteria for the construction of 2-foot thick earthen berms over radiologically contaminated pipeline and structures. Separate calculations are provided for each individual site.

Water Erosion Calculations

Calculations for water erosion effects were not deemed necessary for the TEJON, MULLET, and PLAYER sites. Site visits by CH2M HILL staff in early May 2011 yielded observations that no water erosion rills were present. Additionally, existing berms at other sites have held up well over the last 50 years. Erosion of the berms by wind forces are more likely anticipated and will be periodically repaired per the Operations and Maintenance Plan.

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WIND EROSION CALCULATIONS (TEJON SITE)

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

Purpose of Calculation

This calculation provides an estimate of soil loss due to wind erosion over the designed cover surfaces at the TEJON site.

Affected Documents

Document No.	Rev No.	Document Title

Software

Software Name	Version

Derivative Classification

Signoffs and Approval

Preparer:	**Sign**	/s/ Jennifer McRae	**Date:** 07/15/11
	Print	Jennifer McRae	
Checker: ("N/A" if Peer Review is Required)	**Sign**	/s/ Jennifer Krenz-Ruark	**Date:** 07/18/11
	Print	Jennifer Krenz-Ruark	
Peer Reviewer: (Required for NPH)	**Sign**		**Date:**
	Print		
Approver:	**Sign**	/s/ Gino Nguyen	**Date:** 07/18/11
	Print	Gino Nguyen	

Attachments

Attachment	Title	Pages
A	Soil Ridge Roughness, Soil Erodibility, and Knoll Erodibility Factors	A1-A6
B	Geotechnical Test Results for Area 3 RWMS	B1-B6
C	USDA Wind Erosion Charts	C1-C6
D	Armoring Calculations	D1-D4

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WIND EROSION CALCULATIONS (TEJON SITE)

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

1. Purpose and Objective

This calculation estimates the amount of soil erosion that will be caused by wind on final graded areas for the TEJON site, within the Area 3 Radioactive Waste Management Site (RWMS). It estimates annual erosion and long-term erosion for the proposed design life of the barriers of 1,000 years, using the Wind Erosion Equation (WEQ). The development of a desert pavement from gravels within the cover material is also assessed to estimate the total thickness of cover erosion before a stable surface is developed.

2. Basis

The engineered surface barrier will be constructed using interim cover soils (excess operational covers) and additional engineered fill. The berms will consist of 2 feet total soil thickness over exposed piping and other site structures.

2.1 Design Inputs

Estimates of potential losses due to wind erosion were performed using the Wind Erosion Equation (WEQ), which is presented in the "Methods" section of this document. The factors used in this equation were estimated for the barrier surface as follows:

Soil Erodibility Factor (I)
The soil erodibility factor (I) represents the potential annual wind erosion in tons per acre per year for a given soil on an isolated, level, smooth, unsheltered, wide, and bare field with a non-crusted surface for climatic factor of 100 percent. This factor depends on soil texture (e.g., crusted or non-crusted) and percentage of dry soil retained on U.S. Standard Sieve No. 20. Adjustment factors are used for knoll configuration, and are a function of the slope inclination of the cover. Soil information for the No. 20 sieve was not available for the stockpiled soil, so the percentage of dry soil retained on a No. 10 sieve was used in its place. Because soil from the Area 3 Borrow Pit will be used to construct the berms, Area 3 soil characteristics have been incorporated into the erosion calculations.

From Table 1, the fraction of coarse sand and gravel particles retained on the No. 10 (2.00 mm) sieve is 38 percent.

From Table A-1, with a soil fraction coarser than the No. 10 sieve of 38 percent, an I value was approximated as follows:

Soil Erodibility Factor (I) = 60 tons/acre/year

The Knoll Erodibility Adjustment Factor, A, was used in Table A-2. No factor should be applied for slopes 2% or less (NRCS, 2002).

Adjusted I for 50% slope = 60 x 3.6 = 216 tons/acre/year

Adjusted I for 3.5% slope = 60 x 1.6 = 96 tons/acre/year

Soil data is included in Attachment B.

WIND EROSION CALCULATIONS (TEJON SITE)

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

Ridge Roughness Factor (K)
The ridge roughness factor (K) applies to soil surfaces that are exposed to recurring agricultural practices (e.g., plowing, planting, disking, and harrowing) and is a function of soil ridge roughness (or height). No agricultural activities are planned for the barriers, thus the ridge roughness factor is assumed to be one.

The Ridge Roughness Factor (K) was determined by applying these assumptions as shown in Figure A-1.

K = 1.0 (for the lifetime of the barrier)

Climatic Factor (C)
The climatic factor (C) is an index of climatic erosivity, specifically wind speed and surface soil moisture. The factor for any given location is based on long-term climatic data and is expressed as a percentage of the C factor for Garden City, Kansas, which has been assigned a value of 100. A site-specific C factor was calculated for the project

The climatic factor (C) equation is expressed as:

$$C = 34.48 \times \frac{V^3}{(PE)^2}$$

where:

C = annual climatic factor
V = average annual wind velocity (miles/hour)
PE = precipitation-effectiveness index of Thornthwaite
34.48 = constant used to adjust local values to a common base (Garden City, Kansas)

$$PE = \sum_{Jan}^{Dec} 115 \times \left[\frac{P}{T-10}\right]^{10/9}$$

where:

PE = annual precipitation effectiveness index
P = average monthly precipitation (inches) (minimum of 0.5)
T = average monthly temperature (°F)

BJY Meteorological Data

Month	Average Precipitation (inches)	Average Temperature (°F)
January	0.83	38.7
February	0.94	43.1
March	0.76	48.2
April	0.36	54.4
May	0.36	62.7
June	0.24	71.0
July	0.50	77.9
August	0.62	76.3

September	0.35	68.9
October	0.32	58.6
November	0.50	45.9
December	0.56	38.9

Source: Soule, 2006

BJY Wind Data

Month	Average Wind Speed (knots)	Average Wind Speed (miles/hour)
January	6.7	7.71
February	7.4	8.52
March	7.9	9.09
April	8.6	9.90
May	8.5	9.78
June	8.3	9.55
July	7.8	8.98
August	7.3	8.40
September	7.1	8.17
October	6.8	7.83
November	6.9	7.94
December	6.8	7.83
Average	7.51	8.64

Source: Soule, 2006

Velocity = 8.64 miles/hour

The calculated climatic factor (C) = 136.5

Slope Length Factor (L)

The unsheltered or unbroken field length of slope (L) can be obtained from the design geometry of the cover. This value is normally taken as the longest unbroken slope length of the cover.

The L values from the final grading plan range between 7 feet with an inclination of 50% and 200 feet with an inclination of 3.5%.

Vegetative Factor (V)

The vegetative factor (V) dictates the erosion value. The vegetative factor is calculated as a flat small grain equivalent quantity in pound per acre. The cover for the TEJON site is not planned to be vegetated, thus V = 0.

2.2 Criteria

Compute annual average soil loss due to wind erosion using the Wind Erosion Equation and estimating the development of a desert pavement that will resist further erosion.

2.3 Assumptions

- Two areas of cover slope 3.5% and 50%.
- Length of cover slope ranges from 7 feet (for 50% slope) and 200 feet (for 3.5% slope).
- In-place bulk density of cover soil will be achieved with 90% relative compaction.
- Life of barrier is 1,000 years.
- Once enough erosion loss has occurred to completely armor the soil surface with a desert pavement consisting of the gravel contained in cover soils, it is assumed that the barrier surface will have stabilized and will not be subject to significant additional erosion loss by wind or water.
- A stable cover surface is assumed to have developed once a ¾ inch (19mm) thick average gravel layer is armoring the surface.

3. References

Natural Resources Conservation Service (NRCS). 1998. National Agronomy Manual, Subpart G-Exhibits: Wind Erosion Charts. 190-V-NAM.

Natural Resources Conservation Service (NRCS). 2002. National Agronomy Manual, Part 503. 190-V-NAM, 3rd Edition.

Neptune and Company, Inc. 2006. Alluvium Material Properties Specification for the NTS RWMSs. September 21.

Soule, D.A. 2006. SORD Technical Memorandum SORD 2006-3: Climatology of the Nevada Test Site. Special Operations and Research Division, Las Vegas, Nevada. April.

4. Methods

Wind erosion loss was calculated using the Wind Erosion Equation (WEQ). The WEQ was originally developed for agricultural applications by the USDA Agricultural Research Service.

Potential soil loss from the soil surface due to wind erosion (E) is expressed in terms of the estimated average annual soil loss, in tons per acre per year.

$$E = \text{function of } (I, K, C, L, V)$$

The value of E is obtained by interpolation of the Wind Erosion Charts (NRCS, 1998), given the parameters of I, K, C, L, and V, as presented above.

The wind erosion charts used in the interpolation are presented in Attachment C. These charts show the bounding values for the calculated parameters of the Wind Erosion Equation. Thus, the value of E must be interpolated within these charts. Table 2 presents the interpolation tables for the cover material.

5. Results and Conclusions

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

The estimated wind erosion loss for varying slope lengths from 7 to 200 feet and cover slopes of 3.5% and 50% are presented in Table 3. The wind erosion was calculated as 1.77 cm/year on slopes of 50% and 1.39 cm/year on slopes of 3.5%. These results indicate that the estimated soil loss due to wind erosion over the 1,000-year design life of the barriers ranges between 57.99 feet (1,767.61 cm) for a slope of 50% and slope length of 7 feet, to 45.54 feet (1,387.97 cm) for a slope of 3.5% and slope length of 200 feet.

The Wind Erosion Equation and RUSLE methods used in the estimation of soil loss assume static surface conditions that do not change as a result of erosional processes. However, as fines are eroded from the surface layer of the barrier, the surface will become increasingly protected by the remaining gravel armoring. As a result, these methods tend to be overconservative in estimating soil losses. According to the armoring calculation presented in Attachment D, the degradation depth that will create an erosion-resistant gravel-armored surface is 3.1 inches (8 cm). Consequently, this is estimated to be the upper bound of average soil loss due to wind and water erosion forces. Given the Wind Erosion Equation estimates, complete armoring of the barrier surface will occur during the 1,000 year design life of the barrier. To prevent loss of cover thickness, monitoring is proposed over the design life to ensure the minimum of 2 feet will be maintained.

6. Calculations and Analyses

For purposes of illustration, the calculations below outline the conversion from wind erosion loss in ton/acre/year to cover thickness loss in cm. For a slope length of 7 feet and inclination of 50%, the estimated soil loss due to wind erosion is 123.6 tons/acre/year and 97.05 tons/acre/year for a slope length of 200 feet and inclination of 3.5%. For a 1,000 year design life and in-place density of 97.9 lb/ft^3, the total loss (E) is:

For area of slope 50%:
(123.595 tons/acre/yr) x (1,000 yrs) = 123,595 tons/acre

(123,595 tons/acre) x (2,000 lbs/ton) x (1 acre/43,560 ft^2) = 5,674.7 lbs/ft^2

(5,674.7 lb/ft^2)/(97.9 lb/ft^3) = 57.99 ft = 1,767.61 cm

For area of slope 3.5%:
(97.05 tons/acre/yr) x (1,000 yrs) = 97,050 tons/acre

(97,050 tons/acre) x (2,000 lbs/ton) x (1 acre/43,560 ft^2) = 4,455.9 lbs/ft^2

(4,455.9 lb/ft^2)/(97.9 lb/ft^3) = 45.54 ft = 1,387.97 cm

Armoring Calculation
The gravel in the soil will increasingly armor the soil surface from erosive forces as erosion removes soil fines. A simple soil particle volume balance calculation was performed to determine the depth of cover degradation that must occur to create a 19.0 mm thick (mean desert pavement gravel size diameter) gravel layer on the soil surface, assuming all material less than 2 mm in diameter had been removed. These calculations are presented in Attachment D.

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EWR No.:	EWR Title:	
Calc No.: 00424-CAL-001	Calculation Title: Wind Erosion Calculations (TEJON Site)	Rev No.: 0

Table 1. Soil Grain Size Data

Soil Grain Size Data - Mean Percent Passing Indicated Size

3 in	1.5 in	3/4 in	3/8 in	#4	#10	#40	#100	#200
76.2 mm	38.1 mm	19.0 mm	9.52 mm	4.75 mm	2.0 mm	0.425 mm	0.150 mm	0.075 mm
100%	100%	98%	89%	77%	62%	36%	18%	10.9%

(Neptune and Company, 2006)

Soil Grain Size Data (minus 2.0 mm fraction only)

#10	#40	#100	#200
2.0 mm	0.425 mm	0.150 mm	0.075 mm
100%	74%	30%	49%

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-001	Calculation Title: Wind Erosion Calculations (TEJON Site)	Rev No.: 0

Table 2. Wind Erosion Interpolation Tables

Wind Erosion Equation (WEQ)

E = f (I, K, C, L, V)

Where:

E = The estimated average annual soil loss in tons per acre per year due to wind erosion

f = An indication that the equation include functional relationships that are not straight-line mathematical functions

I = Soil erodibility factor

K = Ridge roughness factor

C = Climatic factor

L = Unsheltered distance

V = Vegetation factor

Values of E were interpolated using Wind Erosion Charts, as part of the National Agronomy Manual.

Natural Resources Conservation Service (NRCS). 1998. National Agronomy Manual, Subpart G-Exhibits: Wind Erosion Charts. 190-V-NAM.

50% slope for L=7 ft			
Adjusted I	220	220	216
C	120	150	136.5
K	1	1	1
L	10	10	7
V	0	0	0
E	104.4	139.3	123.595

3.5% slope for L=200 ft			
Adjusted I	104	104	96
C	120	150	136.5
K	1	1	1
L	200	200	200
V	0	0	0
E	84.4	107.4	97.05

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

Table 3. Calculations for Different Cover Slopes and Lengths

Technical Data		
Cover Slope (%)	50.0%	3.5%
Percent Passing Sieve #20[a] (%)	62	62
Length of Cover Slope (ft)	7	200
In-Place Bulk Density of Cover Soil[b] (lb/ft^3)	97.9	97.9
Life of Barrier (years)	1000	1000
Wind Erosion Equation - Parameters & Calculations		
Soil Erodibility Factor (I) (tons/ac/yr)	60	60
Knoll Adjustment Factor	3.6	1.6
Adjusted I (tons/ac/yr)	216.0	96.0
Ridge Roughness Factor (K)		
First Year	1.0	1.0
Subsequent Years	1.0	1.0
Climatic Factor (C)	136.5	136.5
Unsheltered Field Length (L)(ft)	7	200
Vegetative Factor (V)		
Cover Vegetation During the First Year: (lb/ac)	0	0
Cover Vegetation During Subsequent Years: (lb/ac)	0	0
Soil Loss Due to Wind Erosion (E)		
Soil Loss (tons/ac/yr)	123.60	97.05
Soil Loss (cm/yr)	1.768	1.388
Total Loss During Design Life 1,000 years of Cover (tons/ac)	123,595	97,050
Total Loss During Design Life 1,000 years of Cover (lb/ft^2)	5,674.70	4,455.92
Total Loss Expressed as Thickness of Cover Soil (ft)	57.99	45.54
Total Loss Expressed as Thickness of Cover Soil (cm)	1,767.61	1,387.97

Notes:

[a] Data for percent passing No. 10 sieve was used since data was not available for a No. 20 sieve.

[b] Assumed to be 90% relative compaction of existing site soils.

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Attachment A

Soil Ridge Roughness, Soil Erodibility, and Knoll Erodibility Factors

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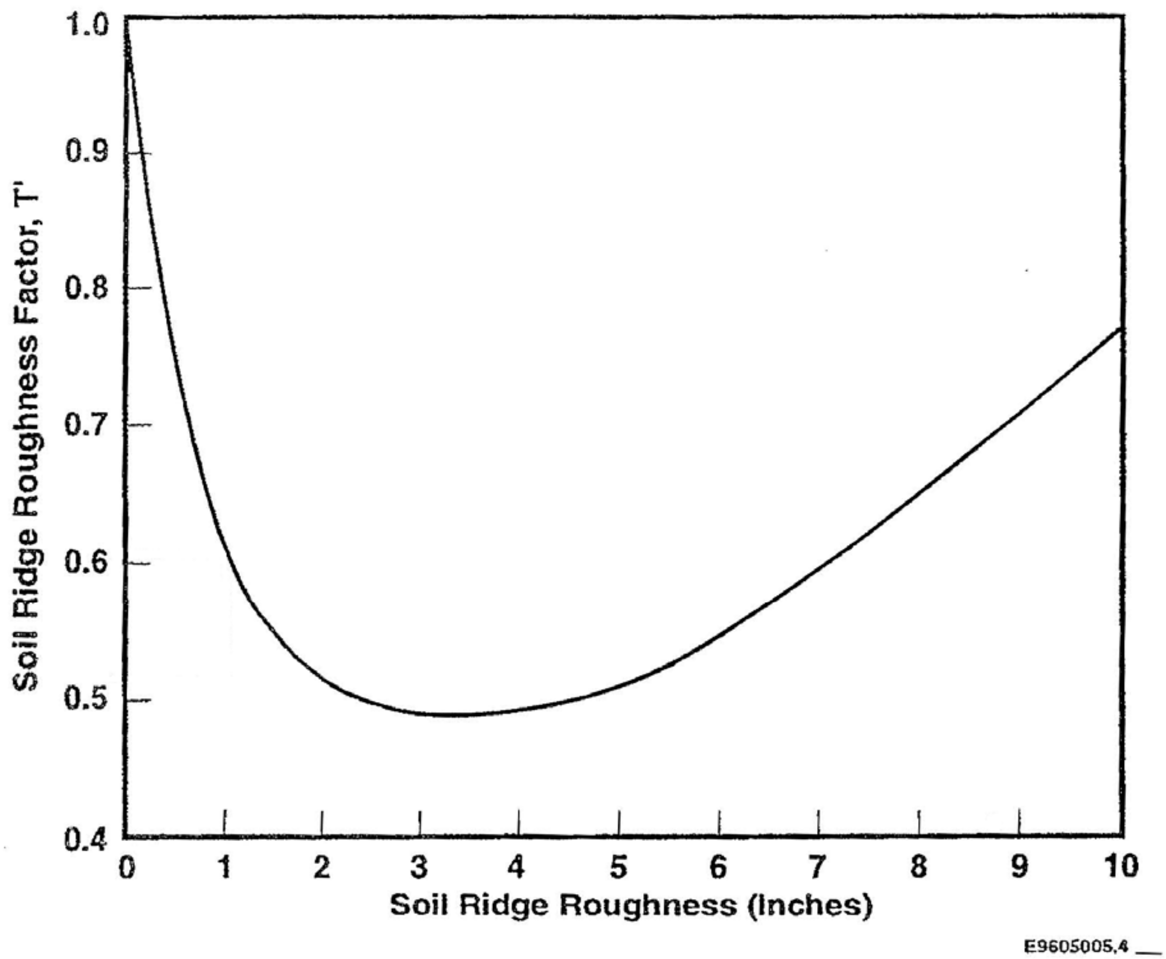
Figure ~~D-2~~ A-1 Soil Ridge Roughness Factor K from Actual Soil Ridge Roughness (EPA 1979).



EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

Table A-1. Soil Erodibility Index "I"

Soil erodibility index in tons/acre determined by percentage of nonerodible fractions

Percent of dry soil not passing a #20 screen	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Tens	Noncrusted soil surface (tons/acre)									
0	—	310	250	220	195	180	170	160	150	140
10	134	131	128	125	121	117	113	109	106	102
20	98	95	92	90	88	86	83	81	79	76
30	74	72	71	69	67	65	63	62	60	58
40	56	54	52	51	50	48	47	45	43	41
50	38	36	33	31	29	27	25	24	23	22
60	21	20	19	18	17	16	16	15	14	13
70	12	11	10	8	7	6	4	3	3	2
80	2	—	—	—	—	—	—	—	—	—

(Adapted from NRCS, 2002)

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

Table A-2. Knoll Erodibility Adjustment Factor for "I"

	A	B
Percent slope change in prevailing wind erosion direction	Knoll adjustment of I	Increase at crest area where erosion is most severe
3	1.3	1.5
4	1.6	1.9
5	1.9	2.5
6	2.3	3.2
8	3.0	4.8
≥ 10	3.6	6.8

(Adapted from NRCS, 2002)

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Attachment B

Geotechnical Test Results for Area 3 RWMS

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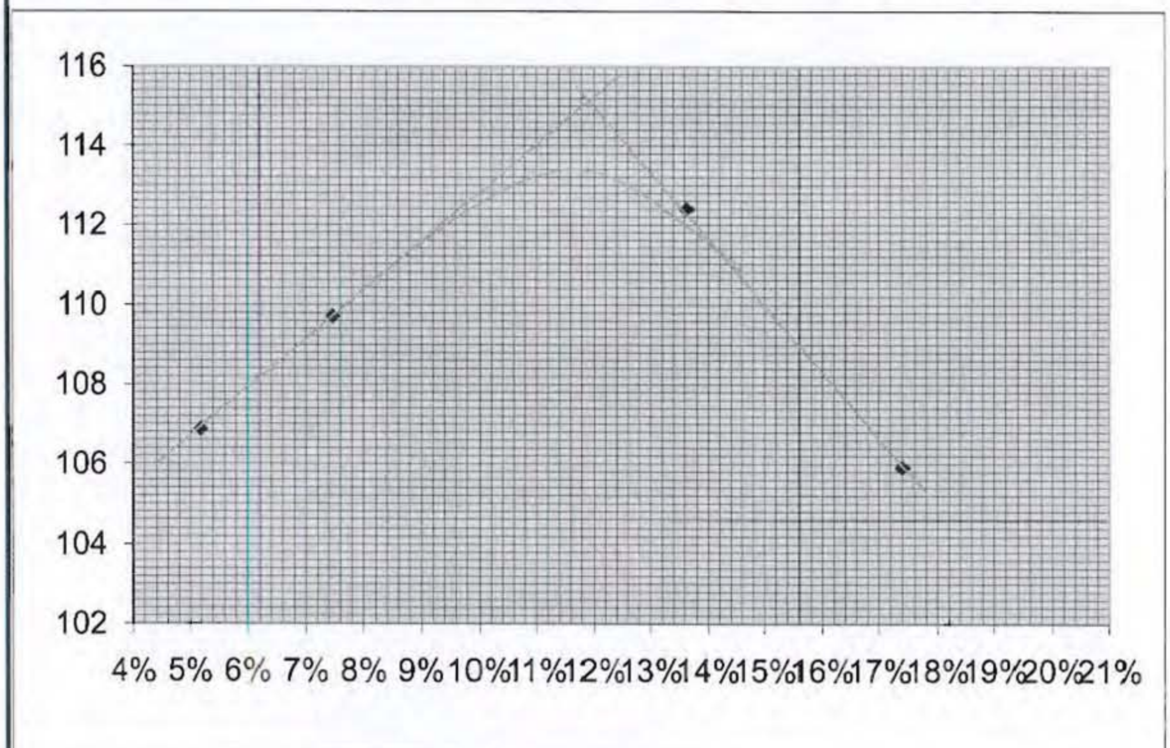
EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

National Security Technologies
Materials testing Laboratory
Nevada Test Site
Modified Proctor Test Results ASTM-D1557 (Method C 6" Mold)

Inpection Request # N/A
Charge # 5B1B70W2
Project: CAU547
User/Agency: NSTec
Date Tested: 5/15/2011
Tested By: /s/ Darrin Anderson

Requested By: Greg Doyle
Work Request# : S-52
Material: A3 Borrow Pit
MTL Lab# 354
Checked By: /s/ Signature on File 5/23/2011

Wt. mold + wet soil (g)	9852.6	9446.7	9967.4	9633.5	N/A	N/A
Wt. mold (g)	5622.3	5622.3	5622.3	5622.3		
Wt. wet soil (g)	4230.3	3824.4	4345.1	4011.2		
Wet density, PCF	124.4	112.4	127.7	117.9		
Moisture Tare#	2	6	4	5		
Wt. wet soil + tare (g)	1325.2	1212.5	1566.3	1284.9		
Wt dry soil + tare (g)	1131.3	1153.6	1380.5	1196.8		
Wt. moisture (g)	193.9	58.9	185.8	88.1		
Wt. tare (g)	17.0	17.5	17.3	17.0		
Wt. dry soil (g)	1114.3	1136.1	1363.2	1179.8		
% moisture	**17.4%**	**5.2%**	**13.6%**	**7.5%**	**#VALUE!**	
Dry Density, PCF	**105.9**	**106.9**	**112.4**	**109.7**	**#VALUE!**	



Max. Den. 113.0 pcf
Opt. Moist. 12.0%

Calibrated Equipment Used:
Scale PM16# 301667 Cal'd 05/04/11 due 05/04/12
Scale PM16# 301256 Cal'd 03/23/11 due 03/23/12
6" Mold# 312653 Cal'd 01/04/10 due 07/04/11
Oven# 308784 Cal'd 11-09-10 due 11-09-11

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

	NATIONAL SECURITY TECHNOLOGIES MATERIALS TESTING LABORATORY P. O. BOX 98521 LAS VEGAS, NV 89193-8521	
[X] Sieve Analysis (ASTM C136) [X] Moisture Content (ASTM C-566) [ ] Unit Weight (ASTM C-29) [X] Passing #200 (ASTM C-117)		Inspection Request # N/A CHARGE # 5B1B70W2 WR # S-52 LAB # 356 DATE 05/13/11

Requested by: Greg Doyle User/Agency: NSTec Material: Native

Project: CAU-547 Location: A-3 Borrow Pit

Date Sampled: 05/12/11 Sampled by: Darrin Anderson / Greg Doyle

Tested by: /s/ Darrin Anderson Checked by: /s/ Signature on File 5/23/2011

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A	N/A	N/A
1 ½"	0.0	0%	0%	100%	↓	↓	↓
3/4"	133.2	2%	2%	98%			
3/8"	620.8	11%	9%	89%			
#4	1323.3	23%	12%	77%			
#10	2180.2	38%	15%	62%			
#40	3656.3	64%	26%	36%			
#100	4642.9	82%	17%	18%			
#200	5063.9	89.1%	7.4%	10.9%			

Sample Wt (g): 5685.4 Pan # 3

REMARKS: Moisture Content = 8.8 %

Proctor Sieve.

EQUIPMENT USED:

	PM 16, ID# 301256,	Calibration Date	03/23/11	Calibration Due:	03/23/12
	PM 16, ID# 301667,	Calibration Date	05/04/11	Calibration Due:	05/04/12
Oven	ID# 308784	Calibration Date:	11/09/10	Calibration Date:	11/09/11
Sieve 3"	ID# 303221	Calibration Date:	10/19/10	Calibration Date:	10/19/11
Sieve 1 1/2"	ID# 303278	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve 3/4"	ID# 310032	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve 3/8"	ID# 303266	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve #4	ID# 302043	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #10	ID# 311621	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #40	ID# 300106	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #100	ID# 300103	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #200	ID# 009506	Calibration Date:	11/30/10	Calibration Date:	11/30/11

cc:
Greg Doyle NSTec
NSTec MTL Files

Liquid Limit Plastic Limit ASTM D-4318	National Securities Technologies Materials Testing Laboratory P.O Box 98521, M/S 188 Las Vegas, NV 89193-8521	Charge #: 5B1B70W2 Lab #: 358 Date Typed: 5-19-11 Page: 1 of 1

IR#: 2010-0196

Requested By:	Greg Doyle	**User/Agency:**	NSTec	**Material:**	NATIVE
Project:	A-3 Borrow Pit		**Test Location:**	A-3 Borrow Pit	
Tested By:	Darrin Anderson 186529	**Date Tested:**	5-19-11	**Checked By:** /s/ Signature on File	5/23/2011

LIQUID LIMIT

Number of Blows	25	22	18		
Correction Factor	N/A	N/A	N/A		
Adjusted Moisture Content %	N/A	N/A	N/A		
Tare No.	1	2	3		
1. Wt Wet Soil + Tare	13.41	15.84	16.17		
2. Wt. Dry Soil + Tare	11.27	13.24	13.41		
3.Wt. of Moisture	2.14	2.60	2.76		
4. Wt. of Tare	1.67	1.53	1.63		
5. Wt. of Dry Soil	9.61	11.71	11.78		
6.Moisture Content %	22.27	22.20	23.43		

PLASTIC LIMIT

1.Wt Wet Soil + Tare	Non Plastic	Non Plastic	Non Plastic	Non Plastic	Non Plastic
2.Wt Dry Soil + Tare	N/A	N/A	N/A	N/A	N/A
3. Wt. of Moisture	N/A				
4.Wt. of Tare	N/A				
5. Wt. of Dry Soil	N/A				
6. Moisture Content %	N/A				

PLASTICITY INDEX

	N/A	N/A	N/A	N/A	N/A
	N/A				
	N/A				

PLASTICITY INDEX FORMULA: PI = LL – PL

EQUIPMENT USED

Model No.	M&TE Identification #	Calibration Date	Calibration Due Date
Scale	301723	5-04-11	5-04-12
# 40 Sieve	300106	11-30-10	11-30-11
Oven	308784	11-09-10	11-09-11

Remarks: Plasticity Index cannot be determined. The soil is Non-Plastic.

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Attachment C

USDA Wind Erosion Charts

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SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 104

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	124.8	111.0	92.3	73.9	48.6	31.9	18.3	10.7	6.5	3.2	1.6	0.1	
8000	124.8	111.0	92.3	73.9	48.6	31.9	18.3	10.7	6.5	3.2	1.6	0.1	
6000	124.8	111.0	92.3	73.9	48.6	31.9	18.3	10.7	6.5	3.2	1.6	0.1	
4000	124.8	111.0	92.3	73.9	48.6	31.9	18.3	10.7	6.5	3.2	1.6	0.1	
3000	124.8	111.0	92.3	73.9	48.6	31.9	18.3	10.7	6.5	3.2	1.6	0.1	
2000	122.6	108.9	90.4	72.2	47.4	30.9	17.6	10.3	6.2	3.0	1.5	0.1	
1000	114.5	101.4	83.8	66.3	43.0	27.5	15.4	8.8	5.2	2.5	1.2	0.1	
800	111.4	98.6	81.2	64.1	41.3	26.2	14.6	8.3	4.9	2.3	1.1	0.1	
600	106.1	93.7	76.9	60.3	38.5	24.1	13.3	7.4	4.3	2.0	0.9	0.1	
400	100.0	88.1	71.9	56.0	35.3	21.7	11.8	6.5	3.7	1.7	0.8	0.1	
300	93.8	82.4	66.9	51.7	32.2	19.5	10.4	5.6	3.2	1.4	0.4		
200	84.4	73.9	59.5	45.3	27.7	16.2	8.4	4.4	2.4	1.0	0.3		
150	77.0	67.1	53.7	40.4	24.3	13.9	7.0	3.6	1.9	0.7			
100	70.4	61.2	48.5	36.2	21.4	11.9	5.9	2.9	1.5	0.6			
80	65.3	56.5	44.6	32.9	19.1	10.4	5.1	2.5	1.3	0.5			
60	57.0	49.0	38.2	27.7	15.7	8.2	3.9	1.8	0.9				
50	53.1	45.6	35.4	25.4	14.2	7.3	3.4	1.5	0.8				
40	49.2	42.1	32.5	23.1	12.8	6.4	2.9	1.3	0.4				
30	43.1	36.7	28.0	19.6	10.6	5.1	2.2	1.0	0.3				
20	34.6	29.2	21.8	14.9	7.7	3.5	1.4	0.5					
10	23.7	19.7	14.3	9.3	4.5	1.8	0.7						

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 104

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	112.3	99.4	82.0	64.8	41.8	26.6	14.8	8.4	5.0	2.3	1.1	0.1	
8000	112.3	99.4	82.0	64.8	41.8	26.6	14.8	8.4	5.0	2.3	1.1	0.1	
6000	112.3	99.4	82.0	64.8	41.8	26.6	14.8	8.4	5.0	2.3	1.1	0.1	
4000	112.3	99.4	82.0	64.8	41.8	26.6	14.8	8.4	5.0	2.3	1.1	0.1	
3000	112.3	99.4	82.0	64.8	41.8	26.6	14.8	8.4	5.0	2.3	1.1	0.1	
2000	109.6	97.0	79.8	62.8	40.4	25.5	14.1	8.0	4.7	2.2	1.1	0.1	
1000	103.2	91.0	74.5	58.2	37.0	22.9	12.5	7.0	4.0	1.8	0.9	0.1	
800	100.8	88.8	72.6	56.6	35.7	22.0	12.0	6.6	3.8	1.7	0.8	0.1	
600	95.0	83.5	67.9	52.5	32.8	19.9	10.7	5.8	3.3	1.4	0.4		
400	87.0	76.2	61.5	47.1	28.9	17.1	9.0	4.7	2.6	1.1	0.3		
300	80.8	70.5	56.6	42.9	26.0	15.0	7.7	4.0	2.2	0.9	0.3		
200	73.1	63.6	50.6	37.9	22.5	12.7	6.4	3.2	1.7	0.6			
150	65.9	57.1	45.0	33.3	19.4	10.6	5.2	2.5	1.3	0.5			
100	58.8	50.7	39.6	28.9	16.5	8.7	4.1	1.9	1.0				
80	55.3	47.6	37.0	26.8	15.1	7.8	3.7	1.7	0.8				
60	48.0	41.0	31.5	22.4	12.3	6.1	2.8	1.2	0.4				
50	43.8	37.3	28.5	20.0	10.8	5.2	2.3	1.0	0.3				
40	39.6	33.6	25.5	17.6	9.4	4.4	1.9	0.8	0.3				
30	34.5	29.1	21.8	14.8	7.7	3.5	1.4	0.5					
20	27.5	23.0	16.9	11.2	5.6	2.4	0.9						
10	18.1	14.9	10.6	6.6	3.1	1.2							

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 104

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	156.0	140.0	118.6	97.6	67.1	46.9	28.4	17.8	11.4	6.1	3.4	0.7	0.4
8000	156.0	140.0	118.6	97.6	67.1	46.9	28.4	17.8	11.4	6.1	3.4	0.7	0.4
6000	156.0	140.0	118.6	97.6	67.1	46.9	28.4	17.8	11.4	6.1	3.4	0.7	0.4
4000	156.0	140.0	118.6	97.6	67.1	46.9	28.4	17.8	11.4	6.1	3.4	0.7	0.4
3000	156.0	140.0	118.6	97.6	67.1	46.9	28.4	17.8	11.4	6.1	3.4	0.7	0.4
2000	153.0	137.2	116.0	95.3	65.3	45.3	27.3	17.0	10.8	5.7	3.2	0.7	0.4
1000	144.0	128.8	108.4	88.3	59.8	40.8	24.2	14.8	9.3	4.8	2.6	0.2	
800	140.8	125.8	105.7	85.9	57.9	39.3	23.2	14.1	8.8	4.5	2.4	0.2	
600	133.9	119.4	99.8	80.6	53.8	36.0	21.0	12.6	7.7	3.9	2.0	0.2	
400	125.2	111.3	92.6	74.2	48.9	32.0	18.4	10.8	6.5	3.2	1.6	0.1	
300	117.5	104.2	86.2	68.5	44.6	28.7	16.2	9.3	5.6	2.7	1.3	0.1	
200	107.4	94.9	78.0	61.3	39.2	24.6	13.6	7.6	4.5	2.0	1.0	0.1	
150	100.0	88.1	71.9	56.0	35.3	21.7	11.8	6.5	3.7	1.7	0.8	0.1	
100	91.7	80.5	65.3	50.3	31.2	18.7	9.9	5.3	3.0	1.3	0.4		
80	85.9	75.2	60.6	46.3	28.4	16.7	8.7	4.6	2.5	1.1	0.3		
60	76.3	66.5	53.1	39.9	23.9	13.6	6.9	3.5	1.9	0.7			
50	71.5	62.2	49.4	36.9	21.8	12.2	6.1	3.0	1.6	0.6			
40	66.5	57.6	45.5	33.7	19.7	10.8	5.3	2.6	1.3	0.5			
30	59.0	50.8	39.8	29.0	16.5	8.8	4.2	2.0	1.0				
20	49.4	42.3	32.6	23.2	12.8	6.5	2.9	1.3	0.4				
10	35.5	30.0	22.5	15.4	8.0	3.7	1.5	0.5					

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 104

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	140.4	125.5	105.3	85.6	57.7	39.1	23.0	14.0	8.7	4.5	2.4	0.2	
8000	140.4	125.5	105.3	85.6	57.7	39.1	23.0	14.0	8.7	4.5	2.4	0.2	
6000	140.4	125.5	105.3	85.6	57.7	39.1	23.0	14.0	8.7	4.5	2.4	0.2	
4000	140.4	125.5	105.3	85.6	57.7	39.1	23.0	14.0	8.7	4.5	2.4	0.2	
3000	140.4	125.5	105.3	85.6	57.7	39.1	23.0	14.0	8.7	4.5	2.4	0.2	
2000	137.4	122.6	102.8	83.3	55.9	37.6	22.1	13.3	8.2	4.2	2.2	0.2	
1000	128.3	114.2	95.2	76.5	50.6	33.4	19.3	11.4	6.9	3.4	1.8	0.1	
800	124.8	111.0	92.3	73.9	48.6	31.9	18.3	10.7	6.5	3.2	1.6	0.1	
600	117.5	104.2	86.2	68.5	44.6	28.7	16.2	9.4	5.6	2.7	1.3	0.1	
400	108.8	96.1	79.0	62.2	39.9	25.1	13.9	7.8	4.6	2.1	1.0	0.1	
300	103.0	90.9	74.4	58.1	36.9	22.9	12.5	6.9	4.0	1.8	0.9	0.1	
200	93.9	82.5	67.0	51.8	32.3	19.5	10.4	5.6	3.2	1.4	0.4		
150	85.4	74.8	60.3	46.0	28.2	16.6	8.6	4.5	2.5	1.0	0.3		
100	77.6	67.7	54.1	40.8	24.5	14.0	7.2	3.7	2.0	0.7			
80	73.4	63.8	50.8	38.0	22.6	12.7	6.4	3.2	1.7	0.6			
60	63.9	55.2	43.5	32.0	18.5	10.0	4.9	2.3	1.2				
50	58.8	50.7	39.6	28.9	16.5	8.7	4.1	1.9	1.0				
40	54.7	47.1	36.6	26.4	14.9	7.7	3.6	1.7	0.8				
30	48.5	41.5	32.0	22.7	12.5	6.3	2.8	1.3	0.4				
20	39.3	33.3	25.2	17.5	9.2	4.4	1.9	0.8	0.3				
10	27.3	22.9	16.8	11.1	5.5	2.3	0.9						

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 220

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
8000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
6000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
4000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
3000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
2000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
1000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
800	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
600	259.0	237.6	209.7	184.1	139.9	112.8	77.2	56.2	40.6	26.8	17.9	4.9	3.3
400	254.0	232.8	205.2	179.7	136.0	109.0	74.3	53.8	38.6	25.3	16.8	4.5	3.1
300	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
200	236.0	215.6	188.9	163.9	122.3	96.0	64.3	45.5	32.1	20.4	13.1	3.4	2.3
150	225.0	205.1	179.0	154.4	114.1	88.4	58.5	40.9	28.5	17.7	11.2	2.8	1.9
100	214.0	194.7	169.2	145.0	106.1	81.0	53.0	36.5	25.1	15.3	9.5	2.4	1.6
80	203.0	184.3	159.4	135.7	98.3	73.9	47.7	32.3	22.0	13.1	8.0	1.9	1.3
60	185.4	167.6	144.0	121.2	86.2	63.2	39.9	26.3	17.5	10.1	5.9	1.4	0.7
50	176.7	159.4	136.4	114.1	80.4	58.1	36.3	23.6	15.5	8.7	5.1	1.1	0.6
40	167.2	150.5	128.2	106.5	74.2	52.8	32.5	20.8	13.5	7.4	4.2	0.9	0.5
30	151.0	135.3	114.3	93.7	64.0	44.3	26.6	16.5	10.5	5.5	3.0	0.6	0.3
20	133.6	119.1	99.6	80.4	53.6	35.8	20.9	12.5	7.7	3.9	2.0	0.2	
10	104.4	92.1	75.5	59.1	37.6	23.4	12.8	7.1	4.1	1.9	0.9	0.1	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 220

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
8000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
6000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
4000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
3000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
2000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
1000	236.6	216.2	189.4	164.4	122.7	96.4	64.6	45.8	32.3	20.5	13.3	3.4	2.3
800	234.0	213.7	187.1	162.1	120.8	94.6	63.2	44.7	31.4	19.9	12.8	3.3	2.2
600	228.6	208.6	182.2	157.5	116.7	90.8	60.3	42.4	29.6	18.6	11.8	3.0	2.0
400	221.6	201.9	176.0	151.5	111.6	86.1	56.8	39.5	27.4	17.0	10.7	2.7	1.8
300	215.2	195.8	170.2	146.0	106.9	81.8	53.6	36.9	25.5	15.6	9.7	2.4	1.6
200	202.4	183.7	158.9	135.2	97.9	73.6	47.5	32.1	21.8	13.0	7.9	1.9	1.2
150	189.2	171.2	147.2	124.3	88.7	65.4	41.5	27.5	18.4	10.7	6.3	1.5	1.0
100	179.4	162.0	138.8	116.3	82.2	59.7	37.4	24.4	16.1	9.1	5.3	1.2	0.6
80	170.1	153.2	130.7	108.8	76.1	54.4	33.7	21.6	14.1	7.8	4.5	1.0	0.5
60	155.0	139.1	117.7	96.9	66.5	46.3	28.0	17.5	11.2	6.0	3.3	0.7	0.4
50	146.1	130.8	110.2	90.0	61.1	41.9	24.9	15.3	9.6	5.0	2.7	0.2	
40	138.9	124.0	104.0	84.4	56.7	38.3	22.6	13.7	8.5	4.3	2.3	0.2	
30	127.3	113.3	94.4	75.8	50.1	33.0	19.0	11.2	6.8	3.4	1.7	0.1	
20	110.3	97.5	80.3	63.3	40.7	25.7	14.3	8.1	4.8	2.2	1.1	0.1	
10	86.1	75.3	60.8	46.4	28.5	16.8	8.8	4.6	2.6	1.1	0.3		

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 220

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
8000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
6000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
4000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
3000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
2000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
1000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
800	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
600	322.9	299.0	268.8	242.6	192.7	165.4	119.3	92.8	70.6	51.0	37.0	11.2	8.1
400	316.0	292.4	262.3	236.1	186.8	159.3	114.4	88.4	66.9	47.9	34.5	10.3	7.4
300	308.0	284.7	254.9	228.7	180.0	152.4	108.7	83.4	62.7	44.4	31.7	9.4	6.7
200	292.5	269.7	240.5	214.4	167.0	139.3	98.2	74.2	55.1	38.2	26.7	7.7	5.4
150	278.9	256.6	227.9	202.0	155.8	128.2	89.4	66.5	48.9	33.2	22.8	6.4	4.5
100	267.0	245.2	217.0	191.2	146.2	118.9	82.0	60.3	43.8	29.2	19.8	5.4	3.8
80	256.0	234.7	207.0	181.4	137.6	110.5	75.5	54.8	39.4	25.9	17.2	4.6	3.2
60	238.0	217.5	190.7	165.6	123.8	97.4	65.3	46.4	32.8	20.9	13.5	3.5	2.4
50	227.5	207.5	181.2	156.5	115.9	90.1	59.8	41.9	29.3	18.3	11.6	3.0	2.0
40	217.0	197.5	171.9	147.5	108.2	83.0	54.5	37.6	26.0	15.9	10.0	2.5	1.6
30	198.9	180.4	155.8	132.3	95.4	71.4	45.8	30.9	20.9	12.4	7.5	1.8	1.2
20	176.2	159.0	135.9	113.7	80.1	57.9	36.1	23.4	15.4	8.7	5.0	1.1	0.6
10	139.3	124.4	104.4	84.7	57.0	38.5	22.7	13.8	8.5	4.4	2.3	0.2	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 220

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
8000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
6000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
4000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
3000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
2000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
1000	295.8	272.9	243.5	217.4	169.7	142.0	100.4	76.1	56.7	39.4	27.7	8.0	5.7
800	292.5	269.7	240.5	214.4	167.0	139.3	98.2	74.2	55.1	38.2	26.7	7.7	5.4
600	285.7	263.2	234.2	208.2	161.4	133.8	93.8	70.3	52.0	35.7	24.7	7.0	4.9
400	277.3	255.2	226.5	200.6	154.5	127.0	88.4	65.7	48.2	32.7	22.4	6.3	4.4
300	270.2	248.3	220.0	194.1	148.8	121.4	84.0	61.9	45.1	30.3	20.5	5.7	4.0
200	257.4	236.0	208.3	182.7	138.7	111.6	76.3	55.5	39.9	26.3	17.5	4.7	3.3
150	244.9	224.1	196.9	171.6	129.0	102.4	69.1	49.5	35.2	22.7	14.9	3.9	2.7
100	232.4	212.2	185.6	160.8	119.6	93.5	62.3	44.0	30.9	19.5	12.5	3.2	2.2
80	222.6	202.9	176.8	152.3	112.3	86.7	57.3	39.9	27.7	17.2	10.8	2.7	1.8
60	205.0	186.1	161.2	137.4	99.7	75.2	48.7	33.1	22.5	13.5	8.3	2.0	1.3
50	193.6	175.3	151.1	127.9	91.7	68.1	43.4	29.0	19.5	11.4	6.8	1.6	1.0
40	184.2	166.5	142.9	120.2	85.3	62.5	39.4	25.9	17.2	9.9	5.8	1.3	0.7
30	169.9	153.1	130.5	108.7	76.0	54.3	33.6	21.6	14.1	7.8	4.5	1.0	0.5
20	148.3	132.8	112.0	91.6	62.4	42.9	25.7	15.8	10.0	5.2	2.8	0.6	
10	117.0	103.8	85.8	68.2	44.3	28.5	16.1	9.3	5.5	2.6	1.3	0.1	

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

Attachment D

Armoring Calculations

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EWR No.:	EWR Title:	
Calc No.: 00424-CAL-001	Calculation Title: Wind Erosion Calculations (TEJON Site)	Rev No.: 0

Engineered Surface Barrier Design - Depth of Cover Degradation to create a Gravel Armored Surface Layer

Input Data

The depth of cover degradation that must occur prior to the creation of gravel armored surface over the barriers is found by relation of the volumetric fraction of gravel in the cover soil to the gravel armoring depth. The soil properties necessary for this calculation are provided as follows:

Gravel mass fraction	M_g	38	%	>2.0 mm
Cover soil bulk density	ρ_t	1.57	g/cm^3	Target soil bulk density, 90% relative compaction
Gravel particle density	ρ_g	2.5	g/cm^3	NTS RWMS Material Properties (Area 3)
Gravel size range		> 2	mm	

Assumptions

A complete gravel armoring capble of resisting any further erosion by wind or water is provided when a gravel layer of 19.0 mm in thickness has been created by hydraulic sorting and erosional removal of all soil particles < 2mm from the cover soil. This gravel layer depth is equivalent to a mean desert pavement gravel size diameter of 3/4 inch and is consistent with observations at the Nevada National Security Site that well-developed desert pavements are not more than a few centimeters thick (Personal communication, Stuart Rawlingson).

Calculations

The mass fraction of gravel M_g is converted to a volumetric gravel fraction (V_g) as follows:

Gravel mass fraction, $M_g = m_g/m_t$

Silt with gravel bulk density, $\rho_t = m_t/v_t$

Gravel particle density, $\rho_g = m_g/v_g$

Volumetric gravel fraction, $V_g = M_g (\rho_t/\rho_g) = m_g/m_t [(m_t/v_t)/(m_g/v_g)] = v_g/v_t$

where:

m_g = mass of gravel

m_t = mass of cover soil

v_g = volume of gravel

v_t = volume of cover soil

The depth of degradation (D_m) is then calculated as follows

$D_m = d_g/V_g$,

where:

d_g = depth of the gravel armoring layer following hydraulic sorting and removal of fines

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-001	**Calculation Title:** Wind Erosion Calculations (TEJON Site)	**Rev No.:** 0

Engineered Surface Barrier Design - Depth of Cover Degradation to create a Gravel Armored Surface Layer

Results

V_g =	0.238	
d_g=	19.0	mm
D_m =	80	mm
	8.0	cm
	3.1	inches

The total depth of cover degradation before a stable desert pavement develops, retarding further wind and water erosion is approximately 8 cm or 3.1 inches.

WIND EROSION CALCULATIONS (MULLET SITE)

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-002	Calculation Title: Wind Erosion Calculations (MULLET Site)	Rev No.: 0

Purpose of Calculation

This calculation provides an estimate of soil loss due to wind erosion over the designed cover surfaces at the MULLET site.

Affected Documents

Document No.	Rev No.	Document Title

Software

Software Name	Version

Derivative Classification

Signoffs and Approval

Preparer:	Sign	/s/ Jennifer McRae	Date: 07/15/11
	Print	Jennifer McRae	
Checker: ("N/A" if Peer Review is Required)	Sign	/s/ Jennifer Krenz-Ruark	Date: 07/18/11
	Print	Jennifer Krenz-Ruark	
Peer Reviewer: (Required for NPH)	Sign		Date:
	Print		
Approver:	Sign	/s/ Gino Nguyen	Date: 07/18/11
	Print	Gino Nguyen	

Attachments

Attachment	Title	Pages
A	Soil Ridge Roughness, Soil Erodibility, and Knoll Erodibility Factors	A1-A6
B	Geotechnical Test Results for Area 3 RWMS	B1-B6
C	USDA Wind Erosion Charts	C1-C4
D	Armoring Calculations	D1-D4

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WIND EROSION CALCULATIONS (MULLET SITE)

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-002	**Calculation Title:** Wind Erosion Calculations (MULLET Site)	**Rev No.:** 0

1. Purpose and Objective

This calculation estimates the amount of soil erosion that will be caused by wind on the final graded areas for the MULLET site, within the Area 2 Radioactive Waste Management Site (RWMS). It estimates annual erosion and long-term erosion for the proposed design life of the barriers of 1,000 years, using the Wind Erosion Equation (WEQ). The development of a desert pavement from gravels within the cover material is also assessed to estimate the total thickness of cover erosion before a stable surface is developed.

2. Basis

The engineered surface barrier will be constructed using interim cover soils (excess operational covers) and additional engineered fill. The berms will consist of 2 feet total soil thickness over exposed piping and other site structures.

2.1 Design Inputs

Estimates of potential losses due to wind erosion were performed using the Wind Erosion Equation (WEQ), which is presented in the "Methods" section of this document. The factors used in this equation were estimated for the barrier surface as follows:

Soil Erodibility Factor (I)
The soil erodibility factor (I) represents the potential annual wind erosion in tons per acre per year for a given soil on an isolated, level, smooth, unsheltered, wide, and bare field with a non-crusted surface for climatic factor of 100 percent. This factor depends on soil texture (e.g., crusted or non-crusted) and percentage of dry soil retained on U.S. Standard Sieve No. 20. Adjustment factors are used for knoll configuration, and are a function of the slope inclination of the cover. Soil information for the No. 20 sieve was not available for the stockpiled soil, so the percentage of dry soil retained on a No. 10 sieve was used in its place. Because soil from the Area 3 Borrow Pit will be used to construct the berms, Area 3 soil characteristics have been incorporated into the erosion calculations.

From Table 1, the fraction of coarse sand and gravel particles retained on the No. 10 (2.00 mm) sieve is 38 percent.

From Table A-1, with a soil fraction coarser than the No. 10 sieve of 38 percent, an I value was approximated as follows:

Soil Erodibility Factor (I) = 60 tons/acre/year

The Knoll Erodibility Adjustment Factor, A, was used in Table A-2. No factor should be applied for slopes 2% or less (NRCS, 2002).

Adjusted I for 50% slope = 60 x 3.6 = 216 tons/acre/year

Soil data is presented in Attachment B.

Ridge Roughness Factor (K)
The ridge roughness factor (K) applies to soil surfaces that are exposed to recurring agricultural practices (e.g., plowing, planting, disking, and harrowing) and is a function of soil ridge roughness (or height). No agricultural activities are planned for the barriers, thus the ridge roughness factor is assumed to be one.

The Ridge Roughness Factor (K) was determined by applying these assumptions as shown in Figure A-1.

K = 1.0 (for the lifetime of the barrier)

Climatic Factor (C)
The climatic factor (C) is an index of climatic erosivity, specifically wind speed and surface soil moisture. The factor for any given location is based on long-term climatic data and is expressed as a percentage of the C factor for Garden City, Kansas, which has been assigned a value of 100. A site-specific C factor was calculated for the project.

The climatic factor (C) equation is expressed as:

$$C = 34.48 \times \frac{V^3}{(PE)^2}$$

where:

C = annual climatic factor
V = average annual wind velocity (miles/hour)
PE = precipitation-effectiveness index of Thornthwaite
34.48 = constant used to adjust local values to a common base (Garden City, Kansas)

$$PE = \sum_{Jan}^{Dec} 115 \times \left[\frac{P}{T - 10}\right]^{10/9}$$

where:

PE = annual precipitation effectiveness index
P = average monthly precipitation (inches) (minimum of 0.5)
T = average monthly temperature (°F)

BJY Meteorological Data

Month	Average Precipitation (inches)	Average Temperature (°F)
January	0.83	38.7
February	0.94	43.1
March	0.76	48.2
April	0.36	54.4
May	0.36	62.7
June	0.24	71.0
July	0.50	77.9
August	0.62	76.3
September	0.35	68.9
October	0.32	58.6
November	0.50	45.9
December	0.56	38.9

Source: Soule, 2006

BJY Wind Data

Month	Average Wind Speed (knots)	Average Wind Speed (miles/hour)
January	6.7	7.71
February	7.4	8.52
March	7.9	9.09
April	8.6	9.90
May	8.5	9.78
June	8.3	9.55
July	7.8	8.98
August	7.3	8.40
September	7.1	8.17
October	6.8	7.83
November	6.9	7.94
December	6.8	7.83
Average	7.51	8.64

Source: Soule, 2006

V = 8.64 miles/hour

The calculated climatic factor (C) = 136.5

Slope Length Factor (L)
The unsheltered or unbroken field length of slope (L) can be obtained from the design geometry of the cover. This value is normally taken as the longest unbroken slope length of the cover.

The L values from the final grading plan average approximately 9 feet of slope length.

Vegetative Factor (V)
The vegetative factor (V) dictates the erosion value. The vegetative factor is calculated as a flat small grain equivalent quantity in pound per acre. The cover for the MULLET site is not planned to be vegetated, thus V = 0.

2.2 Criteria

Compute annual average soil loss due to wind erosion using the Wind Erosion Equation and estimating the development of a desert pavement that will resist further erosion.

2.3 Assumptions

- Cover slope is designed to be 50%.
- Length of cover slope averages approximately 9 feet.
- In-place bulk density of cover soil will be achieved with 90% relative compaction.

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-002	**Calculation Title:** Wind Erosion Calculations (MULLET Site)	**Rev No.:** 0

- Life of barrier is 1,000 years.
- Once enough erosion loss has occurred to completely armor the soil surface with a desert pavement consisting of the gravel contained in cover soils, it is assumed that the barrier surface will have stabilized and will not be subject to significant additional erosion loss by wind or water.
- A stable cover surface is assumed to have developed once a ¾ inch (19mm) thick average gravel layer is armoring the surface.

3. References

Natural Resources Conservation Service (NRCS). 1998. National Agronomy Manual, Subpart G-Exhibits: Wind Erosion Charts. 190-V-NAM.

Natural Resources Conservation Service (NRCS). 2002. National Agronomy Manual, Part 503. 190-V-NAM, 3rd Edition.

Neptune and Company, Inc. 2006. Alluvium Material Properties Specification for the NTS RWMSs. September 21.

Soule, D.A. 2006. SORD Technical Memorandum SORD 2006-3: Climatology of the Nevada Test Site. Special Operations and Research Division, Las Vegas, Nevada. April.

4. Methods

Wind erosion loss was calculated using the Wind Erosion Equation (WEQ). The WEQ was originally developed for agricultural applications by the USDA Agricultural Research Service.

Potential soil loss from the soil surface due to wind erosion (E) is expressed in terms of the estimated average annual soil loss, in tons per acre per year.

$$E = \text{function of } (I, K, C, L, V)$$

The value of E is obtained by interpolation of the Wind Erosion Charts (NRCS, 1998), given the parameters of I, K, C, L, and V, as presented above.

The wind erosion charts used in the interpolation are presented in Attachment C. These charts show the bounding values for the calculated parameters of the Wind Erosion Equation. Thus, the value of E must be interpolated within these charts. Table 2 presents the interpolation tables for the cover material.

5. Results and Conclusions

The estimated wind erosion loss for a slope length of 9 feet and cover slope of 50% (2:1) is presented in Table 3. The wind erosion was calculated as 1.77 cm/year on slopes of 50%. These results indicate that the estimated soil loss due to wind erosion over the 1,000-year design life of the barriers is 57.99 feet (1,767.6 cm) for a slope of 50% and slope length of 9 feet.

The Wind Erosion Equation and RUSLE methods used in the estimation of soil loss assume static surface conditions that do not change as a result of erosional processes. However, as fines are eroded from the surface layer of the barrier, the surface will become increasingly protected by the remaining gravel armoring. As a result, these methods tend to be overconservative in estimating soil losses. According to the armoring calculation presented in Attachment D, the degradation depth that will create an erosion-resistant gravel-armored surface is 3.1inches (8 cm). Consequently, this is estimated to be the upper bound of average soil loss due to wind and water erosion forces. Given the Wind Erosion Equation estimates, complete armoring of the barrier surface will occur during the 1,000 year design life of the barrier. To prevent loss of cover thickness, monitoring is proposed over the design life to ensure the minimum of 2 feet will be maintained.

6. Calculations and Analyses

For purposes of illustration, the calculations below outline the conversion from wind erosion loss in ton/acre/year to cover thickness loss in cm. For a slope length of 9 feet and inclination of 50%, the estimated soil loss due to wind erosion is 123.6 tons/acre/year. For a 1,000 year design life and in-place density of 97.9 lb/ft^3, the total loss (E) is:

For area of slope 50%:
(123.595 tons/acre/yr) x (1,000 yrs) = 123,595 tons/acre

(123,595 tons/acre) x (2,000 lb/ton) x (1 acre/43,560 ft^2) = 5,674.7 lb/ft^2

(5,674.7 lb/ft^2)/(97.9 lb/ft^3) = 57.99 ft = 1,767.6 cm

Armoring Calculation
The gravel in the soil will increasingly armor the soil surface from erosive forces as erosion removes soil fines. A simple soil particle volume balance calculation was performed to determine the depth of cover degradation that must occur to create a 19.0 mm thick (mean desert pavement gravel size diameter) gravel layer on the soil surface, assuming all material less than 2 mm in diameter had been removed. These calculations are presented in Attachment D.

Table 1. Soil Grain Size Data

Soil Grain Size Data - Mean Percent Passing Indicated Size

3 in	1.5 in	3/4 in	3/8 in	#4	#10	#40	#100	#200
76.2 mm	38.1 mm	19.0 mm	9.52 mm	4.75 mm	2.0 mm	0.425 mm	0.150 mm	0.075 mm
100%	100%	98%	89%	77%	62%	36%	18%	10.9%

(Neptune and Company, 2006)

Soil Grain Size Data (minus 2.0 mm fraction only)

#10	#40	#100	#200
2.0 mm	0.425 mm	0.150 mm	0.075 mm
100%	74%	30%	49%

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Table 2. Wind Erosion Interpolation

Wind Erosion Equation (WEQ)

E = f (I, K, C, L, V)

Where:

E = The estimated average annual soil loss in tons per acre per year due to wind erosion

f = An indication that the equation include functional relationships that are not straight-line mathematical functions

I = Soil erodibility factor

K = Ridge roughness factor

C = Climatic factor

L = Unsheltered distance

V = Vegetation factor

Values of E were interpolated using Wind Erosion Charts, as part of the National Agronomy Manual.

Natural Resources Conservation Service (NRCS). 1998. National Agronomy Manual, Subpart G-Exhibits: Wind Erosion Charts. 190-V-NAM.

50% slope for L=9 ft			
Adjusted I	220	220	216
C	120	150	136.5
K	1	1	1
L	10	10	9
V	0	0	0
E	104.4	139.3	123.595

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Table 3. Calculations for Cover Slope and Length

Technical Data	
Cover Slope (%)	50.0%
Percent Passing Sieve #20[a] (%)	62
Length of Cover Slope (ft)	9
In-Place Bulk Density of Cover Soil[b] (lb/ft^3)	97.9
Life of Barrier (years)	1000
Wind Erosion Equation - Parameters & Calculations	
Soil Erodibility Factor (I) (tons/ac/yr)	60
Knoll Adjustment Factor	3.6
Adjusted I (tons/ac/yr)	216.0
Ridge Roughness Factor (K)	
First Year	1.0
Subsequent Years	1.0
Climatic Factor (C)	136.5
Unsheltered Field Length (L)(ft)	9
Vegetative Factor (V)	
Cover Vegetation During the First Year (lb/ac)	0
Cover Vegetation During Subsequent Years (lb/ac)	0
Soil Loss Due to Wind Erosion (E)	
Soil Loss (tons/ac/yr)	123.60
Soil Loss (cm/yr)	1.768
Total Loss During Design Life 1,000 years of Cover (tons/ac)	123595.0
Total Loss During Design Life 1,000 years of Cover (lb/ft^2)	5674.7
Total Loss Expressed as Thickness of Cover Soil (ft)	57.99
Total Loss Expressed as Thickness of Cover Soil (cm)	1767.608

Notes:
[a] Data for percent passing No. 10 sieve was used since data was not available for a No. 20 sieve.
[b] Assumed to be 90% relative compaction of Area 3 RWMS soil.

Attachment A

Soil Ridge Roughness, Soil Erodibility, and Knoll Erodibility Factors

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A-1
Figure ~~D-2~~ Soil Ridge Roughness Factor K from Actual Soil Ridge Roughness (EPA 1979).

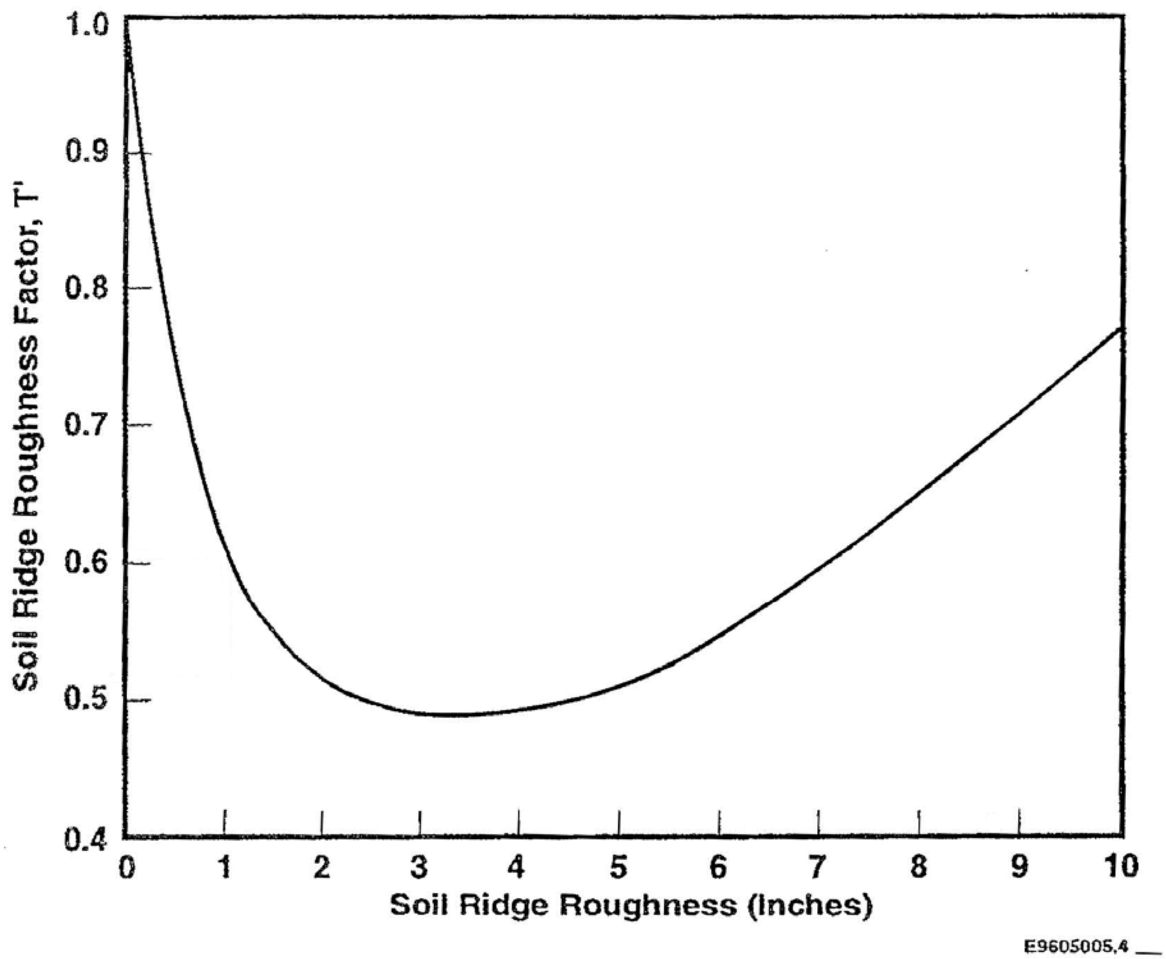

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Table A-1. Soil Erodibility Index "I"

Soil erodibility index in tons/acre determined by percentage of nonerodible fractions

Percent of dry soil not passing a #20 screen	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Tens	Noncrusted soil surface (tons/acre)									
0	—	310	250	220	195	180	170	160	150	140
10	134	131	128	125	121	117	113	109	106	102
20	98	95	92	90	88	86	83	81	79	76
30	74	72	71	69	67	65	63	62	60	58
40	56	54	52	51	50	48	47	45	43	41
50	38	36	33	31	29	27	25	24	23	22
60	21	20	19	18	17	16	16	15	14	13
70	12	11	10	8	7	6	4	3	3	2
80	2	—	—	—	—	—	—	—	—	—

(Adapted from NRCS, 2002)

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Table A-2. Knoll Erodibility Adjustment Factor for “I”

	A	B
Percent slope change in prevailing wind erosion direction	Knoll adjustment of I	Increase at crest area where erosion is most severe
3	1.3	1.5
4	1.6	1.9
5	1.9	2.5
6	2.3	3.2
8	3.0	4.8
≥ 10	3.6	6.8

(Adapted from NRCS, 2002)

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EWR No.:	**EWR Title:**	
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Attachment B

Geotechnical Test Results for Area 3 RWMS

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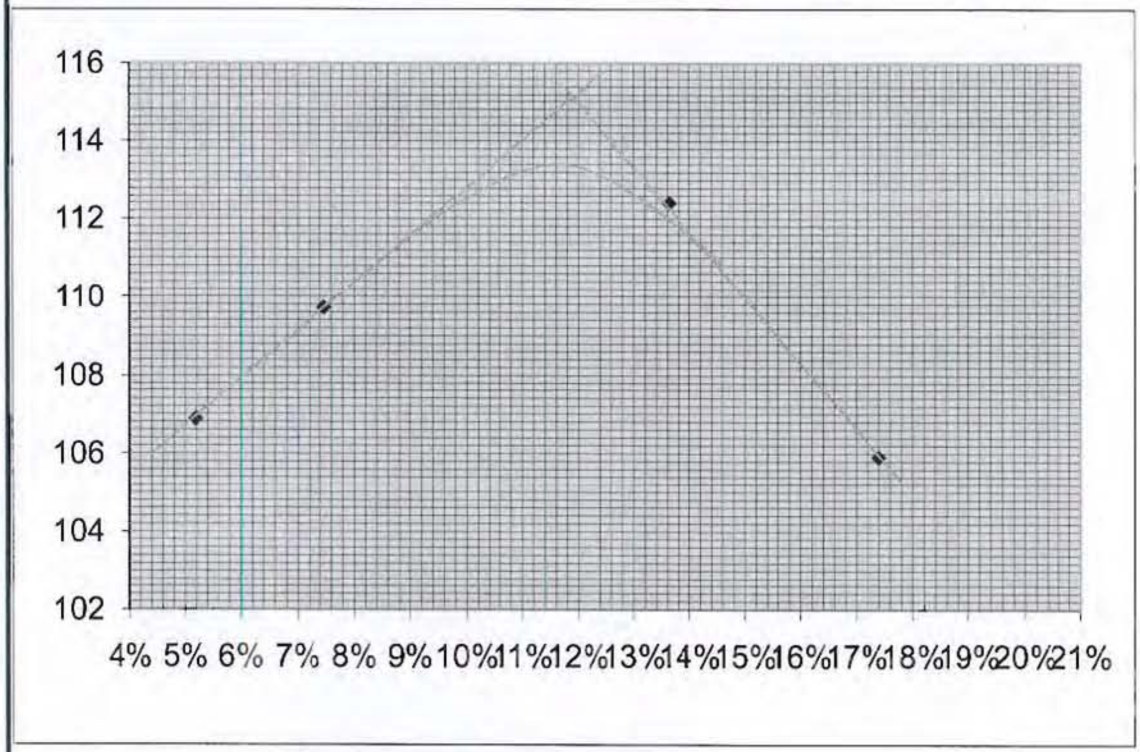
EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-002	**Calculation Title:** Wind Erosion Calculations (MULLET Site)	**Rev No.:** 0

National Security Technologies
Materials testing Laboratory
Nevada Test Site
Modified Proctor Test Results ASTM-D1557 (Method C 6" Mold)

Inpection Request # N/A
Charge # 5B1B70W2
Project: CAU547
User/Agency: NSTec
Date Tested: 5/15/2011
Tested By: /s/ Darrin Anderson

Requested By: Greg Doyle
Work Request# : S-52
Material: A3 Borrow Pit
MTL Lab# 354
Checked By: /s/ Signature on File 5/23/2011

Wt. mold + wet soil (g)	9852.6	9446.7	9967.4	9633.5	N/A	N/A
Wt. mold (g)	5622.3	5622.3	5622.3	5622.3		
Wt. wet soil (g)	4230.3	3824.4	4345.1	4011.2		
Wet density, PCF	124.4	112.4	127.7	117.9		
Moisture Tare#	2	6	4	5		
Wt. wet soil + tare (g)	1325.2	1212.5	1566.3	1284.9		
Wt dry soil + tare (g)	1131.3	1153.6	1380.5	1196.8		
Wt. moisture (g)	193.9	58.9	185.8	88.1		
Wt. tare (g)	17.0	17.5	17.3	17.0		
Wt. dry soil (g)	1114.3	1136.1	1363.2	1179.8		
% moisture	**17.4%**	**5.2%**	**13.6%**	**7.5%**	**#VALUE!**	
Dry Density, PCF	**105.9**	**106.9**	**112.4**	**109.7**	**#VALUE!**	



Max. Den. **113.0** **pcf**
Opt. Moist. **12.0%**

Calibrated Equipment Used:
Scale PM16# 301667 Cal'd 05/04/11 due 05/04/12
Scale PM16# 301256 Cal'd 03/23/11 due 03/23/12
6" Mold# 312653 Cal'd 01/04/10 due 07/04/11
Oven# 308784 Cal'd 11-09-10 due 11-09-11

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X Sieve Analysis (ASTM C136) X Moisture Content (ASTM C-566) ☐ Unit Weight (ASTM C-29) X Passing #200 (ASTM C-117)	NATIONAL SECURITY TECHNOLOGIES MATERIALS TESTING LABORATORY P. O. BOX 98521 LAS VEGAS, NV 89193-8521	Inspection Request # N/A CHARGE # 5B1B70W2 WR # S-52 LAB # 356 DATE 05/13/11

Requested by: Greg Doyle User/Agency: NSTec Material: Native

Project: CAU-547 Location: A-3 Borrow Pit

Date Sampled: 05/12/11 Sampled by: Darrin Anderson / Greg Doyle

Tested by: /s/ Darrin Anderson Checked by: /s/ Signature on File 5/23/2011

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A	N/A	N/A
1 ½"	0.0	0%	0%	100%	↓	↓	↓
3/4"	133.2	2%	2%	98%			
3/8"	620.8	11%	9%	89%			
#4	1323.3	23%	12%	77%			
#10	2180.2	38%	15%	62%			
#40	3656.3	64%	26%	36%			
#100	4642.9	82%	17%	18%			
#200	5063.9	89.1%	7.4%	10.9%			

Sample Wt (g): 5685.4 Pan # 3

REMARKS: Moisture Content = 8.8 %

Proctor Sieve.

EQUIPMENT USED:					
PM 16,	ID# 301256,	Calibration Date	03/23/11	Calibration Due:	03/23/12
PM 16,	ID# 301667,	Calibration Date	05/04/11	Calibration Due:	05/04/12
Oven	ID# 308784	Calibration Date:	11/09/10	Calibration Date:	11/09/11
Sieve 3"	ID# 303221	Calibration Date:	10/19/10	Calibration Date:	10/19/11
Sieve 1 1/2"	ID# 303278	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve 3/4"	ID# 310032	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve 3/8"	ID# 303266	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve #4	ID# 302043	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #10	ID# 311621	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #40	ID# 300106	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #100	ID# 300103	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #200	ID# 009506	Calibration Date:	11/30/10	Calibration Date:	11/30/11

cc:
Greg Doyle NSTec
NSTec MTL Files

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-002	**Calculation Title:** Wind Erosion Calculations (MULLET Site)	**Rev No.:** 0

Liquid Limit **Plastic Limit** **ASTM D-4318**	**National Securities Technologies** **Materials Testing Laboratory** **P.O Box 98521, M/S 188** **Las Vegas, NV 89193-8521**	**Charge #: 5B1B70W2** **Lab #: 358** **Date Typed: 5-19-11** **Page: 1 of 1**

IR#: 2010-0196

Requested By:	Greg Doyle	**User/Agency:**	NSTec	**Material:**	NATIVE
Project:	A-3 Borrow Pit		**Test Location:**	A-3 Borrow Pit	
Tested By:	Darrin Anderson 186529	**Date Tested:**	5-19-11	**Checked By:** /s/ Signature on File	5/23/2011

LIQUID LIMIT					
Number of Blows	25	22	18		
Correction Factor	N/A	N/A	N/A		
Adjusted Moisture Content %	N/A	N/A	N/A		
Tare No.	1	2	3		
1. **Wt Wet Soil + Tare**	13.41	15.84	16.17		
2. **Wt. Dry Soil + Tare**	11.27	13.24	13.41		
3.**Wt. of Moisture**	2.14	2.60	2.76		
4. **Wt. of Tare**	1.67	1.53	1.63		
5. **Wt. of Dry Soil**	9.61	11.71	11.78		
6.**Moisture Content %**	22.27	22.20	23.43		

PLASTIC LIMIT					
1.**Wt Wet Soil + Tare**	Non Plastic	Non Plastic	Non Plastic	Non Plastic	Non Plastic
2.**Wt Dry Soil + Tare**	N/A	N/A	N/A	N/A	N/A
3. **Wt. of Moisture**	N/A				
4.**Wt. of Tare**	N/A				
5. **Wt. of Dry Soil**	N/A				
6. **Moisture Content %**	N/A				

PLASTICITY INDEX					
	N/A	N/A	N/A	N/A	N/A
	N/A				
	N/A				
PLASTICITY INDEX FORMULA: PI = LL – PL					

EQUIPMENT USED

Model No.	**M&TE Identification #**	**Calibration Date**	**Calibration Due Date**
Scale	**301723**	**5-04-11**	**5-04-12**
# 40 Sieve	**300106**	**11-30-10**	**11-30-11**
Oven	**308784**	**11-09-10**	**11-09-11**

Remarks: Plasticity Index cannot be determined. The soil is Non-Plastic.

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Attachment C

USDA Wind Erosion Charts

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SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 220

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
8000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
6000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
4000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
3000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
2000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
1000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
800	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
600	259.0	237.6	209.7	184.1	139.9	112.8	77.2	56.2	40.6	26.8	17.9	4.9	3.3
400	254.0	232.8	205.2	179.7	136.0	109.0	74.3	53.8	38.6	25.3	16.8	4.5	3.1
300	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
200	236.0	215.6	188.9	163.9	122.3	96.0	64.3	45.5	32.1	20.4	13.1	3.4	2.3
150	225.0	205.1	179.0	154.4	114.1	88.4	58.5	40.9	28.5	17.7	11.2	2.8	1.9
100	214.0	194.7	169.2	145.0	106.1	81.0	53.0	36.5	25.1	15.3	9.5	2.4	1.6
80	203.0	184.3	159.4	135.7	98.3	73.9	47.7	32.3	22.0	13.1	8.0	1.9	1.3
60	185.4	167.6	144.0	121.2	86.2	63.2	39.9	26.3	17.5	10.1	5.9	1.4	0.7
50	176.7	159.4	136.4	114.1	80.4	58.1	36.3	23.6	15.5	8.7	5.1	1.1	0.6
40	167.2	150.5	128.2	106.5	74.2	52.8	32.5	20.8	13.5	7.4	4.2	0.9	0.5
30	151.0	135.3	114.3	93.7	64.0	44.3	26.6	16.5	10.5	5.5	3.0	0.6	0.3
20	133.6	119.1	99.6	80.4	53.6	35.8	20.9	12.5	7.7	3.9	2.0	0.2	
10	104.4	92.1	75.5	59.1	37.6	23.4	12.8	7.1	4.1	1.9	0.9	0.1	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 220

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
8000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
6000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
4000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
3000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
2000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
1000	236.6	216.2	189.4	164.4	122.7	96.4	64.6	45.8	32.3	20.5	13.3	3.4	2.3
800	234.0	213.7	187.1	162.1	120.8	94.6	63.2	44.7	31.4	19.9	12.8	3.3	2.2
600	228.6	208.6	182.2	157.5	116.7	90.8	60.3	42.4	29.6	18.6	11.8	3.0	2.0
400	221.6	201.9	176.0	151.5	111.6	86.1	56.8	39.5	27.4	17.0	10.7	2.7	1.8
300	215.2	195.8	170.2	146.0	106.9	81.8	53.6	36.9	25.5	15.6	9.7	2.4	1.6
200	202.4	183.7	158.9	135.2	97.9	73.6	47.5	32.1	21.8	13.0	7.9	1.9	1.2
150	189.2	171.2	147.2	124.3	88.7	65.4	41.5	27.5	18.4	10.7	6.3	1.5	1.0
100	179.4	162.0	138.8	116.3	82.2	59.7	37.4	24.4	16.1	9.1	5.3	1.2	0.6
80	170.1	153.2	130.7	108.8	76.1	54.4	33.7	21.6	14.1	7.8	4.5	1.0	0.5
60	155.0	139.1	117.7	96.9	66.5	46.3	28.0	17.5	11.2	6.0	3.3	0.7	0.4
50	146.1	130.8	110.2	90.0	61.1	41.9	24.9	15.3	9.6	5.0	2.7	0.2	
40	138.9	124.0	104.0	84.4	56.7	38.3	22.6	13.7	8.5	4.3	2.3	0.2	
30	127.3	113.3	94.4	75.8	50.1	33.0	19.0	11.2	6.8	3.4	1.7	0.1	
20	110.3	97.5	80.3	63.3	40.7	25.7	14.3	8.1	4.8	2.2	1.1	0.1	
10	86.1	75.3	60.8	46.4	28.5	16.8	8.8	4.6	2.6	1.1	0.3		

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 220

SURFACE - K =1.00

(L) UNSHELTERED DISTANCE IN FEET	(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE: 0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
8000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
6000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
4000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
3000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
2000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
1000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
800	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
600	322.9	299.0	268.8	242.6	192.7	165.4	119.3	92.8	70.6	51.0	37.0	11.2	8.1
400	316.0	292.4	262.3	236.1	186.8	159.3	114.4	88.4	66.9	47.9	34.5	10.3	7.4
300	308.0	284.7	254.9	228.7	180.0	152.4	108.7	83.4	62.7	44.4	31.7	9.4	6.7
200	292.5	269.7	240.5	214.4	167.0	139.3	98.2	74.2	55.1	38.2	26.7	7.7	5.4
150	278.9	256.6	227.9	202.0	155.8	128.2	89.4	66.5	48.9	33.2	22.8	6.4	4.5
100	267.0	245.2	217.0	191.2	146.2	118.9	82.0	60.3	43.8	29.2	19.8	5.4	3.8
80	256.0	234.7	207.0	181.4	137.6	110.5	75.5	54.8	39.4	25.9	17.2	4.6	3.2
60	238.0	217.5	190.7	165.6	123.8	97.4	65.3	46.4	32.8	20.9	13.5	3.5	2.4
50	227.5	207.5	181.2	156.5	115.9	90.1	59.8	41.9	29.3	18.3	11.6	3.0	2.0
40	217.0	197.5	171.9	147.5	108.2	83.0	54.5	37.6	26.0	15.9	10.0	2.5	1.6
30	198.9	180.4	155.8	132.3	95.4	71.4	45.8	30.9	20.9	12.4	7.5	1.8	1.2
20	176.2	159.0	135.9	113.7	80.1	57.9	36.1	23.4	15.4	8.7	5.0	1.1	0.6
10	139.3	124.4	104.4	84.7	57.0	38.5	22.7	13.8	8.5	4.4	2.3	0.2	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 220

SURFACE - K =0.90

(L) UNSHELTERED DISTANCE IN FEET	(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE: 0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
8000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
6000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
4000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
3000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
2000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
1000	295.8	272.9	243.5	217.4	169.7	142.0	100.4	76.1	56.7	39.4	27.7	8.0	5.7
800	292.5	269.7	240.5	214.4	167.0	139.3	98.2	74.2	55.1	38.2	26.7	7.7	5.4
600	285.7	263.2	234.2	208.2	161.4	133.8	93.8	70.3	52.0	35.7	24.7	7.0	4.9
400	277.3	255.2	226.5	200.6	154.5	127.0	88.4	65.7	48.2	32.7	22.4	6.3	4.4
300	270.2	248.3	220.0	194.1	148.8	121.4	84.0	61.9	45.1	30.3	20.5	5.7	4.0
200	257.4	236.0	208.3	182.7	138.7	111.6	76.3	55.5	39.9	26.3	17.5	4.7	3.3
150	244.9	224.1	196.9	171.6	129.0	102.4	69.1	49.5	35.2	22.7	14.9	3.9	2.7
100	232.4	212.2	185.6	160.8	119.6	93.5	62.3	44.0	30.9	19.5	12.5	3.2	2.2
80	222.6	202.9	176.8	152.3	112.3	86.7	57.3	39.9	27.7	17.2	10.8	2.7	1.8
60	205.0	186.1	161.2	137.4	99.7	75.2	48.7	33.1	22.5	13.5	8.3	2.0	1.3
50	193.6	175.3	151.1	127.9	91.7	68.1	43.4	29.0	19.5	11.4	6.8	1.6	1.0
40	184.2	166.5	142.9	120.2	85.3	62.5	39.4	25.9	17.2	9.9	5.8	1.3	0.7
30	169.9	153.1	130.5	108.7	76.0	54.3	33.6	21.6	14.1	7.8	4.5	1.0	0.5
20	148.3	132.8	112.0	91.6	62.4	42.9	25.7	15.8	10.0	5.2	2.8	0.6	
10	117.0	103.8	85.8	68.2	44.3	28.5	16.1	9.3	5.5	2.6	1.3	0.1	

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

(190-V-NAM, Third Ed., January 1998)

Attachment D

Armoring Calculations

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EWR No.:	EWR Title:	
Calc No.: 00424-CAL-002	**Calculation Title:** Wind Erosion Calculations (MULLET Site)	**Rev No.:** 0

Engineered Surface Barrier Design - Depth of Cover Degradation to create a Gravel Armored Surface Layer

Input Data

The depth of cover degradation that must occur prior to the creation of gravel armored surface over the barriers is found by relation of the volumetric fraction of gravel in the cover soil to the gravel armoring depth. The soil properties necessary for this calculation are provided as follows:

Gravel mass fraction	M_g	38	%	>2.0 mm
Cover soil bulk density	ρ_t	1.57	g/cm^3	Target soil bulk density, 90% relative compaction
Gravel particle density	ρ_g	2.5	g/cm^3	NTS RWMS Material Properties (Area 3)
Gravel size range		> 2	mm	

Assumptions

A complete gravel armoring capble of resisting any further erosion by wind or water is provided when a gravel layer of 19.0 mm in thickness has been created by hydraulic sorting and erosional removal of all soil particles < 2mm from the cover soil. This gravel layer depth is equivalent to a mean desert pavement gravel size diameter of 3/4 inch and is consistent with observations at the Nevada National Security Site that well-developed desert pavements are not more than a few centimeters thick (Personal communication, Stuart Rawlingson).

Calculations

The mass fraction of gravel M_g is converted to a volumetric gravel fraction (V_g) as follows:

Gravel mass fraction, $M_g = m_g/m_t$

Silt with gravel bulk density, $\rho_t = m_t/v_t$

Gravel particle density, $\rho_g = m_g/v_g$

Volumetric gravel fraction, $V_g = M_g (\rho_t/\rho_g) = m_g/m_t [(m_t/v_t)/(m_g/v_g)] = v_g/v_t$

where:

m_g = mass of gravel

m_t = mass of cover soil

v_g = volume of gravel

v_t = volume of cover soil

The depth of degradation (D_m) is then calculated as follows

$D_m = d_g/V_g$,

where:

d_g = depth of the gravel armoring layer following hydraulic sorting and removal of fines

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-002	**Calculation Title:** Wind Erosion Calculations (MULLET Site)	**Rev No.:** 0

Engineered Surface Barrier Design - Depth of Cover Degradation to create a Gravel Armored Surface Layer

Results

V_g =	0.238	
d_g=	19.0	mm
D_m =	80	mm
	8.0	cm
	3.1	inches

The total depth of cover degradation before a stable desert pavement develops, retarding further wind and water erosion is approximately 8 cm or 3.1 inches.

WIND EROSION CALCULATIONS (PLAYER SITE)

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	Calculation Title: Wind Erosion Calculations (PLAYER Site)	Rev No.: 0

Purpose of Calculation

This calculation provides an estimate of soil loss due to wind erosion over the designed cover surfaces at the PLAYER site.

Affected Documents

Document No.	Rev No.	Document Title

Software

Software Name	Version

Derivative Classification

Signoffs and Approval

Preparer:	Sign	/s/ Jennifer McRae	Date: 07/15/11
	Print	Jennifer McRae	
Checker: ("N/A" if Peer Review is Required)	Sign	/s/ Jennifer Krenz-Ruark	Date: 07/18/11
	Print	Jennifer Krenz-Ruark	
Peer Reviewer: (Required for NPH)	Sign		Date:
	Print		
Approver:	Sign	/s/ Gino Nguyen	Date: 07/18/11
	Print	Gino Nguyen	

Attachments

Attachment	Title	Pages
A	Soil Ridge Roughness, Soil Erodibility, and Knoll Erodibility Factors	A1-A6
B	Geotechnical Test Results for Area 3 RWMS	B1-B6
C	USDA Wind Erosion Charts	C1-C4
D	Armoring Calculations	D1-D4

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WIND EROSION CALCULATIONS (PLAYER SITE)

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

1. Purpose and Objective

This calculation estimates the amount of soil erosion that will be caused by wind on the final graded areas for the PLAYER site, within the Area 9 Radioactive Waste Management Site (RWMS). It estimates annual erosion and long-term erosion for the proposed design life of the barriers of 1,000 years, using the Wind Erosion Equation (WEQ). The development of a desert pavement from gravels within the cover material is also assessed to estimate the total thickness of cover erosion before a stable surface is developed.

2. Basis

The engineered surface barrier will be constructed using interim cover soils (excess operational covers) and additional engineered fill. The berms will consist of a 2 feet total soil thickness over exposed piping and other site structures.

2.1 Design Inputs

Estimates of potential losses due to wind erosion were performed using the Wind Erosion Equation (WEQ), which is presented in the “Methods” section of this document. The factors used in this equation were estimated for the barrier surface as follows:

Soil Erodibility Factor (I)
The soil erodibility factor (I) represents the potential annual wind erosion in tons per acre per year for a given soil on an isolated, level, smooth, unsheltered, wide, and bare field with a non-crusted surface for climatic factor of 100 percent. This factor depends on soil texture (e.g., crusted or non-crusted) and percentage of dry soil retained on U.S. Standard Sieve No. 20. Adjustment factors are used for knoll configuration, and are a function of the slope inclination of the cover. Soil information for the No. 20 sieve was not available for the stockpiled soil, so the percentage of dry soil retained on a No. 10 sieve was used in its place. Because soil from the Area 3 Borrow Pit will be used to construct the berms, Area 3 soil characteristics have been incorporated into the erosion calculations.

From Table 1, the fraction of coarse sand and gravel particles retained on the No. 10 (2.00 mm) sieve is 38 percent.

From Attachment A, Table A-1, with a soil fraction coarser than the No. 10 sieve of 38 percent, I values were approximated as follows:

Soil Erodibility Factor (I) = 60 tons/acre/year

The Knoll Erodibility Adjustment Factor, A, was used in Table A-2. No factor should be applied for slopes 2% or less (NRCS, 2002).

Adjusted I for 33% and 50% slope = 60 x 3.6 = 216 tons/acre/year

Soil data is included in Attachment B.

Ridge Roughness Factor (K)
The ridge roughness factor (K) applies to soil surfaces that are exposed to recurring agricultural practices (e.g., plowing, planting, disking, and harrowing) and is a function of soil ridge roughness (or height). No agricultural activities are planned for the barriers, thus the ridge roughness factor is assumed to be one.

WIND EROSION CALCULATIONS (PLAYER SITE)

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

The Ridge Roughness Factor (K) was determined by applying these assumptions as shown in Figure A-1.

K = 1.0 (for the lifetime of the barrier)

Climatic Factor (C)
The climatic factor (C) is an index of climatic erosivity, specifically wind speed and surface soil moisture. The factor for any given location is based on long-term climatic data and is expressed as a percentage of the C factor for Garden City, Kansas, which has been assigned a value of 100. A site-specific C factor was calculated for the project.

The climatic factor (C) equation is expressed as:

$$C = 34.48 \times \frac{V^3}{(PE)^2}$$

where:

C = annual climatic factor
V = average annual wind velocity (miles/hour)
PE = precipitation-effectiveness index of Thornthwaite
34.48 = constant used to adjust local values to a common base (Garden City, Kansas)

$$PE = \sum_{Jan}^{Dec} 115 \times \left[\frac{P}{T - 10}\right]^{10/9}$$

where:

PE = annual precipitation effectiveness index
P = average monthly precipitation (inches) (minimum of 0.5)
T = average monthly temperature (°F)

BJY Meteorological Data

Month	Average Precipitation (inches)	Average Temperature (°F)
January	0.83	38.7
February	0.94	43.1
March	0.76	48.2
April	0.36	54.4
May	0.36	62.7
June	0.24	71.0
July	0.50	77.9
August	0.62	76.3
September	0.35	68.9
October	0.32	58.6
November	0.50	45.9
December	0.56	38.9

Source: Soule, 2006

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

BJY Wind Data

Month	Average Wind Speed (knots)	Average Wind Speed (miles/hour)
January	6.7	7.71
February	7.4	8.52
March	7.9	9.09
April	8.6	9.90
May	8.5	9.78
June	8.3	9.55
July	7.8	8.98
August	7.3	8.40
September	7.1	8.17
October	6.8	7.83
November	6.9	7.94
December	6.8	7.83
Average	7.51	8.64

Source: Soule, 2006

Velocity = 8.64 miles/hour

The calculated climatic factor (C) = 136.5

Slope Length Factor (L)
The unsheltered or unbroken field length of slope (L) can be obtained from the design geometry of the cover. This value is normally taken as the longest unbroken slope length of the cover.

The L values from the final grading plan range between 7 feet (average) and 250 feet (maximum). Plots were developed in these calculations to show the variation of soil losses with slope length varied between 7 and 250 feet and for cover slopes 33% and 50%.

Vegetative Factor (V)
The vegetative factor (V) dictates the erosion value. The vegetative factor is calculated as a flat small grain equivalent quantity in pound per acre. The cover for the PLAYER site is not planned to be vegetated, thus V = 0.

2.2 Criteria

Compute annual average soil loss due to wind erosion using the Wind Erosion Equation and estimating the development of a desert pavement that will resist further erosion.

2.3 Assumptions

- Two areas of cover slope 33% and 50%.
- Length of cover slope ranges from 7 feet (for 50% slope) and 250 feet (for 33% slope).
- In-place bulk density of cover soil will be achieved with 90% relative compaction.

- Life of barrier is 1,000 years.
- Once enough erosion loss has occurred to completely armor the soil surface with a desert pavement consisting of the gravel contained in cover soils, it is assumed that the barrier surface will have stabilized and will not be subject to significant additional erosion loss by wind or water.
- A stable cover surface is assumed to have developed once a ¾ inch (19mm) thick average gravel layer is armoring the surface.

3. References

Natural Resources Conservation Service (NRCS). 1998. National Agronomy Manual, Subpart G-Exhibits: Wind Erosion Charts. 190-V-NAM.

Natural Resources Conservation Service (NRCS). 2002. National Agronomy Manual, Part 503. 190-V-NAM, 3rd Edition.

Neptune and Company, Inc. 2006. Alluvium Material Properties Specification for the NTS RWMSs. September 21.

Soule, D.A. 2006. SORD Technical Memorandum SORD 2006-3: Climatology of the Nevada Test Site. Special Operations and Research Division, Las Vegas, Nevada. April.

4. Methods

Wind erosion loss was calculated using the Wind Erosion Equation (WEQ). The WEQ was originally developed for agricultural applications by the USDA Agricultural Research Service.

Potential soil loss from the soil surface due to wind erosion (E) is expressed in terms of the estimated average annual soil loss, in tons per acre per year.

$$E = \text{function of } (I, K, C, L, V)$$

The value of E is obtained by interpolation of the Wind Erosion Charts (NRCS, 1998), given the parameters of I, K, C, L, and V, as presented above.

The wind erosion charts used in the interpolation are presented in Attachment C. These charts show the bounding values for the calculated parameters of the Wind Erosion Equation. Thus, the value of E must be interpolated from these charts. Table 2 presents the interpolation tables for the cover material.

5. Results and Conclusions

The estimated wind erosion losses for varying slope lengths from 7 to 250 feet and cover slopes of 33% (3:1) and 50% (2:1) are presented in Table 3. The wind erosion was calculated as 1.77 cm/year on slopes of 50% and 3.92 cm/year on slopes of 33%. These results indicate that the estimated soil loss due to wind erosion over the 1,000-year design life of the barriers ranges between 57.99 feet (1,767.61 cm) for a slope of 50% and slope length of 7 feet, to 128.58 feet (3,919.2 cm) for a slope of 33% and slope length of 250 feet.

The Wind Erosion Equation and RUSLE methods used in the estimation of soil loss assume static surface conditions that do not change as a result of erosional processes. However, as fines are eroded from the surface layer of the barrier, the surface will become increasingly protected by the remaining gravel armoring. As a result, these methods tend to be overconservative in estimating soil losses. According to the armoring calculation presented in Attachment D, the degradation depth that will create an erosion-resistant gravel-armored surface is 3.1 inches (8 cm). Consequently, this is estimated to be the upper bound of average soil loss due to wind and water erosion forces. Given the Wind Erosion Equation estimates, complete armoring of the barrier surface will occur during the 1,000 year design life of the barrier. To prevent loss of cover thickness, monitoring is proposed over the design life to ensure the minimum of 2-foot cover will be maintained.

6. Calculations and Analyses

For purposes of illustration, the calculations below outline the conversion from wind erosion loss in ton/acre/year to cover thickness loss in cm. For a slope length of 7 feet and inclination of 50%, the estimated soil loss due to wind erosion is 123.595 ton/acre/year and 274.038 ton/acre/year for a slope length of 250 feet and inclination of 33%. For a 1,000-year design life and in-place density of 97.9 lb/ft^3, the total loss (E) is:

For area of slope 50%:
(123.595 tons/acre/yr) x (1,000 yrs) = 123,595 tons/acre

(123,595 tons/acre) x (2,000 lb/ton) x (1 acre/43,560 ft^2) = 5,674.7 lb/ft^2

(5,674.7 lb/ft^2)/(97.9 lb/ft^3) = 57.99 ft = 1,767.6 cm

For area of slope 33%:
(274.038 tons/acre/yr) x (1,000 yrs) = 274,038 tons/acre

(274,038 tons/acre) x (2,000 lbs/ton) x (1 acre/43,560 ft^2) = 12,582.1 lbs/ft^2

(12,582.1 lb/ft^2)/(97.9 lb/ft^3) = 128.58 ft = 3,919.2 cm

Armoring Calculation
The gravel in the soil will increasingly armor the soil surface from erosive forces as erosion removes soil fines. A simple soil particle volume balance calculation was performed to determine the depth of cover degradation that must occur to create a 19.0 mm thick (mean desert pavement gravel size diameter) gravel layer on the soil surface, assuming all material less than 2 mm in diameter had been removed. These calculations are presented in Attachment D.

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

Table 1. Soil Grain Size Data

Soil Grain Size Data - Mean Percent Passing Indicated Size

3 in	1.5 in	3/4 in	3/8 in	#4	#10	#40	#100	#200
76.2 mm	38.1 mm	19.0 mm	9.52 mm	4.75 mm	2.0 mm	0.425 mm	0.150 mm	0.075 mm
100%	100%	98%	89%	77%	62%	36%	18%	10.9%

(Neptune and Company, 2006)

Soil Grain Size Data (minus 2.0 mm fraction only)

#10	#40	#100	#200
2.0 mm	0.425 mm	0.150 mm	0.075 mm
100%	74%	30%	49%

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

Table 2. Wind Erosion Interpolation Table

Wind Erosion Equation (WEQ)

E = f (I, K, C, L, V)

Where:

E = The estimated average annual soil loss in tons per acre per year due to wind erosion

f = An indication that the equation include functional relationships that are not straight-line mathematical functions

I = Soil erodibility factor

K = Ridge roughness factor

C = Climatic factor

L = Unsheltered distance

V = Vegetation factor

Values of E were interpolated using Wind Erosion Charts, as part of the National Agronomy Manual.

Natural Resources Conservation Service (NRCS). 1998. National Agronomy Manual, Subpart G-Exhibits: Wind Erosion Charts. 190-V-NAM.

50% slope for L=7 ft			
Adjusted I	220	220	216
C	120	150	136.5
K	1	1	1
L	10	10	7
V	0	0	0
E	104.4	139.3	123.60

33% slope for L=200 ft			
Adjusted I	220	220	216
C	120	150	136.5
K	1	1	1
L	200	200	250
V	0	0	0
E	236	292.5	267.08

33% slope for L=300 ft			
Adjusted I	220	220	216
C	120	150	136.5
K	1	1	1
L	300	300	250
V	0	0	0
E	248	308	281.00

33% slope for L=250 ft			
E (L=200 ft)	236	292.5	267.08
E (L=300 ft)	248	308	281.00
E (L=250 ft)			274.04

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

Table 3. Calculations for Different Cover Slopes and Lengths

Technical Data		
Cover Slope (%)	50.0%	33%
Percent Passing Sieve #20[a] (%)	62	62
Length of Cover Slope (ft)	7	250
In-Place Bulk Density of Cover Soil[b] (lb/ft^3)	97.9	97.9
Life of Barrier (years)	1000	1000
Wind Erosion Equation - Parameters & Calculations		
Soil Erodibility Factor (I) (tons/ac/yr)	60	60
Knoll Adjustment Factor	3.6	3.6
Adjusted I (tons/ac/yr)	216.0	216.0
Ridge Roughness Factor (K)		
First Year	1.0	1.0
Subsequent Years	1.0	1.0
Climatic Factor (C)	136.5	136.5
Unsheltered Field Length (L) (ft)	7	250
Vegetative Factor (V)		
Cover Vegetation During the First Year: (lb/ac)	0	0
Cover Vegetation During Subsequent Years: (lb/ac)	0	0
Soil Loss Due to Wind Erosion (E)		
Soil Loss (tons/ac/yr)	123.60	274.04
Soil Loss (cm/yr)	1.768	3.919
Total Loss During Design Life 1,000 years of Cover (tons/ac)	123,595.00	274,037.50
Total Loss During Design Life 1,000 years of Cover (lb/ft^2)	5674.7	12582.1
Total Loss Expressed as Thickness of Cover Soil (ft)	57.99	128.58
Total Loss Expressed as Thickness of Cover Soil (cm)	1,767.61	3,919.18

Notes:

[a] Data for percent passing No. 10 sieve was used since data was not available for a No. 20 sieve.

[b] Assumed to be 90% relative compaction of Area 3 RWMS soil.

Attachment A

Soil Ridge Roughness, Soil Erodibility, and Knoll Erodibility Factors

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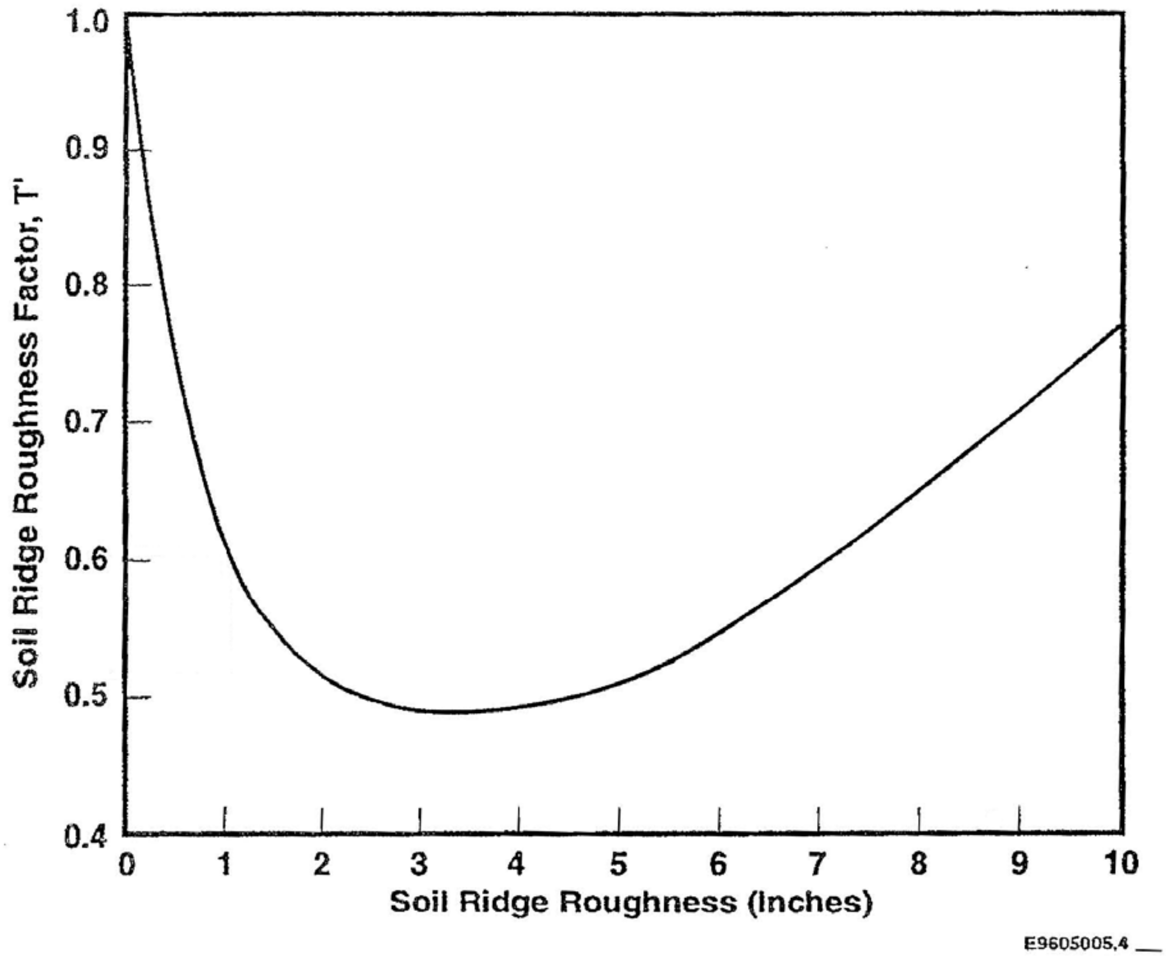
Figure ~~D-2~~ A-1 Soil Ridge Roughness Factor K from Actual Soil Ridge Roughness (EPA 1979).



EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

Table A-1. Soil Erodibility Index "I"

Soil erodibility index in tons/acre determined by percentage of nonerodible fractions

Percent of dry soil not passing a #20 screen	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%
Tens	Noncrusted soil surface (tons/acre)									
0	—	310	250	220	195	180	170	160	150	140
10	134	131	128	125	121	117	113	109	106	102
20	98	95	92	90	88	86	83	81	79	76
30	74	72	71	69	67	65	63	62	60	58
40	56	54	52	51	50	48	47	45	43	41
50	38	36	33	31	29	27	25	24	23	22
60	21	20	19	18	17	16	16	15	14	13
70	12	11	10	8	7	6	4	3	3	2
80	2	—	—	—	—	—	—	—	—	—

(Adapted from NRCS, 2002)

Table A-2. Knoll Erodibility Adjustment Factor for "I"

	A	B
Percent slope change in prevailing wind erosion direction	Knoll adjustment of I	Increase at crest area where erosion is most severe
3	1.3	1.5
4	1.6	1.9
5	1.9	2.5
6	2.3	3.2
8	3.0	4.8
≥ 10	3.6	6.8

(Adapted from NRCS, 2002)

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Attachment B

Geotechnical Test Results for Area 3 RWMS

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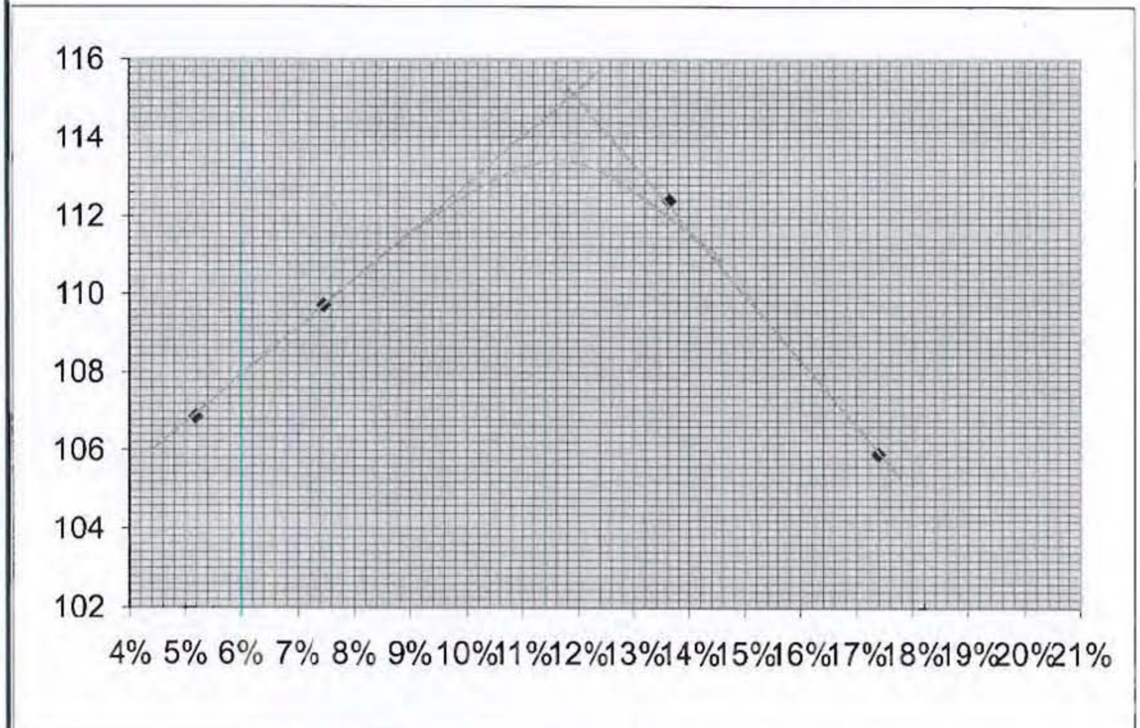
National Security Technologies
Materials testing Laboratory
Nevada Test Site

Modified Proctor Test Results ASTM-D1557 (Method C 6" Mold)

Inpection Request # N/A
Charge # 5B1B70W2
Project: CAU547
User/Agency: NSTec
Date Tested: 5/15/2011
Tested By: /s/ Darrin Anderson

Requested By: Greg Doyle
Work Request# : S-52
Material: A3 Borrow Pit
MTL Lab# 354
Checked By: /s/ Signature on File 5/23/2011

Wt. mold + wet soil (g)	9852.6	9446.7	9967.4	9633.5	N/A	N/A
Wt. mold (g)	5622.3	5622.3	5622.3	5622.3		
Wt. wet soil (g)	4230.3	3824.4	4345.1	4011.2		
Wet density, PCF	124.4	112.4	127.7	117.9		
Moisture Tare#	2	6	4	5		
Wt. wet soil + tare (g)	1325.2	1212.5	1566.3	1284.9		
Wt dry soil + tare (g)	1131.3	1153.6	1380.5	1196.8		
Wt. moisture (g)	193.9	58.9	185.8	88.1		
Wt. tare (g)	17.0	17.5	17.3	17.0		
Wt. dry soil (g)	1114.3	1136.1	1363.2	1179.8		
% moisture	**17.4%**	**5.2%**	**13.6%**	**7.5%**	**#VALUE!**	
Dry Density, PCF	**105.9**	**106.9**	**112.4**	**109.7**	**#VALUE!**	



Max. Den. 113.0 pcf
Opt. Moist. 12.0%

Calibrated Equipment Used:
Scale PM16# 301667 Cal'd 05/04/11 due 05/04/12
Scale PM16# 301256 Cal'd 03/23/11 due 03/23/12
6" Mold# 312653 Cal'd 01/04/10 due 07/04/11
Oven# 308784 Cal'd 11-09-10 due 11-09-11

WIND EROSION CALCULATIONS (PLAYER SITE)

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

X Sieve Analysis (ASTM C136) X Moisture Content (ASTM C-566) ☐ Unit Weight (ASTM C-29) X Passing #200 (ASTM C-117)	NATIONAL SECURITY TECHNOLOGIES MATERIALS TESTING LABORATORY P. O. BOX 98521 LAS VEGAS, NV 89193-8521	Inspection Request # N/A CHARGE # 5B1B70W2 WR # S-52 LAB # 356 DATE 05/13/11

Requested by: Greg Doyle User/Agency: NSTec Material: Native

Project: CAU-547 Location: A-3 Borrow Pit

Date Sampled: 05/12/11 Sampled by: Darrin Anderson / Greg Doyle

Tested by: /s/ Darrin Anderson Checked by: /s/ Signature on File 5/23/2011

SIEVE ANALYSIS

U.S. Standard Sieve #	Cumulative Wt Retained	Total % Retained	% Retained Between Sieves	% Passing	Spec % Passing	Pass	Fail
3"	0.0	0%	0%	100%	N/A	N/A	N/A
1 ½"	0.0	0%	0%	100%	↓	↓	↓
3/4"	133.2	2%	2%	98%			
3/8"	620.8	11%	9%	89%			
#4	1323.3	23%	12%	77%			
#10	2180.2	38%	15%	62%			
#40	3656.3	64%	26%	36%			
#100	4642.9	82%	17%	18%			
#200	5053.9	89.1%	7.4%	10.9%			

Sample Wt (g): 5685.4 Pan # 3

REMARKS: Moisture Content = 8.8 %

Proctor Sieve.

EQUIPMENT USED:

PM 16,	ID# 301256,	Calibration Date	03/23/11	Calibration Due:	03/23/12
PM 16,	ID# 301667,	Calibration Date	05/04/11	Calibration Due:	05/04/12
Oven	ID# 308784	Calibration Date:	11/09/10	Calibration Date:	11/09/11
Sieve 3"	ID# 303221	Calibration Date:	10/19/10	Calibration Date:	10/19/11
Sieve 1 1/2"	ID# 303278	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve 3/4"	ID# 310032	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve 3/8"	ID# 303266	Calibration Date:	02/14/11	Calibration Date:	02/14/12
Sieve #4	ID# 302043	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #10	ID# 311621	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #40	ID# 300106	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #100	ID# 300103	Calibration Date:	11/30/10	Calibration Date:	11/30/11
Sieve #200	ID# 009506	Calibration Date:	11/30/10	Calibration Date:	11/30/11

cc:
Greg Doyle NSTec
NSTec MTL Files

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

Liquid Limit **Plastic Limit** **ASTM D-4318**	**National Securities Technologies** **Materials Testing Laboratory** **P.O Box 98521, M/S 188** **Las Vegas, NV 89193-8521**	**Charge #: 5B1B70W2** **Lab #: 358** **Date Typed: 5-19-11** **Page: 1 of 1**

IR#: 2010-0196

Requested By:	Greg Doyle	**User/Agency:**	NSTec	**Material:**	NATIVE
Project:	A-3 Borrow Pit		**Test Location:**	A-3 Borrow Pit	
Tested By:	Darrin Anderson 186529	**Date Tested:**	5-19-11	**Checked By:** /s/ Signature on File	5/23/2011

LIQUID LIMIT					
Number of Blows	25	22	18		
Correction Factor	N/A	N/A	N/A		
Adjusted Moisture Content %	N/A	N/A	N/A		
Tare No.	1	2	3		
1. Wt Wet Soil + Tare	13.41	15.84	16.17		
2. Wt. Dry Soil + Tare	11.27	13.24	13.41		
3.Wt. of Moisture	2.14	2.60	2.76		
4. Wt. of Tare	1.67	1.53	1.63		
5. Wt. of Dry Soil	9.61	11.71	11.78		
6.Moisture Content %	22.27	22.20	23.43		

PLASTIC LIMIT					
1.Wt Wet Soil + Tare	Non Plastic	Non Plastic	Non Plastic	Non Plastic	Non Plastic
2.Wt Dry Soil + Tare	N/A	N/A	N/A	N/A	N/A
3. Wt. of Moisture	N/A				
4.Wt. of Tare	N/A				
5. Wt. of Dry Soil	N/A				
6. Moisture Content %	N/A				

PLASTICITY INDEX					
	N/A	N/A	N/A	N/A	N/A
	N/A				
	N/A				
PLASTICITY INDEX FORMULA: PI = LL – PL					

EQUIPMENT USED

Model No.	**M&TE Identification #**	**Calibration Date**	**Calibration Due Date**
Scale	**301723**	**5-04-11**	**5-04-12**
# 40 Sieve	**300106**	**11-30-10**	**11-30-11**
Oven	**308784**	**11-09-10**	**11-09-11**

Remarks: Plasticity Index cannot be determined. The soil is Non-Plastic.

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Attachment C

USDA Wind Erosion Charts

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SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 220

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
8000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
6000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
4000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
3000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
2000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
1000	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
800	264.0	242.4	214.3	188.6	143.9	116.6	80.2	58.7	42.6	28.3	19.0	5.2	3.6
600	259.0	237.6	209.7	184.1	139.9	112.8	77.2	56.2	40.6	26.8	17.9	4.9	3.3
400	254.0	232.8	205.2	179.7	136.0	109.0	74.3	53.8	38.6	25.3	16.8	4.5	3.1
300	248.0	227.1	199.7	174.4	131.4	104.6	70.9	51.0	36.4	23.6	15.5	4.1	2.8
200	236.0	215.6	188.9	163.9	122.3	96.0	64.3	45.5	32.1	20.4	13.1	3.4	2.3
150	225.0	205.1	179.0	154.4	114.1	88.4	58.5	40.9	28.5	17.7	11.2	2.8	1.9
100	214.0	194.7	169.2	145.0	106.1	81.0	53.0	36.5	25.1	15.3	9.5	2.4	1.6
80	203.0	184.3	159.4	135.7	98.3	73.9	47.7	32.3	22.0	13.1	8.0	1.9	1.3
60	185.4	167.6	144.0	121.2	86.2	63.2	39.9	26.3	17.5	10.1	5.9	1.4	0.7
50	176.7	159.4	136.4	114.1	80.4	58.1	36.3	23.6	15.5	8.7	5.1	1.1	0.6
40	167.2	150.5	128.2	106.5	74.2	52.8	32.5	20.8	13.5	7.4	4.2	0.9	0.5
30	151.0	135.3	114.3	93.7	64.0	44.3	26.6	16.5	10.5	5.5	3.0	0.6	0.3
20	133.6	119.1	99.6	80.4	53.6	35.8	20.9	12.5	7.7	3.9	2.0	0.2	
10	104.4	92.1	75.5	59.1	37.6	23.4	12.8	7.1	4.1	1.9	0.9	0.1	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 120
I = 220

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
8000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
6000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
4000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
3000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
2000	237.6	217.1	190.3	165.3	123.5	97.1	65.1	46.2	32.7	20.8	13.4	3.5	2.4
1000	236.6	216.2	189.4	164.4	122.7	96.4	64.6	45.8	32.3	20.5	13.3	3.4	2.3
800	234.0	213.7	187.1	162.1	120.8	94.6	63.2	44.7	31.4	19.9	12.8	3.3	2.2
600	228.6	208.6	182.2	157.5	116.7	90.8	60.3	42.4	29.6	18.6	11.8	3.0	2.0
400	221.6	201.9	176.0	151.5	111.6	86.1	56.8	39.5	27.4	17.0	10.7	2.7	1.8
300	215.2	195.8	170.2	146.0	106.9	81.8	53.6	36.9	25.5	15.6	9.7	2.4	1.6
200	202.4	183.7	158.9	135.2	97.9	73.6	47.5	32.1	21.8	13.0	7.9	1.9	1.2
150	189.2	171.2	147.2	124.3	88.7	65.4	41.5	27.5	18.4	10.7	6.3	1.5	1.0
100	179.4	162.0	138.8	116.3	82.2	59.7	37.4	24.4	16.1	9.1	5.3	1.2	0.6
80	170.1	153.2	130.7	108.8	76.1	54.4	33.7	21.6	14.1	7.8	4.5	1.0	0.5
60	155.0	139.1	117.7	96.9	66.5	46.3	28.0	17.5	11.2	6.0	3.3	0.7	0.4
50	146.1	130.8	110.2	90.0	61.1	41.9	24.9	15.3	9.6	5.0	2.7	0.2	
40	138.9	124.0	104.0	84.4	56.7	38.3	22.6	13.7	8.5	4.3	2.3	0.2	
30	127.3	113.3	94.4	75.8	50.1	33.0	19.0	11.2	6.8	3.4	1.7	0.1	
20	110.3	97.5	80.3	63.3	40.7	25.7	14.3	8.1	4.8	2.2	1.1	0.1	
10	86.1	75.3	60.8	46.4	28.5	16.8	8.8	4.6	2.6	1.1	0.3		

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

SUBPART G - EXHIBITS

502.60(a)

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 220

SURFACE - K =1.00

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
8000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
6000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
4000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
3000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
2000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
1000	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
800	330.0	305.9	275.5	249.3	199.0	171.8	124.6	97.6	74.7	54.3	39.8	12.2	8.8
600	322.9	299.0	268.8	242.6	192.7	165.4	119.3	92.8	70.6	51.0	37.0	11.2	8.1
400	316.0	292.4	262.3	236.1	186.8	159.3	114.4	88.4	66.9	47.9	34.5	10.3	7.4
300	308.0	284.7	254.9	228.7	180.0	152.4	108.7	83.4	62.7	44.4	31.7	9.4	6.7
200	292.5	269.7	240.5	214.4	167.0	139.3	98.2	74.2	55.1	38.2	26.7	7.7	5.4
150	278.9	256.6	227.9	202.0	155.8	128.2	89.4	66.5	48.9	33.2	22.8	6.4	4.5
100	267.0	245.2	217.0	191.2	146.2	118.9	82.0	60.3	43.8	29.2	19.8	5.4	3.8
80	256.0	234.7	207.0	181.4	137.6	110.5	75.5	54.8	39.4	25.9	17.2	4.6	3.2
60	238.0	217.5	190.7	165.6	123.8	97.4	65.3	46.4	32.8	20.9	13.5	3.5	2.4
50	227.5	207.5	181.2	156.5	115.9	90.1	59.8	41.9	29.3	18.3	11.6	3.0	2.0
40	217.0	197.5	171.9	147.5	108.2	83.0	54.5	37.6	26.0	15.9	10.0	2.5	1.6
30	198.9	180.4	155.8	132.3	95.4	71.4	45.8	30.9	20.9	12.4	7.5	1.8	1.2
20	176.2	159.0	135.9	113.7	80.1	57.9	36.1	23.4	15.4	8.7	5.0	1.1	0.6
10	139.3	124.4	104.4	84.7	57.0	38.5	22.7	13.8	8.5	4.4	2.3	0.2	

(E)* SOIL LOSS FROM WIND EROSION IN TONS PER ACRE PER YEAR — JANUARY, 1998

C = 150
I = 220

SURFACE - K =0.90

(V)** - FLAT SMALL GRAIN RESIDUE IN POUNDS PER ACRE

(L) UNSHELTERED DISTANCE IN FEET	0	250	500	750	1000	1250	1500	1750	2000	2250	2500	2750	3000
10000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
8000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
6000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
4000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
3000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
2000	297.0	274.1	244.7	218.5	170.7	143.0	101.2	76.8	57.3	39.9	28.1	8.2	5.8
1000	295.8	272.9	243.5	217.4	169.7	142.0	100.4	76.1	56.7	39.4	27.7	8.0	5.7
800	292.5	269.7	240.5	214.4	167.0	139.3	98.2	74.2	55.1	38.2	26.7	7.7	5.4
600	285.7	263.2	234.2	208.2	161.4	133.8	93.8	70.3	52.0	35.7	24.7	7.0	4.9
400	277.3	255.2	226.5	200.6	154.5	127.0	88.4	65.7	48.2	32.7	22.4	6.3	4.4
300	270.2	248.3	220.0	194.1	148.8	121.4	84.0	61.9	45.1	30.3	20.5	5.7	4.0
200	257.4	236.0	208.3	182.7	138.7	111.6	76.3	55.5	39.9	26.3	17.5	4.7	3.3
150	244.9	224.1	196.9	171.6	129.0	102.4	69.1	49.5	35.2	22.7	14.9	3.9	2.7
100	232.4	212.2	185.6	160.8	119.6	93.5	62.3	44.0	30.9	19.5	12.5	3.2	2.2
80	222.6	202.9	176.8	152.3	112.3	86.7	57.3	39.9	27.7	17.2	10.8	2.7	1.8
60	205.0	186.1	161.2	137.4	99.7	75.2	48.7	33.1	22.5	13.5	8.3	2.0	1.3
50	193.6	175.3	151.1	127.9	91.7	68.1	43.4	29.0	19.5	11.4	6.8	1.6	1.0
40	184.2	166.5	142.9	120.2	85.3	62.5	39.4	25.9	17.2	9.9	5.8	1.3	0.7
30	169.9	153.1	130.5	108.7	76.0	54.3	33.6	21.6	14.1	7.8	4.5	1.0	0.5
20	148.3	132.8	112.0	91.6	62.4	42.9	25.7	15.8	10.0	5.2	2.8	0.6	
10	117.0	103.8	85.8	68.2	44.3	28.5	16.1	9.3	5.5	2.6	1.3	0.1	

* NOTE: SOIL LOSS FOR VALUES WHERE 'E' IS LESS THAN 0.1 OR GREATER THAN 440.0 ARE NOT SHOWN; OTHER VALUES NOT SHOWN ARE INVALID

** NOTE: VALUES SHOWN ARE FLAT SMALL GRAIN EQUIVALENT, NOT 'V'

EWR No.:	EWR Title:	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

Attachment D

Armoring Calculations

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Engineered Surface Barrier Design - Depth of Cover Degradation to create a Gravel Armored Surface Layer

Input Data

The depth of cover degradation that must occur prior to the creation of gravel armored surface over the barriers is found by relation of the volumetric fraction of gravel in the cover soil to the gravel armoring depth. The soil properties necessary for this calculation are provided as follows:

Gravel mass fraction	M_g	38	%	>2.0 mm
Cover soil bulk density	ρ_t	1.57	g/cm^3	Target soil bulk density, 90% relative compaction
Gravel particle density	ρ_g	2.5	g/cm^3	NTS RWMS Material Properties (Area 3)
Gravel size range		> 2	mm	

Assumptions

A complete gravel armoring capble of resisting any further erosion by wind or water is provided when a gravel layer of 19.0 mm in thickness has been created by hydraulic sorting and erosional removal of all soil particles < 2mm from the cover soil. This gravel layer depth is equivalent to a mean desert pavement gravel size diameter of 3/4 inch and is consistent with observations at the Nevada National Security Site that well-developed desert pavements are not more than a few centimeters thick (Personal communication, Stuart Rawlingson).

Calculations

The mass fraction of gravel M_g is converted to a volumetric gravel fraction (V_g) as follows:

Gravel mass fraction, $M_g = m_g/m_t$

Silt with gravel bulk density, $\rho_t = m_t/v_t$

Gravel particle density, $\rho_g = m_g/v_g$

Volumetric gravel fraction, $V_g = M_g (\rho_t/\rho_g) = m_g/m_t [(m_t/v_t)/(m_g/v_g)] = v_g/v_t$

where:

m_g = mass of gravel

m_t = mass of cover soil

v_g = volume of gravel

v_t = volume of cover soil

The depth of degradation (D_m) is then calculated as follows

$D_m = d_g/V_g$,

where:

EWR No.:	**EWR Title:**	
Calc No.: 00424-CAL-003	**Calculation Title:** Wind Erosion Calculations (PLAYER Site)	**Rev No.:** 0

Engineered Surface Barrier Design - Depth of Cover Degradation to create a Gravel Armored Surface Layer

d_g = depth of the gravel armoring layer following hydraulic sorting and removal of fines

Results

V_g =	0.238	
d_g=	19.0	mm
D_m =	80	mm
	8.0	cm
	3.1	inches

The total depth of cover degradation before a stable desert pavement develops, retarding further wind and water erosion is approximately 8 cm or 3.1 inches.

Attachment D-1

Radiological Assessment Model

(11 Pages)

Radiological Assessment Model for CAU 547

June 2011

1.0 Objective

Corrective Action Unit (CAU) 547 consists of three Corrective Action Sites, 03-99-19 (TEJON site), 02-37-02 (MULLET site), and 09-99-06 (PLAYER site). All three CASs were locations where effluent from safety tests were piped from the event borehole. These three sites have piping remaining which is contaminated with transuranic radionuclides resulting from these activities. This analysis evaluates closing the three CAU 547 CASs with soil covers, and the resulting long term risk to visitors. For the purposes of this analysis, the PLAYER location was chosen as it has the highest contamination levels of the three sites. A radiological assessment model for CAU 547 was developed from the Area 3 RWMS Performance Assessment model using GoldSim probabilistic simulation software. The cover thickness required to protect the public and environment was determined using this model.

2.0 Summary of Conclusion

This model assumes that contamination from CAU 547 is rapidly released to surface soil by the burrowing of small mammals once pipe integrity is lost. A cover thickness of 1 foot (ft) is found to be sufficient to maintain the annual total effective dose (TED) to a visitor less than 0.25 millisieverts (mSv). Uncertainty analysis performed by Monte Carlo simulation indicates that there is a very high probability that the annual dose to a visitor would be less than 0.25 mSv. The visitor's annual TED at 1,000 years (y) is highly sensitive to uncertainty in the length of the active institutional control period and moderately sensitive to the light activity ventilation rate and underground pipe ^{239}Pu inventory.

3.0 Methods and Assumptions

The CAU 547 version 3.0 GoldSim model was prepared from the Area 3 Radioactive Waste Management Site (RWMS) version 2.0 (A3 RWMS v2.0) GoldSim model. The Area 3 RWMS v2.0 GoldSim model is the most current baseline GoldSim model implementing the performance assessment model (Shott et al., 2001). The CAU 547 model was created by redimensioning the model to correspond with the near-surface source required for the CAU.

3.1 Important Assumptions

3.1.1 Closure

The PLAYER pipe is assumed to be covered by a 1 to 5 ft layer of native alluvium. The cover alluvium is assumed to have the same properties as alluvium at the Area 3 RWMS. The cover thickness is measured from the top of the pipe to the land surface. For the purposes of this model, the expansion joint at the well head, which extends several feet above the land surface, is assumed to be buried in a mound of alluvium.

3.1.2 Institutional Control

A probabilistic period of active institutional control is assumed based on an elicitation of a panel of subject matter experts (Black et al., 2001). Active institutional control is followed by a period of passive institutional control based on site knowledge. The total period of institutional control has a median length of 393 y. The probability that institutional controls will persist 100 and 1,000 y is 97 and 11 percent, respectively. Institutional controls are assumed to maintain doses at negligible levels. Exposures are not quantitatively evaluated until institutional controls end.

3.1.3 Source Term

The contaminated pipe is divided into three segments with similar depths of burial and environmental conditions. These are 1) the wellhead/expansion joint with a more deeply distributed source, 2) the underground pipe section under the berm, and 3) the pipe in the crater with potentially higher subsurface moisture content (Figure 3.1). Each segment has different dimensions, discretization, material properties, and inventory. The length of the well head, underground pipe, and crater pipe segments are 40, 345, and 250 ft, respectively (Nastanski, 2008).

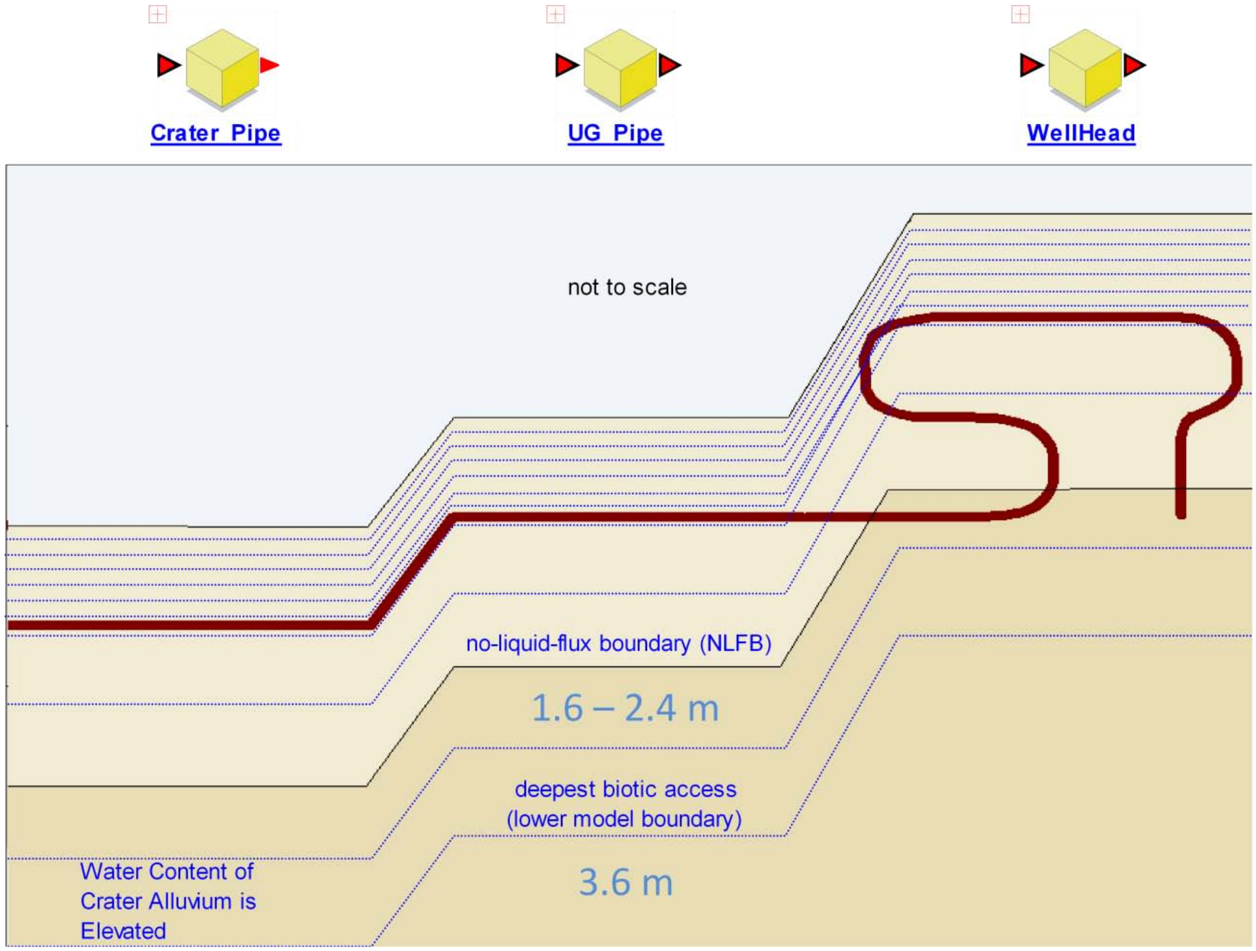

Figure 3.1 Schematic of the model source term boundaries and discretization.

Model layers containing pipe segments are assigned the inventory associated with the pipe segment. A single 4.5 inch layer is assigned to the horizontal pipe segments. Pipe segments in the well head expansion head below the upper horizontal segment are distributed over larger cells.

The pipe is assumed to lose all integrity at the start of the simulation. Contamination is assumed to be immediately available for release and transport.

The inventory is assumed to have the nuclide composition in Table 4 of NSTec (2008). Inventory is assigned to model layers based on the total length of pipe assumed to be in that layer. The uncertainty in inventory is assumed to be normally distributed with a coefficient of variation of 30 percent (Emer, 2009).

3.1.4 Release and Transport

Infiltrating precipitation is assumed to percolate to a depth of 2 m (6.6 ft) or less and then be returned to the atmosphere by evapotranspiration. Multiple lines of evidence suggest recharge of the uppermost aquifer through the valley fill alluvium ceased at the end of the last pluvial period more than 10,000 y ago. Contamination of the uppermost aquifer is assumed to be unlikely over the next 1,000 y.

Radionuclides are assumed to be released upwards to the land surface. Processes included in the model are:

- Upward liquid advection driven by large negative water potential in the near surface, maintained by high evapotranspiration.
- Gaseous and liquid diffusion driven by concentration gradients.
- Liquid phase transport is subject to linear adsorption on the solid phase and solubility limits.
- Plant uptake and translocation to aboveground tissue followed by senescence and transfer to the surface soil.
- Transfer of contaminated soil and waste to surface soil by animal burrowing. Soil is mixed downward by burrow collapse and infilling.
- Soil particulates are resuspended to the atmosphere. Resuspended soil and gases are advected off site.

The concentration of radionuclides released to surface soil is averaged over 33 m^2, the area of the horizontal pipe segments.

3.1.5 Exposure Scenario

The member of public is assumed to be an average adult that spends 80 hours as a visitor at the site. The visitor is exposed by external irradiation, inhalation of resuspended soil, and inadvertent soil ingestion. Inhalation of resuspended soil particulates and inadvertent soil ingestion are assumed to be reduced by an area factors as estimated by RESRAD (Yu et al. 2001). The exposure scenario is evaluated for a period of 1,000 y after closure.

4.0 Results

4.1 Soil Concentration

Radionuclides contained in the CAU 547 pipe are rapidly released to surface soil as soon as the pipe is assumed to lose integrity (Figure 4.1). Afterwards, changes in surface soil concentrations largely reflect radiological decay rather than environmental transport. The relative concentrations of radionuclides are similar to the pipe inventory, with ^{239}Pu being the nuclide present at highest concentrations. The surface soil concentration exceeds the 100 nCi g^{-1} transuranic (TRU) limit at approximately 10 years and reaches a peak concentration of 160 nCi g^{-1} at 180 years.

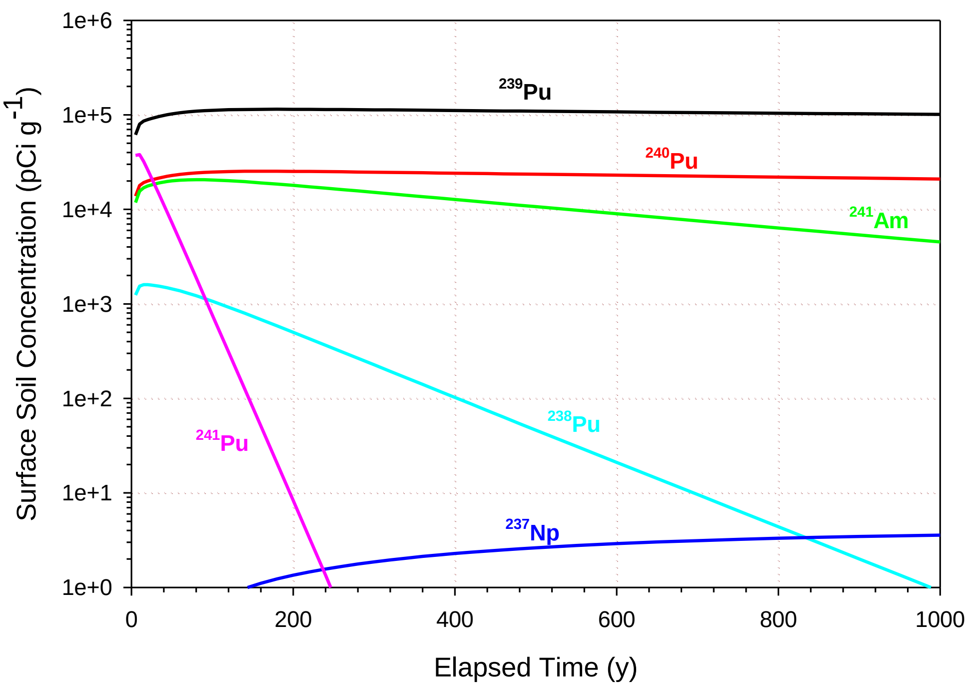

Figure 4.1 Mean surface soil activity concentration at CAU 547 over time with a 1 ft cover.

Transport to the surface soil occurs predominately by small mammal (e.g., rodent) burrowing. Under the animal burrowing model, excavated soil is transported to the surface layer. Collapse of burrows is assumed to occur by infilling from overlaying layers. As a consequence, contamination above the pipe is initially concentrated in the surface layer and gradually over time mixes back into the soil profile (Figure 4.2). Most contamination in the pipe is mixed deeper into the profile due the infilling of burrows excavated below the pipe. Concentration in the upper 1 m (3.3 ft) of soil is relatively stable after 100 years.

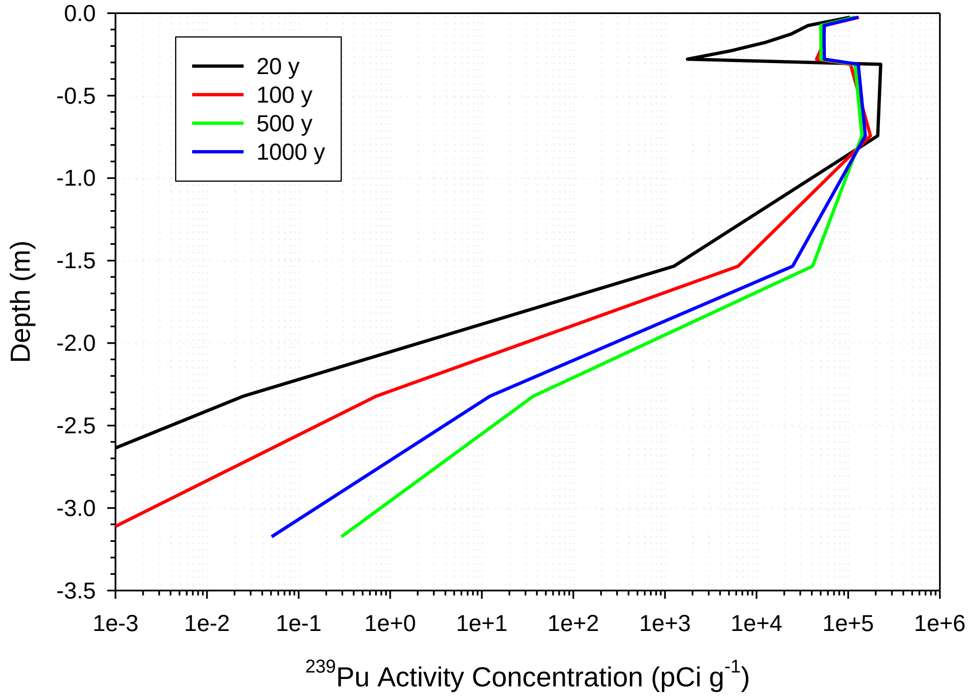

Figure 4.2 Mean ^{239}Pu activity concentration with depth over time for the underground pipe segment. Pipe has a 1 ft cover.

4.2 Visitor Dose

The relationship between visitor annual TED and cover thickness was determined using 2,000 model realizations. Visitor TED was found to be a decreasing function of cover thickness (Figure 4.3). The mean and 95th percentile annual TED was found to be less than 0.25 mSv for all cover thicknesses evaluated from 1 to 5 ft. A significant fraction (~11 percent) of realizations produce zero dose due to institutional controls being effective greater than 1,000 years.

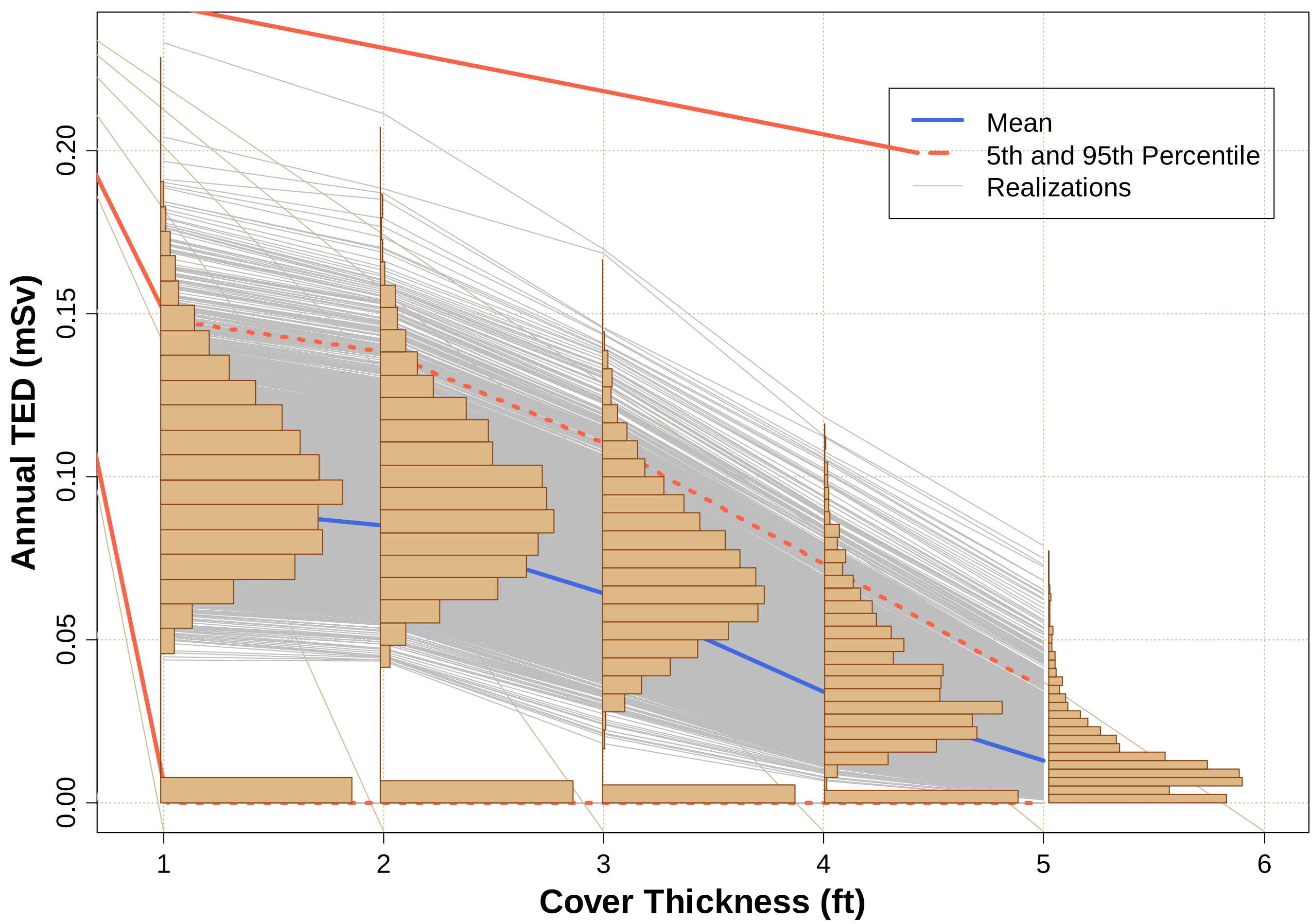

Figure 4.3 Visitor annual TED for CAU 547 as a function of cover thickness.

Examination of individual realizations of the visitor annual TED for a 1 ft cover as a function of time indicates that dose is decreasing slightly with time (Figure. 4.4). The mean annual TED, however, increases initially as a function of time due to the effects of the increasing probability that institutional control will end.

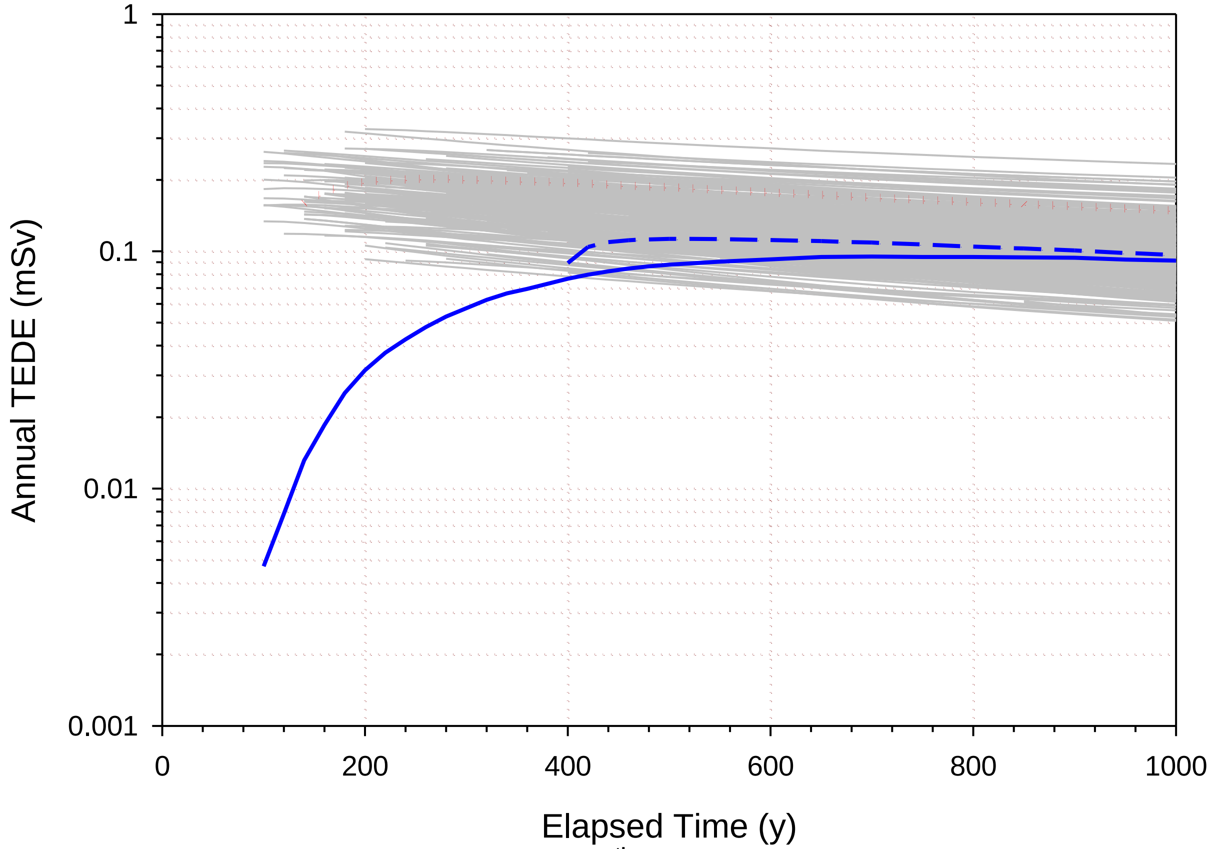

Figure 4.4 Mean (solid), median (dashed), and 95th percentile (doted) visitor TED over time for CAU 547 with a 1 ft cover. Individual model realizations show in grey.

4.3 Uncertainty Analysis

Uncertainty in the visitor annual TED for a 1 ft cover was investigated by propagating parameter uncertainty through the model by Monte Carlo simulation using 2,000 Latin hypercube samples. The cumulative distribution function of the simulated data indicates there is a high probability that the visitor annual TED is less than 0.25 mSv (Figure 4.5).

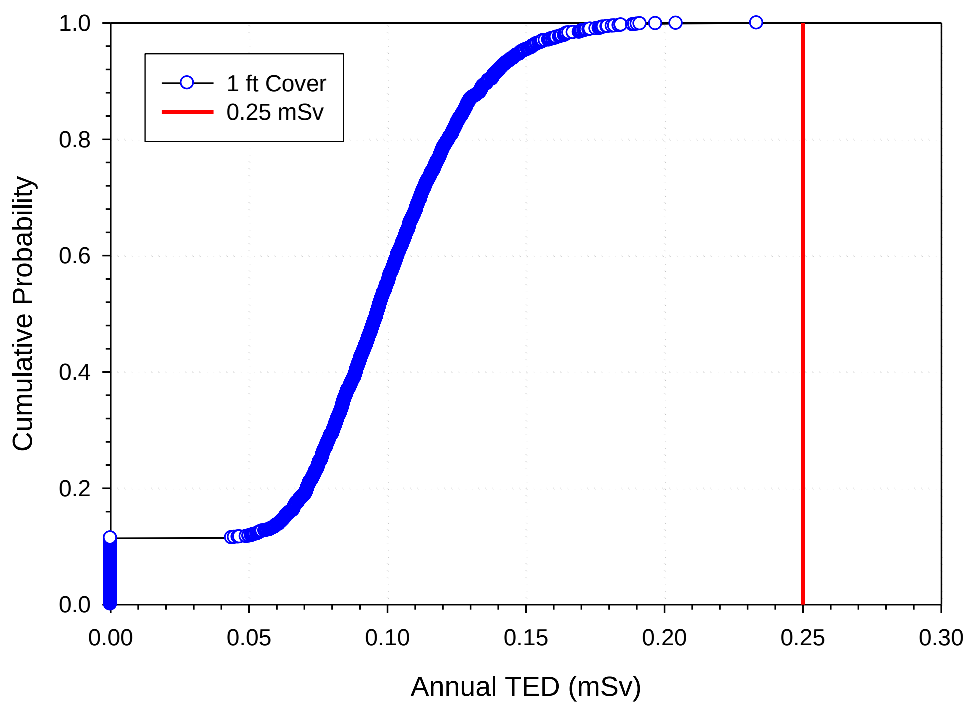

Figure 4.5 Empirical cumulative distribution function of the visitor annual TED at 1,000 years for a 1 ft cover.

4.4 Sensitivity Analysis

Sensitivity analysis was performed for the visitor annual TED with a 1 ft cover at 1,000 years by fitting a generalized boosted model (gbm) to the Monte Carlo simulation results. The data were well fit (r = 0.91) by the model except in those cases where institutional control exceeded 1,000 years and the visitor annual TED was zero.

The visitor annual TED with a 1 ft cover at 1,000 years was found to be strongly sensitive to the length of the active institutional control period, moderately sensitive to the light activity ventilation rate and underground pipe ^{239}Pu inventory, and slightly sensitive to a number of other parameters including the crater pipe ^{239}Pu inventory and underground pipe ^{241}Am inventory (Figure 4.6). Most of the significant sources of uncertainty cannot effectively be reduced. Sensitive parameters with uncertainty that may be reduced include the underground pipe ^{239}Pu inventory, the crater pipe ^{239}Pu inventory, underground pipe ^{241}Am inventory, and the rodent burrow depth distribution. The maximum uncertainty reduction possible is less than 25 percent.

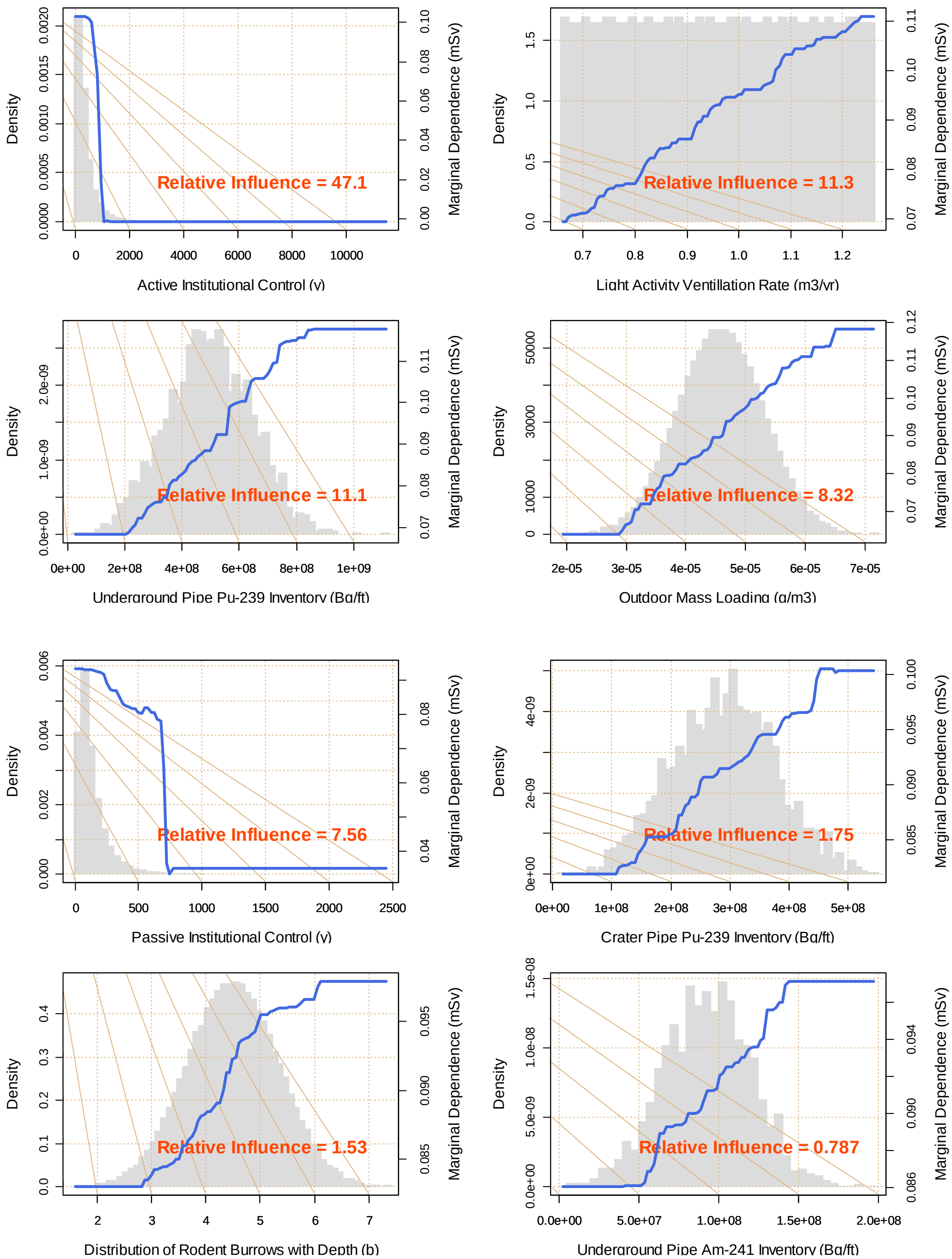

Figure 4.6 Probability density function (grey), marginal dependence (blue), and relative influence (red) of the most sensitive parameters for annual visitor TED at 1,000 years.

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Appendix E

Post-closure Plan

(6 Pages)

Progressive Monitoring Approach for CAU 547

1.0 INTRODUCTION

Corrective Action Unit (CAU) 547, Miscellaneous Contaminated Waste Sites, consists of sites that were a result of direct gas sampling activities during underground safety tests. The gas sampling piping, equipment, and instrumentation were left in place following these tests. A progressive monitoring approach will be used to provide a protective and cost effective method to monitor the CAU 547 sites and address potential contaminant migration in the future.

CAU 547 consists of the following three Corrective Action Sites (CASs):

- CAS 02-37-02, Gas Sampling Assembly (resulting from the MULLET test)
- CAS 03-99-19, Gas Sampling Assembly (resulting from the TEJON and BERNALILLO tests)
- CAS 09-99-06, Gas Sampling Assembly (resulting from the PLAYER test)

2.0 ROUTINE POST-CLOSURE MONITORING AND INSPECTIONS

The CAU 547 CASs will be closed in place by covering the exposed piping and equipment with a 2-foot soil cover, installing concrete barriers and steel casings, and implementing a use restriction (UR) to prohibit unauthorized intrusive activities. Post-closure inspections and monitoring will be required to verify that integrity and effectiveness of the covers are being maintained, and to identify repairs to correct the effects of settling, subsidence, erosion, or other impacts to the cover effectiveness.

The approach for long term monitoring is described below. However, if any changes are required to this approach, these will be documented in the Closure Report. The CADD/CAP will not require modification.

2.1 INSPECTIONS

For the first two years following placement of the covers, quarterly visual site inspections will be completed at the CAU 547 sites. Annual inspections will be performed in the following years. Inspections will be conducted to verify that the UR warning signs are in place and readable and that the UR has been maintained. In addition, the soil covers will be inspected for cracks, animal burrows, or other evidence of subsidence or erosion, and the integrity of the soil covers will be verified. In particular, the sloped section of the PLAYER site will be monitored for indications of erosion. Concrete barriers and steel casings will be visually inspected to verify integrity, stability, and that berms are present along the base as constructed.

In addition, non-scheduled inspections will be conducted if precipitation occurs in excess of 1.0 inch in a 24-hour period at the nearest rain gauge to each site (to be specified). These inspections will be conducted to verify the continued integrity of the soil covers and document erosion or other conditions requiring repair.

Signs and barriers will be repaired or replaced as necessary. If burrows greater than 6 inches deep are observed and/or if erosion/subsidence greater than 6 inches deep and 3 feet long is observed, notification to the Nevada Division of Environmental Protection (NDEP) will be made, the damaged area(s) will be radiologically surveyed prior to repair, and repairs will be made within 90 calendar days of discovery. If contamination is not detected above action levels, no additional monitoring will be required.

The inspection results will be documented in the annual combined post-closure letter report for closed non-*Resource Conservation and Recovery Act* (RCRA) CAUs and submitted to NDEP. The post-closure letter report will include a discussion of observations made during the inspections, and provide a summary of repair and maintenance activities. In addition, copies of the completed inspection checklists will be included in the post-closure letter report.

2.2 MAINTENANCE AND REPAIR

Any identified maintenance or repair requirements will be reported to NDEP and completed within 90 calendar days of discovery. Repair work shall preserve the intent of the cover design. If the cover repair requires the modification of the cover design, the U.S. Department of Energy, National Nuclear Security Administration Nevada Site Office (NNSA/NSO) shall present a formal design modification request to NDEP prior to making the design modification. All repair and maintenance activities will be documented in writing at the time of the repair and included in the annual combined post-closure letter report for non-RCRA CAUs.

2.3 RADIOLOGICAL SURVEYS

As part of the closure process, baseline radiological surveys will be conducted at each site after remedial action is complete to document conditions at closure. While not part of the FFACO process, the newly constructed soil cover over the pipe at CAS 03-99-19 (TEJON/BERNALILLO) will be evaluated in accordance with the Nevada National Security Site (NNSS) Radiation Safety Prime Contractor's (RSPC) radiological control program and down posted, if possible, from a Contaminated Area (CA) to an Underground Radioactive Material Area (URMA) to facilitate future inspections. CAS 02-37-02 (MULLET) is expected to remain a CA because of contaminated soil at this site. The soil cover will remain posted as a CA because of the likelihood of contamination spreading onto it from the surrounding soils. CAS 09-99-06 (PLAYER) is expected to remain an URMA.

Radiological controls, boundaries, and postings will remain in effect at these sites. The sites will be incorporated into the NNSS RSPC demarcation maintenance program for long-term maintenance and will be surveyed to monitor and control the potential for radiological contamination migration. Surveys will be conducted at a minimum frequency of every four years for an URMA and two years for a CA and will be performed in accordance with approved Radiological Control Department procedures and technical basis documents, including TBD-P260-015, *Radiological Posting of Outdoor Areas*, TBD-P260-033, *Removable Soil Contamination Survey: Stomp and Tromp,* and TBD-P260-038, *Demarcation Maintenance Program*. Contamination migration outside of the posted areas will trigger additional posting of the area(s), notification to NDEP, and further evaluation as described in the progressive monitoring approach (Section 3.0).

Table 1 summarizes the post-closure inspection and monitoring activities that will be conducted, the compliance criteria established for each activity, and the actions required if the compliance criteria are exceeded.

TABLE 1. PROGRESSIVE APPROACH FOR CAU 547

PROGRESSIVE MONITORING STEP	BASELINE/ACCEPTABLE CONDITION	TRIGGER CONDITION FOR PROGRESSING TO THE NEXT STEP
Step 1: Routine Monitoring	Contamination is not detected above action levels; no additional monitoring will be required.	General area removable alpha contamination is detected in damaged areas above the CA limits.
Step 2: Evaluate Source (i.e., CAU 547 or nearby sites)	The contamination source is determined not to be from CAU 547. Resume routine monitoring.	The source is either determined to be CAU 547 or a source cannot be determined.
Step 3: Evaluate Extent of Contamination	Contamination is less than 4 square feet • Radiological surveys of the repaired areas for next two quarterly inspections. • Discontinue radiological surveys if additional contamination not detected.	Contamination is greater than 4 square feet **and/or** Additional contamination is discovered during quarterly monitoring.
Step 4: Perform Air Sampling	No airborne hazard exists or air sampling indicates that the source is not CAU 547. Air sampling will be discontinued.	Airborne hazard exists or air sampling indicates that the source is CAU 547.
Step 5: Evaluate Design for Effectiveness	Design effective, increased monitoring will continue.	Design for a CAS or portion of a CAS shown not to be effective, propose design changes to NDEP for approval and implementation.

CA limits are consistent with DOE Orders and are currently specified within the Nevada Test Site Radiological Control Manual Table 2-2.

NDEP: Nevada Division of Environmental Protection
UR: Use restriction

3.0 PROGRESSIVE MONITORING APPROACH

As described in Section 2.0, visual inspections will be conducted periodically, and in the event that precipitation occurs in excess of 1.0 inch in a 24-hour period. Radiological surveys will be conducted as part of the repairs and maintenance activities to determine if there has been a potential release of radioactive material from these sites as a result. These steps are described below and in Table 1. These are also shown in Figure 1.

Routine Monitoring: Visual inspections will be conducted quarterly for the first two years, then annually and in the event that precipitation occurs in excess of 1.0 inch in a 24-hour period. If burrows are observed and/or if erosion/subsidence greater than 6 inches deep and 3 feet long is observed, NDEP will be notified, the damaged area(s) will be radiologically surveyed prior to repair, and repairs will be made within 90 calendar days of discovery. If contamination is not detected above action levels, no additional monitoring will be required.

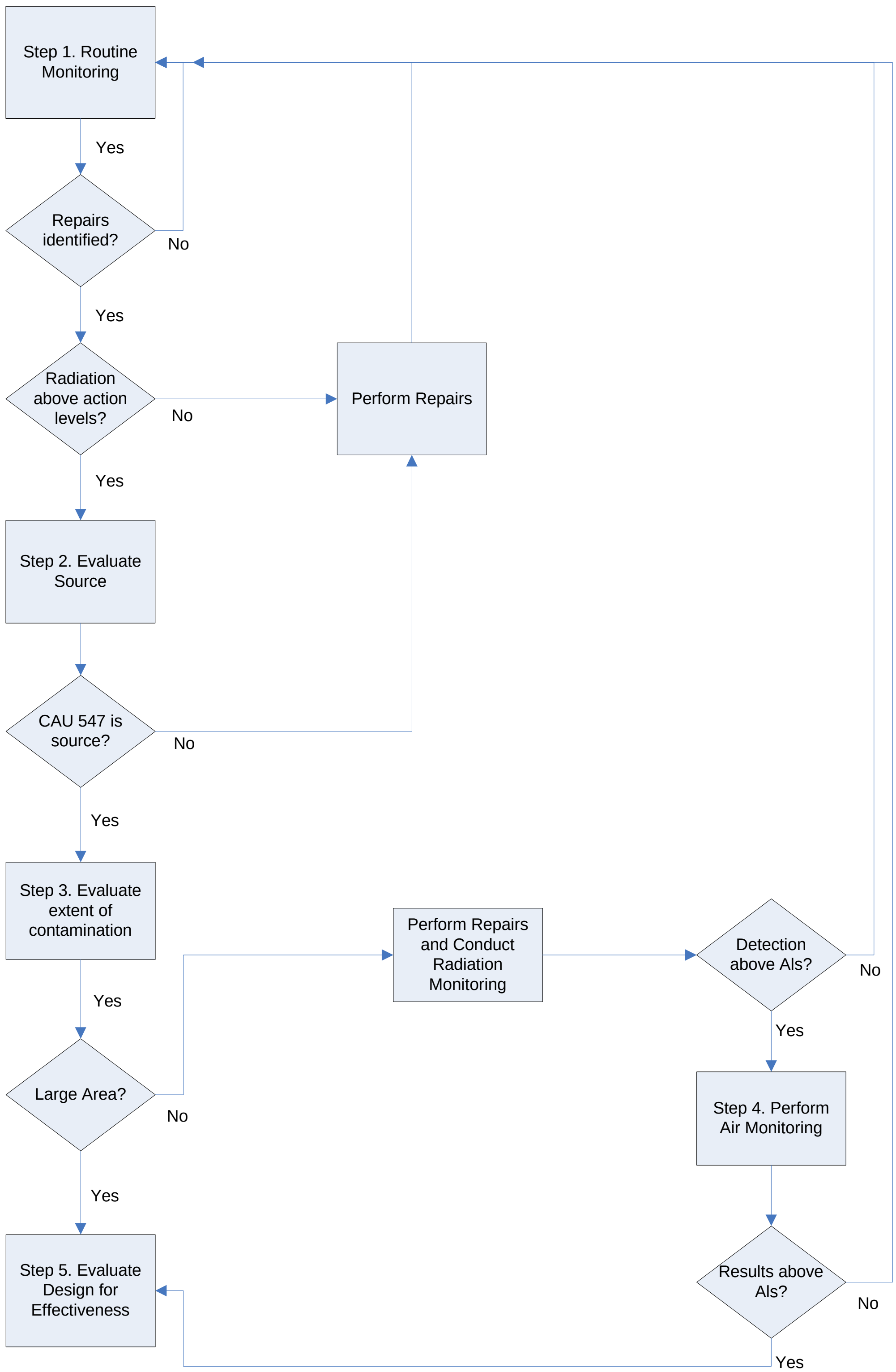
The post-closure program will be evaluated to determine whether the frequency and/or approach should be modified. If there is no additional radiation detected during the monitoring evaluations, NNSA/NSO may request that the frequency and/or complexity of monitoring be adjusted.

Minor Contamination is Detected: If general area removable alpha contamination is detected in damaged areas above CA limits, then an evaluation will be performed to determine the source of the contamination. If the source of the contamination is determined not to be from CAU 547, then no additional monitoring will be required and routine monitoring will resume. The following lines of inquiry will be used as appropriate to guide the evaluation and determine if the contamination is attributable to CAU 547:

- Is the pipe exposed, and/or is there evidence of a breach?
- Do radiological surveys indicate that the contamination is highest in the immediate vicinity of the damaged area, consistent with a compromised pipe, or is it widespread indicating a source other than CAU 547?
- Is contamination present in or on the clean fill material within the damaged area, indicating the source of contamination is from a compromised pipe, or is it primarily on the surface of the berms, indicating a source other than CAU 547?
- Are the contaminants similar to what is in the pipe indicating the source of contamination is from a compromised pipe, or dissimilar, indicating a source other than CAU 547?

If the evaluation described above determines that the source of contamination is CAU 547, then the extent of contamination will be evaluated using approved radiological survey methods and techniques. For areas where contamination is less than 4 square feet, repairs will be made, and the following two quarterly inspections will require radiological surveys of the repaired areas. These radiological surveys of the repaired areas will be discontinued if no additional contamination above CA limits is detected. If additional contamination is discovered during the quarterly surveys, then additional evaluation will be performed to determine the source of the contamination and determine if additional repairs are required.

FIGURE 1. DECISION TREE FOR THE CAU 547 SITES MONITORING



Contamination Detected in Larger Areas: If the extent of removable alpha contamination detected above CA limits is greater than 4 square feet, and if there is a potential risk for spread of contamination outside the posted area, then air sampling/monitoring will be implemented in accordance with approved Radiological Control Department procedures and technical basis documents to determine if an airborne hazard exists. Data from multiple air samplers should be compared to the CAU 547 information to determine if the contamination, if present, is most likely from CAU 547 or most likely from another source (non-CAU 547).

After 2 weeks of consecutive air sampling, if the source of the contamination has been repaired, and an airborne radioactivity hazard is proven not to exist, air sampling can be discontinued. If an airborne radioactivity hazard exists that is related to CAU 547, then the design for that CAS will be evaluated for effectiveness. In areas where the design is not effective, changes will be proposed to NDEP through the Record of Technical Change or revision process and implemented after approval. In addition, where contamination is greater than 20 square feet, the design for that CAS or portion of a CAS will be evaluated for effectiveness. Changes will be proposed as above if the design is shown not to be effective.

4.0 REFERENCES

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National Security Technologies, LLC, 2011. *Direct and Indirect Surveys.* SOP-0441.211. Las Vegas, NV.

Appendix F

Cost Estimates

F.1.1 Cost Estimates

This appendix presents a high-level cost estimate for each CAA evaluated for CAU 547. Because no further action was not included in the CAA evaluation, a cost estimate for this CAA is not presented below.

F.1.2 Corrective Action Alternative A, Clean Closure

The corrective action of clean closure consists of cutting the gas sampling assembly piping at each CAS into 4-ft lengths and containerizing these sections for offsite disposal. All exposed piping and equipment would be removed at each CAS; however, the piping and structures below original grade at the Tejon site would be left in place. The contaminated soil currently in the CA at the Mullet site would also be removed and disposed of under this alternative. The areas where contamination was left in place would be fenced, and UR signs would be posted. The cost estimate for clean closure of all three CASs is presented in Table F.1-1.

Table F.1-1
Cost Estimate for Clean Closure Alternative

Activity	Cost
Site Preparation and Setup	$1.7 M
Field Activities	$14.8 M
Waste Disposal	$0.4 M
TOTAL (fieldwork only)	$16.9 M
Planning Documentation and Pre-Field Activities	$13.2 M
GRAND TOTAL (includes planning documentation and pre-field activities)	**$30.1 M**

F.1.3 Corrective Action Alternative B, Closure in Place

The corrective action of closure in place would require site workers to cover all exposed sections of the gas sampling assembly with a minimum of 2 ft of soil; install new fencing around each site where required; and maintain the soil covering, fencing, and signage. Metal retention structures (i.e., well casings) would be placed over the vertical sections of each gas sampling assembly, filled with concrete, and welded shut with a metal cover. The cost estimate for closure in place of all three CASs is presented in Table F.1-2.

Table F.1-2
Cost Estimate for Closure in Place Alternative

Activity	Cost
Site Preparation and Setup	$0.7 M
Field Activities	$1 M
Waste Disposal	$0.09 M
TOTAL (fieldwork only)	$1.8 M
Planning Documentation and Pre-Field Activities	$1.2 M
GRAND TOTAL (includes planning documentation and pre-field activities)	**$3 M**

F.1.4 Corrective Action Alternative C, Modified Closure in Place

The corrective action of modified closure in place would involve the removal and onsite burial of select gas assembly features and the establishment of URs. The expansion joints at Mullet and Player SGZ would be cut at the ground surface and buried at the bottom of the U9z crater. In addition, the entire length of pipe along the U9z crater slope would be cut into sections, moved down to the crater bottom, and buried with a minimum of 2 ft of soil cover. The cost estimate for modified closure in place of all three CASs is presented in Table F.1-3.

Table F.1-3
Cost Estimate for Modified Closure in Place Alternative

Activity	Cost
Site Preparation and Setup	$0.7 M
Field Activities	$4 M
Waste Disposal	$0.09 M
TOTAL (fieldwork only)	$4.8 M
Planning Documentation and Pre-Field Activities	$9.2 M
GRAND TOTAL (includes planning documentation and pre-field activities)	**$14 M**

F.1.5 Corrective Action Alternative D, No Further Action (with administrative controls)

The corrective action of no further action (with administrative controls) would require a fence around each CAS posted with warning signs. No modification of the gas sampling assembly systems would be required. The cost estimate for no further action (with administrative controls) at all three CASs is presented in Table F.1-4.

Table F.1-4
Cost Estimate for No Further Action (with administrative controls) Alternative

Activity	Cost
Site Preparation and Setup	$0.05 M
Field Activities	$0.1 M
Waste Disposal	$0
TOTAL (fieldwork only)	$0.15 M
Planning Documentation and Pre-Field Activities	$0.15 M
GRAND TOTAL (includes planning documentation and pre-field activities)	**$0.3 M**

Appendix G

Nevada Division of Environmental Protection Comments

(1 Page)

NEVADA ENVIRONMENTAL RESTORATION PROJECT
DOCUMENT REVIEW SHEET

1. Document Title/Number:	Draft Corrective Action Decision Document/Corrective Action Plan for Corrective Action Unit 547: Miscellaneous Contaminated Waste Sites	**2. Document Date:**	7/28/2011
3. Revision Number:	0	**4. Originator/Organization:**	Navarro-INTERA
5. Responsible NNSA/NSO Federal Sub-Project Director:	Kevin J. Cabble	**6. Date Comments Due:**	8/29/2011
7. Review Criteria:	Full		
8. Reviewer/Organization/Phone No:	Jeff MacDougall, NDEP, 486-2850 ext. 233	**9. Reviewer's Signature:**	

10. Comment Number/Location	11. Type*	12. Comment	13. Comment Response	14. Accept
1.) Section 2.1.1	Mandatory	Provide additional information detailing the use of ISOCS at each of the corrective action sites (i.e., describe how ISOCS was applied/performed at each CAS).	Additional detail regarding the conduct of the ISOCS surveys was added to Section 2.1.1, *ISOCS Radiological Surveys.* This section discusses each of the ISOCS surveys separately and provides specific ISOCS measurements collected at different locations on the pipes. In addition, Section 2.2.1, *Data Summary*, was revised to include updated radiological inventories for each CAS and text describing the general method of inventory calculation.	

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