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CHARACTERIZATION REPORT FOR THE 92-ACRE AREA OF THE AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE, NEVADA TEST SITE, NEVADA

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CHARACTERIZATION REPORT FOR THE 92-ACRE AREA OF THE AREA 5 RADIOACTIVE WASTE MANAGEMENT SITE, NEVADA TEST SITE, NEVADA

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EXECUTIVE SUMMARY

The U.S. Department of Energy (DOE), National Nuclear Security Administration Nevada Site Office (NNSA/NSO) manages two low-level Radioactive Waste Management Sites (RWMSs) at the Nevada Test Site (NTS). The Area 5 RWMS uses engineered shallow-land burial cells to dispose of packaged waste. This report summarizes characterization and monitoring work pertinent to the 92-Acre Area in the southeast part of the Area 5 RWMS. The southeast quadrant covers 37 hectare (ha) (92 acres [ac]), and is referred to as the "92-Acre Area."

The cells in the 92-Acre Area include 13 boreholes, 16 narrow trenches, and 9 broader pits. The waste disposal units were gradually established during 45 years of waste operations. Only three disposal units within the 92-Acre Area are currently active. Most of the disposal units have been operationally closed with covers of at least 2.4 meters (m) (8 feet [ft]) of native fill. Closure of the 92-Acre Area disposal units is anticipated by 2011.

Current closure plans organize the disposal cells of the 92-Acre Area into six closure units by physical location, waste types, and regulatory requirements. One of these closure units is Federal Facility Agreement and Consent Order Corrective Action Unit (CAU) 111: Retired Mixed Waste Pits. The CAU 111 pits and trenches were operated prior to the promulgation of the Resource Conservation and Recovery Act (RCRA) and may have received both low-level waste (LLW) and low-level mixed waste (LLMW). A proposed single final closure cover and a monitoring plan will meet the needs of all six closure units within the 92-Acre Area. Studies indicate a monolayer soil cover will provide the equivalent protection of a standard RCRA cover, and offer superior performance with respect to subsidence.

The precursor to the Area 5 RWMS, the Sugar Bunker Dump, began receiving waste by 1960 and began burying waste in January 1961. The Area 5 RWMS was established in 1978 on a 296 ha (732-ac) site incorporating the existing Sugar Bunker Dump waste cells in the southeast corner. The thirteen 37-m (120-ft) boreholes were drilled in the 1980s for the Greater Confinement Disposal (GCD) program. The GCD program was terminated before all the boreholes were used.

Both classified and unclassified materials are managed at this facility. Unclassified disposal records and historic records indicate waste types in the 92-Acre Area include LLW, LLMW, asbestiform waste, transuranic (TRU) waste, and mixed TRU waste. Most of the inventory is LLW, and much of the LLW contains radionuclides that will decay significantly over the next several decades. Most of the TRU and potential mixed TRU waste is in boreholes over 21 m (70 ft) below ground surface. Thorium waste is present in the lowest tier of one disposal pit. Two disposal units have been designated for asbestos waste. Much of the suspected LLMW was deposited at the oldest disposal units prior to the promulgation of RCRA. The contaminants are not readily released or transported, due to the structure (such as lead shielding). The waste acceptance criteria, packaging requirements, monitoring, and other factors in the operation of the interim status RCRA-permitted P03U Mixed Waste Disposal Unit minimize the potential for release and transport of hazardous contaminants from the P03U closure unit.

Much of the radioactivity in the inventory is in relatively immobile forms, with the exception of tritium, a volatile radionuclide which can readily move with water. Most of the tritium inventory is located in containers within a single disposal cell, GCD-05U. The movement of water through the near-surface environment, and the potential for tritium transport and release, have been assessed in detail. Tritium levels in soil gas, groundwater, air, and biota in the vicinity are monitored. Although tritium has been detected in soil gas below 15 m (50 ft) depth near the waste packages, air monitoring and biota monitoring at the Area 5 RWMS suggest that very little, if any, tritium has migrated from the buried waste to ground surface.

Monitoring programs near or at the Area 5 RWMS include direct radiation, air quality, vadose zone moisture, soil gas, biota, groundwater quality, meteorological parameters, and waste-cover subsidence. The programs document environmental conditions, document the performance of the operational soil covers, and provide input parameters for the water balance and performance models. Results to date indicate there has been no significant release of radionuclides to the atmosphere, the plants, or groundwater. Radon flux levels near the waste cells have been consistently at least five times lower than the federal performance objectives and regulatory standards. Direct radiation exposure levels at the facility are very low. Moisture infiltration in the soil covers has been effectively mitigated by evapotranspiration. Settling of the operational covers has been monitored and promptly corrected to mitigate potential erosion.

Over the past few decades, NNSA/NSO and its contractors have produced many documents that summarize pertinent characterization, modeling, and monitoring data. The scope of studies is both broad and detailed, from regional hydrogeological modeling and natural hazard potential evaluations, to the evaluation of the potential for termite and ant communities at the Area 5 RWMS to bring radionuclides to the ground surface. This summary highlights some of the most relevant characterization data. For further details, several key studies, and the Performance Assessment (PA) and the Composite Analysis for the Area 5 RWMS are referenced.

The Area 5 RWMS setting is well-suited for the isolation and disposal of waste. The Area 5 RWMS is located in an access-controlled government facility many miles from residential populations. The site has a windy, arid climate. Average annual potential evapotranspiration (PET) measured from 1995 through 2004 was 152.87 centimeters (60.19 inches). Mean evapotranspiration rates are many times the mean precipitation rates. The ratio of PET to precipitation ranged from 6 to 54 and averaged 17 over the 10 years of record. On an annual basis, even in wet cool years, evaporative demand is high.

The site is far from surface-water supplies. Surface runoff and run-on are insignificant, and engineering evaluations of existing structures indicate a 25-year flood event can be controlled in accordance with RCRA flood-protection requirements.

Risks of significant earthquakes and volcanic hazards at the site are low. Minor subsidence of the ground surface above the edges of waste containers and the margins of the cells is likely; however, this localized subsidence can be mitigated by careful placement of containers and cover fill, and through monitoring and maintaining covers at older cells.

The potential for infiltration of water into the waste material and erosion or biological disturbance of the waste is low. The potential for waste disturbance is mitigated by the facility design and setting. Potential for significant transport or release of contaminants from the waste deposits are minimized by:

- Waste characteristics,
- Soil-cover characteristics,
- Depth of waste burial,
- Shallow plant rooting depths,
- Shallow animal burrow depths,
- Great depth to groundwater,
- Lack of significant surface water runoff,
- Flood mitigation features,
- High evapotranspiration rates,
- Low precipitation rates,
- Alkaline soils, and
- Low risk of significant natural hazards.

Effectively, there is no groundwater pathway. The shallow waste-disposal units are in thick deposits of sandy and silty alluvium. Depth to groundwater is over 230 m (755 ft). Environmental tracers, water potential, and other data suggest there is a zone of upward water movement that extends as much as 35 m (115 ft) deep, underlain by a thick static zone where there is no free gravitational flow. Potential vertical water movement rates through the relatively dry alluvium are slow. The average time modeled for unretarded flow, from the bottom of the static zone to the capillary fringe of the groundwater table, was over 55,000 years. The potential for groundwater recharge in the vicinity of the Area 5 RWMS is extremely low. Consequently, the potential for groundwater contamination from waste disposal activities at the Area 5 RWMS is negligible.

The principle potential processes for upward movement of contaminants away from the buried waste containers to the ground surface and atmosphere include:

- Transport of soluble radionuclides by liquid advection and diffusion by retardation,
- Transport of particulate and soluble radionuclides by plant uptake and animal burrowing, movement of gaseous radionuclides via diffusion and with the moisture, and
- Inadvertent intrusions.

Sufficient information is available about the site’s physical, chemical, hydrological, plant, animal, and climate characteristics, as well as facility design, operation, and source materials to provide the input data necessary to complete the PAs and Composite Analysis, taking into account these transport processes. Assessments and analyses indicate that the Area 5 RWMS will meet the DOE regulatory performance criteria for the 1,000-year compliance period. Predicted potential human exposures for various future potential land-use scenarios are negligible.

The decades of characterization and assessment work at the Area 5 RWMS indicate that the access controls, waste operation practices, site design, final cover design, site setting, and arid natural environment contribute to a containment system that meets regulatory requirements and performance objectives for the short- and long-term protection of the environment and public. The available characterization and PA information is adequate to support design of the final cover and development of closure plans. No further characterization is warranted to demonstrate regulatory compliance. NNSA/NSO is proceeding with the development of closure plans for the six closure units of the 92-Acre Area.

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ACRONYMS AND ABBREVIATIONS

ac	acre
AES	Alternative Evaluation Study
AFM	Alluvial Fan Methodology
ALARA	As Low As Reasonably Achievable
BN	Bechtel Nevada
BEIDMS	Bechtel Environmental Integrated Data Management System
C	Celsius
Ca	Calcium
CA	Composite Analysis
CAU	Corrective Action Unit
CFR	Code of Federal Regulations
^{36}Cl	chlorine-36
cm	centimeter
cm^3	cubic centimeter
cm/sec	centimeters per second
DAS	Disposal Authorization Statement
DCG	Derived Concentration Guide
DoD	Department of Defense
DOE	U.S. Department of Energy
DOE/NV	U.S. Department of Energy/Nevada Operations Office
DQO	Data Quality Objectives
DVRFS	Death Valley Regional Flow System
EPA	U.S. Environmental Protection Agency
FEMA	Federal Emergency Management Agency
F	Fahrenheit
FR	Federal Regulations
FFACO	Federal Facility Agreement and Consent Order
ft	foot, feet
ft^3	cubic feet
ft/yr	feet per year
FY	fiscal year
gal	gallon

g/cm^3	grams per cubic centimeter
GCD	Greater Confinement Disposal
GCDT	Greater Confinement Disposal Test
ha	hectare
HCO_3	bicarbonate
HDP	Heat Dissipation Probe
ICMP	Integrated Closure and Monitoring Plan
in.	inch, inches
K	potassium
kg	kilogram(s)
km	kilometer(s)
km^2	square kilometers
Ksat	saturated hydraulic conductivity
L	Liter
lb	pound(s)
lbs/ft^3	pounds per cubic foot
LCA	Lower Carbonate Aquifer
LLMW	Low-Level Mixed Waste
LLW	Low-Level Waste
LWIS	Low-Level Waste Information System
M	Manual
m	meter(s)
m^3	cubic meters
m amsl	meters above mean sea level
MDC	minimum detectable concentration
mi	miles
mi^2	square miles
mg/L	milligrams per liter
Mg	magnesium
mGy	milliGray
mm	millimeter
mph	miles per hour
mR/day	milliroentgens per day
mrem	milliroentgen equivalent man
MTRU	Mixed Transuranic (waste)

MWDU	Mixed Waste Disposal Unit
m/yr	meters per year
µg/L	micrograms per liter
Na	sodium
NAC	Nevada Administrative Code
NDEP	Nevada Division of Environmental Protection
NESHAP	National Emissions Standard for Hazardous Air Pollutants
NNSA/NSO	National Nuclear Security Administration Nevada Site Office
NTS	Nevada Test Site
NTSWAC	Nevada Test Site Waste Acceptance Criteria
O	Order (as in DOE Order)
OI	Organization Instruction
OP	Organization Procedure
PA	Performance Assessment
pCi/L	picoCurie(s) per liter
pCi/m^3	picoCuries per cubic meter
pCi/m^2/s	picoCurie(s) per square meter per second
PET	Potential Evapotranspiration
PPT	precipitation
RCRA	Resource Conservation and Recovery Act
REECO	Reynolds Electrical and Engineering Co, Inc.
RREMP	Routine Radiological Environmental Monitoring Plan
RSN	Raytheon Services Nevada
RWM	Radioactive Waste Management
RWMS	Radioactive Waste Management Site
^{90}Sr	strontium-90
TDR	Time-Domain Reflectometry
TEDE	Total Effective Dose Equivalent
TFRG	TRU Federal Review Group
TLD	thermoluminescent dosimeter
TOC	total organic carbon
TOX	total organic halogens
TRU	Transuranic
UGTA	Underground Test Area
yr	year

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE) National Nuclear Security Administration Nevada Site Office (NNSA/NSO) manages two low-level Radioactive Waste Management Sites (RWMSs) at the Nevada Test Site (NTS). The Area 5 RWMS uses engineered shallow-land burial cells (trenches, pits, and borings) to dispose of packaged waste (Becker et al., 1998). This report summarizes characterization and monitoring work pertinent to the 92-Acre Area in the southeast part of the Area 5 RWMS. The southeast quadrant covers 37 hectare (ha) (92 acre [ac]), and is referred to as the "92-Acre Area." This information may be used to support development of closure plans. Closure of the 92-Acre Area disposal units is anticipated by 2011.

Although primarily a low-level waste (LLW) disposal facility, the 92-Acre Area includes 11 trenches and pits that may have received radioactive low-level mixed waste (LLMW) prior to the promulgation of the *Resource Conservation and Recovery Act* (RCRA). These were designated "Corrective Action Unit (CAU) 111: Retired Mixed Waste Pits" in the *Federal Facility Agreement and Consent Order* (FFACO). The 92-Acre Area also contains an active mixed-waste pit, two units which have received asbestiform LLW, and six disposal units which are known or suspected to have received some transuranic (TRU) waste. Portions of the 92-Acre Area have already been operationally closed with temporary earthen covers constructed over the waste. The closure strategy is to close the diverse unclassified waste and classified material disposal units in place, as six closure units, each consisting of one or more disposal units, under a single final cover. The final closure plans will meet the regulatory closure requirements for all the disposal unit waste types.

Over the past several decades, the vicinity of the RWMS has been intensely and thoroughly studied. The characterization and environmental monitoring data have been presented in numerous documents. The characteristics pertinent to potential contaminant transport have been well-defined and this information can be used to support closure plans for these facilities.

1.1 SITE LOCATION

The NTS is located in southern Nevada, 105 kilometers (km) (65 miles [mi]) northwest of Las Vegas. The NTS is subdivided into administrative areas, with Area 5 on the eastern edge. The focus of this report is the southeast quadrant of the Area 5 RWMS (Figure 1-1).

The Area 5 RWMS is located in a topographically closed basin approximately 22 km (14 mi) north of Mercury, Nevada, in the north-central part of Frenchman Flat, and approximately 24 km (15 mi) south of the Area 3 RWMS, which is in south-central Yucca Flat. Figure 1-2 shows the RWMS facilities with respect to the approximate hydrographic basin boundaries.

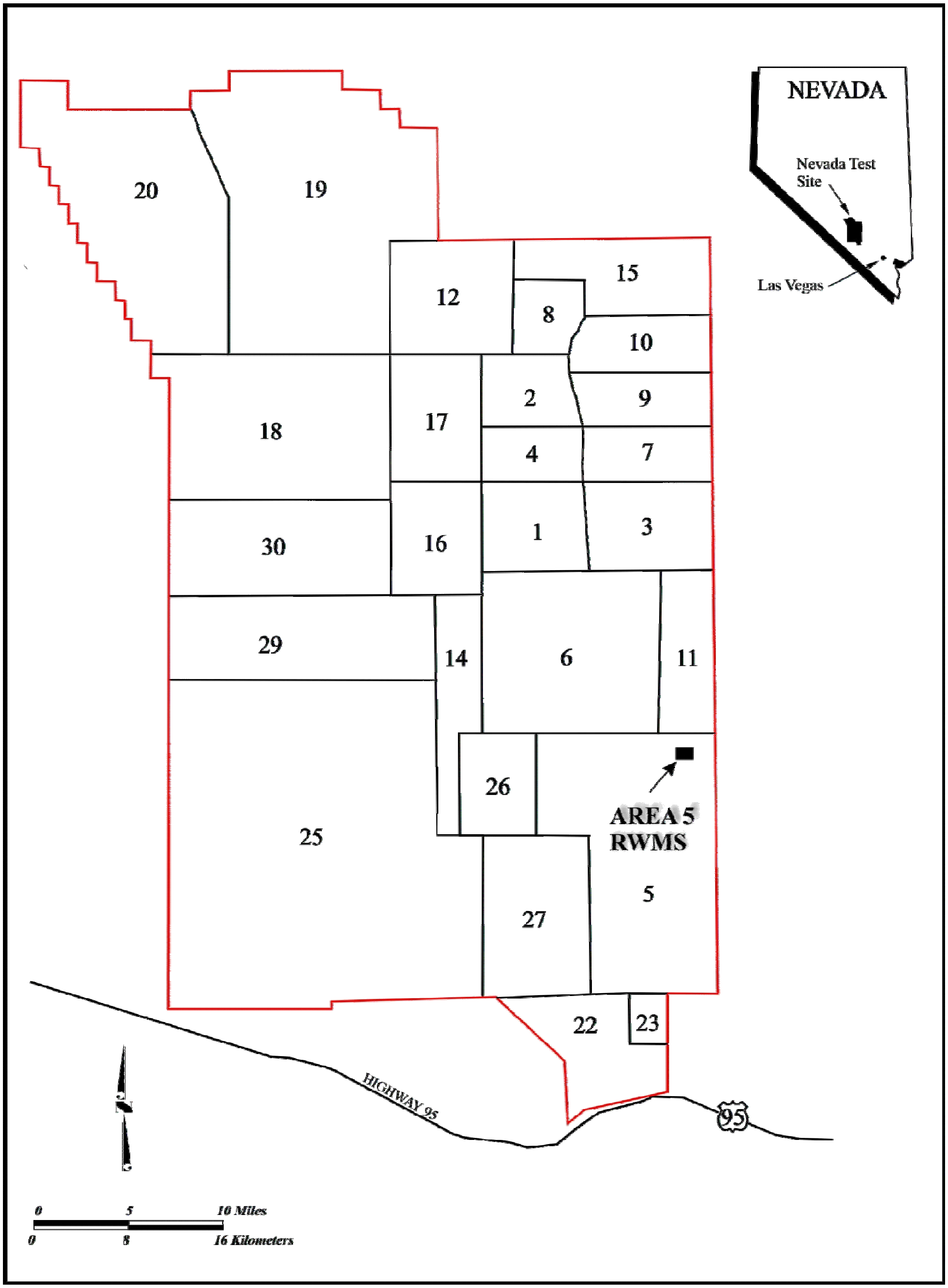

Figure 1-1. Location of the Area 5 Radioactive Waste Management Site, Nevada Test Site

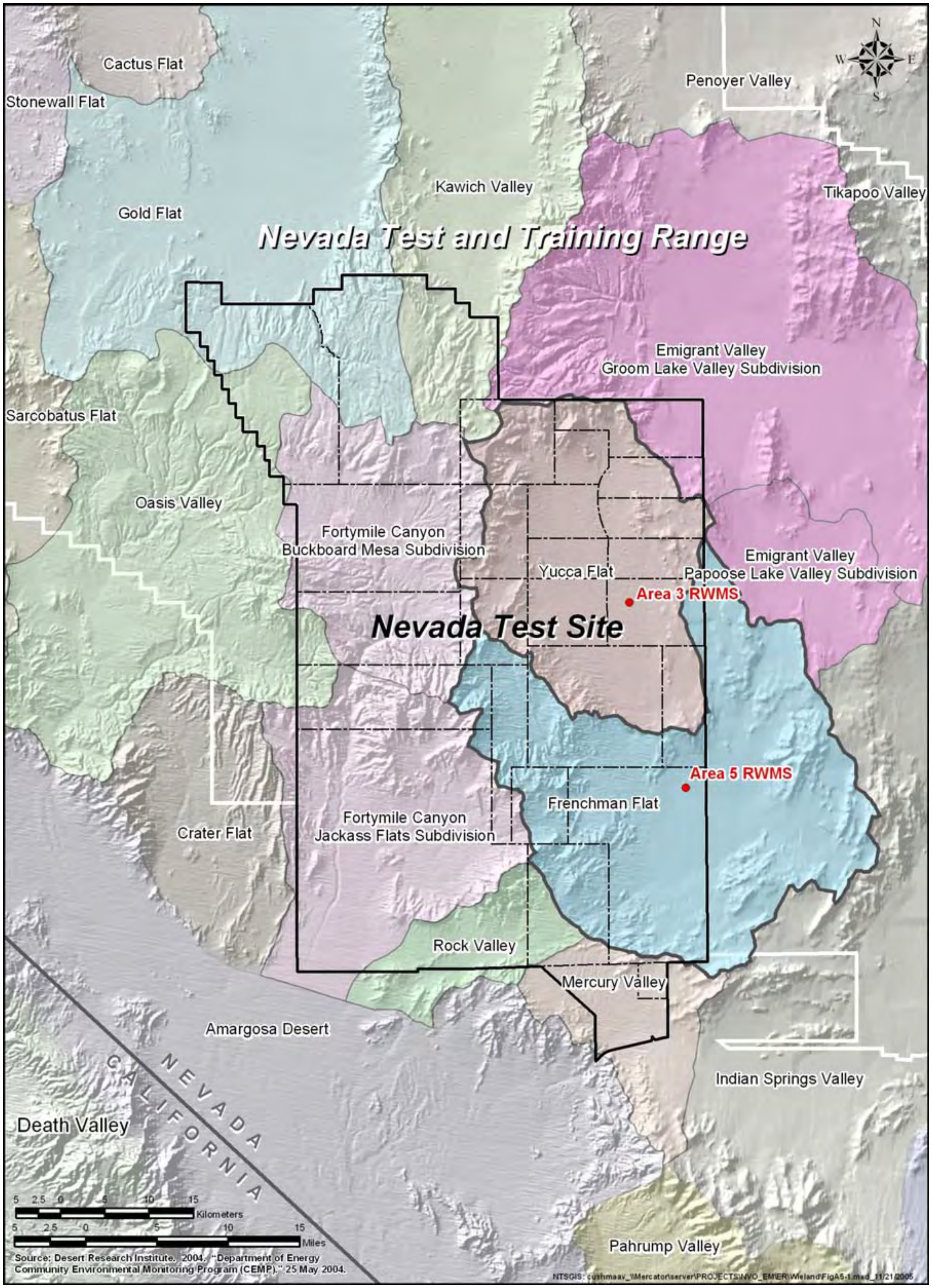

Figure 1-2. Hydrographic Basins

1.2 REPORT OBJECTIVES

This report has been prepared by the NNSA/NSO to summarize characterization data pertinent to closure of the southeast portion of the Area 5 RWMS, known as the 92-Acre Area, including the CAU 111 retired mixed-waste pits and trenches. This report summarizes characterization and monitoring data required to support the development of a conceptual model and closure strategy.

1.3 REPORT CONTENTS

The report summarizes relevant existing data regarding the 92-Acre Area of the Area 5 RWMS. The data are used to develop conceptual models of vadose zone and hydrogeological conditions of the site, general conclusions, and recommendations for a closure strategy. The report is organized as follows:

- 1.0 Introduction (location of site and purpose of document)
- 2.0 Facility Location, Layout, and Waste Unit Status
- 3.0 Waste Disposal Operations (history, general practices, and waste inventory)
- 4.0 Monitoring Programs
- 5.0 Site Characteristics (general summary of site area geography, meteorology, biota, geology, hydrology, soils, air quality, natural hazards/subsidence, and the physical characteristics of existing operational covers)
- 6.0 Conceptual Models and Assessments
- 7.0 Closure Planning (regulatory context, documents, and anticipated schedule)
- 8.0 Work in Progress (ongoing activities and reports due to be published soon, which will contribute to site characterization and closure planning)
- 9.0 Conclusions and Recommendations
- 10.0 References

2.0 LOCATION, LAYOUT, AND WASTE UNIT STATUS

The Area 5 RWMS is approximately 22 km (14 mi) north of Mercury, Nevada, in the northern part of Frenchman Flat. The Area 5 RWMS covers 296 ha (732 ac) and is bounded by a buffer zone 305 meters (m) (1,000 feet [ft]) wide. The southeast and northeast quadrants of the RWMS are actively used for disposal or storage of wastes; although, many of the disposal units in the southeast quadrant are operationally closed or nearing capacity. The southeast quadrant covers 37 ha (92 ac), and is referred to as the “92-Acre Area.” The northeast quadrant is being developed and is referred to as the “Expansion Area.”

Figure 2-1 shows the disposal units of the Area 5 RWMS. The Area 5 RWMS currently consists of 45 disposal cells: 16 shallow excavated pits, 16 shallow excavated trenches, and 13 Greater Confinement Disposal (GCD) boreholes including the Greater Confinement Disposal Test (GCDT) facility (Figure 2-2). Nine of the shallow disposal pits and all 16 trenches and 13 boreholes are within the 92-Acre Area. Seven of the pits are in the new Expansion Area, north of the 92-Acre Area.

The disposal unit names are coded. Each shallow excavation is classified as either a “trench” (designated with the prefix “T”) or “pit” (designated with the prefix “P”), based on width. Generally pits are greater than 30 m [100 ft] wide and are large enough for a truck to turn around. The borehole designations have the prefix “GCD.” The designations are suffixed with either a “U” to indicate “unclassified” waste or “C” for “classified” material. All material in the classified units is deemed to be classified material, not waste; although, in this report, the type of classified material is sometimes described by waste classes with similar properties.

Currently, 22 of the shallow cells are operationally closed with a cover of native soil approximately 2.4 m (8 ft) thick. All of the GCD boreholes are inactive. Six of the GCD boreholes and the GCDT are also operationally closed with thick soil covers. Figure 2-3 shows the operational status. For a detailed description of the facilities at the Area 5 RWMS, refer to the Performance Assessment (PA) (Shott et al., 1998). An addendum to the PA, with updated data and models, was published in January 2006.

The Area 5 RWMS 92-Acre Area has been divided into six closure units based on waste types and regulatory status:

- LLW Unit
- CAU 111 Unit
- Asbestiform Unit
- Pit 3 Mixed Waste Disposal Unit (MWDU)
- TRU GCD Borehole Unit
- TRU Trench Unit.

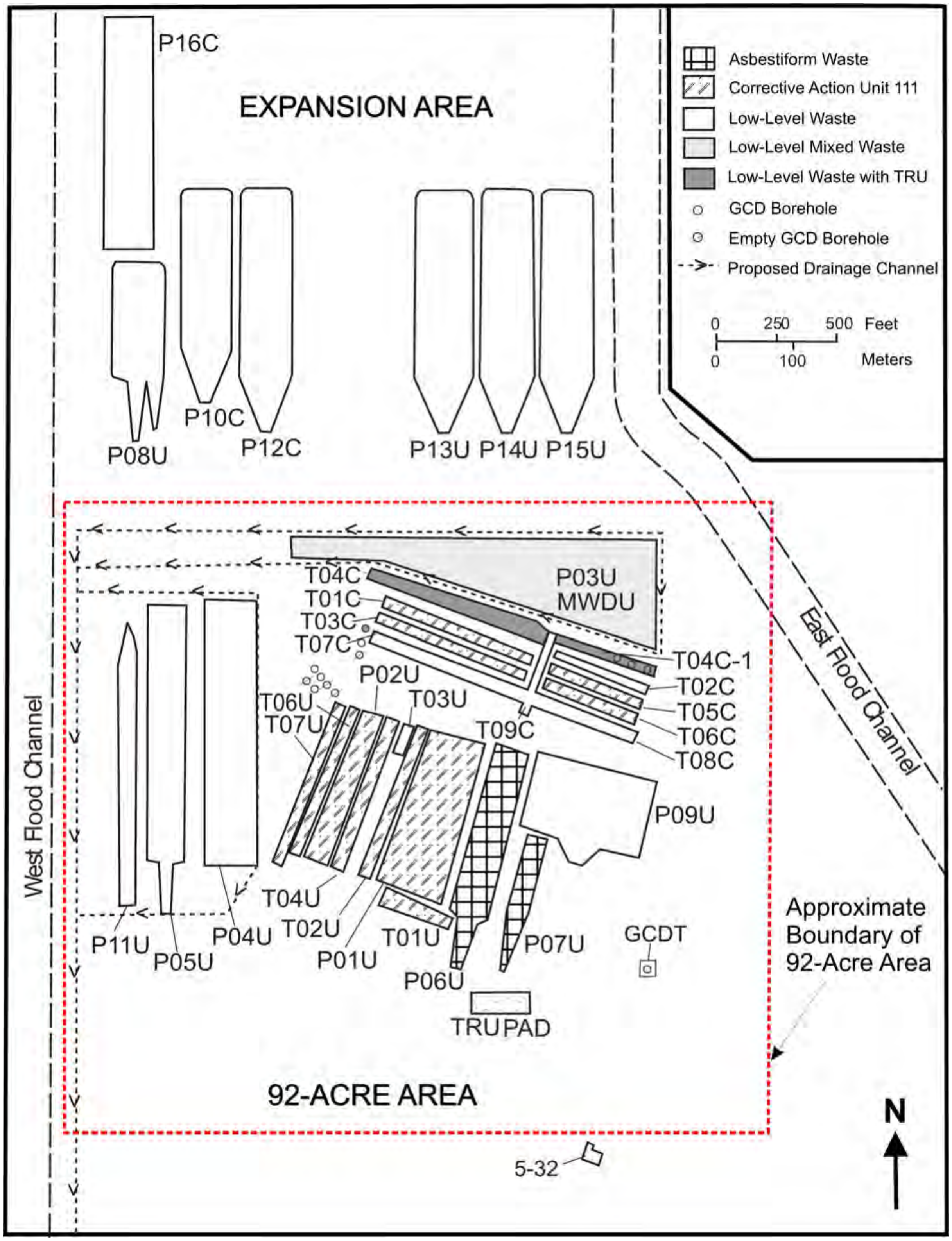

Figure 2-1. Layout of the Area 5 Radioactive Waste Management Site Showing Disposal Units and Waste Types

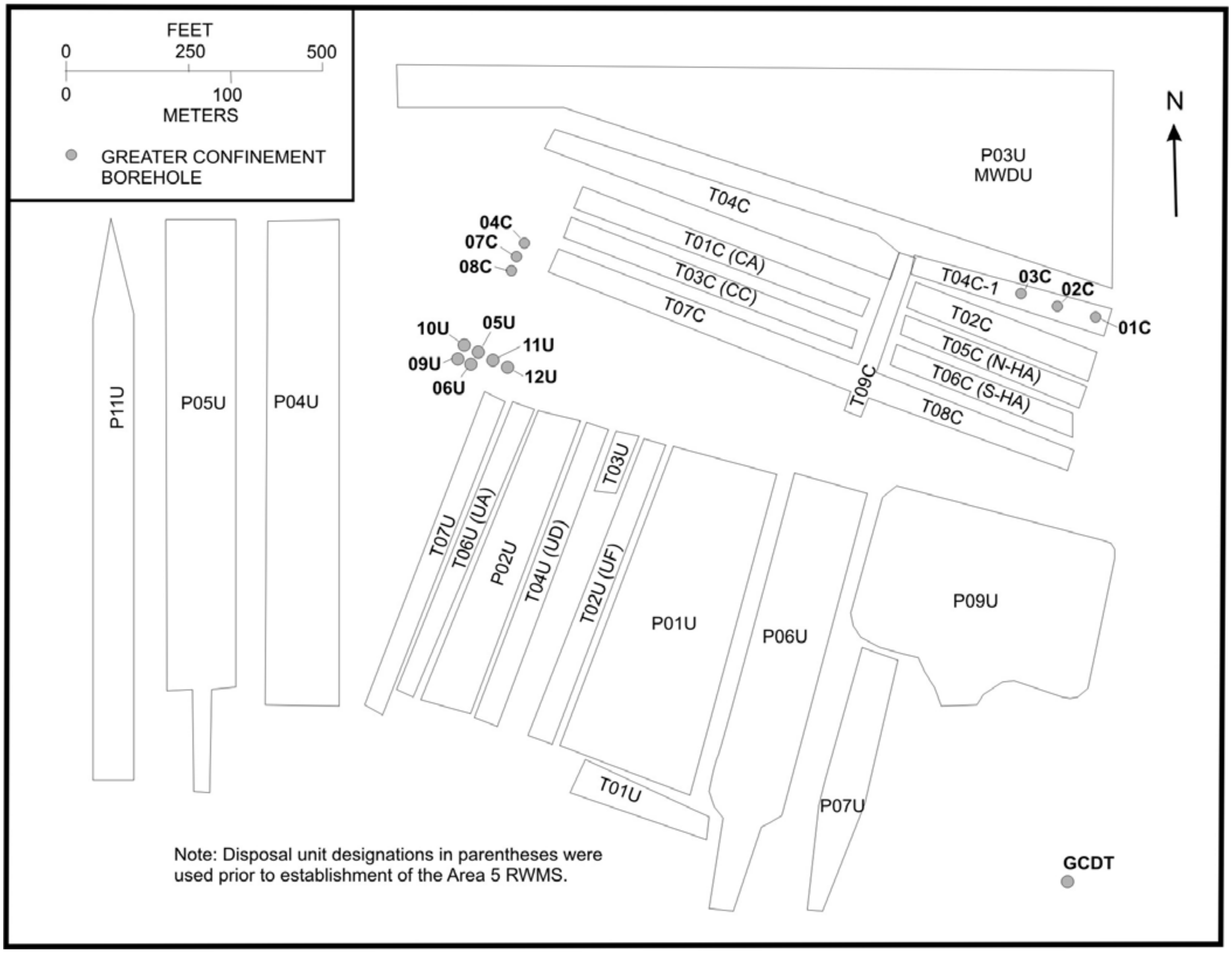

Figure 2-2. Location of GCD Boreholes within the 92-Acre Area of the Area 5 RWMS

Table 2-1 summarizes the type of waste, operational status, and principal closure regulations applicable to each closure unit. The CAU 111 closure unit, within the Area 5 Retired Mixed Waste Pits, is listed in Appendix II of the FFACO (FFACO, 1996), an agreement between DOE and the Nevada Division of Environmental Protection (NDEP), as a single corrective action site (CAS 05-21-01). Operational monitoring of the RWMS facility suggests there has been no migration of contaminants from the operating facility and little potential for post-closure migration of contaminants. Closure of the CAU 111 disposal unit will have to meet RCRA requirements. The site is listed in RCRA Part B Permit NEV HW009 (NDEP, 2000).

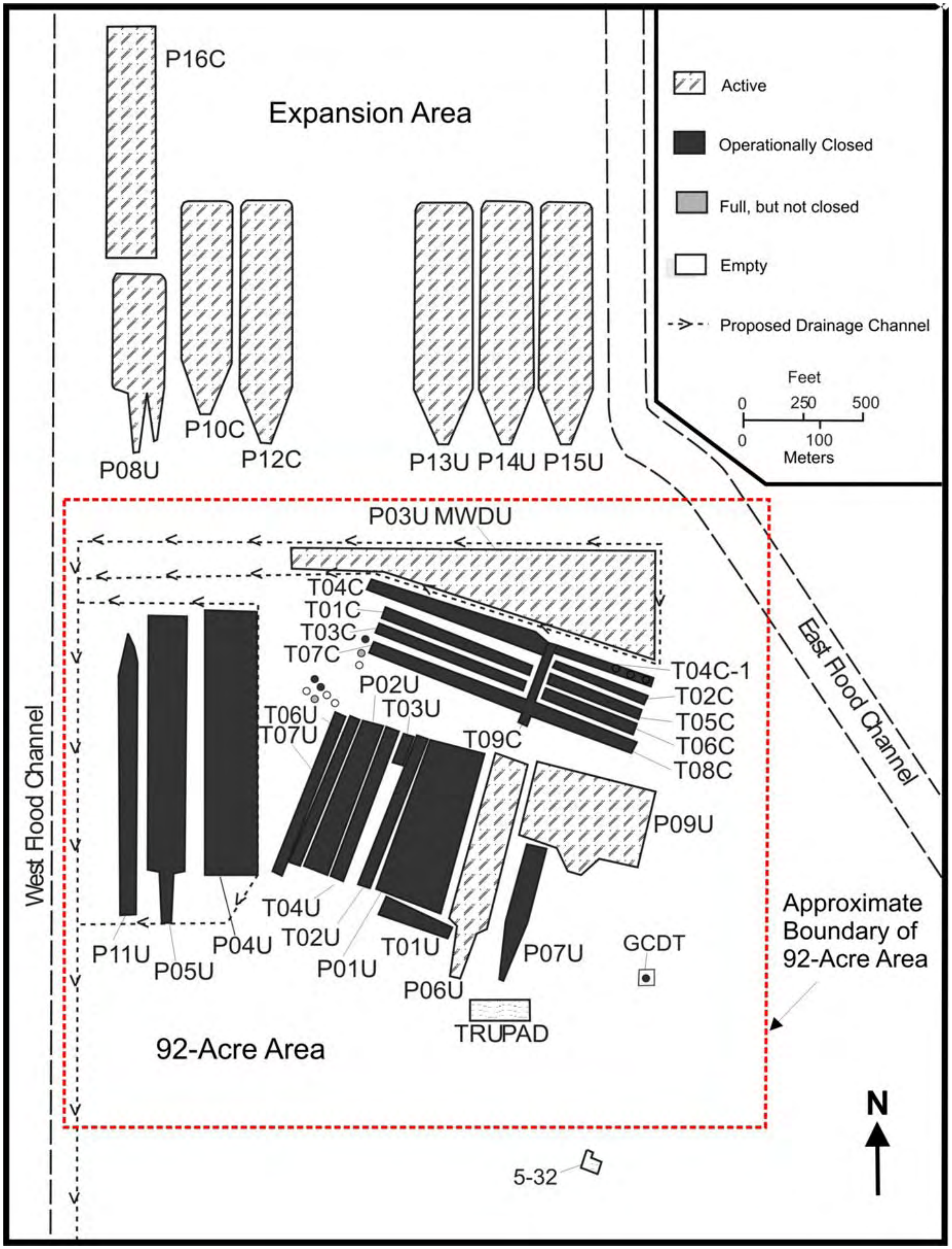

Figure 2.3. Closure Status of Area 5 RWMS Disposal Units, August 2005

CAU 111 primarily includes those pits and trenches that are known or suspected to contain some LLMW, which were operating prior to when RCRA was originated, and which do not have any known TRU waste or TRU classified material. Trench T07U is included in CAU 111 because it was operated prior to the promulgation of RCRA; however, there is no evidence in the waste records that it ever received hazardous constituents. Figure 2-1 shows the CAU 111 disposal features with respect to the other disposal features within the 92-Acre Area of the Area 5 RWMS. CAU 111 includes waste and classified material disposal units which are all operationally closed: P01U, P02U, T01U, T02U, T04U, T06U, T07U, T01C, T03C, T05C, and T06C. CAU 111 is to be closed-in-place concurrently with other features within the Area 5 RWMS.

Units T04C and T04C-1 appear to have originally been a single trench known as T04C. When Trench T09C was excavated perpendicular to T04C in 1995, the north entrance to T09C bisected the T04C trench. The east side of T04C was eventually re-designated T04C-1. The boundaries of T04C-1 are poorly defined, but a past employee recalls the original T04C trench extending east to the facility fence line (Personal Communication, B. Ford, July 14, 2005). Three of the GCD boreholes (GCD-01C, GCD-02C, and GCD-03C) were drilled in the east end of the former T04C trench (now T04C-1) in 1984. Some mixed TRU material was disposed in these boreholes. For further information see Section 3.1, "History."

Table 2-1. Area 5 RWMS 92-Acre Area Waste Unit Status

Closure Unit	Waste Unit	Status of Operation (Dec 2005)	Waste Type/ Material	Principal Closure Regulations
LLW Unit	P09U	Active	LLW	DOE O 435.1
	T03U	Operationally Closed		
	T02C	Operationally Closed		
	T07C	Operationally Closed		
	T08C	Operationally Closed		
	T09C	Operationally Closed		
	GCDT	Operationally Closed		
	GCD-05U	Operationally Closed		
	GCD-06U	Open, full		
	GCD-07C	Open, full		
	GCD-08C	Open, empty		
	GCD-09U	Open, empty		
	GCD-10U	Operationally Closed		
	GCD-11U	Open, empty		
	GCD-12U	Open, empty		
	P04U	Operationally Closed		
	P05U	Operationally Closed		
	P11U	Operationally Closed		

Table 2-1. Area 5 RWMS 92-Acre Area Waste Unit Status (continued)

<table>
<tr><th>CLOSURE UNIT</th><th>WASTE UNIT</th><th>STATUS OF OPERATION (DEC 2005)</th><th>WASTE TYPE/ MATERIAL</th><th>PRINCIPAL CLOSURE REGULATIONS</th></tr>
<tr><td rowspan="11">CAU 111 Unit</td><td>P01U</td><td>Operationally Closed</td><td rowspan="11">LLMW</td><td rowspan="11">FFACO, RCRA Part B Permit # NEV HW009, CFR 265.310</td></tr>
<tr><td>P02U</td><td>Operationally Closed</td></tr>
<tr><td>T01U</td><td>Operationally Closed</td></tr>
<tr><td>T02U</td><td>Operationally Closed</td></tr>
<tr><td>T04U</td><td>Operationally Closed</td></tr>
<tr><td>T06U</td><td>Operationally Closed</td></tr>
<tr><td>T07U</td><td>Operationally Closed</td></tr>
<tr><td>T01C</td><td>Operationally Closed</td></tr>
<tr><td>T03C</td><td>Operationally Closed</td></tr>
<tr><td>T05C</td><td>Operationally Closed</td></tr>
<tr><td>T06C</td><td>Operationally Closed</td></tr>
<tr><td rowspan="2">Asbestiform Unit</td><td>P06U</td><td>Active</td><td rowspan="2">Asbestiform/LLW</td><td rowspan="2">NV Solid Waste Disposal Site Permit #SW 1300001</td></tr>
<tr><td>P07U</td><td>Operationally Closed</td></tr>
<tr><td>Pit 3 MWDU</td><td>P03U</td><td>Active</td><td>LLMW</td><td>RCRA Part B Permit # NEV HW009</td></tr>
<tr><td rowspan="5">TRU GCD Borehole Unit</td><td>GCD-01C</td><td>Operationally Closed</td><td>TRU, MTRU</td><td rowspan="5">40 CFR 191
TFRG Criteria
CFR 265.310</td></tr>
<tr><td>GCD-02C</td><td>Operationally Closed</td><td>TRU, MTRU</td></tr>
<tr><td>GCD-03C</td><td>Operationally Closed</td><td>TRU, MTRU</td></tr>
<tr><td>GCD-04C</td><td>Operationally Closed</td><td>LLW, LLMW, TRU, MTRU</td></tr>
<tr><td>T04C-1</td><td>Operationally Closed</td><td>LLW</td></tr>
<tr><td>TRU Trench Unit</td><td>T04C</td><td>Operationally Closed</td><td>LLW, TRU, MTRU (1.2 kilograms inadvertently disposed in 1986)</td><td>40 CFR 191
TFRG Criteria
Risk –informed process (subject to DOE approval of National Academy of Sciences recommendations)
CFR 265.310</td></tr>
</table>

Note:

CFR	Code of Federal Regulations
DOE	United States Department of Energy
FFACO	Federal Facility Agreement and Consent Order
LLMW	Low-level mixed waste
LLW	Low-level waste
RCRA	Resource Conservation and Recovery Act
TFRG	TRU Federal Review Group
TRU	Transuranic
MTRU	Mixed transuranic

3.0 WASTE DISPOSAL OPERATIONS

This Section summarizes the waste disposal operations at the Area 5 RWMS. The location, history of disposal, waste placement, waste container descriptions, and waste inventory are discussed briefly. For more detail, refer to the *Integrated Closure and Monitoring Plan (ICMP) for the Area 3 and Area 5 RWMSs* (Bechtel Nevada [BN], 2005a), the Area 5 RWMS PA (Shott et al., 1998), and the Addendum to the PA for the Area 5 RWMS (BN, 2006).

The Area 5 RWMS covers 2,936 ha (732 ac) and is bounded by a buffer zone 305 m (1,000 ft) wide. The southeast quadrant was developed first, and is known as the 92-Acre Area. Waste disposal began in the northeast quadrant in May 2002, in an area referred to as the Expansion Area (Personal Communication, Douglas Clark, September 15, 2005).

Disposed materials included LLW and material from on-site, DOE off-site, and other approved off-site generators; LLMW and classified material from on site; TRU classified material; MTRU classified material; and asbestiform waste. The 13 GCD boreholes were used for the disposal of high specific-activity LLW (waste similar to Greater-than Class C). Some of the boreholes contain TRU, MTRU, LLW, and LLMW classified materials.

The RWMS accepts packaged LLW and LLMW generated within Nevada, under the purview of NNSA/NSO, as well as asbestiform waste. A RCRA permit modification was approved November 21, 2005, which allows the P03U MWDU to operate for up to 5 years. The permit also allows disposal of LLMW for other government sites (Personal Communication, M. Dolenc, December 14, 2005).

Classified materials are not regulated as waste and are considered temporarily stored at the Area 5 RWMS. The classified material will be considered retrievable even after placement of the final cover.

3.1 HISTORY

Disposal of radioactive waste by burial in Area 5 started in January 1961, prior to the origination of federal radioactive waste management regulations and RCRA. Waste-profiling practices, analytical methods, and tracking practices have changed significantly since then. Few photographs have been found, especially from the Cold War years. Consequently, information on the earliest inventory and disposal practices is more general and less complete than in later years. Unclassified disposal records for classified trenches are limited. Temporary coverings known as “white elephants” have often been used to conceal disposition of classified material from satellite and aerial photography. Analytical profiling initially focused on radioactivity but, from process knowledge and general descriptions, it can be inferred that some of the older wastes are mixed waste. Inventory tracking and waste characterization are presented in Section 3.5. The historical development of the disposal features follows.

The original facility was called the Sugar Bunker Dump. Historic hard copy/paper records suggest Sugar Bunker Dump accepted waste for surface storage as early as January 1960, and began burying waste by January 1961 when Pit No. 1 (later designated as T01U) was opened. This appears to be the principal disposal feature until 1965, when records indicate trenches CC, UA, and Composite Analysis (CA) (later designated T03C, T06U, T01C) began receiving LLW and classified material. Trench UD (later designated T04U) received waste starting in 1970 and was the principal unclassified Area 5 disposal unit from 1970 through 1972. Trench UF (later designated T02U) opened by July 1972. Classified material trenches N-HA and S-HA (later designated T05C and T06C) were operating by 1974 and appeared to be mostly full by mid-1976. These eight shallow disposal trenches all received LLW/classified material and waste/classified material that contained hazardous constituents or suspected hazardous constituents. All eight trenches were operationally closed by 1978.

Trench T04C began receiving classified material in March 1969. In 1995, when Trench T09C was excavated perpendicular to the T04C trench, the east end of the trench was renamed T04C-1. For a brief time, the three attached trenches were used concurrently. The T04C and T04C-1 trenches were operationally closed in August 1995.

The DOE established the NTS Waste Management Program in 1978, and designated a 2,936-ha (732-ac) site, including the Sugar Bunker Dump, as the Area 5 RWMS. The names of the original Sugar Bunker disposal units changed. Table 3-1 shows the correlation of old designations to the current designations.

Table 3-1. Corresponding Waste Disposal Unit Names

SUGAR BUNKER (source: DOE report NVO-193, 1978)	AREA 5 RWMS (source: Area 5 RWMS 2001 Atlas)
Pit No. 1	T01U
UF	T02U
UD	T04U
UA	TO6U
CA	T01C
CC	T03C
N-HA	T05C
S-HA	T06C
RF#1	T07U

The DOE Nevada Operations Office (now the NSO) began promoting the Area 5 RWMS as a disposal site to other DOE facilities. Starting in 1978, the Area 5 RWMS began receiving LLW from offsite DOE generators (Personal Communication, M. Dolenc, July 12, 2005).
Trench RF#1, later designated as trench T07U, was opened by 1978. Historic photos and waste disposal records show this trench received waste from Rocky Flats. There is no evidence in the disposal records of hazardous material being disposed of in T07U.

Between 1978 and September 26, 1988 (when DOE Order [O] 5820.2A, "Radioactive Waste Management" [now replaced with DOE O 435.1] was promulgated), two pits and one more trench (P01U, P02U, and T07U) were filled and operationally closed.

In 1986, approximately 1.2 kilograms (kg) (2.6 pounds [lbs]) of TRU waste from Rocky Flats were inadvertently disposed in trench T04C. This trench is currently operationally closed.

In 1981, the GCDT borehole was equipped to evaluate the feasibility of disposing high specific-activity waste in alluvial soils at the NTS. The GCDT waste included layers of encapsulated sources of ^{90}Sr, ^{137}Cs, and ^{60}Co; ^{90}Sr in thermoelectric generators; and drums containing ^{226}R, ^{227}Ac, and ^{3}H. Nine 36-m (120-ft) monitoring boreholes were drilled around the GCDT borehole, at locations 3, 4.9 , and 6.7 m (10, 16, and 22 ft) from the GCDT, and were equipped with instruments to monitor soil temperature, soil moisture, and migration of tracers or radionuclides. The GCDT project ran for over 7 years and provided information on potential for waste migration. The GCDT borehole was then operationally closed.

Based on the early results provided by the GCDT, 12 GCD boreholes were augered for operational use in 1984 (BN, 2002a). According to a site employee, three of the borings were drilled in the base of the east end of Trench T04C, later renamed T04C-1 (Personal Communication, B. Ford, July 14, 2005). The rest of the GCD boreholes appear to be drilled from ground surface, outside of the trenches.

The GCD boreholes are generally 3 m (10 ft) in diameter and 36 m (120 ft) deep and unlined, except for 3 m (10 ft) of corrugated metal pipe surface casing. Between 1984 and 1989, 8 of the 12 operational GCD boreholes were used to dispose of "special case" or "orphan" wastes. These are wastes and classified materials that did not meet acceptance criteria for other facilities (BN, 2002a). They have subsequently been classed as high specific-activity LLW, TRU, and MTRU. Materials stored in GCD 1, 2, 3, 4, and 7 are classified. Detailed inventories of waste and materials in the GCD boreholes are presented in Dickman (1989), Chu and Bernard (1998), and summarized in BN (2002a).

Although the GCDT and the Area 5 RWMS monitoring data suggested burial in these boreholes was safe and effective, disposal of waste and classified material in GCD was discontinued in 1989 (Cochran; Crowe, et al., 2001). NDEP determined the borings to be Class IV injection wells, which are prohibited by U.S. Environmental Protection Agency (EPA) regulations and Nevada Administrative Code (NAC). Six GCD boreholes have been filled with waste, to a depth of about 21 m (70 ft) below surface, and operationally closed with backfill consisting of native soil. Two boreholes have received waste and remain open (although inactive), and four boreholes are empty.

In 1993, EPA clarified that underground disposal of containerized radioactive waste in geologic repositories subject to the Part 191 standards does not constitute underground injection under the EPA's underground injection control program (Title 40 Code of Federal Regulations [CFR] Part 191: Environmental Radiation Protection Standards for the Management and Disposal of Spent Nuclear Fuel, High-Level and Transuranic Radioactive Wastes [58 Federal Register {FR} 66398-66416]). However, the GCD program has not been reinstated.

Since the promulgation of federal radioactive waste management regulations in 1988, 14 pits and trenches and 2 GCD boreholes have been active. Eleven of these pits and trenches are now operationally closed.

Most of the waste disposed of at the NTS has been from Defense Programs and the Environmental Management Program. In February 2000, a Record of Decision for the management of LLW expanded the approved generators to include DOE-funded research laboratories. As of October 2005, 29 radioactive waste generators were using the NTS facilities for waste disposal. The NTS LLW disposal volume for FY 2003 was over 90,000 cubic meters (m^3) (3,000,000 cubic feet [ft^3]) (Denton et al., 2004).

There are currently three active pits in the 92-Acre Area: P03U, P06U, and P09U. Pit 3 (P03U) is the only active MWDU. P06U and P09U contain LLW. Pit 6 (P06U) accepts asbestiform LLW and the bottom tier is used for disposal of thorium waste.

3.2 WASTE ACCEPTANCE CRITERIA

For its radioactive waste disposal sites at the NTS, NNSA/NSO has established the Nevada Test Site Waste Acceptance Criteria (NTSWAC) (NNSA/NSO, 2005a). The NTSWAC provides the requirements, terms, and conditions under which the NTS will accept LLW and mixed waste for disposal. Mixed waste generated within the state of Nevada by NNSA/NSO activities is also accepted for disposal. The NTSWAC includes requirements for the characterization, waste form, packaging, and transfer of material and for the generator waste certification program. The Radioactive Waste Acceptance Program personnel review each waste generator's program and documentation for compliance with the NTSWAC. Upon arrival at the NTS, the waste shipments/containers are inspected to verify placards, manifests, marking and labeling, and container integrity (Becker et al., 2002).

NNSA/NSO policies regarding the storage and disposal of radioactive waste are designed to achieve these goals:

- Ensure safe and compliant storage and disposal of radioactive waste.
  - Be consistent with the current revision of all applicable federal, state, and local regulations.
- Protect the environment, personnel, and public from chemical and radiological hazards according to Title 40 CFR, RCRA; Title 10 CFR 835, "Occupational Radiation Protection"; DOE O 435.1, "Radioactive Waste Management"; and state of Nevada and applicable U.S. Department of Transportation regulations.
- Ensure that present and future radiation exposures are kept as low as reasonably achievable (ALARA) and do not exceed the radiation protection standards established in Title 10 CFR 835.
- Ensure that Quality Assurance programs are established and implemented to fulfill the requirements of DOE O 435.1; Title 10 CFR 830.122, "Quality Assurance"; and DOE O 414.1A, "Quality Assurance."

Detailed waste criteria requirements have been established for acceptance of transuranics, radionuclides, polychlorinated biphenyls, explosives, pyrophorics, asbestiform LLW, sealed sources, radioactive animal carcasses, low-level beryllium waste, and classified materials/waste. There are also requirements for minimization of free liquids, immobilization of particulates and gases, chemical and structural stability, chemical compatibility, and the use of chelating agents.

Commercial Greater-Than Class C wastes (as defined by Title 10 CFR 61.55) generated by the U.S. Nuclear Regulatory Commission licensees and etiological agents, are not accepted at the NTS.

Treatment, stabilization, and packaging requirements address specific hazards. Facility waste packaging acceptance criteria fulfill all applicable DOE Orders and federal requirements. Package requirements include design, nuclear safety, radiation levels, activity limits, nuclear heating, strength, shielding, and sealing. For further information on waste acceptance criteria, see *Nevada Test Site Waste Acceptance Criteria-Revision 6* (NNSA/NSO, 2005a).

3.3 WASTE PLACEMENT

Waste is transported to the Area 5 RWMS on trucks. On arrival, manifests are checked and the trucks are inspected, both visually and with instrumentation, to ensure there is no leakage of contaminated materials from the containers. After the vehicles are cleared, the containers are off-loaded and placed in the appropriate active pit or trench (Figure 3-1), depending on waste type and classification. Unloaded trucks are released only after they have been surveyed for contamination and found to be clean.

Pits and trenches range in depth from 4.6 to 15 m (15 to 48 ft). Disposal consists of placing waste in various sealed containers in the unlined pits and trenches. As rows of containers reach approximately 1.2 m (4 ft) below original grade, native alluvium is pushed over the containers in a single lift, approximately 2.4 m (8 ft) thick (Figure 3-2). The newest active units are typically 180 to 210 m (600 to 700 ft) long, 12 to 18 m (40 to 60 ft) wide, and 6 to 9 m (20 to 30 ft) deep.

Three “unclassified” pits (P03U, P06U, and P09U) are currently open in the 92-Acre Area for receipt of waste. Pit P03U is designated for disposal of LLMW, under RCRA interim status. Pit P06U was deepened for disposal of thorium waste.

The 13 GCD boreholes (including the GCDT) have not received waste since 1989. The GCD units are 3-m- (10-ft)-diameter vertical boreholes, 36 m (120 ft) deep. The boreholes are cased from the surface to a depth of 3 m (10 ft). Waste packages were placed in the bottoms of six of the GCD boreholes and the GCDT borehole up to a depth of approximately 21 m (70 ft) below land surface, and then backfilled with native soil. Two others received waste but have not been operationally closed, and four are empty.

For a detailed description of the facilities at the Area 5 RWMS, refer to the PA (Shott et al., 1998). An addendum to the PA is due to be published in FY 2006. For further descriptions of pits, trenches, and GCD boreholes, refer to Cochran et al. (2001b).

Figure 3-1. Waste Container Emplacement in a Typical Pit at the Area 5 Radioactive Waste Management Site

Figure 3-2. Emplacement of Backfill Over Waste Containers

3.4 WASTE CONTAINERS

The following description of waste containers that have been buried at the Area 5 RWMS was excerpted from the ICMP (BN, 2005a).

> *Containers disposed at the Area 5 RWMS are categorized as boxes, drums, or nonstandard. Cardboard, octagonal "tri-wall" boxes were commonly used prior to the mid-1980s. These cardboard boxes were 0.6 or 1.2 m (2 or 4 ft) high and banded to wooden pallets with steel strapping. Waste was contained in plastic bags inside the cardboard boxes. These boxes were stacked as close to each other as the underlying pallet allowed and were susceptible to crushing if stacked too high.*
>
> *Plywood boxes came into wide use thereafter, and range in size from 0.6 m (2 ft) high, 1.2 m (4 ft) wide, and 2.1 m (7 ft) long, to 1.2 m (4 ft) high, 1.2 m (4 ft) wide, and 2.1 m (7 ft) long. Runners are typically attached to the bottom of the boxes to facilitate handling with a forklift. More waste was received in steel boxes in the 1990s. The steel boxes come in standard sizes similar to those of plywood boxes, and steel runners or slots for handling with a forklift are typically part of the box design. Both the plywood and steel boxes are stacked as close to each other as practicable; typically, several inches (in) separate adjacent boxes.*
>
> *Waste has also been disposed in steel drums of various sizes at the Area 5 RWMS. Standard 209-L (55-gallon [gal]) drums and 315-L (83-gal) overpack drums are common; less commonly used are six-drum overpack containers. Drums are stacked either vertically on pallets, horizontally in a square array, or horizontally in a nested array.*
>
> *Containers other than standard-sized boxes and drums are considered nonstandard. Many nonstandard containers have been disposed at the Area 5 RWMS, including containers of unusual shapes or nonstandard-sized boxes or drums. Nonstandard containers are typically stacked to make best use of available pit volume.*

3.5 WASTE INVENTORY

Wastes have been accepted at Area 5 of the NTS since January 1960, and placed in disposal cells since January 1961. The *Low-Level Waste Inventory System User's Guide* (BN, March 2005) provides detailed information on the structure and history of LLW and LLMW tracking systems at the NTS, including field codes and limitations. The completeness, quality, and level of detail of inventory records have changed over time. A brief summary of the evolution of inventory tracking follows.

The oldest records for the original Sugar Bunker Dump generally show load origin, a brief description of the material and containers, estimated radioactivity, date of disposal, and the disposal location (Area 3 or Area 5 RWMS). When necessary, a specific trench or pit can be inferred from burial date and history of the development of the disposal features.

The original paper records were scanned into a digital format, then archived. The quality of some of these scanned images is poor and some of the data are difficult to read. There is also uncertainty as to the completeness of the scanned records (Personal Communication, M. Dolenc, July 21, 2005).

The Radioactive Waste Management (RWM) System was developed in 1988 to comply with DOE O 5820.2A. The RWM System tabulated basic information on a per-shipment basis, for waste received from August 13, 1974 through 1992. A container tracking system was also developed to store older data through FY 1992. The RWM System had design flaws, typical in early databases and early programming capabilities, which resulted in inconsistent entries, incomplete records, and the creation of orphan records due to poor interrelationships between the master tables and detail tables. Users of the system could modify, delete, and add data in sub-tables without changing, deleting, or adding records to the master table. An FY 2005 review of historical data attempted to correlate orphan nuclide and container data with generator shipments.

After September 30, 1992, the Low-Level Waste Information System (LWIS) Oracle application was implemented. Data in this database are stored in a single record, indexed by package. The level of characterization detail and burial location detail also improved. Burial location is provided based on an alphanumeric grid. The tier and location within the cell were recorded. The Oracle relational database structure of the LWIS prevents some of the quality and orphan data problems that plagued the RWM System. The web applications used by generators and waste operations personnel to input data also have built-in validation features that help reduce errors in the database. Bar-coding and scanning systems were implemented to facilitate package tracking.

In May 1997, the NTSWAC system, an enhancement to LWIS, was implemented. The improved waste-tracking system accepts multiple waste profiles, includes more detailed information on waste form and treatment, and is the system currently in use.

The Waste Management Infobank System combines data from source databases, intranet, and internet sites needed to support the Waste Management Program.

To document and improve the accuracy of the historic waste inventory for 1961 through 1978 and make the scattered information more usable, several historic tracking systems including paper records and previously scanned records were reviewed and crosschecked. Bechtel Nevada then incorporated the waste disposal data into one searchable spreadsheet. Chemical hazards were not routinely profiled before landfill regulations and RCRA were implemented. The presence of hazardous constituents and suspected hazardous constituents, and consequently the classification of some waste in these trenches as being potential LLMW, was inferred from general waste descriptions, historic photographs, and other sources. The early RWM System database covering waste disposal from the mid 1970s through 1992 was also checked and crosschecked with other documentation to attempt to verify the locations, volumes, and characteristics of the wastes disposed. A report documenting these record-review efforts is expected to be published in FY 2006.

Appendix A contains preliminary information on waste and material buried at the Area 5 RWMS facilities from 1961 through December 2004. These data are from three sources: scanned paper records, the old RWM System database, and the revised LWIS database, with slightly overlapping periods of record. These data are provisional pending completion of an internal management review. These waste tracking systems primarily address waste disposal at the unclassified trenches, pits, and boreholes. The waste tracking systems have no data regarding classified material deposited at some of the classified disposal cells, and very limited data at other classified disposal cells.

Waste disposal records for the most of the GCD boreholes are also included in Appendix A. The report *Evaluation of Regulations and Issues Associated with Final Closure of the Greater Confinement Disposal Boreholes* (BN, 2002a) includes a detailed summary of the sources, types, volumes, packaging, and activities of waste deposited in the GCD boreholes. Much of the data was presented previously in the *Waste Inventory and Preliminary Source Term Model for the Greater Confinement Disposal Site at the Nevada Test Site* (Chu and Bernard, 1991). Waste and classified materials disposed in the GCD boreholes include radioactive waste and classified material that did not meet the criteria for the disposal of high-level waste, TRU waste, or LLW (Chu and Bernard, 1991). Although the PA (Cochran, Beyeler, et al., 2001) demonstrated compliance with EPA Title 40 CFR 191, disposal of waste at the GCD boreholes was discontinued in 1989 because NDEP deemed the disposal as underground injection.

Waste accounting practices have improved significantly since 1960. The volume of waste deposited at each of the oldest disposal areas cannot be accurately estimated due to the quality and incompleteness of historical records, and the potential for double counting for truck loads split among multiple disposal sites. The estimates of waste volumes presented in Appendix A are most accurate for the newest waste disposal units and the unclassified units.

3.6 FUTURE INVENTORY

The 92-Acre Area of the Area 5 RWMS is expected to close by 2011, and the Expansion Area by 2021. The planned closure dates have changed slightly over time. The Area 5 RWMS PA estimated the inventory and approximate amounts of radionuclides anticipated to be disposed through 2028 in shallow pits and trenches at the entire Area 5 RWMS (Shott et al., 1998). Under DOE Order 435.1 Performance Objectives the PA is limited to waste disposed from September 26, 1988 to closure.

An updated PA is expected to be published in FY 2006. The updated report will include the revised estimated amounts of radionuclides in the Area 5 RWMS at closure, based on a longer history of complete records, and the latest information on expected generator activity. Hard copy/paper, scanned, and electronic records are being reviewed and cross-checked. The updated PA is expected to have an improved projection of the future radionuclide inventory at closure.

Table 3.7 of the PA (Shott et al., 1998) shows estimated activities of radionuclides and estimated mean activity concentrations for radionuclides in wastes disposed by shallow land burial at the Area 5 RWMS from FY 1989 to FY 2028. Table 3.8 of the PA shows preliminary estimates of the thorium waste that could be disposed in the lowest tier of Pit 6 (P06U) by 2028. These estimates are part of the assumptions that have been used as the basis of performance modeling.

Appendix B contains a preliminary revised projection of future inventories for the entire Area 5 RWMS including both the 92-Acre Area and the Expansion Area. The *FY 2004 Area 5 RWMS Closure Inventory Estimate* shows the approximate projected total activity of each nuclide in storage on September 31, 2028, for six inventory subsets. Of these inventory subsets, the 92-Acre Area would include the pre-1988 shallow land burial inventory, the lower cell of Pit 6 inventory, the pre-1988 GCD inventory, the post-1988 GCD inventory, and part of the post-1988 shallow-land burial inventory. The Expansion Area would include some of the post-1988 shallow-land burial inventory and the Pit 13 inventory. The inventory projection is based on the generators' projected future waste volumes and the average concentrations found in random samples of waste disposed in past years (Personal Communication, Gregory Shott, September 7, 2005). These closure inventory estimates are likely to change significantly through time as generators, programs, technology, and the availability of LLW disposal sites change.

4.0 MONITORING PROGRAMS

The Waste Management monitoring program for the Area 5 RWMS is summarized in 4.0. Details of the RWMS monitoring program can be found in the RWMS ICMP (BN, 2005a). Monitoring programs include radiation exposure, air, groundwater, meteorology, vadose zone, subsidence, and biota.

4.1 INTRODUCTION

Environmental monitoring data, subsidence monitoring data, and meteorological monitoring data are routinely collected at and around the Area 3 and Area 5 RWMSs at the NTS. Monitoring at the Area 5 RWMS is required under a variety of regulatory drivers, including federal regulations and DOE Orders. Monitoring data are used to: demonstrate compliance, to evaluate landfill cover performance, to provide data for water and contaminant transport models, and to provide early warning of the need for any mitigative actions.

The programs are addressed in the ICMP (BN, 2005a) for monitoring direct radiation fields, air, vadose zone, biota, groundwater, meteorology, and subsidence during the operational closure period (current), and final closure/active institutional control periods. Monitoring data quality objectives (DQOs) are defined in the *NTS Routine Radiological Environmental Monitoring Plan* (RREMP) (BN, 2003a). The monitoring program is reviewed periodically to determine which data should be routinely collected and which are no longer required to meet regulatory and program needs.

The ICMP (BN, 2005a) describes the program for monitoring direct radiation, air, vadose zone, biota, groundwater, meteorology, and subsidence at the Area 3 and 5 RWMSs during the operational closure period (current), and final closure/active institutional control periods.

At present, direct radiation is continuously monitored at 10 locations at the Area 5 RWMS. Air monitoring for radionuclides, other than radon, is conducted at several locations at the RWMS using air samplers, whereas radon is passively monitored at six locations at the RWMS and at several background locations. Radon flux (through waste covers) is monitored annually at various locations at each RWMS and at background locations. Vadose-zone monitoring for soil-water content and soil-water potential is conducted continuously in waste covers, beneath waste units, and at lysimeter facilities. Surface water runoff is monitored at flumes. Tritium in soil-gas moisture is monitored at least annually in a deep borehole at the Area 5 RWMS (GCD-05U), which contains a large tritium source. Biota are monitored periodically for tritium. Groundwater from the uppermost aquifer is sampled semiannually. Water samples collected from three wells surrounding the Area 5 RWMS are analyzed for radioactive and nonradioactive constituents. Groundwater elevation is measured more frequently. Meteorological parameters are monitored continuously at the Area 5 RWMS. Waste cover subsidence is checked monthly.

Results of most of the monitoring programs are reported at various levels of detail in periodic reports including the *NTS Environmental Report* (e.g., BN, 2004a); the *National Emission Standards for Hazardous Air Pollutants* (e.g., *National Emissions Standard for Hazardous Air*

Pollutants [NESHAP]) (BN, 2002b) report; the annual *Groundwater Monitoring Report* (e.g., BN, 2004b); and the *NTS Waste Management Monitoring Report* (e.g., BN, 2005c).

Appendix C contains a list of sampling and monitoring locations within Area 5 extracted from the Bechtel Environmental Integrated Data Management System (BEIDMS*)*. This data set includes location information for borings and wells included in the NTS Redbook database.

4.2 MONITORING DURING OPERATIONAL CLOSURE

This Section is primarily extracted from Chapter 8.0 of the *Characterization Report, Operational Soil Covers for the Area 5 Radioactive Waste Management Site at the Nevada Test Site* (BN, 2005d). Monitoring during operational closure includes environmental monitoring of direct radiation, air, vadose zone, biota, and groundwater; subsidence monitoring of operational waste covers; and meterological monitoring to support water balance evaluations.

Activities and systems used to support water balance evaluations include:

- Meteorological monitoring to measure precipitation and to calculate potential evapotranspiration (PET).
- Lysimeters (weighing and drainage) to measure infiltration, soil water redistribution, bare-soil evaporation, evapotranspiration, and deep drainage.
- Automated vadose zone monitoring systems with time-domain reflectometry (TDR) probes, and heat dissipation probes (HDPs) to measure soil water content and soil water potential over a large spatial area.
- Surface water runoff monitoring at flumes and at the floor of a nuclear subsidence crater.
- Soil-gas sampling for tritium to confirm PA assumptions and transport coefficients.

Combining a variety of moisture measurements provides an accurate estimate of the RWMS water balance, including any drainage through the RWMS waste covers and potential recharge. These data and other work (Tyler et al., 1996) indicate that there is essentially no recharge to the groundwater under current conditions at the RWMSs. Precipitation is effectively returned to the atmosphere by plant transpiration and soil evaporation.

The RREMP (BN, 2003a) includes a technical design process for development of a detailed Quality Assurance, Analysis, and Sampling Plan for vadose-zone monitoring at the RWMS and guidance for action levels and corrective actions. It is styled after the EPA DQO process (EPA, 1994). The current vadose-zone monitoring program is designed on the basis of a strong understanding of the vadose-zone system through extensive vadose-zone characterization studies (Blout et al., 1995; BN 2005e; Reynolds Electrical & Engineering Co., Inc. [REECo], 1993a, b; Shott et al., 1998, 1995; and Tyler et al., 1996) and modeling studies (Crowe, Hansen, et al., 1998; and Levitt et al., 1999). In addition, the vadose-zone monitoring program is partially designed based on the results of an Alternative Evaluation Study (AES) on vadose-zone monitoring (BN, 1998a) using an organized team approach, and successful vadose-zone monitoring field experience. Annual vadose-zone monitoring data are reported in an annual monitoring report (e.g., BN 2005c). Details of the RWMS vadose-zone monitoring activities can be found in the RWMS vadose-zone monitoring BN Organizational Instructions (OI) and BN Organization Procedures (OP), including OI-2154.111, *Instructions for Datalogger Monitoring Stations*; and OP-2154.113, *Soil Gas Sampling at GCD-05U*.

Meteorological monitoring data are reported in annual reports such as the *Waste Management Monitoring Reports* (e.g., BN, 2004a) and the *NTS Environmental Report* (e.g., BN, 2004). Details of the RWMS meteorology monitoring activities can be found in BN OI-2154.111, *Instructions for Datalogger Monitoring Stations*.

Monitoring results which contribute to characterization of the Area 5 RWMS are included in Chapter 5.0, "Site Characteristics."

4.3 MONITORING DURING FINAL CLOSURE AND ACTIVE INSTITUTIONAL CONTROL

Monitoring activities during the final closure and active institutional control periods of the RWMSs are expected to be reduced and limited to:

- Air monitoring for radon-222 and atmospheric tritium,
- Tritium monitoring of moisture in soil gas at GCD-05U,
- Vadose-zone monitoring of waste covers, waste disposal unit floors, and lysimeter facilities,
- Groundwater monitoring,
- Biota monitoring for tritium, and
- Subsidence monitoring.

Groundwater monitoring for compliance with Title 40 CFR 264 and 265 had been discontinued when a groundwater monitoring exemption was requested from, and approved by, NDEP. However, groundwater monitoring may continue at the Area 5 RWMS pilot wells under the RREMP program.

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5.0 SITE CHARACTERISTICS

5.1 GEOGRAPHY

The Area 5 RWMS is within the boundary of the NTS, a remote federally controlled facility used for nuclear and nonnuclear testing and training. The NTS is bounded to the north, east, and west by restricted areas controlled by the U.S. Air Force: the Nevada Test and Training Range including the Tonopah Test Range. These contiguous federal reserves encompass about 14,200 square kilometers (km^2) (5,483 square miles [mi^2]) of land.

The Area 5 RWMS is located about 130 km (81 mi) northwest of Las Vegas, Nevada (NV), the nearest major city. The closest public population center is Indian Springs, about 42 km (26 mi) southeast. Mercury, a restricted access government facility that houses support facilities for the NTS, is located in the southeast corner of the NTS, and is about 22 km (14 mi) south of the Area 5 RWMS.

The Area 5 RWMS is located in the northern part of the Frenchman Flat hydrographic basin, at the juncture of three coalescing alluvial fan systems (Snyder et al., 1995). Frenchman Flat is a roughly circular, topographically closed basin bounded by the Massachusetts Mountains on the north, the Buried Hills and Ranger Mountains on the east and southeast, Mount Salyer on the west, and Mercury Ridge and Red Mountain on the south (Figure 5-1). Elevations range between 1,600 m (5,250 ft) in the surrounding mountains to 939 m (3,080 ft) at Frenchman Flat Playa. The Area 5 RWMS is at an elevation of about 969 to 975 m (3,180 to 3,200 ft) above mean sea level. It is located about 3.8 km (2.4 mi) north of and 30 to 36 m (98 to 118 ft) above the playa.

For decades, Frenchman Flat has been a research, testing, and industrial land-use area. Atmospheric and underground nuclear tests were conducted in the basin. The closest underground test was about 2.4 km (1.4 mi) northeast of the Area 5 RWMS. Safety tests have also been conducted nearby, at the Gadgets, Mechanics, and Explosives site about 1.8 km (1.1 mi) southeast of the RWMS. The Nonproliferation Test and Evaluation Center (a hazardous materials research center formerly known as the HAZMAT Spill Center), and other active facilities which handle hazardous materials, are located in the Frenchman Flat basin. For further detail on geography and land use, see the PA (Shott et al., 1998).

5.2 METEOROLOGY

The NTS is located between the northern boundary of the Mojave Desert and the southern limits of the Great Basin Desert. This “transitional desert” is considered to be typical of either the dry mid-latitude or dry subtropical climatic zones. The climate is arid and characterized by low precipitation, a large diurnal temperature range, a large evaporation rate, and moderate to strong

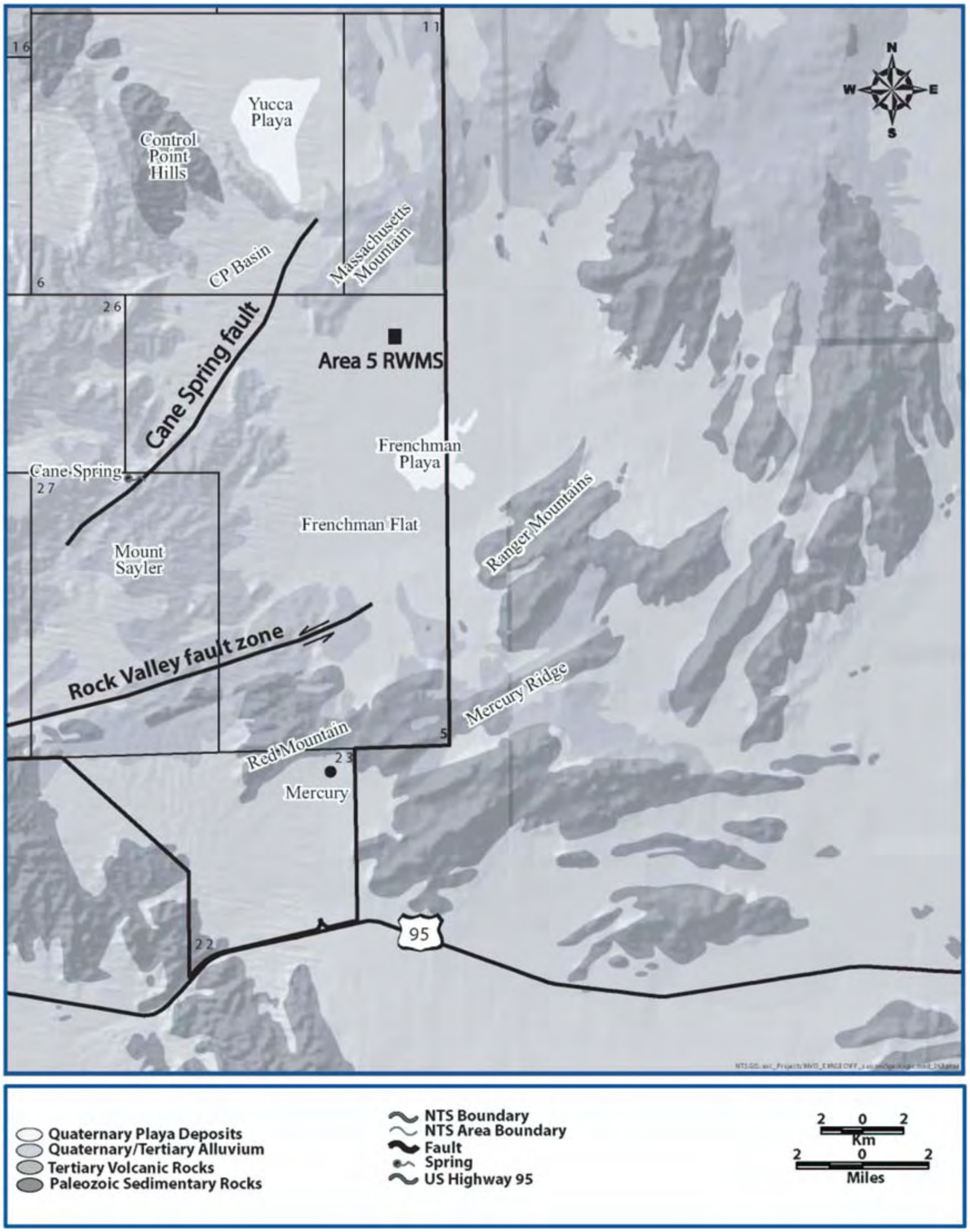

Figure 5-1. General Geologic Map of Frenchman Flat and Vicinity

From: Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site (BN, 2005a).

winds. Detailed discussions on meteorology and climatology specific to the Area 5 RWMS are presented in the PAs (Shott et al., 1998; 1995) and the annual monitoring reports (e.g., BN, 2005c).

The monitoring program fulfills basic regulatory requirements for meteorological monitoring in DOE O 450.1. It also provides data for calculation of PET, a measure of the exchange of water and heat between the earth's surface and the atmosphere, and an important component of the water balance calculation used to evaluate the potential for precipitation to infiltrate and percolate to the waste cells. The DOE maintains a two-level meteorology tower at each RWMS. The Area 5 RWMS meteorology station is located to the southeast of the Area 5 RWMS, about 100 m (328 ft) from Well Ue5PW-1 (Figure 5-2) and has been in operation since 1994. Data routinely collected include: precipitation, air temperature, humidity, wind speed and direction, barometric pressure, and solar radiation load. The air temperature, relative humidity, wind speed, and wind direction are monitored at two heights at the stations.

Other stations in Area 5 with similar conditions offer a longer period of record. Precipitation data have been collected since 1963 at Well 5B, approximately 6.4 km (4 mi) southwest of the boundary of the Area 5 RWMS, at an elevation of approximately 927 m (3,090 ft), which is about 42 m (138 ft) lower than the Area 5 RWMS.

Meteorological data most relevant to potential cover performance, erosion, and contaminant transport are summarized below.

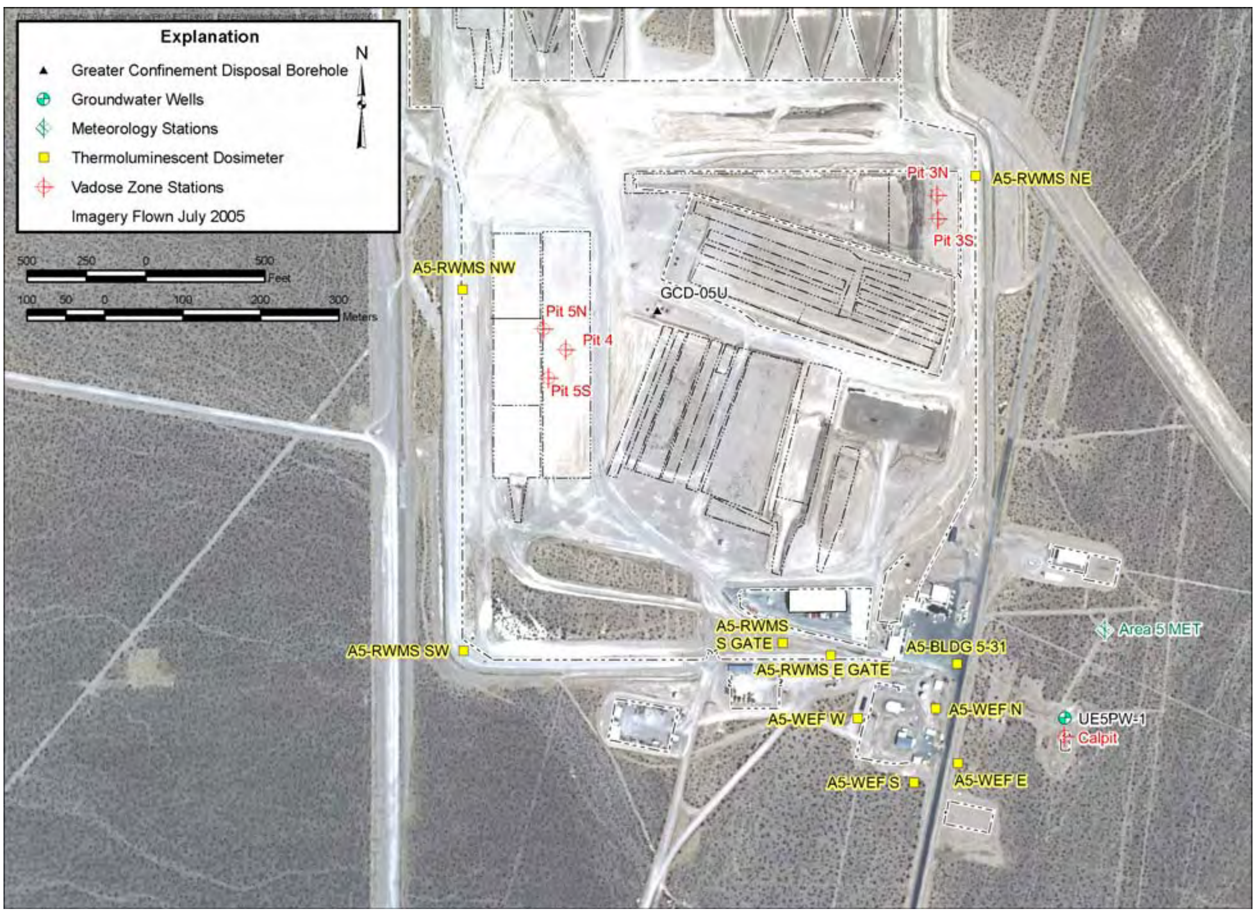

Figure 5-2. Monitoring Stations at the Area 5 Radioactive Waste Management Site

Source: 2004 Waste Management Monitoring Report, Area 3 and Area 5 Radioactive Waste Management Sites (BN, 2005c)

5.2.1 Precipitation

Most precipitation in the Transitional Desert occurs in winter and summer. Winter precipitation is generally associated with transitory low-pressure systems originating from the west and occurring as uniform storms over large areas. Summer precipitation is generally associated with convective storms originating from the south or southwest and occurring as intense local events. The average annual precipitation on the NTS ranges from 7.6 and 25.4 centimeters (cm) (3 and 10 in), depending on elevation.

In Frenchman Flat, precipitation is low, yet highly variable. Average annual precipitation based on the 10-year record from 1995 to 2004 at the Area 5 RWMS meteorological station is 129 millimeters (mm) (5.08 in) with a standard deviation of 64 mm (2.56 in). The maximum was 259 mm (10.20 in) in 1998 and the minimum was 38 mm (1.50 in) in 2002. The average annual precipitation based on a 42-year record from 1963 to 2004 at the Well 5B station 6.4 km (4 mi) south of the Area 5 RWMS is 125.1 mm (4.92 in) (BN, 2005c). Figure 5-3 depicts the precipitation record for Area Well 5B and Area 5 RWMS monitoring stations.

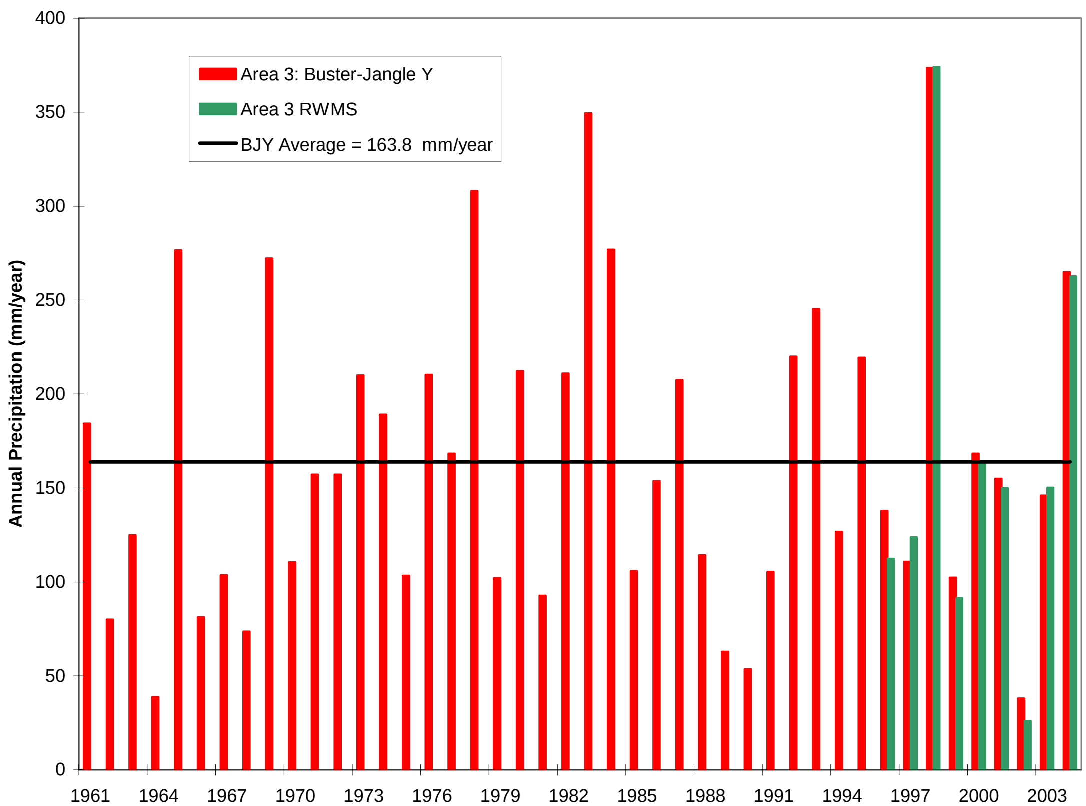

Figure 5-3. Historical Precipitation Record for Area Well 5B and Area 5 Radioactive Waste Management Site

Source: 2004 Waste Management Monitoring Report, page 37 (BN, 2005c)

5.2.2 Temperature

Average daily temperatures at the NTS are between 2 degrees Celsius (°C) (35 degrees Fahrenheit [°F]) in January to 24°C (75°F) in August. Large daily fluctuations are common on the valley floors (BN, 2005a).

At the Area 5 RWMS, in 2004, the minimum recorded temperature at 3 m (9.8 ft) above ground surface was -9.7°C (14.5°F) and the maximum was 41.1°C (106.0°F) (BN, 2005c).

5.2.3 Potential Evapotranspiration

Potential evapotranspiration at the NTS is high because of the large-incident solar radiation and high average wind speeds, and occurs at a potential, or energy-limiting, rate. It is calculated using several widely accepted equations. The Penman Equation was the calculation method used in most data reports through 2001. A modified version of the radiation-based equation of Doorenbos and Pruitt (1997) has been used since 2002. Results are similar, but the Doorenbos and Pruitt (1997) approach reduces input requirements because no net radiation data are used. The equation calculates PET from hourly measurements of solar radiation, air temperature, relative humidity, wind speed, and barometric pressure (BN, 2005c).

Table 5-1 shows total annual PET and precipitation through time at the Area 5 RWMS. Average annual PET from 1995 through 2004 was 152.87 cm (60.19 in) and ranged from 139.05 to 165.30 cm (54.74 to 65.08 in). The minor variations between years can be attributed to natural variations in energy conditions such as wind speeds and solar radiation (heat). The ratio of PET to precipitation ranged from 6 to 54 and averaged 17 over the ten years of record. On an annual basis, even in wet cool years, evaporative demand is high.

Seasonal variations and relationship to other factors of the water budget are discussed further in the discussions of lysimeter data and vadose zone hydrology in Section 5.6.

5.2.4 Wind

The open and sparsely vegetated Frenchman Flat basin is windy, and enhances evaporation rates. Wind speed and direction have been recorded at the Well 5B meteorology station since 1981 and at the Area 5 RWMS meteorology station since 1994. Localized differential heating of the land surface and orographic effects can affect local conditions. Although the overall order of magnitude of the velocity and directional frequency distribution are very similar for the two monitoring stations, there are some slight differences that may partly be explained by geography. The position of the Area 5 RWMS station is closer to the mountains bounding the north end of the basin, than the Well 5B station which is more central. The Area 5 RWMS station gets more wind from the north than Well 5B.

Table 5-1. Annual Potential Evapotranspiration Compared to Annual Precipitation, Area 5 RWMS

Year	Precipitation (cm)	Potential Evapotranspiration (cm)	Ratio PET:PPT
1995	15.18	146.41	9.64
1996	7.59	158.87	20.94
1997	8.29	149.98	18.09
1998	23.91	139.05	5.82
1999	10.46	147.51	14.10
2000	12.82	149.34	11.65
2001	10.47	153.60	14.68
2002	3.05	165.02	54.12
2003	13.98	153.57	10.99
2004	18.74	165.30	8.82
MEAN	**12.45**	**152.87**	**16.89**
VARIANCE	**48%**	**5%**	**82%**

Notes:
cm = centimeters
PET= potential evapotranspiration
PPT= total annual precipitation

Wind rose diagrams illustrate the frequency of wind velocities with respect to wind-source direction over a period of record, using hourly wind data measured at a height of 3.0 m (10 ft) above the ground surface. The 2004 wind rose from the Area 5 RWMS meteorology station is presented in Figure 5-4 (BN, 2005c). In 2004, the average daily wind speed was 2.6 meters per second (m/s) (5.8 miles per hour [mph]) and the maximum gust measured was 20.4 m/s (45.6 mph).

Figure 5-5 shows hourly wind speed and direction data from 1994 through 2004 at the Area 5 RWMS Meteorology Station. Figure 5-6 shows hourly wind speed and direction from 1981 to 2004 at the Well 5B Meteorological Station a few miles southwest of the Area 5 RWMS. The wind speeds on these summary diagrams are in knots. Ten knots is approximately equivalent to a rate of 5.14 m/s or 11.51 mph. Only 2 percent of the surface wind readings were rated as calm at the Area 5 RWMS station and 3 percent at Well 5B station. Most of the wind comes from the southwest and north. Maximum wind speeds were generally less than 30 knots, and most of the hourly wind speeds over 5 knots came from the southwest.

Appendix D contains monthly wind data for the Area 5 RWMS from 1994 through 2004. The diagrams show seasonal trends. The site is generally windy. Winds are primarily from the southwest during the spring and summer months and from the north during the winter months. Wind speeds tend to be greatest in the spring. Surface wind speed was never calm in April and was categorized as calm only 6 percent of the time in November.

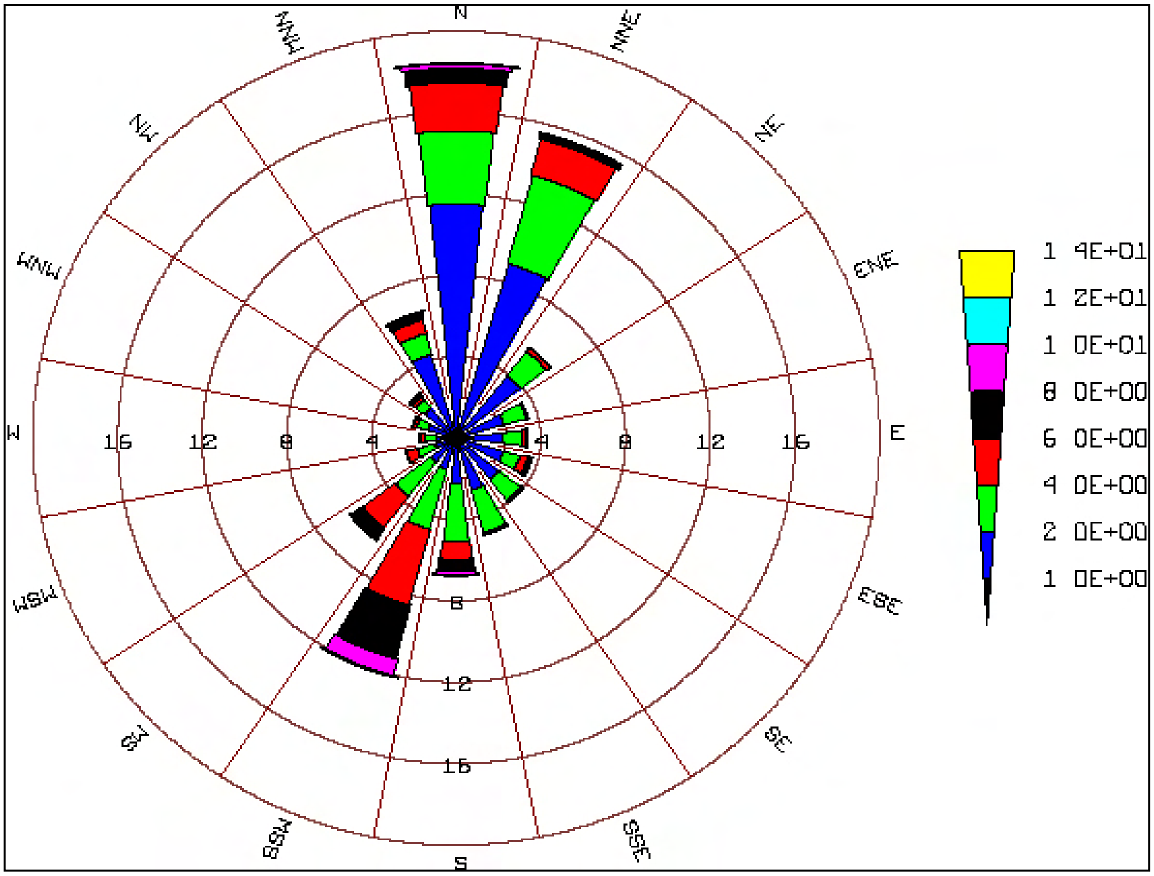

Figure 5-4. 2004 Wind Rose Diagram for the Area 5 RWMS Meteorology Station

Note: Distance from the center reflects percent frequency; petal shading shows wind speed in meters per second at a height of 3 meters above ground surface, and petal direction indicates the direction of the wind source.

5.3 VEGETATION (FLORA) AND WILDLIFE (FAUNA)

The information in this Section is largely derived from the ICMP (BN, 2005a) and from the *Characterization Report Operational Closure Covers for the Area 5 RWMS* (BN, 2005d). The vegetation of the Area 5 RWMS vicinity is characterized in Hansen and Ostler (2003). Descriptions of plant and animal species and communities near the Area 5 RWMS are also presented in the PA (Shott et al., 1998). Additional detailed discussions of NTS ecology are presented in Wills and Ostler (2001).

The nature and distribution of plants and animals and their ecological interactions are of interest both as agents of contaminant transport and as potential receivers of contaminants. Vegetation and burrowing wildlife affect the permeability of near-surface soil and alluvium. They have a complex role in potential transport of water and radioactive particles through soil landfill covers. DOE O 450.1, “Environmental Protection Program,” includes specific requirements for the protection of natural resources and for evaluation of the potential impacts to biota in the vicinity of DOE activities, including waste management. Details of the monitoring process are in the BN OI for RWMS biota monitoring, BN OI-2154.110, *Biota Sampling and Sample Preparation for Animals and Vegetation*.

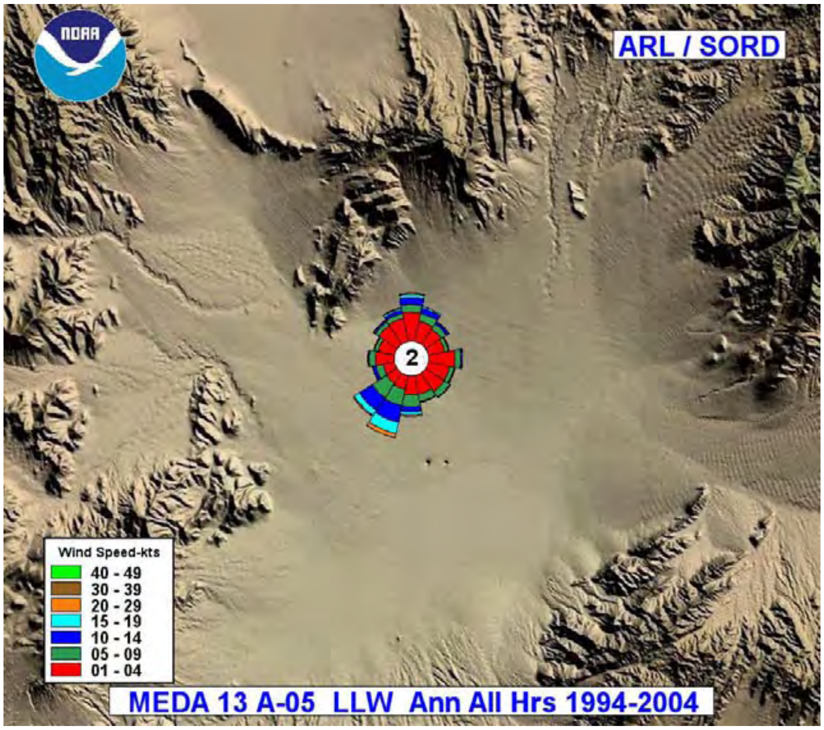

Figure 5-5. Nevada Test Site, Area 5 RWMS, Wind Rose for 1994 to 2004

Source: DOE webpage, http:/sord.nv.doe.gov/products/climate/wind-roses/MEDA/meda-13/fancy_colors/rose_13.jpg, accessed on July 27, 2005.

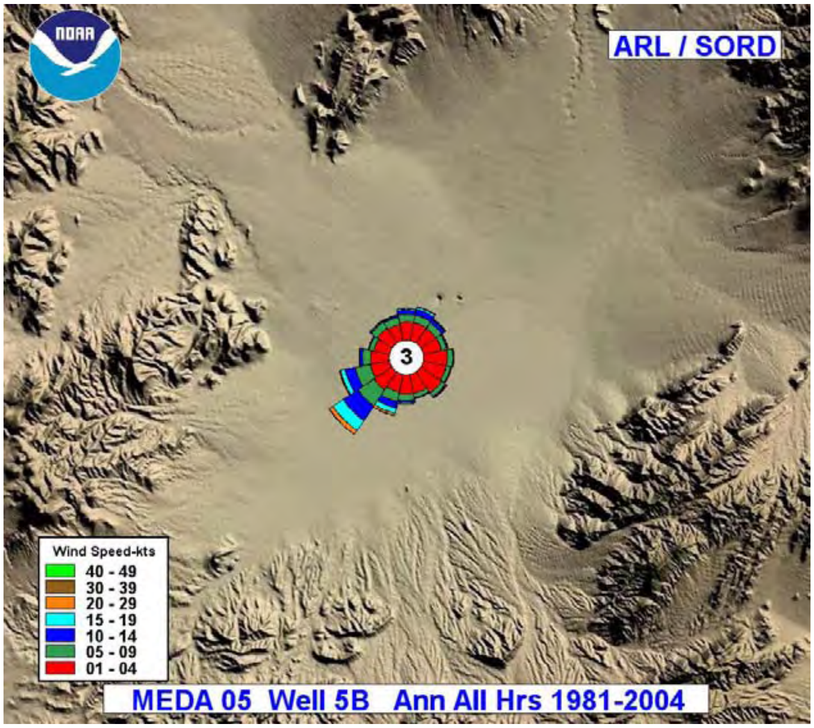

Figure 5-6. Nevada Test Site, Well 5B, Wind Rose for 1981 to 2004

Source: DOE webpage, http:/sord.nv.doe.gov/products/climate/wind-roses/MEDA/meda05/fancy_colors/rose_13.jpg, accessed on July 27, 2005.

A DOE committee developed a DOE technical standard, DOE-STD-1153-2002 *A Graded Approach to for Evaluating Radiation Doses to Aquatic and Terrestrial Biota,* which established conservative protective dose limits, based on current understanding. DOE operating policies are designed to ensure these limits are not exceeded. The current standards are:

Dose limit to terrestrial plants = 1 rad/day (10 milliGray [mGy]/day)

Dose limit to terrestrial animals = 0.1 rad/day (1mGy/day)

The following subsections focus primarily on biota characteristics and monitoring relevant to vadose-zone hydrology and contaminant transport.

5.3.1 Vegetation (Flora)

The type, maturity, and density of vegetation affects runoff characteristics, infiltration characteristics, the temperature of surface soils, wind speeds at ground surface, and consequently, the potential for evapotranspiration, soil erosion, and infiltration of rainwater. Vegetation is one factor among many affecting the maintenance of landfill covers and potential movement of water within the first few meters of soil and alluvium. Rooting depth is closely tied to soil moisture availability. The potential for plants to enhance vertical movement of water downward towards buried waste is offset by their use of water to live and grow. Decomposition of roots provides channels for water and vapor and may enhance infiltration and percolation through the rooting depth, but plants remove water from the soil, store it in biomass, and transpire moisture back to the atmosphere. Further implications of vegetation with respect to water budget are discussed in the context of the lysimeter data and vadose zone hydrology (Section 5.6) and in the studies referenced. Because plants can take radionuclides from the soil, concentrate them in their biomass, and potentially release some to the atmosphere via transpiration, vegetation can also be a factor in the movement of radionuclides in the near surface environment.

Plants are often an integral part of a landfill soil-closure cover system, whether the plants are intentionally selected and planted in ways to maximize the benefits of the vegetative cover, or whether the cover is designed to allow the gradual natural population of the area by surrounding species. Plant evapotranspiration minimizes potential water transport through the cover and the plant canopy and roots help control erosion of the surface by wind and rain.

Studies on floral communities occurring within Frenchman Flat (Romney et al., 1973; Hunter and Medica, 1989; Ostler et al., 2000; and Beatley, 1976) have classified the vicinity of the Area 5 RWMS as a *Larrea-Ambrosia* Mojave Desert community. Mojave Desert communities can have highly variable floristic compositions, but all are dominated by creosote bush and various co-dominant shrubs. Shrub coverage varies from 7 to 23 percent for Mojave Desert communities on the NTS (Beatley, 1976). Several reports indicate plant communities near the Area 5 RWMS are dominated by creosote bush, including Ostler et al., (2000). Hansen and Ostler (2003) noted the *Larrea-Ambrosia* shrublands at the NTS are actually typically dominated by white bursage (*Ambrosia dumosa*) in terms of total biomass, relative abundance, and cover. However, because the creosote are larger plants, they appear to dominate the landscape.

Schockley goldenhead (*Acamptopappus shockleyi*) was another common shrub species observed at two of three study sites investigated near the Area 5 RWMS.

Roots of shrubland species that grow at the NTS are mostly confined within the top 5 m (16.4 ft) of soil (see studies by Hansen and Ostler [2003], Foxx et al. [1984a and 1984b], and Tierney and Foxx [1987]). The roots of Mojave Desert and transitional desert plants at the NTS are concentrated near the surface, to maximize capture of infiltration (Winkel et al., 1995; Hansen and Ostler, 2003). Availability of oxygen has been found to limit creosote root depths, perhaps even more than the availability of soil moisture (Personal Communication, D. Hansen, September 20, 2005).

All of the species observed at the Area 5 RWMS have shallow root systems, and observed root depths are generally less than 2 m (6.6 ft). Wallace and Romney (1972) described root systems of plants excavated from a wash in Rock Valley on the NTS, at a study site selected because of an absence of caliche hardpan, which can restrict rooting depths. Creosote bush roots reached 168 cm (66 in) below surface, but over 82 percent of the creosote roots were in the top 30 cm (12 in) of soil. White bursage plant roots reached up to 50 cm (20 in), but most of the roots were in the top 20 cm (8 in) of soil. About 85 percent of the Schockley goldenhead roots were in the top 20 cm (8 in) of soil, and none reached below 40 cm (16 in) depth. Other less abundant shrub species were also shallowly rooted: desertthorn roots reached 122 cm (48 in) below surface, Mormon tea roots reached 91 cm (36 in) below surface, and winterfat roots reached 64 cm (25 in) below surface.

Wallace et al. (1980) also excavated root systems of several Mojave Desert species at the NTS. The roots were distributed in the top 51 cm (20 in), except for fourwing saltbush and shadscale. Less than 2 percent of the roots of these two species were found below 51 cm (20 in). Beatley (1969) noted that winter annuals root in the top 20 cm (8 in.) of soil. Wirth et al. (1999) also compiled rooting depths of various plant species found on the NTS.

Hansen and Ostler (2003) studied rooting characteristics of vegetation near to and at the Area 3 and Area 5 RWMSs. In August 2001, excavations and observations of the pit walls at P08U in the Expansion Area of the Area 5 RWMS indicated that root depths did not exceed 1.5 m (5 ft). Small isolated root hairs, apparently unrelated to the current plants, were found below 1.5 m (5 ft) depth. Most creosote bush roots were concentrated in the top 2 m (6.6 ft) of soil and the largest average maximum rooting depth for creosote at the three study plots near to, but outside of, the Area 5 RWMS was less than 116 cm (3.8 ft). Raytheon Services Nevada ([RSN], 1991) noted that modern and ancient roots observed in the pit walls often have up to a 15-cm- (6-in)-diameter zone of carbonate cementation around them, indicative of water or vapor migration in these zones.

The natural vegetation in the vicinity of the Area 5 RWMS is sparse. Total shrub cover at three study plots varied from 18.6 percent to 32 percent (Hansen and Ostler, 2003).

Several studies have estimated the time for disturbed areas to naturally revegetate and the characteristics of communities likely to become established. These studies give an indication of how long it may take a native alluvium landfill cover to naturally revegetate. Sutter et al. (1993)

suggests revegetation of the Area 5 RWMS waste covers, whether managed in the beginning or left to occur naturally, will likely progress from bare soil to desert shrubland in less than 50 years. However many studies suggest recovery of vegetative cover may take much more time. Webb et al. (2003) looked at changes in plots originally established at the NTS by Dr. Janice Beatley in 1963. The plots had been disturbed by fires and other factors, and were ecologically monitored from 1963 to 1975 and from 2000 to 2003. Webb concluded that species compositions of disturbed plots compared to undisturbed plots at the NTS are very different. Although some vegetative cover will reestablish in 50 years, as long as a millennium may be required for recovery of the native species composition.

Similarly, Ostler et al. (2002) studied recovery of plants at sites disturbed by military activities in the Mojave Desert and projected that recovery may require hundreds of years to achieve predisturbance levels of vegetation cover in arid lands.

Angerer et al. (2004) studied plant succession on disturbed sites at Yucca Mountain, Nevada. The study area included the west edge of the NTS. Extrapolation of observations indicated approximately 845 years would be required for the amount of cover on disturbances to reach that of undisturbed areas. Estimates of individual recovery rates for 10 dominant species ranged from 31 years to 1,100 years. Time to develop a plant community very similar to the original undisturbed community would be much greater. Angerer et al. (2004) cites several other studies of plant succession in disturbed areas in the Mojave Desert with similar rates.

Even with predicted climatic changes of 3°C (37°F) warmer and then 2°C (35°F) cooler and 50 percent wetter conditions, creosote is likely to continue to be the dominant shrub in the Area 5 RWMS Area for the foreseeable future (RSN, unpublished written communication, 1991). The PA prepared for the TRU material in four of the GCD boreholes (Cochran, Beyeler, et al., 2001) suggesting deeper-rooted plants such as piñon and juniper might enter the Area 5 RWMS Area under glacial conditions. Hansen and Ostler (2003) noted a big sagebrush community could eventually result if the climate became sufficiently cooler and wetter at the Areas 3 and 5 RWMSs. However, piñon and juniper trees are unlikely to become established at the RWMS sites, which have deep soils and are in valley bottoms vulnerable to drought and fire. Therefore, even under wetter, cooler conditions, rooting depths of native plant communities are likely to remain shallow. Additional discussion on NTS vegetation can be found in Wills and Ostler (2001) and in Hansen and Ostler (2003).

5.3.2 Wildlife (Fauna)

Fauna have a potential role in transport of radioactive contaminants through burrowing and the food chain.

Fauna within the Mojave Desert plant communities at Frenchman Flat are diverse. Invertebrates, particularly insects, are the most abundant (O’Farrell and Emery, 1976). Ants and termites are the most numerous burrowing insects on the NTS (O’Farrell and Emery, 1976). Allred et al. (1963) report 20 ant species for *Larrea-Ambrosia* Mojave Desert communities. Vertebrates are less numerous and diverse. They include game and fossorial (burrowing) species. Both small and large burrowing mammals are present in the areas of the RWMSs. Rodents are the most common of the mammalian species on the NTS (Allred et al., 1963). For a summary on the NTS fauna, see Shott et al., 1998; Winkel et al., 1996; and Thompson, 1993.

The depth of burrowing is closely tied to soil conditions and plant rooting depths. The majority of animals at the NTS appear to confine burrowing activities to the upper 3 m (10 ft) of soil. Termites have been known to excavate burrows as deep as 6 m (20 ft) in the arid southwest (Thompson, 1993); however, because plant roots are a primary food source for termites, their burrowing depths are also closely related to rooting depth. Creosote and other shrubs with shallower rooting depths predominate around the Area 5 RWMS (see previous section); therefore, termites in the vicinity are unlikely to be found below 2 m (6.6 ft) depth.

Recent studies suggest termites have little potential to move contaminated materials. Ants may burrow deeper. The volume of material moved from the subsurface to the surface by these insects is small (Personal Communications, J. Tauxe and G. Shott, November 16, 2005).

Vertebrate animal burrows were noted as modern and ancient post-depositional during an evaluation of Area 5 RWMS surface geology by Raytheon Services Nevada (September 1991). Modern burrows observed at the RWMS tend to be below shrubs. Most of the burrows are 5 to 10 cm (2 to 4 in) in diameter and extend below ground surface a few tenths of a meter. Larger burrows, about 20 cm (8 in) diameter, are much less abundant. Many modern burrows were observed extending to the rooting depth, about 1.3 m (4.3 ft), in the walls of “Pit 4C” (T04C from mapped location). One inactive burrow was found to 3.4 m (11.2 ft), but the observers suspected it may have been dug from the side wall of the pit due to a ledge near the opening (RSN, 1991).

Neptune and Company is currently writing a report for NNSA on recent biota characterization studies. The results have not been published yet, however the new data have been used to modify some of the biota input parameters for the Area 5 RWMS GoldSim probabilistic model. The Area 5 RWMS PA addendum due to be published in FY 2006 incorporates these model updates (Personal Communication, G. Shott, November 16, 2005).

5.3.3 Biota Monitoring

At the Area 5 RWMS, biota monitoring has mainly focused on sampling vegetation for tritium. Plant tissue has also been analyzed for alpha- and gamma-emitting radionuclides and Sr-90. Tritium is the primary radionuclide monitored due to its high mobility as tritiated water. The cycle of plant uptake and transpiration is one of the mechanisms that transport tritium up through waste covers and into the atmosphere, in addition to gaseous diffusion, gaseous advection, bioturbation, and evaporation (BN, 2005c, 2004c).

Plant roots absorb radionuclides from soil water and draw the radionuclides up into the leafy parts of the plant. Potential uptake is affected by root depth, density, and activity; the ability of plants to concentrate radionuclides; plant biomass production and turnover; soil type; climate; and weather. Studies by Sheppard and Evenden (1988), Whicker (1978), and Dreesen and Marple (1979) document the variability in the ability of plants to take up radionuclides. The amount of tritium released into the atmosphere by plant transpiration is affected by several factors including plant size, species, and available moisture.

Vegetation from on and near waste covers, as well as vegetation from control areas far from waste covers, is usually sampled in mid-summer. Timing of the sampling is important because vegetation is forced to remove soil water from greater depths (closer to waste) as surface soils dry out in summer. Plant water is extracted from the vegetation samples by room temperature vacuum distillation and analyzed by liquid scintillation for tritium.

If tritium concentrations in vegetation are exceedingly high, or if animal burrows on or near waste covers are observed in significant numbers, wild animals and soil from animal burrows may be sampled. Vegetation sampling may be limited year to year, depending on rainfall and waste cover operations during operational closure. Biota monitoring data are included in the annual waste management monitoring reports for the Areas 3 and 5 RWMSs. The most recent available published results at the time of report preparation were for the sampling event in 2002. The results of the 2005 sampling will be published in the *2005 Waste Management Monitoring Report, Area 3 and 5 Radioactive Waste Management Sites*, to be published in FY 2006.

The tritium concentrations found in 1999, 2000, 2001, and 2002 were much lower than those measured in 1995 and 1996 (BN, 2005c). The monitoring staff speculates that samples collected in the mid 1990s may have been from areas closer to the sources of tritium than vegetation samples collected in later years, due to a change in cover maintenance. More vegetation was present on the covers in the mid 1990s than in later years (Personal Communication, R. Warren via D. Hudson, September 6, 2005).

Biota should continue to be monitored for tritium as part of a multi-phase program. Potential tritium migration at the Area 5 RWMS is monitored through multi-depth soil-gas sampling at the GCD-05U disposal unit, air quality monitoring, and biota monitoring. Low levels of tritium have been found in soil-gas near the waste, and traces of tritium have been found in plant tissue and air samples. Monitoring data indicate that there may be an upward pathway for tritium migration, possibly through diffusion and plant transpiration processes.

5.4 GEOLOGY

A detailed description of the geology of Frenchman Flat is in the PA for the Area 5 RWMS (Shott et al., 1998). Much of the following description is extracted from the ICMP (BN, 2005a).

5.4.1 Regional Geology

A sequence of rocks at the NTS composed of Proterozoic and Paleozoic, primarily marine, sedimentary rocks; locally intrusive Cretaceous granitic rocks; Miocene volcanic rocks; and post-volcanic sand and gravel would be approximately 10,500 m (35,000 ft) thick if stacked at one location according to age (Frizzell and Shulters, 1990). The geometry of these rocks is complex. The Proterozoic and Paleozoic rocks were significantly deformed in Late Mesozoic time (approximately 70 million years ago). At that time, older rocks were thrust eastward tens of km (tens of mi) over younger rocks, in some places resulting in repetition of the sequence of rocks (Orkild, 1983). In mid-Tertiary (Miocene) to Quaternary time, the Proterozoic and Paleozoic rocks and the overlying Miocene volcanic rocks were deformed by large-scale extensional block faulting, which is largely responsible for the present Basin and Range topography in Nevada. The extensional faulting is thought to have occurred in two phases across the NTS. The initial phase, about 16 to 14 million years ago, consisted of high-angle northwest- and northeast-trending normal faults, and detachment faults (Cole et al., 1989). A second phase, younger than 11 million years ago, consisted of steeply dipping north-to-south-trending normal faults. This later phase is responsible for the basin-forming faults presently obvious in Yucca Flat (Dockery-Ander, 1984).

5.4.2 Frenchman Flat Geology

The mountain ranges surrounding Frenchman Flat consist primarily of Tertiary volcanic rocks and underlying Paleozoic sedimentary rocks (Figure 5-1). These ranges bound rotated and down-dropped blocks in the basin. Erosion of the mountain ranges has resulted in deposition of a significant thickness of alluvium. The stratigraphy of rocks within Frenchman Flat has been deduced from mapping and boreholes drilled for water wells and underground nuclear testing. Thickness of alluvium in Frenchman Flat ranges between 0 and 1,500 m (0 and 4,900 ft), based on recent drillhole and 3-D seismic reflection data. The alluvium directly below the Area 5 RWMS is approximately 914 m (3,000 ft) thick (BN, 2005f).

Basalt flows with numerical ages of 8.6 and 8.4 million years are interbedded in the alluvium in the northern part of Frenchman Flat, approximately 270 m (900 ft) below the ground surface (Well ER-5-3 log [NNSA/NSO, 2005b]). These flows tend to separate alluvium with a predominant percentage of Tertiary-aged tuff from underlying alluvium with a predominant percentage of Paleozoic-aged sediments (Snyder et al., 1994). This suggests that the source of alluvium in northern Frenchman Flat changed from being predominantly from the northeast to being predominantly from the north about 8.5 million years ago.

The alluvium is underlain by interbedded Tertiary ash-flow and ash-fall tuff estimated to be over 1,190 m (3,900 ft) thick directly below the Area 5 RWMS. On the basis of 3-D seismic reflection data (BN, 2005f), the upper surface of the underlying carbonate rocks is about 2,100 m (6,900 ft) below the surface at the Area 5 RWMS, and perhaps as deep as 2,740 m (9,000 ft) near the center of the basin. A well recently drilled in northern Frenchman Flat as part of the Underground Test Area (UGTA) Program showed the top of the carbonate rocks to be 1,426 m (4,678 ft) below surface, approximately 3.2 km (2 mi) northeast of the RWMS.

Principal faults in Frenchman Flat are the Cane Spring Fault and the Rock Valley Fault (Figure 5-1). The Cane Spring Fault is a left-lateral, strike-slip fault that strikes southwest to northeast in the northern part of Frenchman Flat, 6.4 km (4 mi) northwest of the RWMS. The Rock Valley Fault is a left-lateral, strike-slip fault with a minor dip-slip component (down to the north) that strikes southwest to northeast in the southern part of Frenchman Flat, about 8.8 km (5.5 mi) south of the RWMS. Both of these faults are active and responsible for earthquakes within the recent past (see Section 5.10.1, Seismicity).

5.5 SURFACE WATER

No permanent surface water is present within Frenchman Flat, with the exception of small artificial impoundments and Cane Spring, which issues from a perched aquifer recharged from infiltration through fractures in the nearby mountains. Cane Spring is approximately 14.4 km (9 mi) southwest of the Area 5 RWMS. Alluvial fans within Frenchman Flat are cut by numerous arroyos that drain storm runoff to the playa. Water that accumulates on the playa typically evaporates or infiltrates, or both, within a short period of time. Frenchman Playa is approximately 6.4 km (4 mi) southeast of the Area 5 RWMS (BN, 2005a).

Design of structures and closure covers that can best accommodate run-on from precipitation events over long periods of time must rely on historical precipitation and discharge data. Precipitation data have been collected at various locations around the NTS for several decades. However, until recently, the locations of data collection were not near the middle reaches of watersheds that potentially collect and discharge waters to the vicinities of facilities. To collect precipitation and discharge data relevant to PA and eventual design activities, two precipitation gauges and two flumes were installed in FY 2000 in watershed channels near the Area 5 RWMS. A precipitation gauge and a flume are located in a watershed channel northwest of the Area 5 RWMS. The flume was installed in FY 2000. The intent is to collect precipitation and discharge data through FY 2007, after which, activities associated with final closure of the currently active, 92-Acre Area of the Area 5 RWMS will be initiated. Flooding hazard assessment data are discussed in Section 5.10.3.

5.6 VADOSE ZONE

Many studies and models have been completed that have contributed to our understanding of the stratigraphy and physical properties of the unsaturated zone in Area 5, the physical properties of the existing operational covers, and the potential for movement of water through the vadose zone. In the early 1990s, several studies were conducted which characterized the unsaturated alluvium in the vicinity of the Area 5 RWMS. The studies provided physical property data useful for further evaluation of: hydrogeologic processes; the potential for contaminant transport, erosion, and subsidence; and other factors that must be considered in planning for closure of Area 5 RWMS disposal cells. These studies also enhanced environmental monitoring capabilities in the immediate vicinity of the Area 5 RWMS. Several of the original data reports, which had a very limited distribution, were recently published by NNSA for broader release. This section summarizes a few key results for the natural unsaturated deposits. The operational landfill cover data are presented in Section 5.11.

5.6.1 Key Studies Regarding Vadose-Zone Properties

Some of the key studies and data reports for physical properties of the unsaturated alluvium in the vicinity of the Area 5 RWMS include:

Area 5 Site Characterization Project

- Broad objective to characterize the subsurface hydrogeology of the Area 5 RWMS. Incorporated at least four subprojects listed below.
- Report: *Area 5 Site Characterization project Report FY 1994* (Albright et al., 1994).

Existing Excavations Project

- Purpose was to characterize hydrologic properties of the near-surface alluvium which affect infiltration and redistribution of water and solutes, and to provide guidance for the design of sampling and testing programs.
- Scope included collecting core and bulk soil samples from 183 m-(600-ft)-long transects within Trench 8 and Pit 3, one approximately parallel and one approximately perpendicular to the principle direction of sediment transport. Evaluated spatial variability of gravimetric water content, bulk density, saturated conductivity, and particle size distribution. Characterized coarse and fine layers.
- Report: *Hydrologic Data for Existing Excavations at the Area 5 RWMS, NTS, Nye County, Nevada* (REECo, 1993a).

Science Trench Boreholes Project

- Purpose was to obtain physical, geochemical, and hydrologic property information for the near-surface alluvium in the vicinity of the Area 5 RWMS to support the RCRA Part B permit application for disposal of hazardous waste and to obtain the additional data needed to develop a three-dimensional model of water and gas flow and solute transport for the area. The study supplemented the Existing Excavations project.
- Scope included drilling and sampling seven boreholes by hollow stem auger up to 36.5 m (120 ft) deep along a 61-m (200-ft) transect across the Halfpint Alluvial Fan, parallel to the direction of sediment transport. The alluvium was too loose to leave the boreholes open for later installation of vadose zone monitoring wells. Four borings were subsequently drilled by the ODEX method to allow completion of the borings. Boring ST-1 was overdrilled and ST-2A, ST-4A, and ST-6A were step outs from the original exploratory borings. Laboratory tests and other studies conducted on selected cores and cuttings samples included:
    - Geologic descriptions of stratigraphy and lithology,
    - Mineralogy,
    - Inorganic carbon,
    - total organic carbon,
    - Particle size distribution,
    - Bulk density,
    - Computed porosity,
    - Saturated porosity,
    - Saturated hydraulic conductivity (ksat),
    - Van genuchten water characteristic curves,
    - unsaturated hydraulic conductivity,
    - Gravimetric and volumetric water content,
    - Matric potential, water potential, and
    - Tracers (chloride, bromide, stable isotopes, chlorine-36 [^{36}cl], and sulfate).

- Results were documented in at least two reports including: *Hydrogeologic Data for Science Trench Boreholes at the Area 5 Radioactive Waste Management Site, Nevada Test Site, Nye County, Nevada* (REECo, 1993b) *and Site Characterization Data from the Area 5 Science Boreholes, NTS, Nye County, Nevada* (D. Blout et al., 1995).

Shallow Soil Trenches Project

- Purpose was to characterize soil parameters that affect the movement of water in the uppermost few meters of undisturbed soil in the vicinity of the Area 5 RWMS, partly to support a petition for a RCRA groundwater monitoring waiver and a RCRA exemption from leachate collection and detection systems at new cells.
- Scope included excavation of four trenches 1.5 to 3 m (4.9 to 9.8 ft) deep and 23 to 182 m 75.4 to 597 ft) long, perpendicular to the depositional trend in different fan deposits. The researchers described soils and established stratigraphic relationships, ages of deposits, and alluvial stability with respect to erosion, and they collected multiple cores and grab samples along vertical transects for analysis. Analyses of various samples included gravimetric and volumetric moisture content, dry bulk density, porosity, Ksat, particle size distribution by sieve, organic matter, inorganic carbon, and ^{36}Cl.
- Results were documented in at least two reports including: *Hydrogeologic Characterization Data from the Area 5 Shallow Soil Trenches, Nevada Test Site, Nye County, Nevada*, NNSA report DOE/NV/11718--1060 (BN, 2005g) and a written communication prepared for DOE regarding: *Geological Components of Site Characterization and Performance Assessment for a Radioactive Waste Management Facility at the Nevada Test Site* (Snyder et al., 1994).

Pilot Wells Project

- The purpose of the project was to characterize the uppermost aquifer and “to characterize the lithologic, stratigraphic, and hydrologic conditions that influence infiltration, redistribution, percolation, and chemical transport through the thick vadose zone in the vicinity of the Area 5 RWMS” (BN, 2005e).
- Scope involved drilling three wells to about 21.3 m (70 ft) below the water table and performing the following:
- Collecting cuttings samples approximately every .76 m (2.5 ft);
- Collecting cores at intervals of interest;
  - Analysis and testing of selected core samples for Ksat, moisture retention curves, volumetric water content,
  - Gravimetric water content,
  - Dry bulk density,
  - Air permeability,
  - Particle size distribution,
  - Chloride,
  - Bromide,
  - Inorganic carbon,
  - Organic carbon,
  - Stable isotopes of hydrogen and oxygen,
  - Water potential, ^{36}Cl, and
  - Clay mineralogy;

- Testing of drill cuttings samples for particle size distribution, gravimetric water content, chloride, bromide, sulfate, inorganic carbon, organic carbon, and ^{36}Cl;
- Geologic descriptions;
- Tracer tests to evaluate disturbance from air drilling;
- Radiological surveys;
- Installation and instrumentation of the wells;
- Soil gas surveys;
- Surface and borehole geophysical surveys;
- Nuclear logging;
- Air permeability tests;
- Water level measurements;
- Slug tests, in situ hydraulic conductivity tests; temperature profiles; and
- Baseline groundwater quality sampling and analysis.

- Results were documented in the following NNSA report: *Site Characterization and Monitoring Data from the Area 5 Pilot Wells*, DOE/NV/11718--1067 (BN 2005e).

Samples of core and cuttings from drilling the boreholes for the pilot wells were tested and analyzed for many parameters. The detailed data, as well as summaries of the descriptive statistics for the alluvium from all three wells, and the tuff encountered at UE5PW-3 with no differentiation between unsaturated and saturated zones, are in BN (2005e).

Other Studies

Air permeability studies (e.g., Sully et al., 1992); modeling studies (Crowe, Hansen, et al., 1998), Levitt et al., 1999; Lindstrom et al., 1993; Levitt et al., 1996); the PA studies for the Area 5 RWMS (Shott et al., 1998, 1995); and broader studies of the Great Basin (Tyler et al., 1996) provide further understanding of vadose-zone properties and potential for contaminant transport. Statistical studies provide analysis of spatial variability useful for defining modeling parameters (Sully et al., 1993; and Istock et al., 1994).

Figure 5-7 shows the approximate locations of borings, trenches, and wells in the vicinity of the RWMS. Many have been plugged and abandoned. Appendix C contains a table of sampling locations within Area 5, which includes basic location and descriptive data for these features. Appendix E, Borehole Data and Well Details, includes graphical logs of the Area 5 pilot wells (RCRA monitoring wells), well-construction details for the science trench boreholes completed as wells, and well-construction details for the Area 5 pilot wells.

In FY 2002, samples were collected from the Area 5 RWMS operational covers to document current physical characteristics including basic hydrogeological parameters. See Section 5.11 for discussion of the cover data.

General trends in properties for the unsaturated zone are summarized in the following sections.

5.6.2 Physical and Hydrologic Properties

5.6.2.1 Particle Size Distribution/Soil Classification Data

Soil classes based on particle-size distributions can often be related to physical factors affecting the movement of water and contaminants including porosity and hydraulic conductivity trends. The uniformity of the lithologies, the stratification, and the lateral extensiveness of layers with different physical characteristics has a significant affect on how liquids, gases, and particles can move through the material.

At the shallow soil trenches, mean silt and clay content at trenches SST-1, SST-2, and SST-3 varied from 2.7 percent to 28.4 percent, with mean values for various depth interval sets ranging from 8.4 percent to 14.5 percent and coefficient of variance within depth interval sets of 23 percent to 61.9 percent. Mean gravel and other material above No. 4 mesh was 25.7 percent to 31 percent with less variability than the silt fraction. Dominant texture was silty sand at SST-1 and SST-3 and well-graded sand with silt at SST-2 (BN, 2005g).

At the Science Trench Boreholes, approximately two-thirds of the samples were classified as poorly graded sands with silt or well-graded sands with silt. Few samples contained significant amounts of clay or gravel. The soils were generally weakly-cemented to un-cemented. Silty sand predominated at borehole ST-3. Individual soil horizons were generally less than 1.5 m (5 ft) thick, and the thickest layers were well-graded, fine grained material, alternating with thin layers of poorly-graded, coarse-grained materials. The layers were laterally discontinuous between boreholes spaced 15.25 m (50 ft) apart. In some cases it was difficult to correlate textural units between the augered borings and the ODEX borings drilled 1.5 m (5 ft) away. The discontinuous stratigraphy is consistent with deposition by sheet flood and channel flows on alluvial fans (REECo, 1993b).

The particle size distributions at the Science Trench Boreholes were very consistent with space and depth. The physical and hydrologic properties consequently were also similar. The researchers concluded the portion of the unsaturated alluvium penetrated by the Science Trench Boreholes was an approximately homogeneous hydrologic system (REECo, 1993b).

At the Pilot Wells, the particle size distribution of the alluvial materials did not vary greatly with depth, but were slightly coarser in texture than the very shallow alluvium from the soil trench study. The soil classifications are consistent with the middle to distal alluvial fan depositional environment. Sands with silt and silty sands predominate with thin intervals of gravels. These coarser grained intervals are probably not very laterally extensive, and may represent channel deposits as they shifted back and forth across the fan face and debris flows. Appendix E includes graphical profiles of soil textural classes logged for the cuttings from the borings.

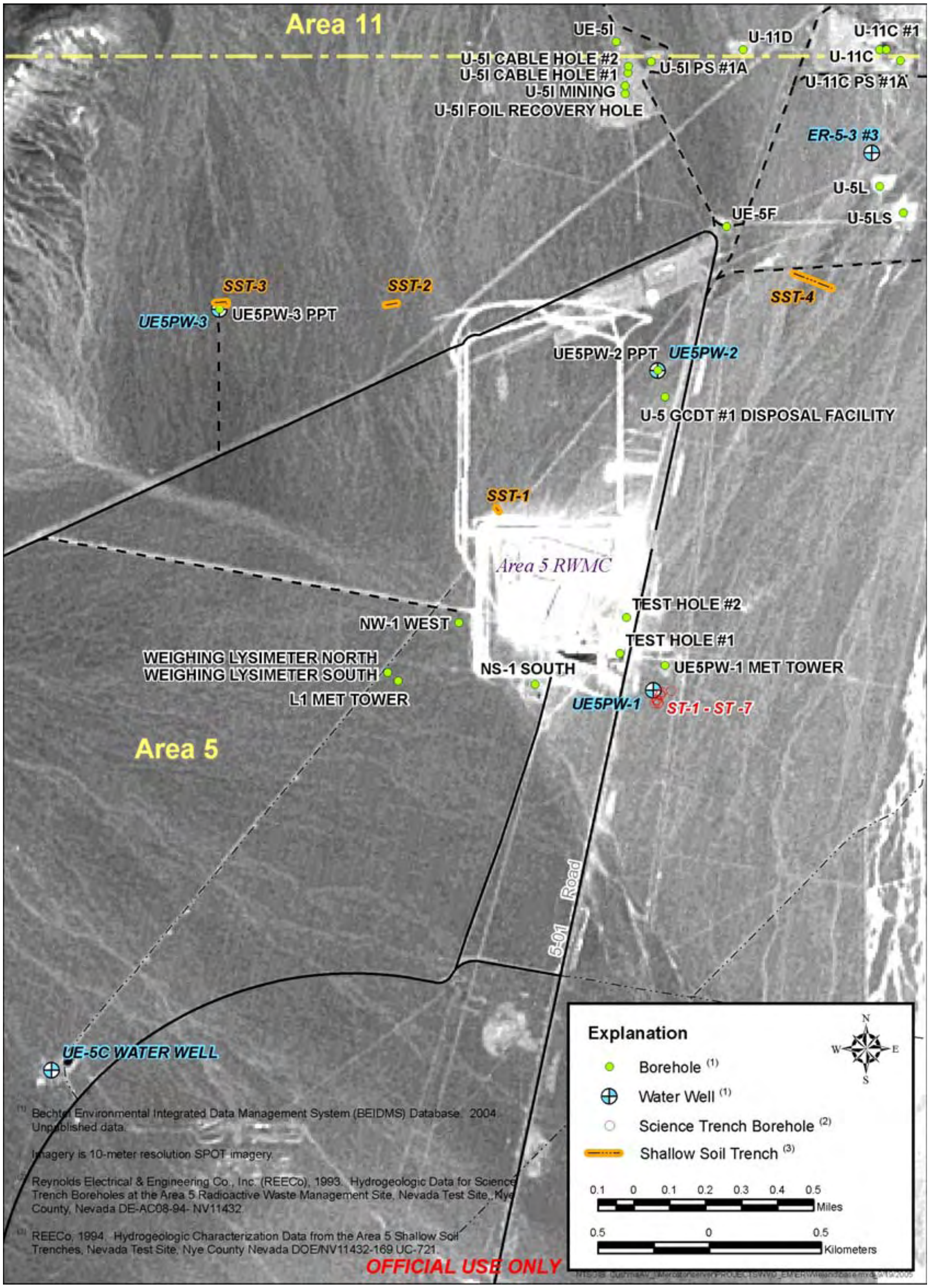

Figure 5-7. Locations of Borings, Trenches and Wells in the Vicinity of the Area 5 RWMS

The unsaturated alluvium at UE5-PW-1 was very uniform. Percent silt and clay was generally less than 15 percent at UE5-PW-1, with mean percentages for core samples of 6.68 percent and cutting samples 7.24 percent. Sands and sands with silt predominate, with the occasional thin interval of silty sand. Very thin gravel layers were found at cuttings intervals approximately: 39.6-40.4 m, 77.7-78.5 m, and 184.4-185.2 m (130-132.5 ft, 255-257.5 ft, and 605-607.5 ft) below ground surface. These are unlikely to be laterally extensive based on the depositional environment and observations at the closely spaced Science Trench Boreholes. Hydrochloric acid reactions in the upper 61 m (200 ft) with few exceptions tended to be strong or moderate.

The unsaturated alluvium at UE5-PW-2 was a little more variable. Above the water table, percent silt and clay were generally less than 35 percent at Ue5-PW-2, with mean values for core samples of 11.08 percent and cuttings samples 12.82 percent. Sand with silt and silty sands predominate, with generally a little more silt than at Ue5-PW-1 or Ue5-PW-3. In the top 15.8 m (52 ft), thin gravel layers were interlayered with the sands and silty sands. More thin gravel lenses were encountered at PW-2 than PW-1, mainly below 122 m (400 ft) depth.

The unsaturated alluvium at UE5-PW-3 was very similar to UE5-PW-2. Percent of silt and clay was generally less than 22 percent at UE5-PW-3, with mean values for core samples of 9.59 percent and for cuttings samples 10.04 percent. Sands with silts and silty sands predominate. In the top 8.4 m (27.5 ft), thin gravel layers were interlayered with sands and silty sands. Thin gravel lenses were encountered at random intervals at greater depths. The contact with welded tuff was encountered at about 617 ft (188 m) depth. See BN, 2005e for further information.

5.6.2.2 Mineral Composition and Geochemistry

Mineral composition affects density, which affects how readily alluvial materials will erode. It can also affect soil water chemistry with sufficient residence times. The geochemistry of the native alluvium affects the transport of radionuclides by affecting their solubility and sorption characteristics. The alluvium is dominated by quartz, feldspar, and cristobalite, with calcite, gypsum, and minor amounts of clays and zeolites. Measured pH values range between 7 and 9, indicating neutral to alkaline conditions (Cochran, Beyeler, et al., 2001). The presence of clays and zeolites in an alkaline environment generally inhibit the mobility of most radionuclides. The geochemical environment of the closure cover is anticipated to be largely determined by the geochemistry of the constituent alluvium. The alluvium of the floors and walls of the disposal units is similar to the operational covers and very dry.

The alluvium at the shallow soil trenches was predominantly weakly cemented to cemented tuffaceous material at SST-2 and SST-3. Alluvium at SST-1 and part of SST-4 also included Paleozoic quartzite and limestone.

Similar to the shallow soil-trenches data, the alluvium at the Science Trench Boreholes was composed primarily of tuff, with occasional clasts of quartzite and limestone, and infrequently with basalt. Soils were generally weakly cemented to uncemented. The source area appears to be basic rhyolitic Tertiary volcanics from the Massachusetts Mountains. Inorganic carbon concentrations were low (mean less than 1 percent by weight) throughout the profile, suggesting there are no significant accumulations of cemented carbonate layers (caliche), which tend to have low porosities, and hydraulic conductivities that can slow percolation rates. Organic carbon content was also very low and uniform throughout the study area. (REECo, 1993b).

Analytical oxide and elemental composition data for the core samples from the pilot wells were very uniform. The native soils naturally contain small amounts of RCRA regulated metals from natural sources. There is very little secondary mineralization.

5.6.2.3 Dry Bulk Density

Bulk density is a parameter required for numerical models of fluid, heat, and solute transport. Mean dry bulk densities for various sets of cores from the shallow soil trenches varied from 1.55 to 1.70 grams per cubic centimeter (g/cm^3) with coefficients of variance less than 7 percent. There were no consistent trends in bulk density with depth.

Similarly at the Science Trench Boreholes, there was significant uniformity of bulk density. Mean values of bulk density ranged from 1.527 g/cm^3 at ST-4 to 1.623 g/cm^3 at ST-7 with coefficients of variation of 7.3 percent or less. However plots of bulk density and porosity versus depth for ST-1, ST-2, ST-4, and ST-6 showed a slight increase in bulk density and slight decrease in porosity in the upper 20 ft of these boreholes (REECo, 1993b).

Mean dry bulk densities of core samples from Ue5PW-1, Ue5PW-2, and UE5PW-3 were 1.64 g/cm^3, 1.64 g/cm^3, and 1.66 g/cm^3 respectively (BN, 2005e). These values are only slightly higher than the average dry bulk density of the compacted operational covers on the landfills. Coefficient of variance was less than 10 percent. There are no consistent trends with depth. This fits with the overall consistency in particle size distributions and lithologies, and the lack of much cementation.

5.6.2.4 Porosity

Porosity (saturated volumetric water content) is a parameter required for modeling fluid, heat, and solute transport. It can be computed using measured saturated porosities and bulk densities.

Porosities were calculated from dry bulk densities for the shallow soil trench cores. Mean porosity for various sample sets varied from 36.0 percent to 41.7 percent with variances 10.5 percent and less.

Plots of porosity and bulk density versus depth for Science Trench Boreholes ST-1, ST-2, ST-4, and ST-6 showed a slight decrease in porosity and slight increase in bulk density in the upper 20 ft of these boreholes. However, overall porosity was very uniform among the samples tested. Mean computed porosities ranged from 38.11 percent at ST-5 to 42.45 percent at ST-4 with coefficients of variation of less than 12 percent (REECo, 1993b).

For samples from the wells, water saturated porosities were less than porosities calculated from dry bulk densities partly due to drainage losses from coarse sample cores prior to measurement. Mean dry bulk densities and porosities from each well were very similar. Table 5-2 summarizes selected hydrological property data for core samples from the pilot wells, including the range and average porosity by well. Variances were low, indicative of the homogeneity of the alluvium.

Table 5-2. Hydrogeological Properties, Core Samples from Pilot Wells

Property (Units)	UE5PW-1 Alluvium			UE5PW-2 Alluvium			UE5PW-3 Alluvium			UE5PW-3 Tuff		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Ksat (centimeters per second)	1.4E-6	5.8E-3	1.7E-3	2.1E-6	4.0E-3	5.7E-4	5.6E-6	3.2E-3	1.1E-3	6.0E-7	2.7E-5	1.4E-6
Gravimetric Water Content (%)	2.6	13.9	6.6	2.0	12.2	6.5	1.5	8.4	4.9	0.8	7.6	5.0
Volumetric Water Content (%)	5.6	23.0	11.1	7.3	21.0	10.9	2.6	13.2	7.9	14.9	15.1	15.0
Calculated Porosity (%)	27.53	55.85	37.93	29.81	56.60	38.79	26.04	50.94	37.27	21.90	23.10	22.40
Saturated Porosity (%)	27.50	39.20	33.50	27.93	39.77	32.70	26.88	35.87	30.31	-	-	-
Water Potential (bars)	-81.5	-0.03	-9.0	-86.6	-0.3	-14.5	-374.8	-6.8	-39.1	-23.2 cores	-16.3 cores	-19.8 cores
Water Potential below 150 ft (bars)	-21.8	-0.03	-5.6	-24.0	-0.3	-9.0	-	-	-	-	-	-
Water Potential below 100 ft (bars)	-	-	-	-	-	-	-19.8	-6.8	-13.3	-	-	-

NOTES:
Except for water potential, these results are for analyses of only the core samples. The alluvium water content summary data are for only the cores from above the water table.
See BN, 2005e for complete data sets, methodologies, and limitations.

5.6.2.5 Saturated Hydraulic Conductivity

For cores from the shallow soil trenches, Ksat values ranges from 1.3 E-05 to 1.8E-02 centimeters/second (cm/sec) with means for various sample sets ranging from 5.8E-04 to 3.1E-03 cm/sec and coefficients of variation from 106 to 261 percent. The finer textured upper parts of SST-1 and SST-3 were less permeable, but there were no obvious trends in Ksat with depth at the shallow trenches, and Ksat values were typical of silty sand alluvial deposits (Page 3-19, BN, 2005g).

At the Science Trench Boreholes, measured Ksat values ranged from 1E-05 to 4.9E-03 cm/sec. Mean values at each borehole ranged from 2.91 E-04 cm/sec at ST-4 to 9.89 E-04 cm/sec at ST-6. There were no apparent trends with depth (REECo, 1993b).

Saturated hydraulic conductivities were obtained from tests on three in-core samples from the pilot wells. Hydraulic conductivities ranged from 1.4E-06 to 5.8E-03 cm/sec (BN, 2005e). The report noted that there were no obvious trends as a function of depth and that these values are typical of silty sand alluvial deposits (BN, 2005b). Table 4 includes the range and average Ksat values for core samples analyzed from each well.

5.6.2.6 Water Potential, Water Characteristic Curves, and Unsaturated Hydraulic Conductivity

Water potential differences help drive the movement of water. Water potential is related to water content by water characteristic curves. The highest potential flow rates are under saturated conditions. At lower moisture levels, the geometry of the small pores, viscosity, surface tension, and other factors increase in importance. Trapped air and vapor in the pores also affects the potential for water movement. Water movement rates in unsaturated conditions are significantly slower than in saturated conditions. Soil moisture retention data are used to estimate unsaturated hydraulic activity for arid soil with low water contents.

Plots of water potential versus volumetric water content for core samples from Science Trench Boreholes ST-1 and ST-4 showed similar relationships for all of the cores. The range in fitted van Genuchten parameters was small. The van Genuchten parameters for the water characteristic curve data were similar to the values found for individual fine and coarse layers in the existing excavations study. Mean residual water contents (Θr) for data from all core samples was 0.511 cm3/cm3, mean saturated water contents (Θs) was 0.363 cm3/cm3, mean shape parameter (α) was 0.041 cm-1, and mean shape parameter (n) was 0.456 (REECo, 1993b).

Plots of computed unsaturated conductivity functions versus volumetric water content for core samples from the Science Trench Boreholes show that in the vicinity of the Area 5 RWMS, unsaturated hydraulic conductivities decrease sharply with decreasing water contents. As for the measured in situ soil moisture contents, the unsaturated hydraulic conductivity is 5 to 20 orders of magnitude less than Ksat (REECo, 1993b).

The pilot well data are very similar. Moisture retention curves and fitted unsaturated hydraulic conductivity functions for core samples from the pilot wells are presented in the revised REECo pilot wells report (BN, 2005e) and in the PA (Shott et al., 1998). The van Genuchten parameters for the water characteristic (moisture retention) curve data varied slightly between wells, but the average values for all the cores collected from the wells were similar orders of magnitude to those found at the Science Trench Boreholes.

At the pilot wells, depth profiles of water potential indicated a positive gradient (an upward movement of liquid) to at least a depth of 30.5 m (100 ft) in each borehole. At greater depths, the water potential gradient is nearly zero, indicating that gravity is the main driver of liquid water movement through that zone. Below about 45.7 m (150 ft) there is no upward flux. Table 4 presents selected summary statistics including mean water potential values for the cores samples for each well as a whole and for the deeper samples from each well. For further detail see the report by BN (2005e).

Data implies that travel rates are slow for water transport through the upper vadose zone. Calculation of the unsaturated hydraulic conductivity for a mean water content of 11.2 percent at Ue5PW-1 was less than 1E-07 cm/sec for all cases. The median unsaturated hydraulic conductivity curve was about 1E-09 cm/sec. Assuming a water filled porosity of 10 percent, the average flux (in the deeper alluvium below the zone of positive water potential) is equivalent to a water travel rate of about 3E-03 m/year (or 1E-02 ft/year). It would take 1,000 years for water to travel 3 m (10 ft) (p. 3-51 BN, 2005e).

5.6.3 Tritium Transport in Soil Gas

Monitoring of tritium concentrations in soil gas at multiple depths over time provides key data for evaluating the rate of vertical migration of radionuclides. Gas-phase tritium monitoring has been conducted via soil-gas sampling at GCD-05U (Figure 2-1) since 1990. This disposal unit has a large tritium inventory (2.2 million Ci at time of disposal) and is instrumented with two strings of nine soil-gas sampling ports buried at depths ranging from 3 to 37 m (10 to 120 ft) below surface. Tritium sampling at GCD-05U provides a direct measure of tritium migration from waste packages with time due to degradation of waste containers and the natural transport processes of advection and diffusion. Figure 5-8 shows the soil-gas tritium concentrations at GCD-05U at each sampling depth over time. Results from 1990 through 2004 indicate that soil-gas tritium concentrations have gradually increased at depths between 15 and 37 m (50 and 120 ft), but vertical migration is extremely slow.

Soil-gas sampling ports have been installed at other locations at the Area 5 RWMS, including beneath pits P03U and P05U. The ports are not currently monitored.

5.6.4 Environmental Tracers

Environmental tracers provide a way to estimate vadose-zone water movement, travel times, and recharge. Infiltrating precipitation and runoff carry conservative, non-sorbing materials that can be tracers for water as it percolates through the vadose zone. Tracer data were collected and evaluated from the Science Trench Boreholes and the pilot wells.

5.6.4.1 Chloride and Bromide

Chloride and bromide are deposited as water moving through the soil evaporates. At the Science Trench Boreholes, plots of concentrations versus depth indicate chloride levels were high throughout the 36.5 m (120 ft) depth, but there was a significant increasing trend upward through the top 15.2 m (50) ft, with a sharp increase above about 15 ft depth. Bromide profiles showed similar trends, with gradual increases through the top 15.25 m (50 ft) and a prominent increase in the top about 4.5 m (15 ft) of each boring. The data are consistent with other data indicating high evaporation rates and an upward water potential gradient in the shallow alluvium (REECo, 1993b).

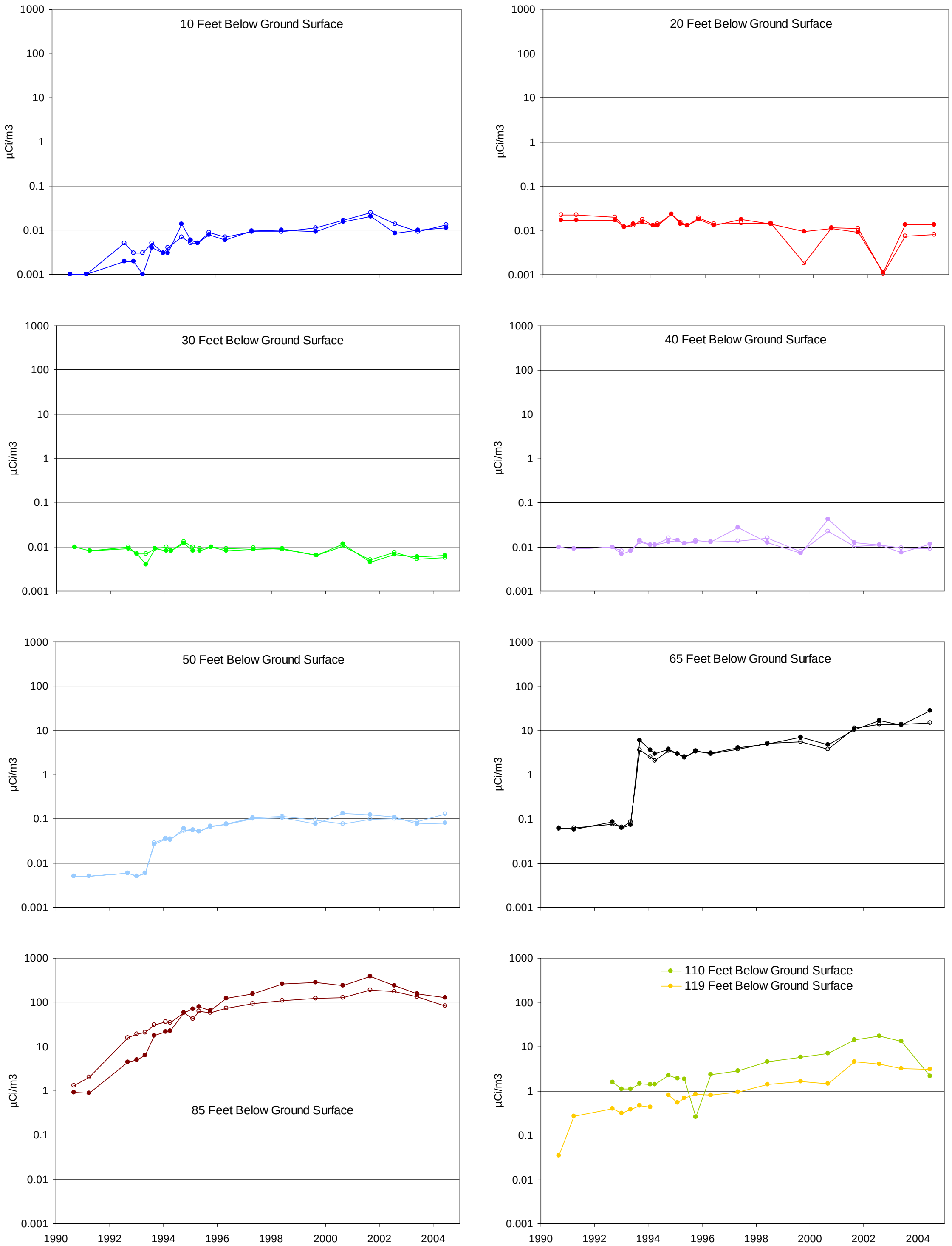

Figure 5-8. Soil Gas Tritium Concentrations at Each Sampling Depth Over Time, 1990-2004

Source: NTS 2004 Waste Management Monitoring Report (BN, 2005c)

At the pilot wells, the chloride distribution data also supports the water potential observations. Evaporation appears to be occurring in at least the upper 30.5 m (100 ft). Chloride and bromide concentrations were very low and approximately constant below about 76.2 m (250 ft) in UE5PW-1, 30.5 m (100 ft) at UE5PW-2 and 121.9 m (400 ft) at UE5PW-3. Relatively high concentrations were found in the shallow subsurface indicative of high evaporation rates. The Bromide concentration profiles were very similar (BN, 2005e).

5.6.4.2 Sulfate

Sulfate is a less soluble and less mobile tracer than chloride and bromide. In the upper 9.1 m (30 ft) of the Science Trench Boreholes, the concentrations of sulfate were high and very variable, with a gradual decrease in concentrations between 9.1 m (30 ft) and 36.5 m (120 ft). The variability in the uppermost 9.1 m (30 ft) may be due to sulfate mineral deposits (e.g., gypsum). The amount of adsorbed sulfate on soil colloids is small compared to soluble sulfates, which is consistent with the small amounts of clay in the alluvium (REECo, 1993b, p.78).

Sulfate concentration profiles show high and variable sulfate present in the top 60 m (197 ft) at well UE5PW-2 and 80 m (262 ft) at well UE5PW-3. At greater depths, concentrations were low and more consistent. Analysis for this tracer was added to the suite after work had already begun at UE5PW-1, so there is not a complete data set for that well (BN, 2005b).

5.6.4.3 Stable Isotopes of Hydrogen and Oxygen

Hydrogen and oxygen tracers are part of the water molecules themselves. Evaporation of rainwater results in a preferential reduction in the light end stable isotopes and concentration of high end stable isotopes. Hydrogen and deuterium ratios for soil moisture samples analyzed from the Area 5 RWMS studies fall below the meteoric water line. At both the Science Trench Boreholes and at the pilot wells, the researchers found enrichment in heavy isotopes in the upper vadose zone suggesting that the shallow soil water has been subject to more evaporation. See REECo (1993b).

Plots of the isotopes with depth at the Science Trench Boreholes for cores from borings ST-1, ST-2, and ST-4 indicate there is a gradual increase in deuterium and oxygen-18 from the deepest samples collected from about 36.6 m (120 ft) depth to the shallowest samples analyzed, from about 3 m (10 ft) depth. An increase in the rate occurs somewhere between 21.3 m and 18.3 m (70 and 60 ft) depth, and another increase in the rate occurs above 6.1 m (20 ft) depth. These trends correlate well with chloride and bromide data.

5.6.4.4 Chlorine-36

Chlorine-36 (^{36}Cl) and stable chlorine profile data were collected to evaluate relative age of soil water. The ^{36}Cl is produced naturally in the atmosphere. More ^{36}Cl is thought to be produced during geomagnetic fluctuations. The most recent geomagnetic fluctuation is thought to have occurred 15,000 to 25,000 years ago, and elevated ratios have been found in 21,000 year old pack rat middens (Phillips et al., 1988 as cited in BN, 2005e). Nuclear weapons tests in the South Pacific produced a spike in atmospheric levels of ^{36}Cl from 1952 to 1964 (BN, 2005g). At both the Science Trench Boreholes and Pilot Wells, the ratios of $^{36}Cl:Cl$ found in samples above a depth of 30.5 m (100 ft) are higher than the ratios found in rain water today. If the ^{36}Cl enrichment in the soil water at 100 ft is primarily due to age, the downward percolation of water through the near-surface vadose zone is extremely slow. This finding appears to be consistent with the hydraulic parameter data and environmental tracer data.

The scientists concluded that these environmental tracer profiles imply that in the present arid climate, the portion of the precipitation that infiltrates does not move very far into the upper vadose zone, due to evaporation. The soil water present in the lower vadose zone infiltrated thousands of years ago under a more humid climate when evaporation demand was much lower (BN, 2005e).

5.6.5 Vadose Zone Water Balance Monitoring

Vadose-zone monitoring is conducted at the Area 5 RWMS to support hydrogeologic characterization, to demonstrate compliance with DOE Orders 450.1 and 435.1, and to monitor performance. Near-surface soil-moisture levels have been monitored in the past by neutron logging surveys. The TDR data from automated waste cover monitoring systems provide direct measurement of moisture fluxes. Water-balance changes in the vadose zone are evaluated using meteorology data to calculate PET; direct measurements of actual evapotranspiration, and bare-soil evaporation at the Area 5 RWMS weighing lysimeter facility; and measured fluxes of soil-water content and soil-water potential in waste cell covers and floors from an automated waste-cover monitoring system. Figure 5-2 shows the location of automated vadose-zone stations collecting data from the moisture and temperature sensors installed in floors and covers of selected pits. Figure 5-9 shows the locations of the groundwater monitoring wells and the weighing lysimeters.

As a result of this extensive characterization and monitoring work, there is an excellent understanding of vadose-zone processes and characteristics in the vicinity of the Area 5 RWMS, and a strong conceptual model of water and vapor transport, which enhances our understanding of the potential for contaminant transport.

5.6.5.1 Soil Moisture Monitoring

Neutron Logging

Neutron logging historically was conducted at selected neutron access tubes at the Area 5 RWMS to provide profiles of soil-water content with depth and time. Automated TDR systems have replaced neutron logging at the Area 5 RWMS. For a detailed history of the neutron logging monitoring program at the Area 5 RWMS, refer to BN (1997). Figure 5-9 shows the approximate locations of access tubes. There are access tubes in the east end of the operationally closed portion of P03U MWDU, and in the operational covers of P01U, P02U, P04U, and P05U. There are also a few access tubes around the perimeter of the 92-Acre Area. The neutron access tubes are anticipated to remain in the operational covers and most should be accessible until the final landfill cover is emplaced.

Figure 5-9. Locations of Neutron Probe Access Tubes

The Neutron Probe Calibration Facility south of pilot well Ue5PW-1 (Figure 5-2) was equipped in 1998 with TDR probes around each type of casing used for neutron probe access ports. The TDRs are buried at depths of 30, 60, and 90 cm (1, 2, and 3 ft).

Automated Monitoring System Data

In 1998, TDR probes were installed at depths of 0.3, 0.6, and 1.2 m (1, 2, and 4 ft) at the north end of the open pit floor of P03U, and at 1.2 m (4 ft) at four locations beneath the open pit floor of P05U at the Area 5 RWMS. Waste was deposited above the probes (BN, 2005c). In January 2002, the station and probes in the floor of Pit 3 were removed to accommodate waste operations. The station was near a pit edge requiring earth work (Personal Communication, D. Rudolph, November 22, 2005).

The Pit 5 North (Pit5N) floor sensors include CS 610 TDRs approximately 16 and 28 m (52.5 and 92 ft) west of the Pit5N station which is on the edge of Pit 4 (Figure 5-2) and CS615 reflectometers located approximately 16, 28, and 42 m (52.5, 92, and 138 ft) west of the Pit5N station. A thermocouple wire for measuring soil temperature is located about 16 m (52.5 ft) west of these stations. All of these sensors are buried about 1.2 m (4 ft) below the floor. The Pit 5

South (Pit5S) floor TDR and reflectometer array is similar to Pit5N. (Personal Communication, D. Rudolph, November 22, 2005). The south floor sensors are monitored at the Pit5S vadose-zone station which is located on the operational cover of P04U (Figure 5-2). A gas-sampling port with a stainless steel tube was also installed for each station.

Measured volumetric soil water content at the P03U and P05U floor sensors has consistently been approximately 10 percent, which indicates no moisture has migrated to 1.2 m (4 ft) below the waste during the respective periods of record, December 1998-2002 and December 1998-December 2004 (BN, 2005c). Because the likelihood of infiltrated storm water ever reaching pit floor sensors after emplacement of waste and the operational covers is negligible (based on monitoring of moisture in operational covers), no further instrumentation of the pit floors at the Area 5 RWMS is currently planned. Water balance data from the lysimeter studies, and performance modeling is discussed in later sections of this report.

Automated monitoring of moisture in operational soil covers has also been implemented at three unclassified pits. In 1999, nests of TDR probes were installed in the operational cover of Pit 3 (P03U) at two sites (north and south), at depths ranging from 10 to 180 cm (0.3 to 5.9 ft), and in 2000, in the operational covers of Pits 4 and 5 (P04U and P05U) at depths ranging from 15 to 180 cm (0.5 to 5.9 ft). Heat dissipation probes, which are essentially water potential and temperature sensors, were installed in the operational covers of P05U and P04U at similar depths as the TDRs, ranging from 15 to 180 cm (0.5 to 5.9 ft). The sensors are connected to dataloggers at the vadose zone stations shown in Figure 5-2. Telemetry for remote downloading of data by telephone has been installed at some stations.

Past monitoring reports (e.g., BN, 2002c) noted that moisture percolation through the soil covers rarely exceeded 60 cm (2 ft) depth. However, during a relatively wet fall season in 2004, precipitation percolated to slightly greater depths at all three of the monitored Area 5 unvegetated operational landfill covers. At P03U, water percolated past a depth of 120 cm (3.9 ft) at the north TDR nest location and past a depth of 150 cm (4.9 ft) at the south nest location. Fall 2004 precipitation percolated more than 120 cm (3.9 ft) in the cover of P04U, and deeper than 60 cm (2 ft) at P05U. See the *2004 Waste Management Monitoring Report* (BN, 2005c) for further information. These depths are very shallow compared to the extent of the zone of upward water movement indicated by tracer and water potential data.

5.6.5.2 Area 5 Weighing Lysimeter Facility Evapotranspiration, Evaporation, and Storage Data

The Area 5 Weighing Lysimeter Facility consists of two precision weighing lysimeters located about 400 m (1,312 ft) southwest of the Area 5 RWMS (Figure 5-10). Each lysimeter consists of a steel box 2 m (6.6 ft) deep, filled with soil and having a ground-surface area of 2 by 4 m (6.6 by 13 ft) and a volume of 16 m^3 (565 ft^3). The top of the soil tank is flush with the ground surface, and access to the side of the soil tank is provided through an underground entry. Each lysimeter is mounted on a sensitive scale, which is continuously monitored using an electronic loadcell.

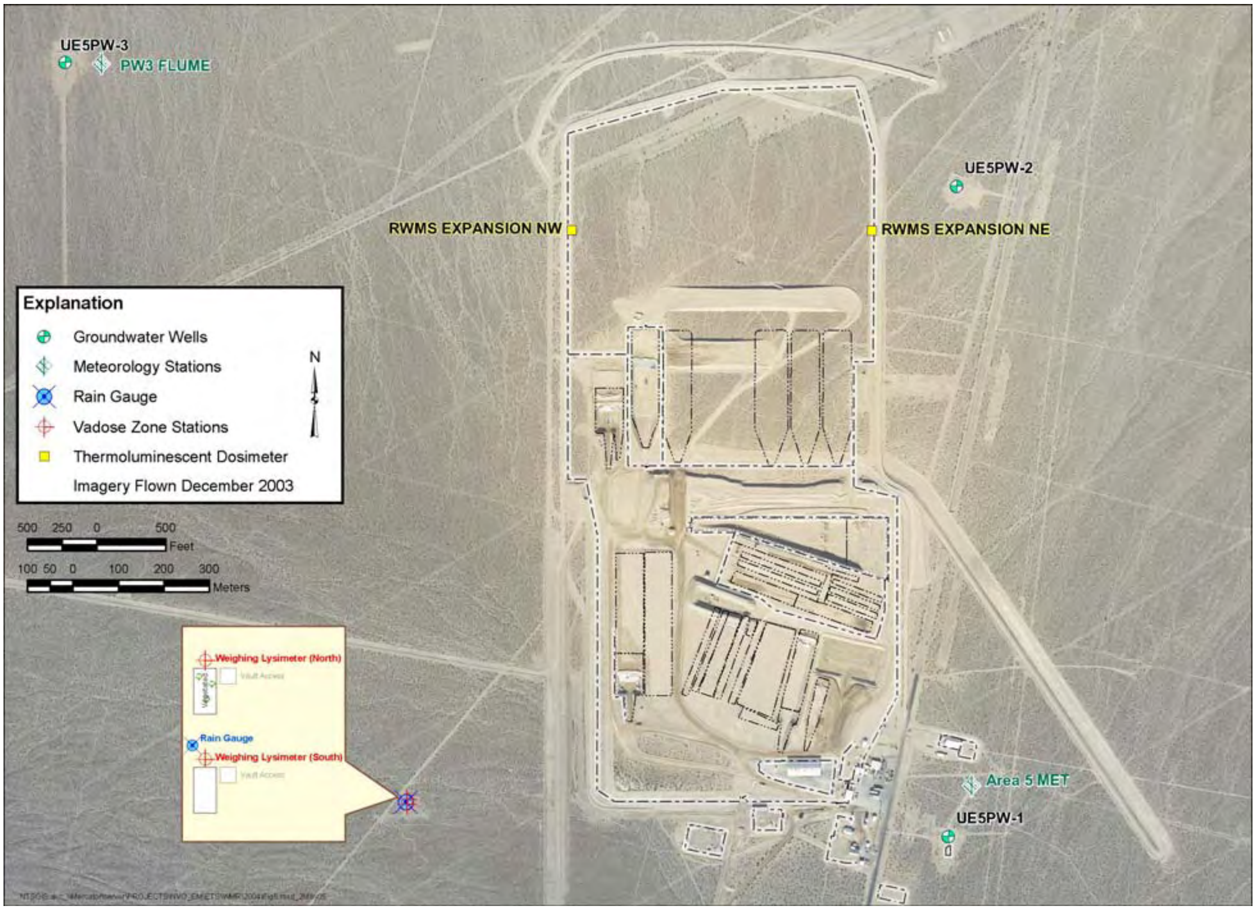

Figure 5-10. Locations of the Area 5 RWMS Pilot Wells and Weighing Lysimeter Facility

One lysimeter is vegetated with native plant species at the approximate density of the surrounding desert. The other is kept bare, to simulate the bare operational waste covers at the Area 5 RWMS. Each of the weighing lysimeters is instrumented with TDR probes to measure volumetric soil-water content at depths ranging from 10 to 170 cm (4 to 67 in). The TDR probes are connected to automated datalogger systems that provide daily profiles of soil-water content. The loadcells have been monitored continuously since March 1994 and provide an accurate dataset of the surface water balance at the Area 5 RWMS. This monitoring time period also includes the wet “El Nino” year of 1998, when rainfall was twice the annual average. For details of the weighing lysimeters, refer to Levitt et al. (1996).

Weighing lysimeter data provide a simplified water balance: change in soil water storage is equal to precipitation minus evaporation or evapotranspiration. A 1-in- high lip around the edge of the lysimeters prevents run-on or runoff.

Total soil-water storage and daily precipitation totals are illustrated in Figure 5-11 for the period of March 30, 1994, through December 2004. The plants transplanted to the vegetated lysimeter initially required irrigation to become established. Soil-water storage data for the vegetated lysimeter for April 25, 1994, through November 18, 1994, reflects the additional artificial irrigation (Personal Communication, D. Hudson, September 6, 2005).

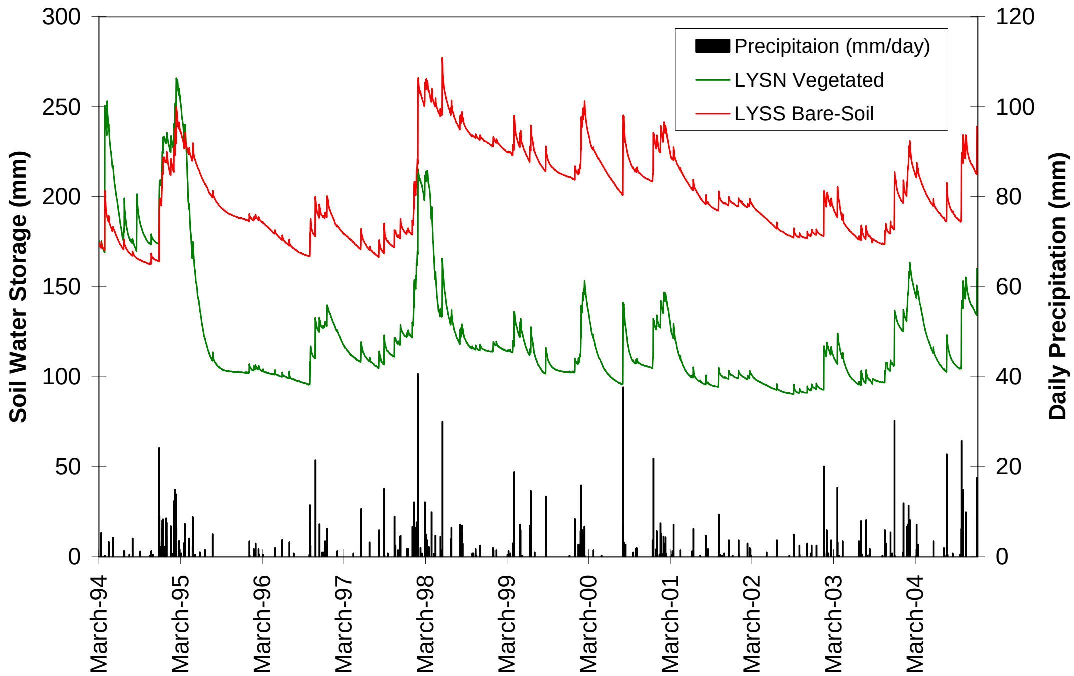

Figure 5-11. Soil Water Storage and Precipitation over Time, March 1994 through 2004

Source: 2004 Waste Management Report (BN, 2005c)

Although the vegetative cover is only about 15 percent of the area, the vegetated lysimeter is significantly drier than the bare-soil lysimeter, due to transpiration. The moisture storage at the vegetated lysimeter has never exceeded 1.2 m (4 ft) depth. However, in the spring of 2005, the moisture in the bare-soil lysimeter reached the base of the lysimeter at 2 m (6.6 ft) depth and water began to pond at the bottom. Eventually there may be some drainage out the bottom of the lysimeter. A conservative estimate is a flux of 1 cm (.4 in)/yr (L. Desotell, Personal Communication September 21, 2005).

Conservative modeling results also indicate that some slight drainage (1 percent of rainfall) will eventually leak from the bottom of the bare-soil lysimeter (Levitt et al., 1999). Although this suggests that a small amount of precipitation may eventually percolate through the operational waste covers of the trenches and pits to waste levels, given that average annual precipitation is 12.9 cm (5.08 in), there is little potential for production of leachate from the landfill. The thick vadose zone below the waste cells has low water potentials, low unsaturated hydraulic conductivity rates, and ample water storage capacity. Therefore, the potential for significant downward transmission of water, much less recharge, in the vicinity of the Area 5 RWMS, is extremely low in the absence of open boreholes or other conduits.

Figure 5-12 shows cumulative precipitation, evapotranspiration, and evaporation in 2004, the latest published year of record. Figure 5-13 shows monthly precipitation, evaporation, and evapotranspiration measured in the weighing lysimeters in 2004. The cumulative data suggest precipitation exceeded evapotranspiration rates in the spring and fall concurrent with peaks and rapid declines in storage. The monthly data show evapotranspiration and evaporation exceeded precipitation for 8 months in 2004.

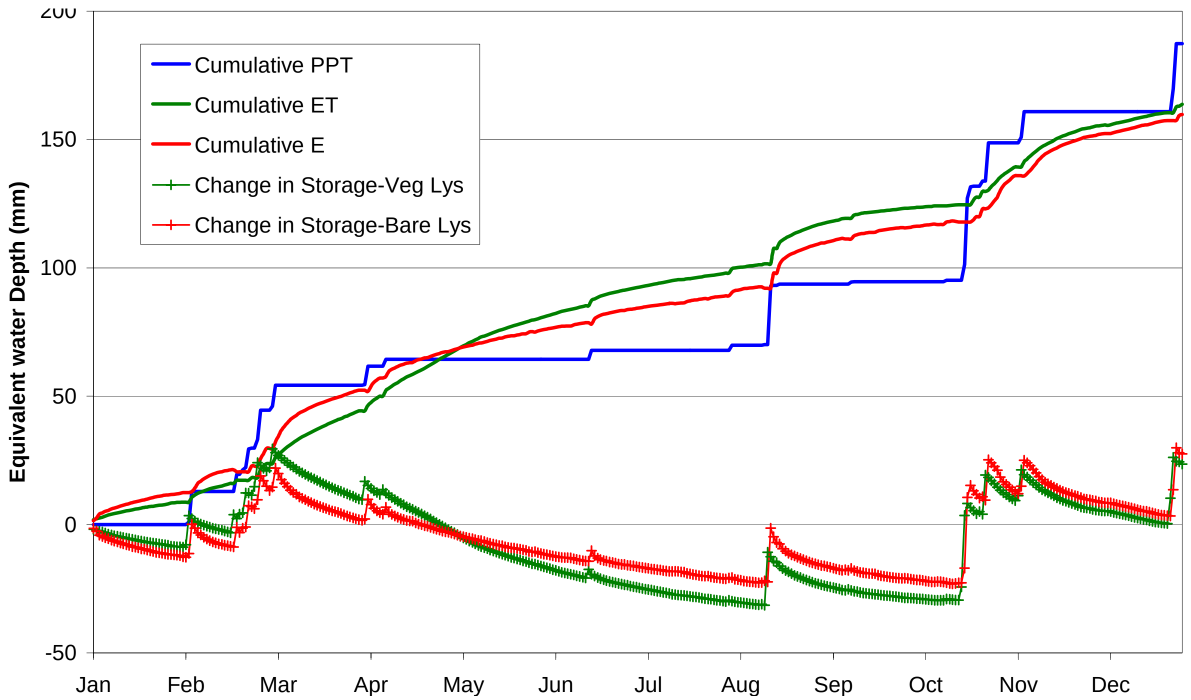

Figure 5-12. Cumulative Precipitation, Evapotranspiration, Evaporation, and Storage Change for Weighing Lysimeter in 2004

Source: 2004 Waste Management Report (BN, 2005c)

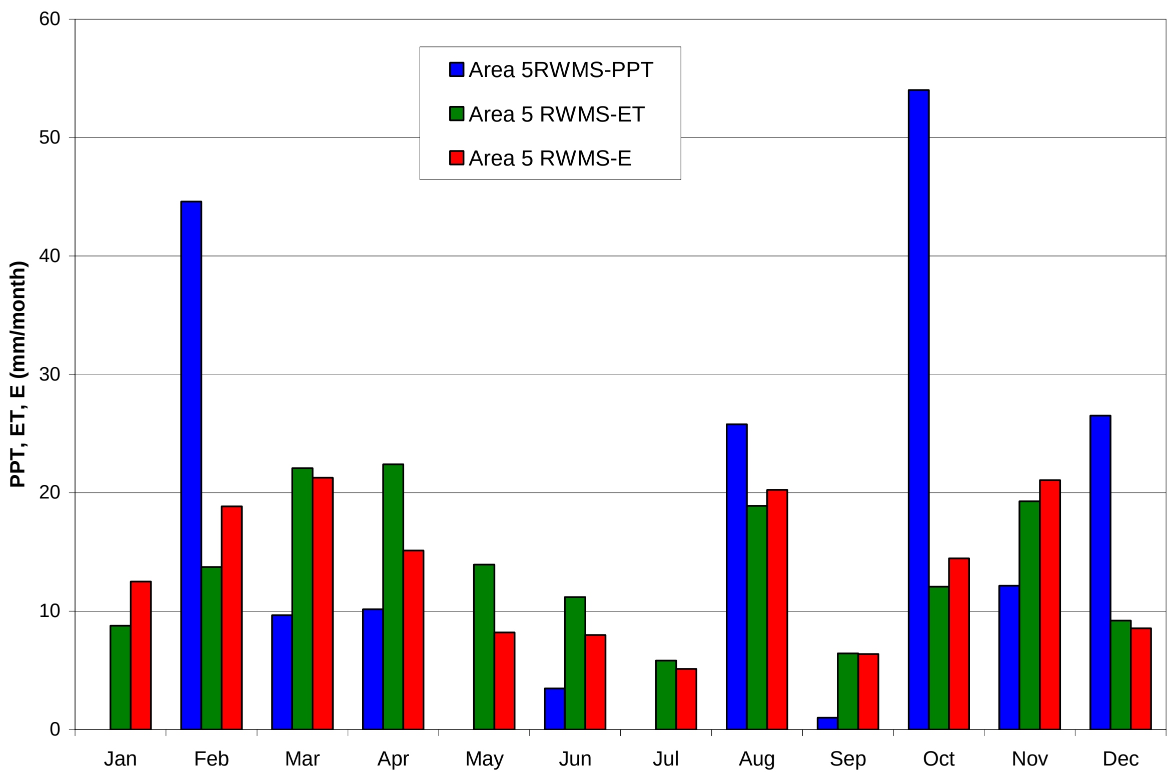

Figure 5-13. Monthly Precipitation, Evaporation, and Evapotranspiration Measured at Weighing Lysimeters in 2004.

Source: 2004 Waste Management Monitoring Report (BN, 2005c)

5.6.6 Key Findings

Climate and vegetation strongly influence the movement of water in the near-surface alluvium (upper 2.0 m [6.5 ft]). Except for periods following precipitation events, water content in the near-surface region is low. Below this region is a zone where steady upward movement of water is occurring, primarily via evaporation (Tyler et al., 1996). This zone extends to depths as great as 3 to 40 m (10 to 131 ft) in Area 5. Below this zone, water potential measurements indicate the existence of a static zone between approximately 40 to 90 m (131 to 295 ft) below the ground surface in Area 5 (Shott et al., 1995; 1998). In this static zone, essentially no vertical liquid flow is currently occurring. Below this static zone, flow is downward, due to gravity.

Monitoring and modeling data for Area 5 have indicated conditions of zero recharge (Levitt et al., 1996; Shott et al., 1998). Recent studies show that under bare-soil conditions such as those at the Area 5 operational waste-cell covers, some drainage may occur through the covers and into the waste zone. Monitoring data from the Area 5 bare-soil weighing lysimeter indicate that in the spring of 2005 the infiltrated water reached a depth of 2m (6.6 ft) and began to pond at the bottom of the lysimeter.

Climate and vegetation strongly control the movement of water in the upper 2 m (6 ft) of the alluvium. The magnitude and direction of both liquid and vapor fluxes vary seasonally and often daily. Except for periods following precipitation events, water contents in this near-surface region are low. Below the near-surface region is a region where relatively steady upward movement of water is occurring. In this region of slow upward water movement, stable isotope compositions of soil pore water show that evaporation is the dominant process (Tyler et al., 1996). This region extends to depths from approximately 3 to 49 m (10 to 160 ft) in Area 3, and from approximately 3 to 40 m (10 to 130 ft) in Area 5. Below this region, water potential measurements indicate the existence of a static region, which occurs between approximately 49 to 119 m (160 and 390 ft) in Area 3, and between approximately 40 to 90 m (131 and 295 ft) in Area 5 (Shott et al., 1998, 1997, 1995). In this static region, essentially no vertical liquid flow is currently occurring. Below this static region, flow is steady and downward, due to gravity.

A conceptual model of unsaturated zone processes is shown in Figure 5-14. Stable isotope compositions of pore water indicate that infiltration into the static region must have occurred under cooler, climate conditions in the past (Tyler et al., 1996). In the unlikely event contaminants were to migrate below the static region to the part of the aquifer where vertical flow by gravity is possible, movement to the groundwater would be extremely slow. Conservative median modeling estimates of the time it would take water to move from beneath the static region (about 90 m (98.4 yards) depth at pilot well UE5PW-1) to the groundwater (about 220 m [240.6 yards] depth) in Area 5 are in excess of 50,000 years (Shott et al., 1995 and 1998). Under the model assumptions there was a 99 percent probability that the travel time would exceed 30,000 years (Shott et al., 1998).

Based on the results of extensive research, field studies, modeling data, and monitoring data, which are summarized in the Area 5 RWMS PAs (Shott et al., 1998, 1995) and in Levitt et al. (1998), there is no aerially distributed groundwater recharge under current climatic conditions at the RWMS. Recent studies indicate that under bare-soil conditions such as those found at the operational waste unit covers, some drainage may occur through the covers into the waste zone.

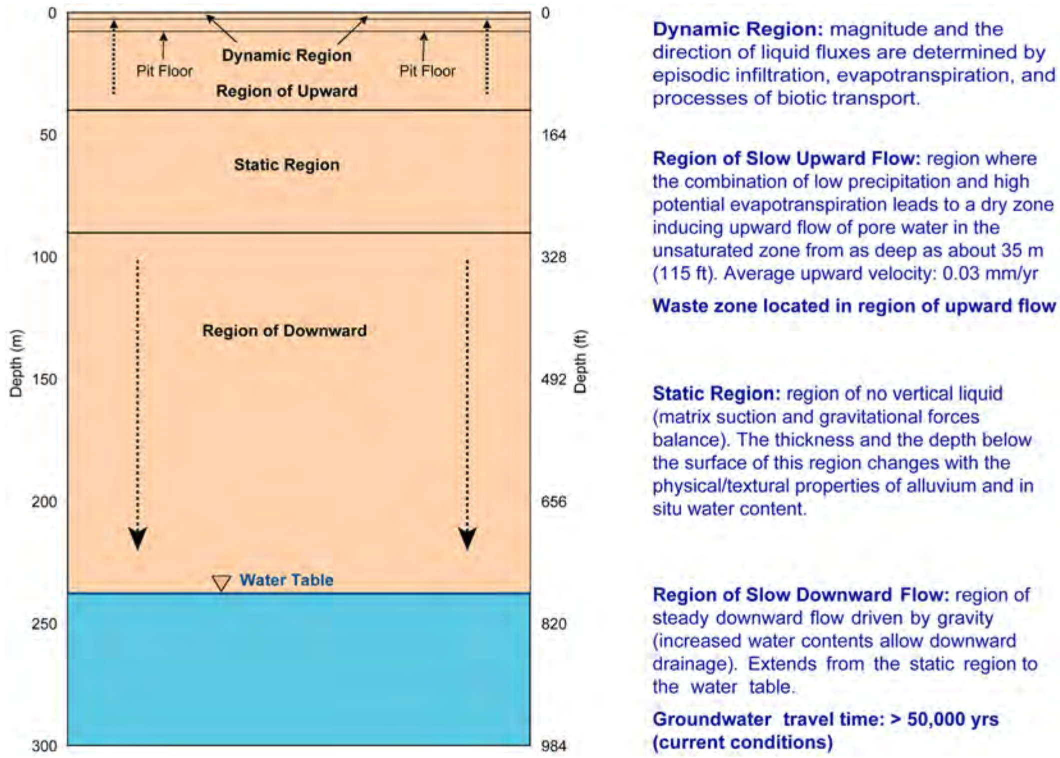

Figure 5-14. Conceptual Model of Water Flow in the Unsaturated Zone in the Vicinity of the Area 5 Radioactive Waste Management Site

Source: Personal communication B.M. Crowe (2004) cited in BN 2005d.

In March 2005, after a wet winter, soil-water began to accumulate at the base of the bare-soil lysimeter, at a depth of 2 m (6.6 ft) (Personal Communication, L. Desotell, September 21, 2005).

Drainage through the waste covers should not result in any groundwater recharge because the covers will ultimately become partially vegetated, increasing the evapotranspiration. Furthermore, the water storage potential of the thick vadose zone is very high, and the hydraulic conductivity is low. Deep drainage and potential groundwater recharge appear to be occurring primarily along mountain fronts at the NTS.

5.7 GROUNDWATER

5.7.1 Regional System

The NTS is located within the Death Valley Regional Flow System (DVRFS), one of the major hydrologic subdivisions of the southern Great Basin. The DVRFS covers an Area of about 40,920 km^2 (15,800 mi^2). This regional flow system consists primarily of volcanic rock in the west and carbonate rock in the east, and is estimated to transmit more than 8.6 million m^3 (70,000 ac ft) of groundwater annually. Most of this flow moves through a thick sequence of Paleozoic carbonate rock extending throughout the subsurface of central and southeastern Nevada and is sometimes referred to as the “central carbonate corridor.” The division of the

DVRFS into different groundwater flow systems within the NTS is based on the concept of a groundwater subbasin, defined as the area that contributes water to a major surface discharge.

The three principal groundwater subbasins identified within the NTS region are Ash Meadows, Oasis Valley, and Alkali Flat-Furnace Creek Ranch subbasins. Yucca Flat and Frenchman Flat lie within the Ash Meadows subbasin (Laczniak et al., 1996). Figure 5-15 shows the NTS with respect to these subbasins and general groundwater flow directions. Each of the subbasins consists of several connected hydrographic basins (compare to Figure 1-2).

The Ash Meadows subbasin covers an area of about 10,360 km^2 (4,000 mi^2). Precipitation is believed to recharge the subbasin along its northern boundary at the Belted, Reveille, Timpahute, and Pahranagat Ranges, along its eastern boundary at the Sheep Range, and along its southern boundary at the Spring Mountains. Recharge is also suspected to occur within the subbasin at higher elevations of the Spotted, Pintwater, and Desert Ranges. Groundwater primarily flows through the lower carbonate-rock aquifer and discharges along a line of springs in Ash Meadows. Groundwater flow rates through the different lithologic units of the Ash Meadows subbasin are highly variable. Estimates range from less than 0.3 to more than 300 meters per day (1 to 1000 feet per day), depending on the unit. In general, the regional carbonate-rock aquifer is believed to transmit water at the fastest rate, whereas the basement and Eleana confining units transmit water at the slowest rate, and volcanic and valley-fill aquifers and confining units transmit water at intermediate rates (Laczniak et al., 1996).

The lower carbonate-rock aquifer (LCA) within the Ash Meadows subbasin is the only subsurface pathway by which groundwater leaves Yucca Flat and Frenchman Flat basins. Groundwater flows south from Yucca Flat into Frenchman Flat and then southwest toward downgradient areas (primarily Ash Meadows). Water levels within the lower carbonate-rock aquifer indicate that the gradient is nearly flat (less than 0.3 m/km [1.6 ft/mi]) between Yucca Flat and Frenchman Flat and down to the discharge Area at Ash Meadows. This flat gradient is an indication of a high degree of hydraulic continuity within the aquifer, which is probably a result of a high fracture (secondary) permeability (Laczniak et al., 1996).

Winograd and Thordarson (1975) described suites of rock facies and lithologies which exhibit similar hydrologic character. The PA (Shott et al., 1998) summarizes regional hydrogeologic characteristics from this early work.

Recent work for the UGTA project has enhanced the understanding of the hydrology of the NTS through further definition of hydrogeologic and hydrostratigraphic units for use in modeling the geology and hydrology of the NTS Area (Gonzales et al., 1998; Gonzales and Drellack, 1999; and BN, 2005f).

Based on the existing data, and as interpreted from a regional groundwater flow model (DOE, 1997), the overall groundwater flow direction in Yucca Flat and Frenchman Flat is to the south. Groundwater ultimately discharges at Ash Meadows and Franklin Lake Playa to the south and Death Valley to the southwest.

At the NTS, localized perched water occurs principally within the tuff and lava aquitards, in the foothills and ridges flanking the basins. Perched water is not known to occur beneath Yucca Flat or Frenchman Flat (Shott et al., 1998).

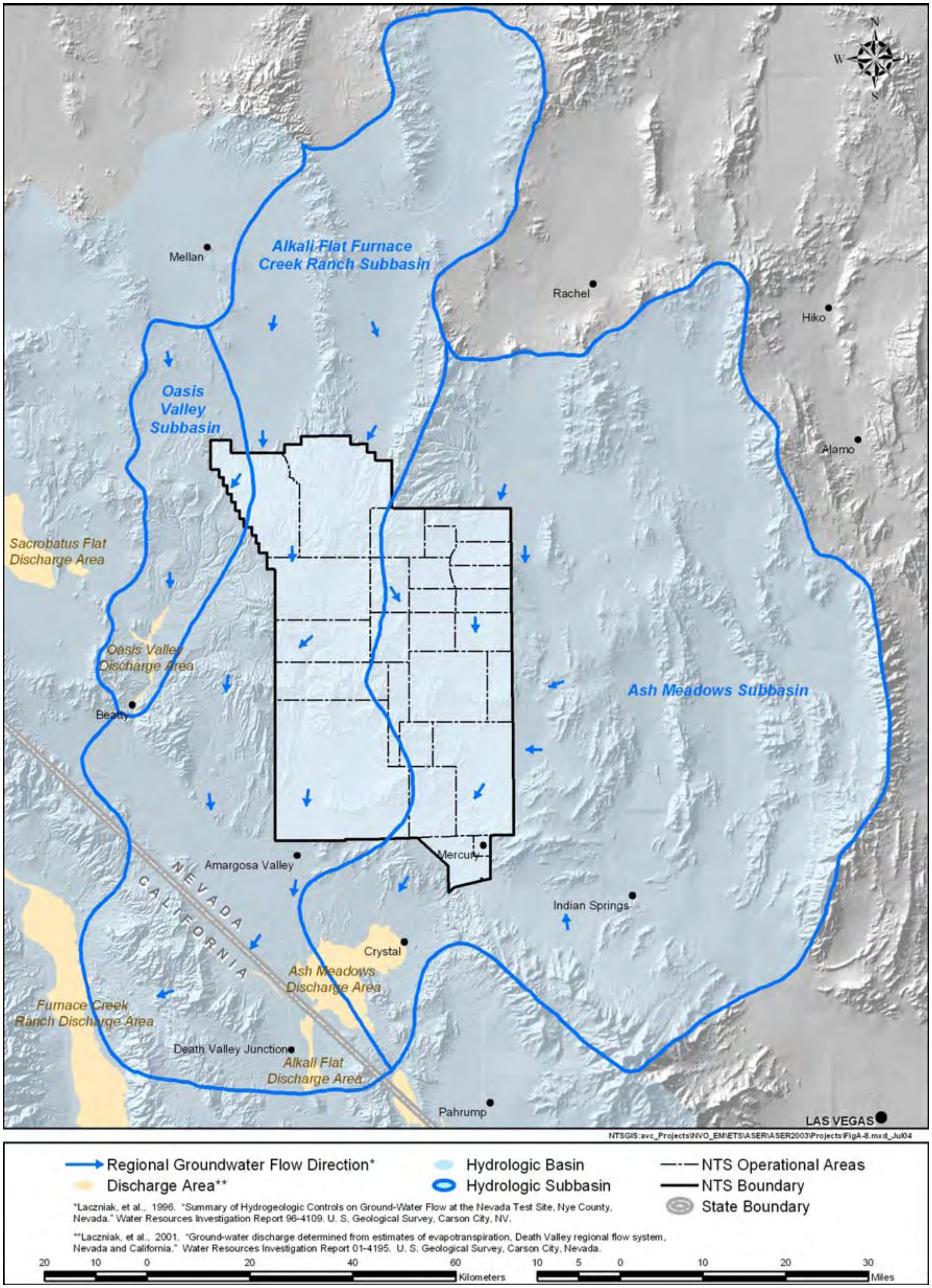

Figure 5-15. Groundwater Basins and Regional Groundwater Flow Directions

In the area of Frenchman Flat there is essentially a two aquifer system. Unsaturated alluvium overlies the interconnected Alluvial Aquifer and Timber Mountain Aquifer, which is separated from the deeper LCA by low permeability confining units. Figure 5-16 presents a schematic regional cross-section, of the west east profile through the location of Well ER-5-3#2, which is about 2,500 m (8,200 ft) northeast of the Area 5 RWMS. The profile was generated from a hydrostratigraphic model of the region (BN, 2005f).

The depth to the static water level in Frenchman Flat ranges from 210 m (690 ft) near the central playa to more than 350 m (1,150 ft) at the northern end of the valley. In the deeper, central portions of the basin, more than half of the alluvium section is saturated. Water-level elevation data in the alluvial aquifer indicate a very flat water table (IT, 1998).

Water-level data for the LCA in the southern part of the NTS are limited, but indicate a fairly low gradient in the Yucca Flat, Frenchman Flat, and Jackass Flats area. This gentle gradient implies a high degree of hydraulic continuity within the aquifer, presumably due to high fracture permeability (Laczniak et al., 1996). Furthermore, the similarity of the water levels measured in Paleozoic rocks (LCA) in Yucca Flat, Frenchman Flat, and Mercury Valley implies that, at least for deep interbasin flow, there is no groundwater barrier among the three basins. Inferred regional groundwater flow through Frenchman Flat is to the south, turning southwest in Mercury Valley toward discharge areas in Ash Meadows. An increasing westward flow vector in southern NTS may be due to preferential flow paths subparallel to the northeast-trending Rock Valley fault (Grauch and Hudson, 1995) and/or a northward gradient from the Spring Mountain recharge area (IT, April 1999a, b).

In 1998, a three-dimensional framework model of the hydrostratigraphy of the Frenchman Flat CAU was developed for the DOE/NV UGTA Subproject of the Environmental Restoration Program. The framework model will be used in computer models to predict groundwater flow and contaminant migration within Frenchman Flat. This hydrostratigraphic model (IT, 1998), is still being refined as new data are gathered. The latest information is in the BN (2005f) report, *A Hydrostratigrapohic Model and Alternatives for the Groundwater Flow and Contaminant Transport Model of Corrective Action Unit 98: Frenchman Flat, Clark, Lincoln, and Nye Counties, Nevada.*

Recent hydrogeological investigations and geophysical studies under the UGTA program have contributed to the understanding of the subsurface structure and hydrogeology at Frenchman Flat. Two hydrogeologic investigation well clusters were recently drilled. The first group of wells was drilled in northern Frenchman Flat. The deepest of those wells, Well ER-5-3#2, was drilled to a total depth of 1,732 m (5,683 ft), and it penetrated the regional carbonate aquifer (known as the lower carbonate aquifer). A second cluster of wells was drilled in central Frenchman Flat. The deepest well in this group, Well ER-5-4#2, was drilled to a total depth of 2,134 m (7,000 ft) and does not penetrate the lower carbonate aquifer. These wells are located roughly 2,500 m (8,200 ft) to the northeast and 3,400 m (11,155 ft) to the southwest of the Area 5 RWMS.

A three-dimensional seismic survey was conducted in Frenchman Flat in 2002 to help delineate the subsurface geologic units and to adjust the UGTA three-dimensional framework model (L. Prothro, written communication to P. K. Ortego [BN], August 8, 2002). The U.S. Geological Survey estimated the depth of the Frenchman Flat basin using a gravity inversion method (Phelps and Graham, 2002).

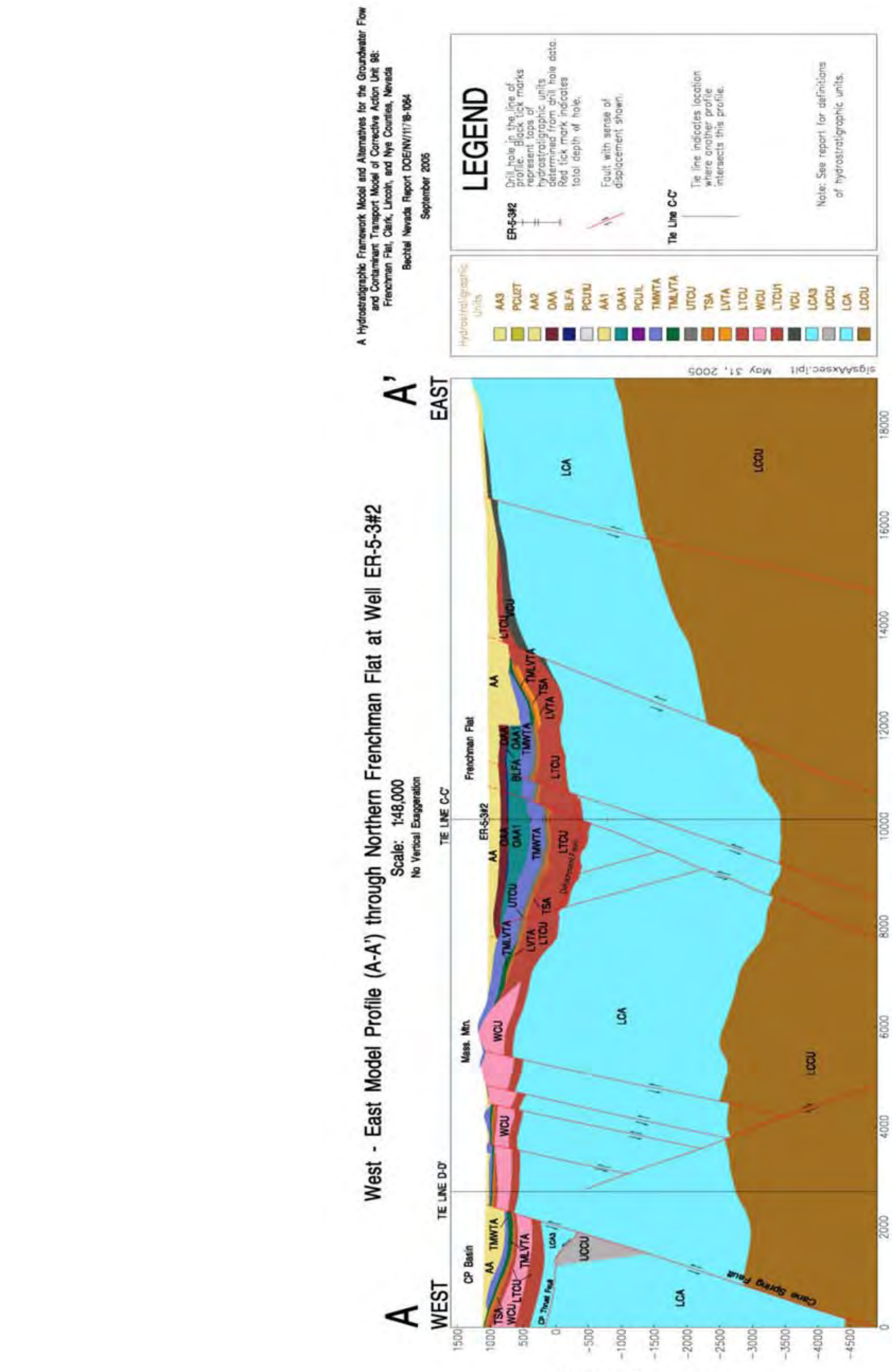

Figure 5-16. Regional Cross-Section of Northern Frenchman Flat

5.7.2 Area 5 RWMS Groundwater Levels and Flow

From March 1993 through 1997, groundwater levels were measured frequently and on an irregular schedule at the three pilot wells surrounding the Area 5 RWMS. Since 1998, groundwater levels have been measured quarterly. Groundwater data are presented in annual data reports, the latest published was for 2004 (BN, 2005h). Table 5-3 summarizes elevation, gradient, and flow-direction results.

Table 5-3. March 22, 1993, through January 2 2005, Groundwater Elevation Flow

	UE5PW-1 Elevation (m amsl)	UE5PW-2 Elevation (m amsl)	UE5PW-3 Elevation (m amsl)	Approximate Flow Direction Degrees East of North	Gradient (m/m)	Velocity (m/yr)
Number of readings	93	93	93	94	94	94
Minimum	733.59	733.64	733.46	5	9.95E-06	0.01
Maximum	734.01	733.99	733.88	176	1.48E-04	0.14
Mean	733.77	733.74	733.64	103	7.61E-05	0.07
Coefficient of Variation	0.01%	0.01%	0.02%	48%	52%	52%

Notes:
mamsl = meters above mean sea level
Elevations are corrected for borehole deviation and distance of top of casing to ground surface.
Source: Statistics derived from data within the 2004 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site (BN, 2005h) and an unpublished spreadsheet including the January 2005 results (personnel communication, David Hudson, 2005).

The gradient of the potentiometric surface of the groundwater in the alluvial/tuff aquifer has consistently been very low, almost flat, across the Area 5 RWMS site. The average gradient is only 7.61E-05 m/m. Calculated groundwater flow velocities have generally been less than 0.15 meters per year (m/yr) (0.5 ft per year [ft/yr]). The average velocity observed between March 1993 and January 2005 was approximately 0.07 m/yr (0.23 ft/yr). The average flow velocity in 2004, the latest published year of record, ranged from 0.02 to 0.12 m/yr (0.066 to 0.39 ft/yr) with an average of 0.08 m/yr (0.33 ft/yr). The calculated flow direction is highly variable but generally has had an eastern component; it has ranged from about 5 degrees to 170 degrees east of north since 1993.

Because the water table is so flat, even small typical groundwater measurement errors of plus or minus 0.25 cm (0.01 in) can significantly affect the calculated flow direction and velocity. Consequently, although the measured elevations at each well are very consistent through time, the gradient and flow velocities have a much higher coefficient of variance.

Figure 5-17 graphically presents groundwater elevations from 1993 through 2004. Groundwater elevations and depth-to-water from ground surface have varied very little. The depth-to-water measurements collected between March 22, 1993, and October 21, 2002, ranged from 0.35 m

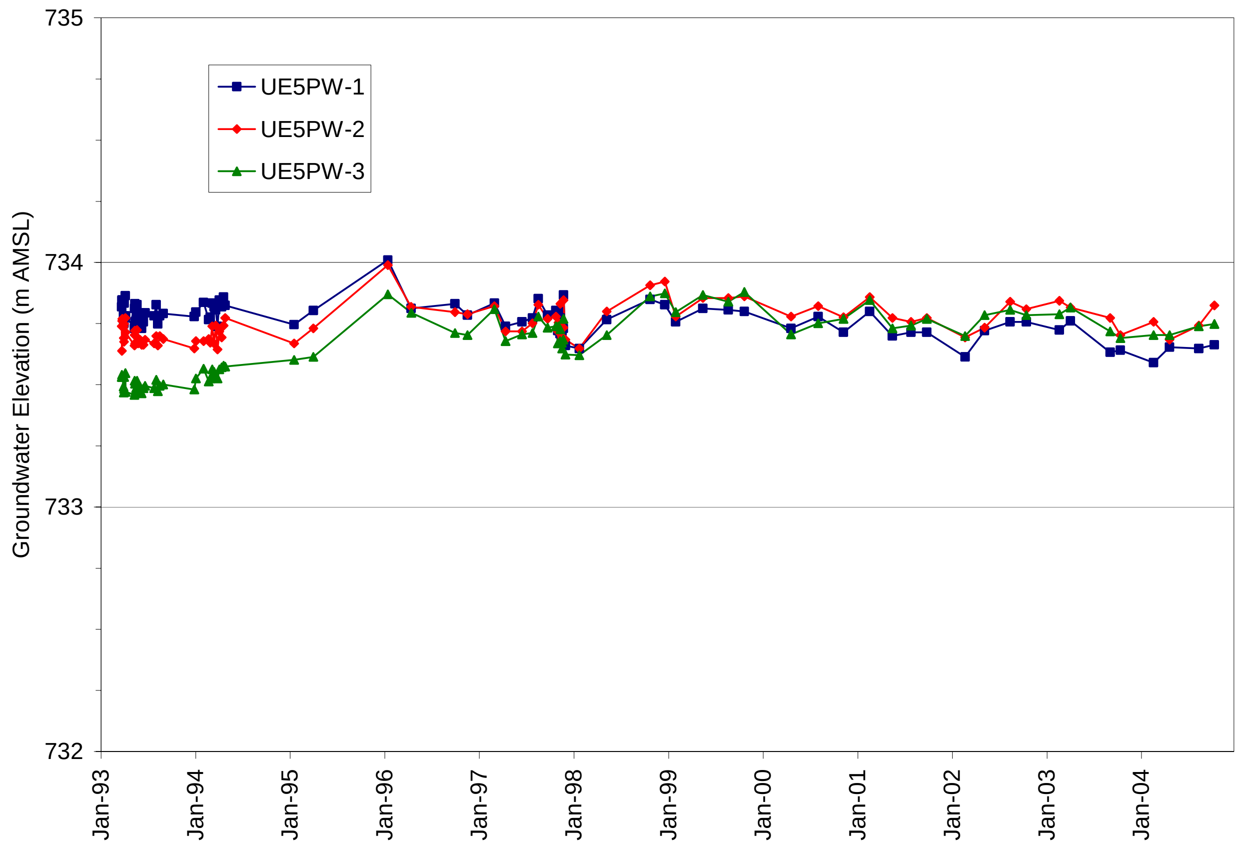

Figure 5-17 Groundwater Elevation at the Area 5 RWMS 1993 through 2004

Source: BN (2005c)

(1.15 ft) at Ue5PW-2, to 0.4 m (1.3 ft) at Ue5PW-1, and 0.42 m (1.38 ft) at Ue5PW-3 over this 10-year period. Average depth-to-water from ground surface at UE5PW-1, UE5PW-2, and UE5PW-3 has remained about 235. m (772 ft), 256 m (842 ft), and 271 m (891 ft) respectively (BN, 2003b and 2005c).

5.7.3 Groundwater Chemistry

Three types of groundwater chemistry facies dominate the region: (I) a calcium-magnesium bicarbonate (Ca-Mg-HCO_3) facies within the carbonate units, (II) a sodium and potassium bicarbonate (Na-K-HCO_3) facies derived from groundwater in volcanic rocks, and (III) a mixed facies containing components from both (I) and (II). The Na-K-HCO_3 facies (II) is found within the lava-flow aquifer and tuff-aquitards units. The facies also is seen in portions of the valley-fill aquifer, where a major portion of the alluvial-fill material has been derived from the erosion of volcanic units. The Ca-Mg-HCO_3 composition (I) is found within the Paleozoic carbonate units, such as the LCA and in the valley-fill aquifers that are composed of carbonate detritus. Most of the calcium and magnesium present is from the dissolution of limestone and dolomite ($CaCO_3$ and $CaMg [CO_3]_2$) mineralization in the unit as it conducts flow. Water of the mixed facies (III) contains portions of both the Na-K and Ca-Mg ions groups (Chapman, 1994; Winograd and Thordarson, 1975).

The *2002 Data Report: Groundwater Monitoring Program, Area 5 Radioactive Waste Management Site* (BN, February 2003) indicates the groundwater pumped from the three wells immediately surrounding the Area 5 RWMS is sodium bicarbonate water. Wells Ue5PW-1 and Ue5PW-2 are completed in the alluvial aquifer and Ue5PW-3 to the northeast is completed in the Timber Mountain Tuff Aquifer. These two aquifers have similar hydrochemistry and groundwater elevation, and may be connected.

5.7.4 Groundwater Quality

This section is extracted from the *Characterization Report for the Operational Soil Covers* (BN, 2005d).

> *Groundwater quality in the vicinity of the Area 5 RWMS is monitored in accordance with the requirements of RCRA and DOE Orders. In 1993, DOE began monitoring the three pilot wells surrounding the Area 5 RWMS (Ue5PW-1, -2 and -3) in compliance with Title 40 CFR 265, Interim Status Standards for Owners and Operators of Hazardous Waste Treatment, Storage and Disposal Facilities. The wells were originally drilled in 1992 as characterization wells for determination of physical and chemical properties of drill core, for determination of chemical properties of groundwater in the uppermost aquifer, and for determination of depths to the uppermost aquifer. NDEP agreed that these wells appear to meet the applicable design, construction, and development criteria for RCRA groundwater monitoring wells. Details of pilot well construction can be found in BN (2005e). Copies of the well logs and details are in Appendix E.*
>
> *The monitoring program originally included all parameters required by Title 40 CFR 265 including drinking water parameters in Appendix III. A revised groundwater monitoring program outline was approved by NDEP in 1998. The approved modified monitoring program is modeled after the Title CFR 264.98 Detection Monitoring Program, and monitors parameters particular to the use and character of the site.*
>
> *Currently, groundwater samples from the three pilot wells are analyzed semiannually for the following parameters (BN, 2004b):*
>
> *Indicators of Contamination:*
>
> - *pH*
> - *Specific conductance*
> - *Total organic carbon (TOC)*
> - *Total organic halogen (TOX)*
> - *Tritium*
>
> *General Water Chemistry Parameters:*
>
> - *Total Ca, Fe, Mg, Mn, K, Na, Si*
> - *Total SO4, Cl, F*
> - *Alkalinity*

Conservative investigation levels for the indicators of contamination were negotiated between NDEP and DOE in 1998. Under the semi-annual monitoring program for RCRA compliance, if a parameter investigation level is exceeded, the groundwater is resampled and analyzed for that parameter to confirm the result. Table 5-4 lists the investigation levels. The investigation levels for pH and specific conductance are based on statistical analysis of data collected from 1993-1996. The levels for TOX and TOC are set slightly above the method detection limits and the tritium level is set at 10 percent of the drinking water standard. See the data reports for further detail (e.g., BN, 2004b).

Table 5-4. Investigation Levels for Indicator Parameters

Parameter	Investigation Level
pH	Less than 7.6 and greater than 9.2
Specific Conductance	0.440 millimhos per centimeter
TOC	1 milligrams per liter (mg/L)
TOX	50 micrograms per liter (µg/L)
Tritium	2,000 picocuries per liter (pCi/L)

(BN, 2003)

Additional groundwater monitoring requirements driven by DOE Orders, and independent of EPA requirements, were determined through a DQO-driven process and are detailed in the Nevada Test Site Routine Radiological Environmental Monitoring Plan (DOE/NV/11718--804, BN, 2003a). Based on Tables B-2 and B-3 in Appendix B of the plan, the three wells surrounding the RWMS are also tested:

Annually for:

- *Enriched tritium analysis*

Biennially for:

- *Gross alpha*
- *Gross beta*
- *Gamma spectroscopy*
- *Plutonium*
- *pH*
- *Specific Conductivity*
- *Temperature*
- *Principal cations and anions*
- *Total dissolved solids*
- *Alkalinity*

And every 3 years for:

- *Strontium-90 (^{90}Sr)*
- *Technetium-99 (^{99}Tc)*
- *Carbon-14 (^{14}C)*

Groundwater monitoring data are presented in detail in the annual groundwater monitoring data report (e.g., BN, 2004b). Appendix F contains a summary of groundwater quality data from the latest annual report (BN, 2005h). All groundwater sampling data from the Area 5 RWMS pilot wells to date indicate that the groundwater in the uppermost aquifer is unaffected by RWMS or NNSA weapons testing activities.

Highlights of the results to date:

- *Tritium concentrations in the groundwater beneath the Area 5 RWMS have never exceeded the method detection limit for enriched tritium analysis (approximately 15 pCi/L).*
- *TOX and TOC analytical results were rechecked a few times in 1998-2000 due to exceedances of investigation limits; however, the follow up samples results were all below the action levels.*
- *Specific conductance and pH have been very consistent through time and are well within the investigation limits.*
- *General water chemistry parameter analytical results have also been very consistent since monitoring began. No site-specific investigation levels appear to have been established for these parameters. Concentrations have been low, and generally well below aesthetic secondary standards for drinking water, with two isolated exceptions: 0.11 mg/L of manganese was found in a sample from UE5PW-2 in March 1993, which is above the 0.05 mg/L manganese secondary standard; and 0.33 mg/L of iron was detected in a sample from UE5PW-2 in October 2002, which is above the 0.3 mg/L iron secondary standard. The National Secondary Drinking Water Regulations are non-enforceable guidelines for water quality parameters that can affect drinking water taste, odor, or color or may cause cosmetic staining.*

The potential for groundwater quality impacts from the Area 5 RWMS waste storage is low because vertical movement of percolating water is limited by many factors including climate and geology. Except for short term events, evapotranspiration is much higher than precipitation. There is insignificant stormwater runoff, there has been no apparent recharge in the immediate vicinity, and there are no known potential conduits deeper than the GCD boreholes that could speed transmission of potential leachate deeper. See Section 5.5.2 (Unsaturated Zone).

Groundwater elevation data indicate that the water table beneath the Area 5 RWMS is nearly flat, with groundwater flowing in a northeastern direction at a horizontal velocity of approximately 23 cm (9 in) per year (BN, 2004b). If contaminants from any source were find a way to reach groundwater, lateral movement of the plume would be relatively slow in this area. UE5PW-2 is downgradient of the Area 5 RWMS, UE5PW-1 is crossgradient to downgradient and UE5PW-3 is upgradient of the Area 5 RWMS. See Section 5.7.2., "Area 5 RWMS Groundwater Levels and Flow."

5.8 AIR QUALITY

Air monitoring is conducted to confirm that RWMS activities do not result in significant radionuclide concentrations above background and to confirm compliance with the National Emissions Stgandard for Hazardous Air Pollutants (NESHAP). Air quality results are summarized in the annual *Waste Management Monitoring Report*. The latest report is for 2004 (BN, 2005c).

5.8.1 Tritium

The NTS began an air sampling program for tritium in January 1980. Tritium is a highly mobile conservative tracer. Tritium concentration in the air near the RWMS, compared to background concentrations at the NTS, is an indicator of how well the waste disposal cells are mitigating migration of volatile radionuclides from waste cells. Data from Guard Station 510, at the southwest edge of the NTS, is considered representative background. Tritium concentrations from the RWMS are also compared to tritium concentrations from the Area 20 Schooner monitoring station at the northwest corner of the NTS, in the vicinity of the soils with elevated tritium levels from the Plowshare tests.

Routine sampling at Area 3 RWMS was terminated in 1997 because of lack of detectable tritium and the relatively low volume of tritium sources disposed at the Area 3 RWMS. Due to recent and potential future disposal of tritium sources, bi-weekly sampling for tritium in atmospheric moisture resumed November 8, 2004, at two monitoring stations at the Area 3 RWMS.

Monitoring at the northeast station at the Area 5 RWMS was abandoned in June 2003 due to development of additional disposal pits. The station will not be replaced because remaining stations (U.S. Department of Defense [DoD] and Sugar Bunker North) provide adequate monitoring coverage of the prevailing downwind locations from the buried tritium sources (south and north). The stations are typically monitored twice a month.

Most of the RWMS samples to date have had no detectable tritium at or above the mean minimum detectable concentration (MDC) for the analytical method, which is about 1 picoCurie per cubic meter (pCi/m^3). The tritium concentrations in atmospheric moisture samples from near the Area 3 and 5 RWMS have consistently been orders of magnitude below the DOE Derived Concentration Guide (DCG) for tritium, which is 1E05 pCi/m^3. The DCG is the concentration of a radionuclide in air that could be inhaled for one year and not exceed the DOE primary radiation standard to the general public of 100 milliroentgens equivalent man per year (mrem/yr) effective dose equivalent.

In 2004, the tritium concentrations in air samples from the Area 5 and Area 3 RWMS, the Schooner site, and the Guard Station 510 were below the DCG limit for a 10 mrem/yr exposure. Area 5 RWMS tritium levels were similar to the background levels for most of 2004, and significantly lower than the concentrations in samples from the Schooner monitoring station. For several months, tritium levels in air samples from the Area 5 RWMS were slightly higher than background levels at the guard Station 510, but in samples collected in August and November, the Area 5 air concentrations of tritium were below background (2005c).

The Sugar Bunker North station tritium concentrations have been slightly higher than the DoD station tritium concentrations, with few exceptions. Concentrations in samples from the DoD station were often below the MDC. Measured concentrations have been so low and so near background it is difficult to determine if this trend has any significance with respect to the landfill or potential offsite sources.

Comparison of the Area 5 RWMS air monitoring data to soil gas and biota data suggests tritium migration to ground surface has been negligible to date. For the past 15 years, soil gas tritium concentrations measured at shallow depths at the GCD-05U borehole have been fairly low (Section 5.6.3). Although there has been some evidence of tritium migration upward through the soil from the waste (the top of which is below 19.8 m [65 ft] to about 15 m [50 ft] depth), not much if any has migrated to the root zone of plants. Minimal amounts of tritium have been found in biota surveys (Section 5.3.3).

5.8.2 Particulates

Air particulates have been monitored since January 1980. Air particulate samples are collected weekly from monitoring stations near the RWMSs and are screened for gross alpha and gross beta activity to provide early detection of any changes. Monthly composites of filters from each sampling location are analyzed for gamma emitters, and americium and plutonium concentrations. Air particulate monitoring data indicate that radionuclide concentrations in air at the RWMSs are not above those of other nearby stations. The concentrations of all the analytes in samples from the RWMSs were similar to concentrations elsewhere at the NTS and well below the DCG for each radionuclide.

Bechtel Nevada (2005c) summarizes the 2004 analytical results graphically, and indicates no detectable man-made gamma activity. Americium-241 was detected in samples at concentrations very near or below the MDCs for the analytical method. At the Area 5 RWMS, Americium-241 was detected slightly above the average MDC in the February Sugar Bunker North sample and in the September Area 5 DoD sample. Plutonium-238 was not detected in any Area 5 or Area 3 RWMS particulate sample above the MDC. Plutonium-239 was detected in two monthly samples from the Sugar Bunker North station and four samples from the Area 5 DoD station. Plutonium-239 concentrations at several NTS locations showed a slight increasing trend between January and September 2004 and a declining trend in October and November 2004, but all measurements were below the DCG limit for a 10 mrem/year dose exposure. Concentrations detected in Area 3 RWMS samples are generally higher than Area 5 RWMS levels but there are contaminated areas around the Area 3 RWMS which could be contributing to air particulate levels in that area.

5.8.3 Radon

Radon is both a natural and man-made radionuclide. Radon flux has been monitored several times at locations around the NTS since 2000. Future monitoring is planned on at least an annual basis. The performance objectives under DOE O 435.1 and the regulatory limit under Title 40 CFR 61, Part Q for the Area 5 and Area 3 RWMSs are the same: 20 picocuries per square meter per second ($pCi/m^2/s$). Measurements of radon flux at the operational waste covers compared to undisturbed and control locations away from the waste areas were of similar magnitude, at or below 4 pCi/m2/s. Radon flux measured at operationally closed waste cells has consistently been at least five times lower than the standards.

Bechtel Nevada (2005c) summarizes radon flux data from 2004. Three areas at the Area 5 RWMS were monitored that year:

- POU1, which is a closed landfill cell with a relatively high radium inventory compared to the rest of the Area 5 RWMS;
- The north end of Pit 13 which contains thorium waste and is in the expansion Area outside of the 52 Acre Area; and
- A broad survey of the expansion area.

The highest measured fluxes were in the expansion area, but the levels were still below about 4 $pCi/m^2/s$. RWMS waste management activities do not appear to have significantly affected radon levels at the NTS.

5.9 RADIATION EXPOSURE

Information for this Section is derived from the *2004 Waste Management Monitoring Report* (BN, 2005c).

> *Ionizing radiation from both natural and man-made sources is measured quarterly through a network of thermoluminescent dosimeters (TLD). Twelve TLD stations are located around and in the Area 5 RWMS. Pairs of Panasonic UD-814AS TLDs are maintained at each location. The results from these locations are compared to other locations at the NTS including the Gate 100 entrance at the south end of the NTS. The readings are used to calculate the potential dose to a hypothetical person living year round at the RWMS, a scenario unlikely to occur during active maintenance of the NTS as a limited access federal facility. The data are also collected to detect changes in gamma radiation levels, which must be evaluated in the context of on-RWMS and near-RWMS activities and operations, to determine if these changes may indicate a breach in the containment.*
>
> *Evaluation of any contribution of radiation from operations at the RWMSs is complicated by other sources in the area. Historic activities contribute to exposure rates in the vicinity of the RWMSs. Between1965 and 1971, 9 of 10 underground nuclear tests conducted within 3 km (1.9 miles) of the Area 5 RWMS released radioactivity to the surface.*
>
> *Data collected from 1998 through 2004 indicate that direct radiation exposure at the Area 5 RWMS is low. Levels at all the sites were below 1.8 milliroentgens per day (mR/day). The performance objective set in DOE O 435.1 states LLW disposal facilities be sited, designed, operated, maintained, and closed so that a reasonable expectation exists that dose to representative members of the public, shall not exceed 25 mrem/yr total effective dose equivalent (TEDE) from all exposure pathways, excluding the dose from radon.*

The 2004 average exposure rate at the RWMS boundaries and inside the RWMSs was 0.36 mR/day and similar magnitude to the average exposure rate at background NTS locations, which was 0.30 mR/day. The net average dose in or at the Area 3 and Area 5 RWMS boundaries is approximately 0.06 mrem/day or 22 mrem/year.

In the first quarter of 2004, the exposure rate at the northwest corner of the Area 5 RWMS TLD location was slightly higher than background stations, but still far below regulatory limits. This variation is thought to be from waste shipments being placed in Pit P11U.

For further information, see the annual Waste Management Monitoring Reports (e.g., BN, 2005c).

5.10 Natural Hazards and Subsidence

Subsidence is expected to occur as waste and cover-fill materials settle through time. Differential settling, especially across disposal feature margins, causes cracks at ground surface which could provide vertical migration pathways for water, vapor, and mobile contaminants. Depressions, which can retain water after rainstorms, allow more water to infiltrate and more plants to grow on the landfill covers. Large-volume groundwater withdrawals could also cause regional subsidence as the alluvial aquifer is dewatered, should groundwater pumping increase substantially in the future. However, such broad-scale subsidence is less likely to impact the future waste covers.

Natural hazards that may affect the LLW disposal areas include seismic activity and flooding. The hazard of volcanic activity has a sufficiently low probability to be discounted over the operational life and foreseeable future of the facility.

While these natural and incidental hazards are unpredictable, studies have been done to determine the relative risk of these hazards impacting the disposal sites and measures have been implemented to reduce the risk of containment failure. The following subsections summarize some of the studies and monitoring activities related to these hazards.

5.10.1 Seismicity

This Section is from the ICMP (BN, 2005a).

Seismic hazard studies conducted at the NTS (Campbell, 1980; Battis, 1978; Rogers, et al., 1977; and Hannon and McKague, 1975) agree that the predicted maximum Richter magnitude for an earthquake is between 5.8 and 7.0, with a peak acceleration between 0.7 and 0.9 g (Note: g is the acceleration of gravity 9.8 (m/s2) or the strength of the gravitational field (N/kg). The predicted maximum magnitude earthquake (and the associated peak acceleration) has a return period between 12,700 and 15,000 years (Metcalf, 1983). The seismic studies show a 0.54 probability of an earthquake with a Richter magnitude greater than 6.8 within the next 10,000 years.

Earthquakes with magnitudes between 4.3 and 4.5 occurred in Frenchman Flat in 1971 and 1973 (Case, et al., 1984) and in 1999 (see www.earthquake.usgs.gov; www.seismo.unr.edu). The 1973 and 1999 earthquakes were associated with the Rock Valley Fault, whereas the 1971 earthquake was associated with the Cane Spring Fault. The focus of this latter earthquake was in the Massachusetts Mountains which separate Yucca Flat and Frenchman Flat. No surface rupture was reported from any of these earthquakes.

Because of the absence of layers that could be disrupted by movement, the monolayer-evapotranspiration design anticipated for closure covers at both RWMSs is intrinsically not prone to significant damage from earthquakes.

5.10.2 Volcanism

The following Section is from the ICMP (BN, 2005a).

The risk of volcanism in the NTS region is indicated by the potential for either future silicic or basaltic volcanism. Silicic volcanism is characterized by large-volume, explosive eruptions; whereas basaltic volcanism is characterized by cinder cones and lava flows of limited extent. The hazard for silicic volcanism is considered to be negligible because:

- *Since its peak (from 15 to 9 million years ago), there has been a significant decrease and, in most areas, a cessation of silicic volcanism within the central and southern parts of the Great Basin. The last major silicic events were the Black Mountain caldera which erupted 9.4 million years ago and the Stonewall Mountain caldera which erupted 7.6 million years ago.*
- *Silicic volcanism has been absent in the NTS region for the past 7.6 million years.*
- *Quaternary (less than 10,000 years) silicic volcanism is restricted to the eastern and western margins of the Great Basin (Crowe, et al., 1983). A transition from predominantly silicic volcanism to basaltic volcanism occurred approximately 10 million years ago.*

Late- and post-Miocene basaltic volcanism in the NTS region is divided into two episodes: (1) large-volume basaltic centers that are spatially and temporally associated with the waning phase of silicic volcanism; and (2) small-volume, spatially scattered basalt centers that postdate silicic volcanism (Crowe, 1990). The latter episode of volcanism is subdivided into two cycles: late Miocene basalt centers in the east and north-center of the NTS, and Pliocene and Quaternary basalt centers primarily in the southwest part of the NTS region. The youngest basaltic volcanic center in the NTS region is the 70,000-year-old basalt of Lathrop Wells. The youngest basalt within Yucca Flat, at 8.4 million years, is between 226 and 308 m (740 and 1,010 ft) deep in borehole UE-1h, 1.6 km (1 mi) southwest of the Area 3 RWMS. The youngest basalt within Frenchman Flat, at 7.4 million years, is exposed at the surface in Nye Canyon, approximately 21 km (13 mi) northeast of the Area 5 RWMS.

> *The greatest hazard of future basaltic volcanism in the NTS region is within zones of Pliocene and Quaternary volcanism (Crowe, Wallman, et al., 1993). The Area 3 and Area 5 RWMSs are outside and a considerable distance from all Pliocene and Quaternary volcanic zones. Based on studies at Yucca Mountain, Crowe, Wallman, et al. (1998) calculated the probability of magmatic disruption of an equivalent Area outside a volcanic zone to be 3E-09, or 3E-06 over a 1,000-year compliance period. This probability is sufficiently low that basaltic volcanism can be dismissed as a credible event for the RWMSs.*

5.10.3 Flooding

Three watersheds comprise the drainage area that could impact the Area 5 RWMS: the Barren Wash, Scarp Canyon, and Massachusetts Mountains/Halfpint Range. The total drainage Area of these water sheds is approximately 363 km^2 (140 m^2). The RWMS is in the middle zone of the Scarp Canyon alluvial fan, near the converging edge of three alluvial fans. Both sheet flow and concentrated flows in ephemeral channels must be considered to evaluate flood hazards for this area. While most of the channels in this Area are shallow and braided, there is a defined drainage which crosses the southwest corner of the RWMS, at the boundary between the Barren Wash Alluvial Fan and the Massachusetts Mountains/Halfpint Range watershed.

Stratigraphic studies of the P03U and P04U wells by Raytheon Services Nevada (1991) indicate the landfill trenches and pits are dug into sheetflood and shallow channel deposits. Observed cut and fill structures were generally less than a meter thick, similar to modern channels, except for one laterally contiguous soil horizon up to 2-m thick. Although the pre-development stratigraphy shows the accretion of sediments through time with periodic erosion. The potential for future flood and erosion impacts at the Area 5 RWMS must take into the account the berms, ditches, roads, and other structures diverting flow from this area.

The RWMSs must comply with the NAC, federal regulations, and DOE policies and orders regarding protection of hazardous and radioactive waste facilities from floods. At least three flood hazard assessments have been performed for the Area 5 RWMS Area to fulfill regulatory requirements and to define criteria for flood protection design.

Schmetzer, et al. (1993) conducted a flood hazard study based on the Federal Emergency Management Agency (FEMA) Alluvial Fan Methodology (AFM). They found that the southwest corner of the Area 5 RWMS was within a 100-year flood hazard zone. This zone is defined by FEMA to have a 0.01 (1 percent) probability that a flood with a depth of flow greater than 0.3 m (1 ft) could occur within any given year. The southwest corner of the RWMS has the potential for flooding from both alluvial-fan flow on the Barren Wash fan and shallow concentrated flow on the Massachusetts Mountains/Halfpint Range alluvial fan. Other parts of the Area 5 RWMS are within an area referred to as Zone X, where sheetflow resulting from a 100-year, 6-hour precipitation event is anticipated to be less than 0.3 m (1 ft) deep. Figure 5-18 is a flood hazard map of the vicinity of the Area 5 RWMS.

Miller and Gustafson (1994) conducted a flood assessment using a combination of methods including: the FEMA AFM, HEC-2 modeling for shallow concentrated flow and the Manning equation for sheetflow to identify the 100-year flood hazard at and near the Area 5 RWMS. This

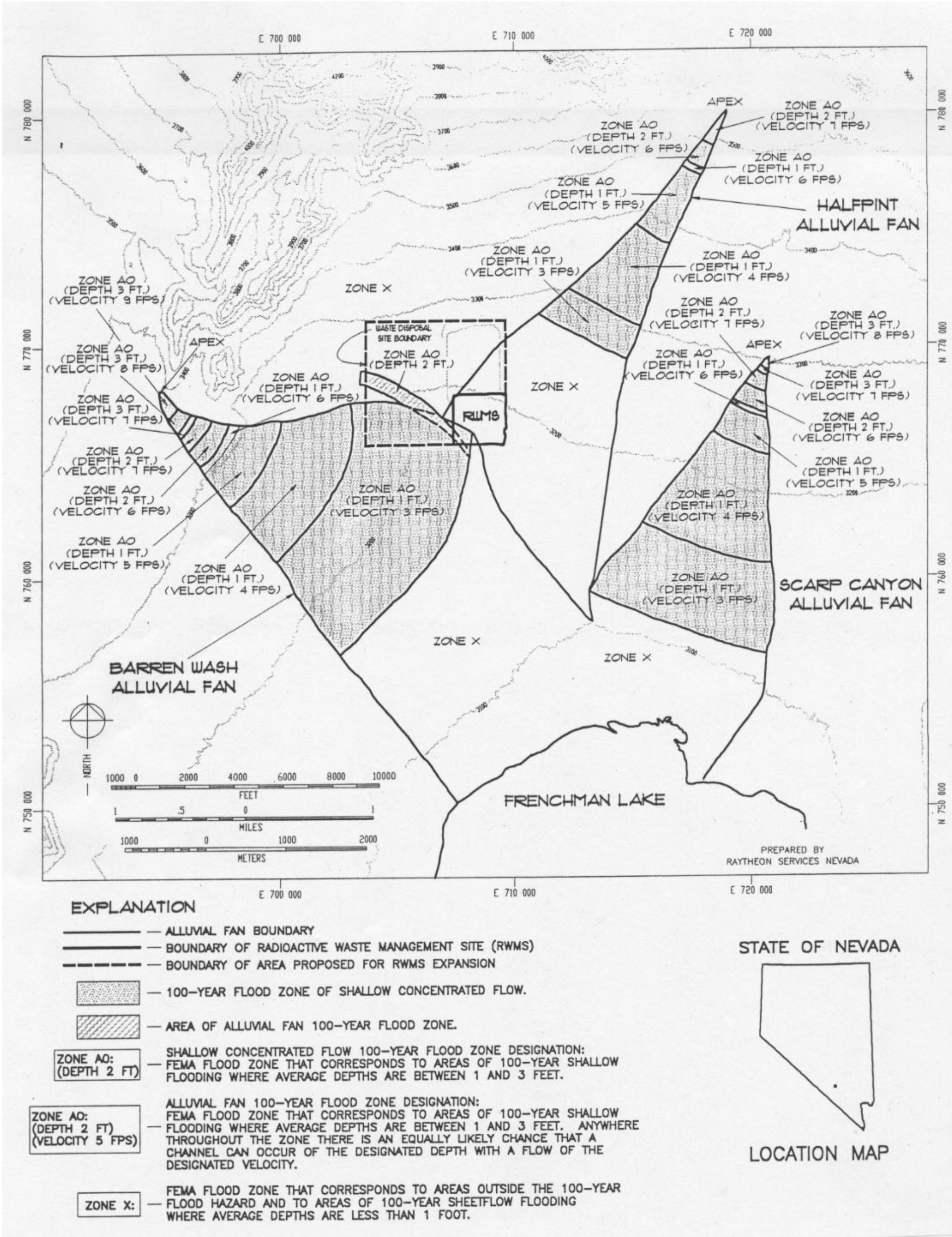

Figure 5-18. 100-Year Flood Zone Delineation Map

Source: A Multiple-Method Approach to Flood Assessment at a Low-Level Radioactive Waste Site in Southern Nevada, by Julianne J. Miller and Dennis L. Gustafson, Raytheon Services Nevada, March 1994.

study also found that the 100-year flood-hazard zone of the Barren Wash Alluval fan impinges on the southwest corner of the Area 5 RWMS. It was noted that the flood-hazard potential from Barren Wash is actually less than the potential determined from the FEMA AFM because the AFM assumption of a uniform probability of a channel being formed may be invalid. Empirical evidence suggests fan-head channels tend to occur near or along the fan centerline. Since the

RWMS is located along the boundary of a fan and not in the center, the flood hazard potential from Barren Wash may be less than the FEMA model suggests. The study concluded that use of the FEMA AFM for analysis of the Barren Wash Alluvial Fan, with respect to the RWMS, was reasonable but conservative.

The RWMS is within the Zone X flood zone of the Halfpint alluvial fan, a flood-hazard designation that corresponds to areas outside of the 100-year flood hazard zone, with 100-year average sheet flow flooding of less than 0.31 m (1 ft) depth, assuming that discharge in sheetflow regions is spread equally over the surface. Existing channels within this part of the Halfpint alluvial fan are generally less than 0.31 m (1 ft) deep, but deeper channels have been found, suggesting that channelized flow depths might actually exceed 0.31 m (1 ft). The study concluded flood protection should address potential for channelized flow at the RWMS in this Zone X hazard area.

HEC 2 model results indicate the drainage between fans which crosses the southwest corner of the Area 5 RWMS has a shallow concentrated flow 100-year flood zone with average depths of 0.62 m (2 ft). The report notes that FEMA AFM alone would not have delineated the drainage as a flood hazard.

Miller, et al (Raytheon Services Nevada, June 1994) conducted a 25-year and 500-year flood hazard assessment of the Area 5 RWMS to determine discharges at points of concentration along the outer edges of berms flanking the Area 5 RWMS. RCRA regulations require the 25-year assessment and DOE O 6430.1a requires the 500-year discharge assessment for “critical action” facilities.

The currently active part of the Area 5 RWMS is now protected from a 25-year, 24-hour flood event via a channel and dike system. These features meet regulatory requirements for flood protection of a RCRA facility.

The original soil berms around the Area 5 RWMS were not designed to any particular flood event. There were reportedly constructed around the north edge as the original pits were excavated. In the mid-1990s new channels and berms were designed and built. The new berms extend from the existing dirt berms north of P03U (Pit 3) along the east and west sides. During the design, both the existing berm and the new ones were analyzed for the 25-year, 24-hour storm event. The construction of the new berms was completed in 1996. Calculation No. FD-DA-C-117 (BN, 1999b) took the calculated flood flows from an actual 25-year, 24-hour storm event (February 23 and 24, 1998) and assessed the adequacy of the existing and as-constructed channel/berm systems (Personal Communication, J. Sorola, August 3, 2005.)

The calculations confirmed that the berm system has adequate freeboard to handle a 25-year 24-hour storm (Personal Communication, Vefa Yucel, August 4, 2005). Recent studies suggest that actual depths of flow and flow velocities may be considerably less than modeled because of water lost into the ground during transmission (French and Curtis, 1999).

Changes in the regulatory status of the site prompted a brief hazard analysis evaluating the potential impacts of a 2000-year storm flood event. DOE has allocated budget to do further analysis of flood potential for up to a 2000-year storm event in FY 2006 (Personal Communication, V. Yucel, August 4, 2005).

5.10.4 Subsidence

Many factors affect potential subsidence of the landfill covers including but not limited to:

- The types of containers,
- The structural integrity of containers,
- How the containers were packed into the pits and trenches,
- The weight of the stacked containers and the soil covers above,
- The amount of void space within and around the containers, and
- How well the soil covers were compacted.

Potential for subsidence may vary across the 92-Acre Area reflecting the changes in waste types, waste packaging, waste management, and landfill cover operations over the past 45 years. Other factors related to surface erosion and soil structure such as drainage patterns and the distribution of vegetation and animal burrows could eventually influence the potential for local subsidence.

A formal program to monitor the subsidence of waste covers was initiated in October 2000. Subsidence monitoring is conducted to ensure that subsidence features are repaired in a timely manner, to prevent erosion and the development of preferential pathways through the waste covers, and to ensure that vadose zone monitoring data are representative of the entire RWMS. The effectiveness of subsidence monitoring is periodically evaluated as part of the PA process.

At the Area 5 RWMS, subsidence monitoring is conducted monthly at all operationally closed disposal units and at partially buried open disposal units. The monitoring consists of routine inspections of operational and final waste covers for subsidence features such as cracks and depressions, ponding, and erosion. When such features are observed, their locations are recorded using a Global Positioning System and digital camera, and operations personnel are informed to take corrective action.

Locations of observed subsidence features are presented in the annual waste management monitoring reports. Generally, subsidence features have been observed mostly in locations of recently covered waste as well as concentrated along the edges of cells, where compaction may be less complete. In other locations within the Area 5 RWMS, only a few minor cracks and depressions required maintenance (BN, 2005d and 2005c).

In 2004, 62 yd^3 of fill dirt were used to fill cracks and depressions at the Area 5 RWMS. Subsidence was only found at two disposal units. Seventeen small features were identified and filled at the P05U cover and three features were filled around the northeast corner of the P04U pit (BN, 2005c). These disposal units are on the west side of the 92-Acre Area and are relatively recent pits. P04U was closed sometime after October 31, 1994, and P05U sometime after October 31, 2001 (Denton et al., 2004).

In the late 1990s, a working group of subject matter experts was convened to evaluate the consequences of subsidence at the Area 3 and Area 5 RWMSs. Relevant major observations and recommendations of that study (DOE, 1998a) were:

- None of the regulations for disposal of LLW at the NTS include specific design requirements for closure caps.
- Performance assessment models should be used to optimize designs for closure of waste disposal sites.
- Closure cover designs should satisfy minimum engineering performance standards and dose-related PA standards.
- An alternative closure cover design consisting of a thick layer of native alluvium should be developed for use at the RWMSs. The cover design should rely upon thickness and evapotranspiration to provide containment.
- The cover should be monitored during the Institutional Control period to monitor performance and allow modification and maintenance if necessary.
- Void spaces between and within the waste packaging should be minimized.

An Alternative Evaluation Study (Barker, 1997) initiated to address potential subsidence concerns recommended:

- Close all NTS waste cells with soft covers, possibly thicker than present operational covers.
- Do not grout or use deep dynamic compaction on any NTS waste cells.
- Encourage generators to minimize spaces void of waste containers.
- Create a database of waste container locations and observed waste subsidence.
- Whenever possible, consider bulk-waste disposal.

Many of these recommendations have already been implemented. Operation practices are now in place to mitigate potential future subsidence over modern disposal units as much as reasonably practicable.

5.11 Operational Soil Covers

The operational soil covers at the Area 5 RWMS consists of locally derived native fill collected from the unsaturated alluvium. Generally past closure covers for the shallow pits and trenches at the Area 5 RWMS have been approximately 2.4 m (8 ft) thick, with 1.2 m (4 ft) below grade and 1.2 m (4 ft) above grade (BN, 2005a). The GCD boreholes have about 21.3 m (70) ft of fill on top of the waste. The characteristics and performance of the existing operational closure covers is being considered in the design of the final closure cover for the 92-Acre Area.

In FY 2002, samples were collected from the operational covers over the shallow trenches and pits within the 92-Acre Area of the Area 5 RWMS to document physical characteristics, including basic hydrogeological parameters. The laboratory analytical data reports were presented in a previous characterization report with minimal interpretation (BN, 2005d). This section summarizes data relevant to water, vapor, and potential contaminant transport. Refer to the laboratory reports in BN 2005d for the complete data set and further detail on methods, calibrations, and Quality Assurance/Quality Control.

Sampling and test location grids were established for four operational landfill cover areas: P04U, P03U, T01U to T07U, (T01U, T02U, T03U, T04U, T06U, and T07U) and T01C to T06C (T01C, T02C, T03C, T04C, T04C-1, T05C, and T06C).

Sampling access was very limited at T01C-T06C, the cover of the classified material trenches, because security personnel did not want any digging or coring in the classified material area. They did permit collection of a bulk sample from about 1-ft depth from grid point C10. Coring was unsuccessful at this location. The cover material appeared to be unscreened and contained more rocks than at the other sampling locations. It is unknown if this single sample location is representative of the entire cover, based on the data from this study.

All four landfill covers were surveyed for elevation. Nuclear density tests were performed on two of the unclassified covers.

Core samples were collected from a total of 16 locations on the unclassified trench covers at depths of approximately 1 ft and 3 ft. Two 6-in core samples and one 3-in core sample were collected from each sample location. Cores were analyzed for bulk density, compaction, soil moisture, porosity, and permeability. One core was also analyzed for hydraulic conductivity.

Bulk samples were collected from six locations, at least one from each of the four landfill covers. Two 5-gal buckets were filled for each bulk sample. The disturbed bulk samples were used for sieve, specific gravity, and Proctor compaction tests.

Tables 5-5 through 5-10 summarize the results. Table 5-5 presents general grain-size distributions derived from sieve analyses results. The six samples had very similar textures, and were comprised primarily of sands. The average fines fraction was about 8 percent by weight, and gravel 21 percent. Most of the gravel was fine (less than about ¾-in diameter). All the sample material passed a 3-in sieve. The detailed sieve results and gradation curves can be found in Appendix B-6 of the Characterization Report (BN, 2005d).

Table 5-6 summarizes specific gravity data. Average specific gravity of the gravel fraction for the six bulk samples collected from the landfill covers was 2.299. Average specific gravity of the finer-than-US Sieve #4 fraction was 2.454.

Table 5-7 summarizes Proctor Test (ASTM D 1557-2000) results. The test results for the six samples were very similar. Four to five trials were run for each sample. The average maximum achievable compaction is 109.1 lbs/ft^3 at an optimal moisture condition of 11.6 percent. After correction for the presence of gravel, the average maximum achievable compaction is 111.2 lbs/ft^3 at an optimum moisture condition of 10.9 percent. Variance of maximum compaction densities was less than 2 percent across the site.

The Proctor Test results are very similar to results from nuclear density tests using a Troxler 3440 gauge. One of the 15 sample locations attempted was not tested due to probe refusal on coarse rocks and cobbles. Table 5-8 summarizes nuclear density data. The average of 14 values collected from 14 locations at P03U and P04U on August 19, 2002, yielded a range of dry densities of 99.6 to 109.8 lbs/ft3 with a mean of 105.6 lbs/ft^3 and a coefficient of variance of 2.5 percent. Moisture percent ranged from 1.9 to 3.9 with a mean of 2.5 percent and a coefficient of variance of 21.2 percent. Maximum density in lbs/ft^3 for soils from P03U was 110.1 and for P04U 112.1. Optimum moisture was 10.8 percent at P03U and 10.6 percent at P04U. Percent compaction values ranged from 90.5 to 97.9 with a mean of 94.6 percent and a coefficient of variance of 2.3 percent. The low variance values are indicative of the homogeneity of the operational covers.

Table 5-5. Operational Covers - Grain Size Distribution

Location	Class[1]	Percent Gravel by Weight[2]	Percent Sand by Weight[3]	Percent Silt and Clay by Weight[4]
P03U Logging Tube 22	SM/SW	21	71.6	7.4
P04U Grid Pt B4	SM/SP	18	71.6	10.4
P04U Grid Pt C10	SM/SW	25	68.6	6.4
T01U-T07U Grid Pt F4	SM/SP	21	70.6	8.4
T01U-T07U Grid Pt B4	SM/SW	21	73.1	5.9
T01C-T06C	SM/SP	20	71.0	9.0
Average		**21**	**71.1**	**7.9**
Coefficient of Variance[5]		**11%**	**2.1%**	**21.3%**

Notes:

[1] Assume textural class determined based on ASTM D 2488-90 “Standard Recommended Practice for the Description of Soils – Visual Manual Procedure”

[2] Percent gravel is roughly equivalent to materials retained on a US Standard # 4 sieve.

[3] Percent sand is equivalent to material passing a #4 sieve yet retained on a #200 sieve.

[4] Most silt and clay passes through a US standard #200 sieve.

[5] Coefficient of Variance = 100 (standard deviation/mean) percent

Source: Derived from sieve analyses in BN Materials Testing Laboratory September 2002 data report in Appendix B-6 of the Characterization Report DOE/NV/11718—758, Rev 1 (BN, 2005d).

Table 5-6. Operational Covers – Specific Gravity

Landfill Cover	Sample Location	Approximate Depth	Specific Gravity Gravel (>sieve #4)	Specific Gravity Sand and Fines (< sieve #4)
P03U	Near tube 22	3-feet	2.303	2.528
P04U	B4	3-feet	2.311	2.496
P04U	C10	3-feet	2.254	2.372
T01U-T07U	F4	3-feet	2.210	2.382
T01U-T07U	B4	3-feet	2.336	2.499
T01C-T06C	C10	1-foot	2.381	2.447
Average			**2.299**	**2.454**
Coefficient of Variance			**2.6%**	**2.7%**

Source: BN Materials Testing Laboratory 8/23/2003 data report in Appendix B-4 of Characterization Report DOE/NV/11718 – 758, Rev 1 (BN, 2005d).

Same samples as used for Proctor Tests.

Table 5-7. Operational Covers - Maximum Achievable Compaction, Proctor Test

Location	Sample Date	Maximum Density (lbs/ft^3)	Optimum Moisture percent	100% Saturation Moisture	Corrected Maximum Density[2] (lbs/ft^3)	Corrected Optimum Moisture Percent[2]
PO3U, near Logging Tube 22	5/29/02	108.3	11.5	17.9-18.8 (4 trials)	110.1	10.8
P04U Grid Pt B4	5/29/02	110.5	11.1	16.4-17.5	112.1	10.6
P04U Grid Pt C10	6/19/02	107.2	13	16-16.4	109.8	12.0
T01U-T07U Grid Pt F4	6/19/02	111.1	12.2	14.2-15.9	113.1	11.5
T01U-T07U Grid Pt B4	7/3/02	107.2	9.4	17.9-18.6 (5 trials)	110.0	8.7
T01C-T06C Grid Pt C10	7/3/02	110.2	12.5	16-17.1 (4 trials)	112.4	11.6
Average		**109.1**	**11.6**		**111.25**	**10.9**
Coefficient of Variance[3]		**1.6%**	**11.0%**		**1.3%**	**10.9%**

Notes:

[1] lbs/ft^3 = pounds per cubic foot

[2] Correction of unit weight and water content for soils containing oversize particles using ASTM D 4718-87.

[3] Coefficient of variance= 100 (standard deviation/mean)percent

Same samples as used for specific gravity tests.

Source: BN Materials Testing Laboratory 9/12/2002 data report, Characterization Report DOE/NV/11718 – 758, Rev 1 (BN, 2005d)

Table 5-8. Operational Covers - Nuclear Density

Location	Station	Test Date	Dry Density (lbs/ft^3)	Moisture Percent	Maximum Density (lbs/ft^3)	Optimum Moisture Percent	Percent Compaction
PO3U	A-1[1,2]	8/19/02	NT[1]	NT	NT	NT	NT
PO3U	A-2[2]	8/19/02	106.6	2.4	110.1	10.8	96.8
PO3U	A-3	8/19/02	104.9	2.1	110.1	10.8	95.3
PO3U	Near-sampling Tube 22	8/19/02	99.6	1.9	110.1	10.8	90.5
P04U	A-1[2]	8/19/02	105.6	1.9	112.1	10.6	94.2
P04U	C-1[2]	8/19/02	103.4	2.6	112.1	10.6	92.2
P04U	B-2	8/19/02	105.1	2.5	112.1	10.6	93.8
P04U	A-3[2]	8/19/02	104.8	3.9	112.1	10.6	93.5
P04U	C-3[2]	8/19/02	103.8	3.1	112.1	10.6	92.6
P04U	B-4	8/19/02	107.4	2.9	112.1	10.6	95.8
P04U	A-5[2]	8/19/02	109.8	2.2	112.1	10.6	97.9
P04U	C-5[2]	8/19/02	109.3	2.4	112.1	10.6	97.5
P04U	B-6[2]	8/19/02	105.1	2.1	112.1	10.6	93.8
P04U	A-7[2]	8/19/02	104.6	2.5	112.1	10.6	93.3
P04U	C-7	8/19/02	108.2	2.5	112.1	10.6	96.5
Average			**105.6**	**2.5**			**94.55**
Coefficent of Variance[3]			**2.5%**	**21.2%**			**2.3%**

Notes:

(lbs/ft^3) = pounds per cubic foot.

[1] No test performed at grid station A-1 at P03U due to probe refusal on coarse rock and cobbles.

[2] Probe driven less than 12 in due to condition of material at these stations.

[3] Coefficent of Variance = 100(standard deviation/mean)percent

Source: BN Materials Testing Laboratory, Nuclear Density data report typed 9/23/02, in Characterization Report DOE/NV/11718—758, Rev 1 (BN, 2005a)

In-place bulk density and percent compaction tests for 15 samples out of 16 collected between May 29, 2002, and July 3, 2002, from the P03U, P04U and T01U-T07U covers yielded results that were very consistent with the previous data. One of the 16 samples was not tested. Table 5-9 presents the in-place density, compaction, and calculated porosity results for the core samples. In-place dry densities calculated from core samples were slightly lower than Proctor dry densities. Mean in-place dry density was 98.1 lbs/ft^3, or 1.572 g/cm^3. Mean in-place saturated density was 1.933 g/cm^3. Mean moisture content was 5.6 percent by weight. Mean Proctor dry density was 111.6 lbs/ft^3. Mean compaction was 87.9 percent. Variances in compaction and density results were less than 4 percent.

Table 5-9. Operational Covers – Bulk Density, Compaction, and Permeability

Sample Location (cover, grid or descriptive location and depth below ground surface)	Date	In-place Dry Density (lbs/ft^3)	Proctor Dry Density (lbs/ft^3)	In-place Dry Density (g/cm^3)	In-place Saturated Density (g/cm^3)	Moisture (percent g/g)	Percent Compaction	Average Permeability (4-6 tests per sample) (cm/sec)
P03U, by Location 22, 1 foot	5/29/02	97.4	110.1	1.561	1.874	4.7	88.5	2.86E-03
P03U, by Location 22, 3 foot	5/29/02	94.1	110.1	1.507	1.918	5.2	85.5	3.26 E-03
P04U, B4, 1- foot	5/29/02	94.7	112.1	1.517	1.932	5.7	84.5	6.49E-03
P04U, B4, 3-foot	5/29/02	91.2	112.1	1.461	1.827	6.7	81.4	3.12E-03
P04U, C10, 1-foot	6/19/02	98.5	109.8	1.578	1.934	6.4	89.7	1.88E-04
P04U, C10, 3-foot	7/3/02	101.0	109.8	1.618	1.939	6.3	92.0	3.72E-05
T01U-T07U, F4, 1-foot	6/19/02	97.6	113.1	1.564	2.057	5.1	86.3	1.33E-04
T01U-T07U, F4, 3-foot	6/19/02	99.3	113.1	1.591	1.910	5.9	87.8	4.39E-04
T01U-T07U, F7, 1-foot	6/25/02	NA	NA	NA	NA	NA	NA	NA
T01U-T07U, F7, 3-foot	6/25/02	97.7	113.1	1.564	1.879	5.9	86.4	4.01E-04
T01U-T07U, D5,1-foot	6/25/02	102.7	113.1	1.645	1.991	5.8	90.8	6.68E-04
T01U-T07U, D5, 3-foot	6/25/02	97.5	113.1	1.562	1.868	5.9	86.2	8.39E-04
T01U-T07U,B4, 1-foot	7/3/02	100.4	110.0	1.607	1.933	5.6	91.2	5.02E-04
T01U-T07U, B4, 3-foot	7/3/02	97.6	110.0	1.564	1.956	6.8	88.7	9.12E-03
T01U-T07U, B8, 1-foot	7/3/02	106.1	112.4	1.699	2.079	3.6	94.4	7.65E-04
T01U-T07U, B8, 3-foot	7/3/02	96.2	112.4	1.542	1.900	4.6	85.6	5.94E-04
Average		**98.1**	**111.6**	**1.572**	**1.933**	**5.6**	**87.9**	**1.96E-03**
Coefficient of Variation		**3.7%**	**1.3%**	**3.65%**	**3.51%**	**15.3%**	**3.8%**	**135.53%**

Sources:

BN Materials Testing Laboratory data report typed 8/13/02 for tests performed 7/8/02 to 7/18/02, in Appendix B-3 NNSA report DOE/NV/11718 – 758, Rev 1 (BN, 2005d).

Undated BN Materials Testing Laboratory data report for ASTM D 2434-68 (re-approved 1974) permeability tests performed 7/15/02 to 7/29/02. This lab report is in Appendix B-7 of NNSA report DOE/NV/11718—758, Rev 1 (BN, 2005d).

Table 5-10 also shows permeability data from the three unclassified landfill covers. Permeabilities for the 15 core samples tested ranged from 3.72E-05 to 9.12E-03 cm/sec with a mean of 1.96E-03 cm/sec. Four to six tests were run for each sample. Consistency between test runs for each sample was very high. Variability in permeability values between sample locations was much greater, but the permeability values found are typical of sands and silty sands, indicating consistency with soil texture data from the sieve analyses. The detailed data are in the undated lab report presented in Appendix B-7 of the Characterization Report (BN, 2005d).

Core samples collected from the same 16 locations at Pit 3, Pit 4 and T01U-T07U were evaluated at Daniel B Stephens & Associates Laboratory for initial moisture content, dry bulk density, and wet bulk density. Table 5-10 summarizes the data. The data from the two laboratories for the splits were fairly consistent. The average dry bulk density calculated from results from the Daniel B. Stephens & Associates lab data was 1.55 g/cm^3 compared to 1.572 g/cm^3 from the BN lab data. The average moisture content reported for samples sent to Daniel B Stephens & Associates on a volume basis was slightly higher than the moisture contents for the samples sent to BN Materials Testing Laboratory reported on a weight basis.

Table 5-10 also summarizes calculated porosities. Porosities of the core samples ranged from 37.3 percent to 47.3 percent with a mean of 41.6 percent and a coefficient of variance of only 5.4 percent.

A constant head analysis of a soil core sample collected from somewhere in the 1 foot to 2.5 foot depth interval at grid point #F7 in the operational cover over the T01U-T07U cells yielded a saturated conductivity value of 5.4E-05 cm/sec.

According to BN (2005d), comparison of these new physical properties and hydrogeologic data to previous values obtained for alluvium under the Area 5 RWMS (REECo, 1993a, b; Blout et al., 1995; Levitt et al., 1996) indicates that both data sets are similar.

The Characterization Report (BN, 2005d) contains copies of the laboratory and survey reports, including: operation cover core sample data; nuclear density data test point survey maps for P04U, P03U, T01C-T06C and T01U-T07U; nuclear density lab test results; bulk density, percent compaction and moisture content data; specific gravity data, proctor tests to determine maximum density at optimum moisture content; sieve analysis results for classification of the cover soil; permeability data from constant head tests on core samples; and plots of relative hydraulic conductivity versus pressure head. The laboratory reports provide more detail than summarized herein, including some Quality Assurance/Quality Control information, and the methods used.

The Characterization Report (BN, 2005d) also contains a topographic map. A topographic survey was completed in FY 2002 to document the configuration of the Area 5 RWMS (92-Acre Area) prior to any changes that might be made to the closure covers and intervening areas, inclusive of the GCD boreholes, from the time of the survey up to development of final covers for closure of the area.

Table 5-10. Operational Covers - Porosity

Sample Location (Cover, grid or descriptive location)	Depth (feet)	Gravimetric Moisture Content (Percent g/g)	Volumetric Water Content (Percent cm^3/cm^3)	Dry Bulk Density (g/cm^3)	Wet Bulk Density (g/cm^3)	Calculated Porosity (Percent)
P03U, by tube 22	1	5.6	8.8	1.58	1.67	40.4
P03U, by tube 22	3	6.7	10.3	1.53	1.63	42.2
P04U, B4	1	6.0	9.5	1.59	1.69	39.8
P04U, B4	3	7.4	11.4	1.53	1.64	42.3
P04U, C10	1	7.0	10.9	1.55	1.66	41.6
P04U, C10	3	6.6	10.6	1.61	1.72	39.3
T01U-T07U, F4	1	5.8	9.0	1.53	1.62	42.1
T01U-T07U, F4	3	6.4	10.3	1.60	1.70	39.6
T01U-T07U, F7	1	6.7	10.5	1.56	1.67	41.0
T01U-T07U, F7	3	5.1	8.4	1.66	1.74	37.3
T01U-T07U, D5	1	6.1	9.2	1.51	1.61	42.9
T01U-T07U, D5	3	6.4	10.0	1.56	1.66	41.1
T01U-T07U,B4	1	5.9	8.8	1.49	1.57	43.9
T01U-T07U, B4	3	6.8	10.3	1.51	1.61	43.0
T01U-T07U, B8	1	3.8	5.8	1.54	1.60	42.0
T01U-T07U, B8	3	4.7	6.6	1.40	1.46	47.3
Average		**6.1**	**9.4**	**1.55**	**1.64**	**41.6**
Coefficient of Variation		**15.2%**	**16.1%**	**3.8%**	**4.0%**	**5.4%**

Notes:
g/cm^3 = grams per cubic centimeter

Source:
Daniel B. Stephens & Associates, Inc., lab report, no date, in Appendix B-3 of the NNSA report DOE/NV/11718 – 758, Rev 1 (BN, 2005d).

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6.0 CONCEPTUAL MODELS AND ASSESSMENTS

Many models have been developed that have application to the characterization and assessment of the Area 5 RWMS. Some are quite specific and address a single factor, and others are more complex, addressing numerous aspects of the total disposal system and environment. Examples include:

- Hydrogeologic (IT, 1998, 1999ab; Blout et al., 1995; Laczniak et al., 1996; Winograd and Thordarson, 1975)
- Unsaturated Flow (Dixon, 1999; BN, 1998a)
- Groundwater Recharge (Levitt and Yucel 2002a, b; Hokett and French, 1998)
- Subsidence (DOE, 1998; Obi et al., 1996)
- Source Term (Shott et al., 1998)
- Transport and Exposure (Cochran, Crowe, et al., 2001a; Estrella, 1994)
- Inadvertent Human Intrusion (BN, 2001; Black, 2001; Shott et al., 1998)
- Biological (Hansen and Ostler, 2003; Winkel et al., 1995; Wirth et al., 1999)
- General Performance Assessment (Shott et al., 1998; Levitt et al., 1999; Cochran, Beyeler, et al., 2001)

Most scenarios for radionuclide release and transport ultimately involve some aspect of the hydrologic system. Additionally, the hydrologic environment affects monitoring, PA, and closure cover design decisions. The hydrologic conceptual model for the Area 5 RWMS, the PA, and the Composite Analysis are described below.

6.1 HYDROLOGIC CONCEPTUAL MODELS FOR THE AREA 5 RWMS

Climate and vegetation strongly control the movement of water in the upper few meters of the alluvium. The magnitude and direction of both liquid and vapor fluxes vary seasonally and often daily. Except for periods following precipitation events, the moisture content in this near-surface zone is quite low. Below the near-surface region is an area where relatively steady upward movement of water is occurring. In this zone of slow upward moisture movement, analyses of stable isotope compositions of soil pore water confirm that evaporation is the dominant process (Tyler et al., 1996). This zone extends to depths as great as 3 to 40 m (10 to 131 ft) in Area 5.

Below this zone, water-potential measurements indicate the existence of a static zone, which is approximately 40 to 90 m (131 to 295 ft) below the ground surface at well UE5PW-1 in Area 5 (Shott et al., 1998). In this static zone, essentially no vertical liquid flow is currently occurring. Below this static zone, flow is quasi-steady-state and downward due to gravity. Stable isotope compositions of pore water from these depths indicate that infiltration into this zone occurred under cooler, past climatic conditions (Tyler et al., 1996).

See Figure 6-1 for a diagram of the vadose zone hydrologic conceptual model at the Area 3 and Area 5 RWMS, as well as Figure 5-14 from Section 5.6.6.

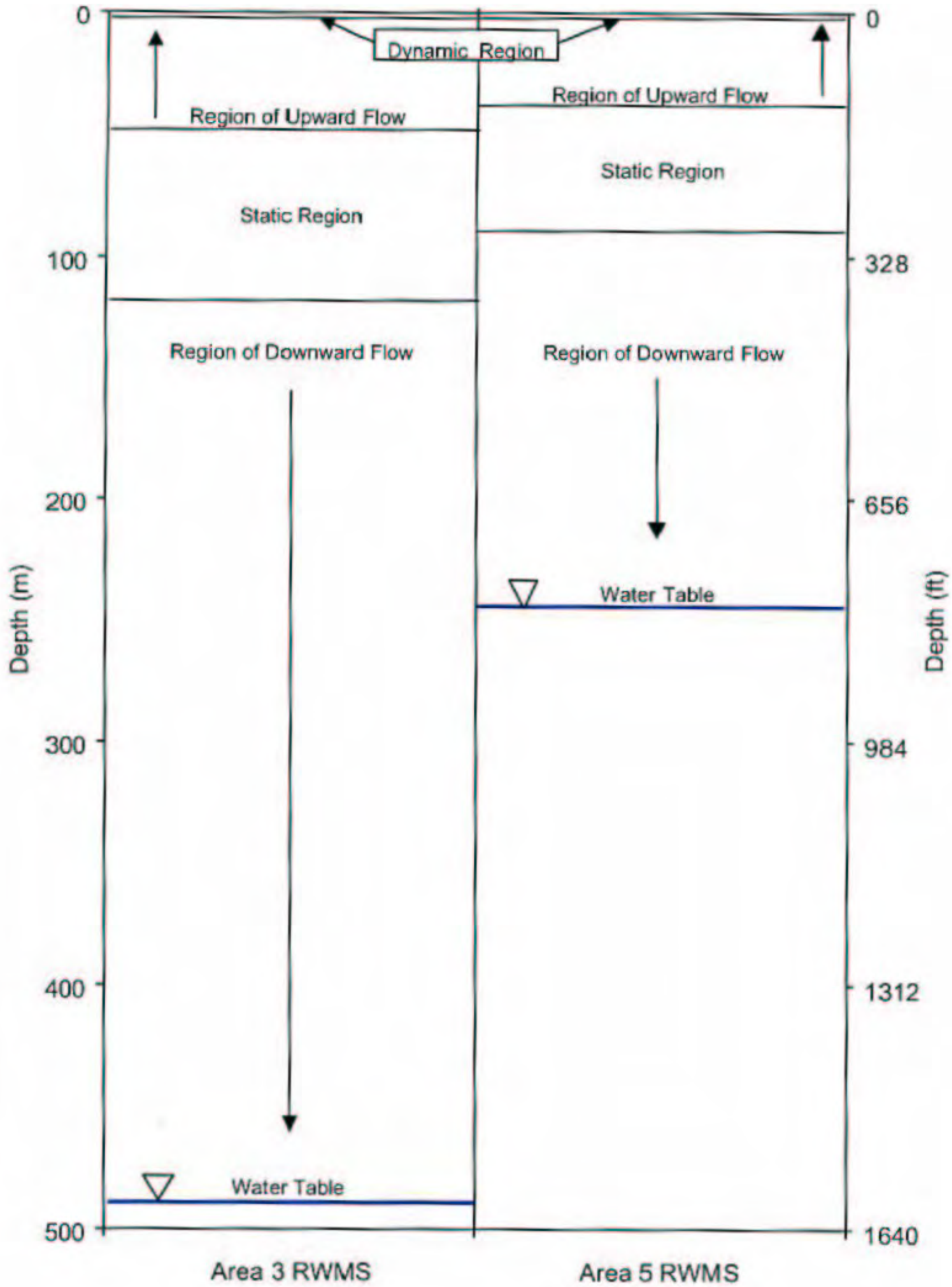

Figure 6-1. Vadose Zone Hydrologic Conceptual Model of the Area 5 Radioactive Waste Management Site

Source: BN (2005a)

Results of the extensive research, field studies, modeling efforts, and monitoring data summarized in the Area 5 Performance Assessment (Shott et al., 1998), in Levitt et al. (1999, 1998), and in Levitt and Yucel (2002a, 2002b) suggest the potential for recharge is negligible.

Lysimeter studies indicate that under bare-soil conditions such as those found at the operational waste cell covers, some drainage may eventually occur through the operational waste covers into the waste zone. This drainage is estimated to be about 1 percent of the annual rainfall at Area 5, based on conservative one-dimensional modeling results (Levitt et al., 1998, 1999).

In the unlikely event that water would migrate below the current static zone, movement to the aquifer would be extremely slow due to the low water content of the alluvium. An unsaturated flow model was used to predict estimated travel times for the unretarded movement of water from the bottom of the static zone to the capillary fringe zone of the groundwater table in the uppermost aquifer. The model used Area 5 rainfall data from 1980 to 1993 to help define the upper boundary conditions, hydrological parameter data from the Science Trench Borehole project, and alluvium layer thickness and hydraulic property variation data from Snyder and Gustafson (1994) and other Area 5 characterization work to define the conditions. Two cases were evaluated, one where all the alluvial layers had a constant thickness, and one to capture the variations in grain-size distributions and measured hydrologic parameters through the vadose zone profile. Shott et al. (1988) reported that after applying statistics to 7500 model realizations for each case, the mean travel time was over 55,000 years for both cases. The modelers concluded that there is a 95 percent probability that the travel time (under the assumption that horizontal layer thickness is uniformly distributed between 0.6 and 2.6 m [1.9 and 8.5 ft]) is between 31,795 to 101,944 years.

Given the lysimeter data that indicates less than 1 percent of precipitation is thought to make it down to 2 m (much less below the static zone which extends to from 40 to 90 m [131 to 295 ft] below the ground surface at UE5PW-1), and the modeled slow travel rates, no recharge is occurring within the vicinity of the Area 5 RWMS under current climatic conditions.

Even if sufficient water could get into the waste to create a leachate contaminated with radionuclides, and if recharge were to occur, significant decay would occur over the thousands of years required to reach the groundwater. Groundwater is therefore an unlikely pathway of contaminant transport with respect to the shallow waste cells of the Area 5 RWMS.

More recent vadose zone studies by Walvoord, Plummer, et al. (2002) and Walvoord, Phillips, et al. (2002) support and extend the conceptual moisture and contaminant transport vadose zone model for the Area 5 RWMS. Wolfsberg and Stauffer (2003) refined estimates of upward liquid flux and confirmed they are low.

The conceptual model for radionuclide transport and release at the Area 5 RWMS therefore focuses on the upward transport of soluble radionuclides by liquid advection and diffusion with retardation, the movement of soluble and particulate radionuclides by plants and burrowing animals, and the movement of gaseous radionuclides by diffusion with the liquid phase.

The PA model incorporates the hydrological and contaminant transport conceptual models to evaluate potential exposures of people to contaminants in the future under various land use and inadvertent intrusion scenarios.

6.2 PERFORMANCE ASSESSMENT AND COMPOSITE ANALYSIS

A PA is a systematic analysis of potential risks, and includes a comparison of those risks to the established performance objectives. A PA is conducted to provide the NNSA/NSO with reasonable expectation that disposal of LLW will meet radiological performance objectives for long-term protection of the public and the environment, as established in DOE Manual (M) 435.1-1. Regulated LLW under DOE O 435.1 is limited to waste disposed from September 26, 1988, to the assumed closure date.

Composite Analyses (CA) are planning tools used by the NNSA/NSO to ensure that the combined effect of all sources of residual radioactive material that could contribute to the dose calculated from disposal facilities will not compromise requirements for future radiological protection of the public and environment. The CA takes into account all potential sources including the waste deposited before September 26, 1988, and any classified materials. Potential sources of contaminants in the vicinity of the Area 5 RWMS considered for the Area 5 RWMS CA included the:

- Frenchman Flat UGTA,
- Frenchman Flat Playa soil site which is an area of soil contaminated by historic atmospheric nuclear weapons tests,
- GMX soil site which is an area of plutonium-contaminated soil created by historic non-nuclear detonations of nuclear weapons components.

Annual reviews of the adequacy of the PAs and CAs are recommended under the *Maintenance Plan for the Performance Assessments and Composite Analyses for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site* (BN, 2000a). They are required under the *Disposal Authorization Statement for the Department of Energy Nevada Operations Office Nevada Test Site Area 5 Radioactive Waste Management Site* (DOE, 2000a). These annual reviews and resulting reports provide interim updates between PA and CA document revisions and progress on meeting conditions and provisions in the Disposal Authorization Statement (DAS). Addendum reports to the PA and CA have also been issued (BN, 2001a, 2001b). The process of review and revision ensures that the analyses intended to ensure protection of the public and environment are conducted with the best data available at the time.

Monitoring during operation of a facility, closure of that facility, and monitoring after closure are inextricably tied to the PA and CA. The PA and CA provide information useful for designing a monitoring plan and for determining the best method of closure to realize radiological protection of the public and environment. Conversely, results obtained through monitoring are part of the data needed to revise the PA and CA. Documents related to the PA and CA and to the ICMP (BN, 2005a) include the Auditable Safety Analysis (BN, 2000b), the NTSWAC (NNSA/NSO, 2005), and the RREMP (BN, 2003a).

A PA and a CA have been completed for the Area 5 RWMSs (Shott et al., 1998; BN, 2001c). The PA was reviewed and approved, with conditions, by DOE/Headquarters in 1996. A conditional DAS (DOE, 2000a) was issued for the Area 5 RWMS in FY 2001 following the review of the CA. The DAS conditions were removed in May 2002 with acceptance of the PA addendum (BN, 2001a). Another PA was completed specifically for the TRU material placed in four GCD boreholes (Cochran, Beyeler, et al., 2001).

In the PA of the Area 5 RWMSs (Shott et al., 1998), the analyses assumed that the closure cover would consist of native alluvium, with its thickness corresponding to the thickness of the operational cover. The hydrogeologic properties of the cover material used in the models were based on results of field and laboratory tests. The assessments were done under closure conditions that were assumed to be more adverse than would likely occur. In the Area 5 RWMS PA, as a base case, the closure cover was assumed not to subside. As a worst case, the closure cover was assumed to thin, crack, and subside below grade. Performance objectives and results of modeling conducted for the PA are shown in Table 4.2 of the *Integrated Closure and Monitoring Plan* (BN, 2005a). Based on these analyses, the Area 5 RWMS meets performance objectives by a wide margin. The dose from all interacting sources to a member of the public is calculated for the Area 5 RWMSs to be 7 mrem/yr. The CA performance objective is 100 mrem/yr (BN, 2005a).

The PA evaluates the potential exposures to people in the future for various land-use scenarios including recreation, ranching, and a non-commercial farmer residing at the NTS boundary. Land-use plans and use restrictions are assumed to prohibit construction and well drilling within the site boundaries in perpetuity, but if administrative restrictions are ineffective, the PA also models inadvertent intrusions in the landfill area, resulting in exhumed contaminants and residency in the resulting contaminated area. The scenarios include excavation to construct a house and drilling to install a well. Modeling results indicate potential doses to a member of the public at the relevant points of compliance for each pathway and the scenario met the performance objectives by wide margins. The Area 5 RWMS also achieves the intruder protection, radon flux density, and groundwater protection objectives by wide margins.

Progress on the conversion and integration of the approved Area 5 RWMS PA model into a probabilistic, dynamic modeling platform using Golder Associates GoldSim® computer code is presented in the 2002 Annual Summary Report (BN, 2003c). Addendum 2 of the Area 5 RWMS PA is scheduled to be published in Fiscal Year 2006 and will include:

- Presentation of results of the Area5 RWMS goldsim® model with updated input parameter distributions and processes; updated closure inventory estimates; and
- Modifications to address the reduction of the regulatory compliance period from 10,000 to 1,000 years to be consistent with the latest DOE guidance (DOE O 435.1 which superseded O 5820.2A).

Monitoring results continue to support PA assumptions and models. The biotic transport model has been refined with the results of new more-detailed studies of plant rooting and animal burrowing characteristics. Site-specific measurements of the Radon-222 effective diffusion coefficient in cover material have also been incorporated in the model. Preliminary data suggests Addendum 2 of the PA will demonstrate that the Area 5 RWMS continues to meet all performance objectives by wide margins.

The DOE Office of Site Closure and the DOE Office of Environment also approved the PA report for TRU material in four GCD boreholes (Cochran, Beyeler, et al., 2001) on the recommendation of the Transuranic Waste Disposal Facility Federal Review Group (DOE Memorandum, February 5, 2002). In the GCD PA, future inadvertent exposure scenarios modeled included an off-site resident farmer and an on-site homebuilder who drills a groundwater well through a GCD borehole location. The model took into account many transport processes including dissolution, precipitation, reversible chemical sorption onto soil, advection, diffusion, dispersion, radioactive decay, plant uptake, and bioturbation. Calculated potential whole body and lung radiation doses for all scenarios were far below regulatory limits. One model scenario included both the TRU material and the other non-TRU material disposed in GCD boreholes GCD-01C, GCD-02C, GCD-03C and GCD-04C.

The GCD PA also evaluated potential effects of subsidence and climate change to a wetter and cooler glacial climate. The PA concluded that even if subsidence and a glacial climate began just 170 years from now, surface water would not infiltrate and reach the groundwater table in 10,000 yrs (Cochran, Beyeler, et al., 2001).

The purpose of the CA is to determine if continuing operation of the Area 5 RWMS poses an acceptable risk to the public considering the total waste inventory and all other interacting sources of radioactive material in the vicinity. The CA for the Area 5 RWMS indicates the combined TEDE for the Area 5 RWMS and the three contaminated soil sites in Frenchman Flat will be far below the 100 mrem dose limit throughout the 1,000-yr compliance period. If land use controls are assumed to be effective at limiting the groundwater dose from the Frenchman Flat UGTA, the combined TEDE for the Area 5 RWMS and the three contaminated soil sites will also remain below the 30mrem dose constraint throughout the 1,000-yr compliance period. 1,000 yrs from now, the annual TEDE for a future resident of the Area 5 RWMS is estimated to be 1 mrem. The highest TEDE for an individual source, 6 mrem per year, is expected at the GMX soil site at 250 years after closure. These doses change very little from 250 to 1000 yrs after closure (BN, 2001c).

An Addendum to the CA (BN, November 2001b) provided “Supplemental Information” in response to comments generated during DOE Headquarters review of the CA. The “Supplemental Information” was reviewed and accepted by the Low-Level Waste Disposal Facility Federal Review Group, known as LFRG. Much of the requested information consisted of clarifications. The Addendum also presents a crosswalk of the PA and CA models for both the Area 3 and the Area 5 RWMSs which was used primarily to address questions regarding consistency of models and model parameter values. The Addendum also expanded the discussion of how DOE addresses maintaining doses ALARA at the NTS, and refers to the ALARA analysis presented in the PA. The cost-benefit analysis indicated that the only significant radiation exposure to an individual or population in the Frenchman Flat Basin can occur as the result of the loss of institutional control, and that there are no cost-effective alternatives in the Area 5 operation which would result in a significantly lower individual or population dose (BN, 2001b).

7.0 CLOSURE PLANNING

7.1 REGULATORY CONTEXT

The current DOE Order governing management of radioactive waste is 435.1 (DOE, 1999). Closure standards are presented in DOE Order 435.1, Title 40 CFR 265, Title 40 CFR 191, NAC 444.743, and RCRA requirements as incorporated in NAC 444.8632. Monitoring standards are included in DOE Order 435.1, DOE Order 450.1, Title 40 CFR 61, Title 40 CFR 264, Title 40 CFR 265, and Title 40 CFR 191. A summary of the key requirements is in the ICMP (BN, 2005a).

7.2 EXISTING SUPPORTING DOCUMENTS

The DOE M 435.1 and DOE Guidance 435.1-1, which specifies that preliminary closure and monitoring plans for a LLW management facility be developed and initially submitted with the PA and CA for that facility are associated with the DOE Order 435.1. Development of these plans is also a condition of the Disposal Authorization Statements issued for the Area 5 RWMS. Key documents in place for the Area 5 RWMS include the following:

- PA for the Area 5 RWMS at the NTS, Nye County, Nevada, Revision 2.1 (Shott et al., 1998). The second addendum to the PA is due out in Fiscal Year 2006.
- Composite Analysis for the Area 5 RWMS at the NTS, Nye County, Nevada (BN, 2001c).
- Consequences of Subsidence for the Area 3 and Area 5 RWMSs, Nevada Test Site (DOE, 1998).
- Integrated Closure and Monitoring Plan for the Areas 3 and 5 RWMSs at the NTS (BN, June 2005a).
- Disposal Authorization Statement for the DOE/NV NTS Area 5 RWMS (DOE, 2000a).
- NTSWAC, Revision 6 (NNSA/NSO, 2005a).

The previous characterization report, *Characterization Report*, *Operational Closure Covers for the Area 5 Radioactive Waste Management Site at the Nevada Test Site,* DOE /NV/11718 – 758, Rev. 1 (BN, 2005d) includes an annotated bibliography of selected references relevant to the characterization and closure of the Area 5 RWMS, an extensive photo log, and the analytical reports for a 2002 evaluation of the properties of the operational closure covers. This report supplements the previous report with a focus on summarizing characteristics affecting future potential water and contaminant transport and is in a format similar to the FFACO CAU 110 Characterization Report.

The ICMP (BN, 2005a) for closing and monitoring both RWMSs was developed in 2001, and revised in 2005. The ICMP defines the approach and schedule for both closing and monitoring the Area 3 RWMS and Area 5 RWMS sites. The closure and monitoring plans were integrated for efficiency because much of the information that would be included in individual plans is the same.

The conceptual closure approach consists of ensuring that the performance of the actual cover at least meets that modeled in the PAs. The actual cover will be vegetated monolayer, using evapotranspiration, with the monolayer comprised of native alluvium. Throughout a period of active institutional control, the cover will be maintained at its proper thickness by infilling subsided areas and cracks. Performance of the cover will be monitored at a frequency and for a period to be determined based on observed trends in monitoring data.

A single cover and post-closure monitoring program can be developed that meets the needs of all of the disposal units within the 92-Acre Area of the Area 5 RWMS. The regulatory status and closure requirements for each unit depend on the type of waste, when it was disposed, and permitting. Closure units have been defined for subsets of the waste disposal units based on waste type and regulatory status. Each closure unit will be closed in accordance with the pertinent requirements.

7.3 ANTICIPATED SCHEDULE

Activities associated with final closure of the 92-Acre Area of the Area 5 RWMS started in FY 2005 and are anticipated to be completed by FY 2011. Activities associated with final closure of the Area 5 RWMS Expansion Area are expected to begin in FY 2019 and be completed in FY 2021. Final closure activities at the Area 3 RWMS are expected between FY 2006 and FY 2008.

8.0 WORK IN PROGRESS

There are several ongoing monitoring programs and planned studies that will provide additional characterization data in the near future. The anticipated data will primarily support compliance and PAs. The existing body of site characterization data collected over the past three decades provides ample basis for closure planning at the Area 5 RWMS.

New products expected by the end of FY 2005, concurrent with the development of this document, include the formal publication of key characterization reports for the Area 5 RWMS originally prepared by NNSA contractors. Five reports relevant to the Area 5 RWMS were reviewed and revised to bring them up to current DOE publication standards. The reports which entered the DOE Scientific and Technical Information Product review process in FY 2005 are listed in Table 8-1. Several of these have been referenced in this report.

Table 8-1. Updated Documents

Document	NNSA Document Identification
BN, 2005a: Integrated Closure and Monitoring Plan for the Area 3 and Area 5 Radioactive Waste Management Sites at the Nevada Test Site	DOE/NV/11718--449-Rev 2
BN, 2005d: Re-release of BN ,2002: Characterization Report Operational Closure Covers for the Area 5 Radioactive Waste Management Site at the Nevada Test Site	DOE/NV/11718--758- Rev 1
BN, 2005: Re-release of Lee, YJ; Van Remortel, RD; Snyder, KE (1996): Soil Characterization Database for the Area 5 Radioactive Waste Management Site, Nevada Test Site, Nye County, Nevada	DOE/NV/11718--1014
BN, 2005g: Re-release of REECo (1994): Hydrogeologic Characterization Data from the Area 5 Shallow Soil Trenches, Nevada Test Site, Nye	DOE/NV/11718--1060
BN, 2005e: Combined re-release of REECo (1994): Site Characterization and Monitoring Data from Area 5 Pilot Wells, Nevada Test Site, Nye County, Nevada and REECo (1993): Site Characterization and Monitoring Data from Area 5 Pilot Wells Nevada Test Site Nye County, Nevada. Appendices A through I	DOE/NV/11718--1067

New products expected by the end of FY 2006 include:

- An addendum updating the PA.
- An annual data report for the Area 5 RWMS Groundwater Monitoring Program.
- An annual data report for the Waste Management Monitoring Program which summarizes radiation exposure, air quality, groundwater, meteorology, vadose zone, biota tritium, and cover subsidence monitoring data for both the Area 3 and Area 5 RWMS.
- A report on the historic waste inventory records.

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9.0 CONCLUSIONS AND RECOMMENDATIONS

9.1 CONCLUSIONS

Much characterization, environmental monitoring, and transport modeling work has been performed in the vicinity of the Area 5 RWMS over the past several decades to assess facility performance. The potential pathways for contaminant transport have been well defined. The results show the potential for release and transport of radionuclides from the waste facility is very low. The natural setting restricts potential movement of contaminants with minimum controls.

Although most of the radioactive inventory is relatively immobile, there is some tritium, a volatile radionuclide that can readily move with water. Tritium should continue to be closely monitored, particularly in the vicinity of GCD-05U, the main tritium waste disposal cell. The current monitoring program consists of periodic monitoring of soil gas, air moisture, and biota, and is adequate to catch any release of tritium in a timely manner.

The quality of waste tracking has improved over time, as operational needs and regulations became more stringent. Current waste-tracking systems are very detailed and accurate. Although the historic public unclassified waste records are not complete, much about the nature of the waste is known from process data. The nature of the waste is adequately defined to safely close the site without further assessment.

This characterization work and the PAs completed to date indicate that the regulatory performance objectives for the closure of the Area 5 RWMS have been and will continue to be met. The existing monitoring programs should be continued and reevaluated as needed under the PA.

9.2 RECOMMENDATIONS

- Continue with site monitoring and reporting activities.
- Proceed with development of the Closure Plans for the Area 5 RWMS.

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APPENDIX A

NTS WASTE DISPOSAL RECORD SUMMARIES

1961-2004

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NTS WASTE DISPOSAL RECORDS - PAPER

Location	Ship Cnt	First Disposal	Last Disposal	Ext Vol (ft^3)	Curies
T01C	72	10/10/1965	5/19/1976	17695.8	2093.55409
T01U	391	1/7/1961	4/1/1989	29418.2	8.8899325
T02U	73	7/5/1972	5/5/1978	35026.4	2.84048194
T03C	158	8/26/1969	12/10/1976	25116.6	2006.87325
T04U	573	2/25/1970	9/21/1977	47712.18	888.073779
T05C	1	1/31/1974	1/31/1974	2000	0.0002
T06U	845	7/1/1965	5/25/1970	166139.218	12620.2522
T07U	111	5/16/1978	9/22/1978	90155	1.78273632
UNKN	13	6/30/1970	12/16/1976	1346.05	0.9986112
TOTALS	**2237**			**414609.448**	**17623.26528**

Source: Bechtel Nevada, Personnal Communication, R. Denton, September 15, 2005.

Summary of data from legible scanned historic NTS radioactive waste disposal records (paper records). Paper records span from 1961 through 1978.

NTS WASTE DISPOSAL RECORDS - RWMS

Location	First Disposal	Last Disposal	Ext Vol (m3)	Ext Vol (ft3)	Curies
P01U	3/12/1979	4/24/1985	46612.04712	1646104.444	2214643.893
P02U	12/18/1984	11/19/1995	25115.15245	886941.6088	201013.6639
P03U	3/25/1986	8/29/1992	68129.68064	2405999.672	141692.9205
P04U	6/14/1988	10/25/1995	43819.37887	1547481.365	35157.69981
P06U	12/3/1994	12/3/1995	507.455	17920.77333	38.95556174
T02C	11/7/1988	9/28/1992	1268.083686	44782.37537	119.670152
T03U	3/2/1992	9/10/1992	673.235168	23775.29996	2.0465447
T04C	12/12/1985	1/31/1992	349.85981	12355.29919	41.34241655
T04U	3/31/1976	11/29/1977	62.976	2223.99744	670900.0609
T07U			664.74	23475.2931	0.343301715
U5RWMS04C	7/19/1985	1/14/1987	56.271	1987.210365	16.8704
U5RWMS05U	2/5/1986	4/8/1987	76.538	2702.93947	1947490.031
U5RWMS06U	7/16/1986	2/20/1987	6.7677	239.0013255	6530.92
U5RWMS07C	7/7/1989	7/7/1989	10.873728	384.0057043	1.885
U5RWMS10U	12/11/1987	10/27/1989	57.72827	2038.673855	602624.6209
TOTAL			**187410.7874**	**6618411.959**	**5820274.923**

Source: Bechtel Nevada, Personnal Communication, R. Denton, September 15, 2005.

Summary of radioactive waste disposal data from the Radioactive Waste Management System database which was developed and implemented in 1988. This database was replaced by the Low Level Waste Information System in 1992. The data period covered by the RWMS database overlaps with the paper records.

NTS WASTE DISPOSAL RECORDS - LWIS

Location	First Disposal	Last Disposal	Ext Vol (ft3)	Curies
P03U	9/11/1996	9/25/2003	17633.5338	0.060459215
P04U	10/1/1992	6/8/1995	935852.493	79846.8344
P05U	5/15/1995	5/25/2004	2153116.14	2148720.19
P06U	12/3/1994	4/25/2002	159009.407	248.517483
P06UA	2/13/2003	6/28/2004	253621.959	108.313865
P07U	9/15/1997	2/10/2003	180912.51	66.0598055
P08U	5/21/2002	7/1/2004	592807.046	188285.59
P09U	12/10/2003	6/28/2004	29972.5915	66.8851214
P10C	6/24/2002	7/1/2004	818133.14	44930.794
P11U	1/27/2004	6/30/2004	74876.592	13683.1928
T02C	10/1/1992	7/22/1993	15196.4476	23.0380161
T04C	6/23/1993	8/3/1995	51231.45	1615.91419
T07C	5/14/2001	4/23/2003	663314.162	2544.34894
T09C	8/3/1995	10/31/2002	43997.9722	71147.6239
Total			**5989675.444**	**2551287.363**

Source: Bechtel Nevada, Personnal Communication, R. Denton, September 15, 2005.

Summary of radioactive waste disposal records from the current database system, October 1, 1992 through December 2004. This includes an overlap of the Nevada Test Site Waste Acceptance Criteria format which was implemented in May 1997 and the Low-Level Waste Information System which was implemented October 1, 1992.

APPENDIX B

CLOSURE INVENTORY PROJECTIONS

FY 2004 Area 5 RWMS Closure Inventory Estimate

Prepared by: G. Shott
Date: 9/7/2005
Program A5 Inventory.gsm
Vers. v2.014
Realizations 500
All activities are decayed to 9/31/2028
All activities are the geometric mean

Nuclide	Pre-1988 Shallow Land Burial Inventory (Ci)	Post 1988 Shallow Land Burial Inventory (Ci)†	Lower Cell of Pit 6 Inventory (Ci)	Pit 13 Inventory (Ci)†	Pre-1988 GCD Inventory (Ci)	Post-1988 GCD Inventory (Ci)
H3	8.14E+05	1.59E+06	0.00E+00	0.00E+00	5.61E+05	4.28E+03
C14	6.67E+00	3.63E+00	0.00E+00	0.00E+00	5.81E-07	0.00E+00
Al26	2.16E-04	9.15E-07	0.00E+00	0.00E+00	2.09E-11	0.00E+00
Cl36	1.21E+00	5.74E-03	0.00E+00	0.00E+00	1.28E-07	0.00E+00
Ar39	5.53E+00	2.51E-02	0.00E+00	0.00E+00	5.77E-07	0.00E+00
K40	3.14E-01	2.40E-01	0.00E+00	0.00E+00	3.44E-08	0.00E+00
Ca41	8.64E+00	3.92E-02	0.00E+00	0.00E+00	8.83E-07	0.00E+00
Ni59	2.30E-01	9.43E-03	0.00E+00	0.00E+00	2.28E-08	0.00E+00
Ni63	1.73E+01	2.57E+00	0.00E+00	0.00E+00	1.98E-06	0.00E+00
Co60	4.67E+01	1.06E+01	0.00E+00	0.00E+00	2.94E+01	0.00E+00
Kr85	1.05E+01	3.20E-02	0.00E+00	0.00E+00	5.55E-07	0.00E+00
Sr90	4.65E+04	8.49E+02	4.93E-04	0.00E+00	2.03E+05	2.29E-03
Zr93	2.95E-02	1.43E-04	0.00E+00	0.00E+00	3.22E-09	0.00E+00
Nb93m	2.84E+00	2.36E-02	0.00E+00	0.00E+00	5.38E-07	0.00E+00
Nb94	7.21E+00	3.18E-02	0.00E+00	0.00E+00	7.47E-07	0.00E+00
Tc99	2.80E+02	4.58E+03	2.53E-02	0.00E+00	2.56E-01	1.26E-01
Pd107	1.32E-03	5.93E-06	0.00E+00	0.00E+00	1.45E-10	0.00E+00
Cd113m	2.34E+00	2.26E-02	0.00E+00	0.00E+00	5.04E-07	0.00E+00
Sn121m	6.48E+01	3.45E-01	0.00E+00	0.00E+00	7.77E-06	0.00E+00
Sn126	1.28E-02	6.85E-05	0.00E+00	0.00E+00	1.40E-09	0.00E+00
I129	9.41E-04	4.06E-02	0.00E+00	0.00E+00	7.42E-11	0.00E+00
Ba133	4.49E-03	7.79E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cs135	2.31E-02	1.08E-04	0.00E+00	0.00E+00	2.52E-09	0.00E+00
Cs137	6.54E+04	2.05E+04	0.00E+00	0.00E+00	9.02E+03	0.00E+00
Eu150	9.49E+00	5.01E-02	0.00E+00	0.00E+00	1.08E-06	0.00E+00
Eu152	6.15E+01	2.82E-01	0.00E+00	0.00E+00	3.93E-06	0.00E+00
Eu154	6.74E+00	8.00E-02	0.00E+00	0.00E+00	8.11E-07	0.00E+00
Sm151	2.69E+01	1.38E-01	0.00E+00	0.00E+00	3.31E-06	0.00E+00
Ho166m	2.76E-01	1.22E-03	0.00E+00	0.00E+00	2.87E-08	0.00E+00
Bi207	1.23E-05	1.82E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Pb210	2.61E+01	1.97E+00	1.78E-01	1.03E+00	7.48E+01	9.15E-07
Ra226	3.39E+01	2.44E+00	5.06E-01	2.19E+00	1.00E+02	3.01E-06
Ra226	3.39E+01	2.44E+00	5.06E-01	2.19E+00	1.00E+02	3.01E-06
Ra228	1.23E+00	2.04E+01	1.57E+02	1.38E+02	2.01E-02	6.24E-19
Ac227	2.85E-01	1.01E-01	6.46E-05	0.00E+00	2.85E+00	1.32E-05
Th228	1.63E+00	2.32E+01	1.56E+02	1.34E+02	2.00E-02	5.27E-19
Th229	4.14E-03	2.23E-02	1.31E-01	0.00E+00	2.19E-09	1.16E-09
Th230	9.99E-01	1.18E+01	3.93E+01	3.54E+01	2.33E-03	3.62E-04
Th232	1.24E+00	2.16E+01	1.60E+02	1.47E+02	2.03E-02	9.44E-19
Pa231	1.76E-01	1.32E-01	1.73E-04	0.00E+00	2.00E-04	3.10E-05
U232	2.96E-01	2.27E+00	0.00E+00	0.00E+00	3.50E-08	0.00E+00
U233	8.86E-01	9.52E+00	4.90E+01	0.00E+00	1.11E-06	6.37E-07
U234	1.94E+03	2.66E+03	4.80E+00	0.00E+00	5.87E+00	1.02E+00
U235	7.88E+01	1.17E+02	2.56E-01	0.00E+00	2.19E-01	3.81E-02
U236	2.41E+01	7.83E+01	4.90E-03	0.00E+00	1.73E-02	9.92E-10
U238	2.20E+03	4.86E+03	5.96E+00	0.00E+00	9.97E-01	1.90E+00
Np237	5.39E+00	1.51E+00	2.25E-05	0.00E+00	6.73E-03	3.80E-03
Pu238	1.60E+02	1.00E+02	3.83E-01	0.00E+00	4.70E+00	7.38E-05
Pu239	3.22E+02	1.38E+02	9.20E-05	0.00E+00	2.60E+02	4.14E-03
Pu240	7.51E+01	3.17E+01	0.00E+00	0.00E+00	5.85E+01	8.68E-04
Pu241	9.01E+01	8.72E+01	2.91E-01	0.00E+00	6.34E+01	1.26E-03
Pu242	1.62E-02	1.73E+01	0.00E+00	0.00E+00	5.63E-03	0.00E+00
Pu244	1.39E-01	2.19E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Am241	1.02E+02	3.13E+01	2.71E-02	0.00E+00	1.09E+02	7.70E-04
Am243	1.14E-02	1.08E-02	0.00E+00	0.00E+00	2.93E-10	0.00E+00
Cm243	1.28E-01	9.46E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm244	1.95E+00	6.74E+00	0.00E+00	0.00E+00	6.63E-08	0.00E+00
Cm245	3.34E-06	8.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm246	1.93E-06	1.32E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cm248	1.66E-06	6.84E-08	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Cf250	6.33E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

† Includes estimated future inventory

APPENDIX C

AREA 5 SAMPLING AND MONITORING LOCATIONS

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
10848	U-5A	BH EMP	EXPENDED	NV ST PLN-NAD27	753500	709999	FT	-115.950092	36.817962	3086	3086	FT
10849	U-5A PS #1A	BH POST SHOT	ACTIVE	NV ST PLN-NAD27	753266	709885	FT	-115.95049	36.817322	3083	3083	FT
10861	UE-5C WATER WELL	BH EXPL	ACTIVE	NV ST PLN-NAD27	760133	700997	FT	-115.980683	36.836362	3216	3216	FT
10862	U-5D	BH EMP	ACTIVE	NV ST PLN-NAD27	756600	707901	FT	-115.957181	36.82652	3120	3120	FT
10863	U-5E	BH EMP	EXPENDED	NV ST PLN-NAD27	755419	704831	FT	-115.967699	36.823338	3137	3137	FT
10864	U-5E PS #1A	BH POST SHOT	ACTIVE	NV ST PLN-NAD27	755823	704831	FT	-115.967689	36.824448	3136	3136	FT
10867	UE-5F	BH EXPL	ACTIVE	NV ST PLN-NAD27	772499	710901	FT	-115.946521	36.870128	3301	3301	FT
10868	U-5G	BH EMP	ACTIVE	NV ST PLN-NAD27	752542	709097	FT	-115.953198	36.815349			FT
10870	UE-5I	BH EXPL	PLUGGED	NV ST PLN-NAD27	775216	709282	FT	-115.951986	36.877624	3427	3427	FT
10871	U-5I FOIL RECOVERY HOLE	BH TEST	ACTIVE	NV ST PLN-NAD27	774447	709415	FT	-115.951551	36.875509	3395	3395	FT
10872	U-5I CABLE HOLE #1	BH CABLE	PLUGGED	NV ST PLN-NAD27	774755	709458	FT	-115.951396	36.876354	3404	3404	FT
10874	U-5I PS #1A	BH POST SHOT	ACTIVE	NV ST PLN-NAD27	774924	709798	FT	-115.95023	36.876811	3404	3404	FT
10877	U-5K	BH EMP	EXPENDED	NV ST PLN-NAD27	773094	715146	FT	-115.931994	36.871673	3349	3349	FT

Data extracted September 2005 from the Bechtel Integrated Data Management System (BEIDMS)

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
10878	UE-5K	BH EXPL	PLUGGED	NV ST PLN-NAD27	773094	715247	FT	-115.931649	36.871671	3349	3349	FT
10879	U-5L	BH EMP	PLUGGED	NV ST PLN-NAD27	773094	713147	FT	-115.938828	36.871715			FT
10881	UE-5M	BH EXPL	ACTIVE	NV ST PLN-NAD27	732500	682000	FT	-116.046211	36.760818			FT
10883	RNM #1	BH RNM	ACTIVE	NV ST PLN-NAD27	755823	704831	FT	-115.967689	36.824448	3136	3136	FT
10853	WATER WELL 5A	WL POT	ACTIVE	NV ST PLN-NAD27	738361	707514	FT	-115.958964	36.77643	3093	3093	FT
10854	U-5B	BH EMP	EXPENDED	NV ST PLN-NAD27	753500	707999	FT	-115.956925	36.818003	3095	3095	FT
10855	U-5B PS #1A	BH POST SHOT	ACTIVE	NV ST PLN-NAD27	753698	707802	FT	-115.957593	36.818551	3095	3095	FT
10858	WATER WELL 5B	WL POT	ACTIVE	NV ST PLN-NAD27	747359	704263	FT	-115.969841	36.801211	3092	3092	FT
10859	U-5C	BH EMP	ACTIVE	NV ST PLN-NAD27	754800	709000	FT	-115.953472	36.821553	3100	3100	FT
10860	WATER WELL 5C	WL POT	ACTIVE	NV ST PLN-NAD27	742860	705888	FT	-115.964403	36.788821	3081	3081	FT
10893	U-5 RWMS #6U	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27			FT					FT
10894	U-5 RWMS #7C	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27	767625	708217	FT	-115.955821	36.856796			FT
10895	U-5 RWMS #8C	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27	767601	708208	FT	-115.955852	36.85673			FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
10896	U-5 RWMS #9U	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27	767407	708087	FT	-115.956271	36.8562			FT
10897	U-5 RWMS #10U	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27	767427	708103	FT	-115.956215	36.856254			FT
10898	U-5 RWMS #11U	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27			FT					FT
10899	U-5 RWMS #12U	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27			FT					FT
10900	RCRA #1	BH EM	ACTIVE	NV ST PLN-NAD27			FT					FT
10901	USGS HTH #3	BH HTH	ACTIVE	NV ST PLN-NAD27	750189	736937	FT	-115.858162	36.808279	3477	3477	FT
10884	RNM #2	BH RNM	ACTIVE	NV ST PLN-NAD27	755264	705088	FT	-115.966825	36.822907	3132	3132	FT
10869	U-5I MINING	SHAFT	EXPENDED	NV ST PLN-NAD27	774568	709412	FT	-115.951559	36.875841	3395	3395	FT
10905	TEST HOLE #1	BH TEST	PLUGGED	NV ST PLN-NAD27	766241	709337	FT	-115.952028	36.852971			FT
10906	TEST HOLE #1A	BH TEST	ACTIVE	NV ST PLN-NAD27			FT					FT
10907	TEST HOLE #2	BH TEST	ACTIVE	NV ST PLN-NAD27	766771	709435	FT	-115.95168	36.854425			FT
10908	U-5 SEISMIC #1	BH SEISMIC	PLUGGED	NV ST PLN-NAD27	749607	668099	FT	-116.093317	36.808045	3869	3869	FT
10909	U-5 SEISMIC #2	BH SEISMIC	PLUGGED	NV ST PLN-NAD27	749623	668122	FT	-116.093238	36.808089	3868	3868	FT
10910	UE5PW-1	BH EM	ACTIVE	NV ST PLN-NAD27	765702	709832	FT	-115.95035	36.851481	3177.99	3180.35	FT
10911	UE5PW-2	BH EM	ACTIVE	NV ST PLN-NAD27	770395	709894	FT	-115.950018	36.86437	3246.23	3248.42	FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
10912	UE5PW-3	BH EM	ACTIVE	NV ST PLN-NAD27	771291	703460	FT	-115.971989	36.866961	3295.51	3297.97	FT
10902	TEST HOLE #4	BH TEST	PLUGGED	NV ST PLN-NAD27	763910	689551	FT	-116.019708	36.846956	3405	3405	FT
10885	RNM #2S	BH RNM	ACTIVE	NV ST PLN-NAD27	755200	704809	FT	-115.96778	36.822737	3133	3133	FT
10886	U-5 RNM #3	BH RNM	PLUGGED	NV ST PLN-NAD27			FT					FT
10887	U-5 RNM #4	BH RNM	ACTIVE	NV ST PLN-NAD27			FT					FT
10888	U-5 RNM #5	BH RNM	ACTIVE	NV ST PLN-NAD27	754015	706383	FT	-115.962432	36.81945	3111	3111	FT
10889	U-5 RWMS CONTROL #1	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27			FT					FT
10890	U-5 RWMS #4C	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27			FT					FT
10891	U-5 RWMS #5	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27			FT					FT
10892	U-5 RWMS #5U	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27			FT					FT
10882	UE-5N	BH EXPL	ACTIVE	NV ST PLN-NAD27	754460	706415	FT	-115.962312	36.820672	3112	3112	FT
10903	TEST HOLE #5	BH TEST	PLUGGED	NV ST PLN-NAD27	734799	690124	FT	-116.018424	36.766985	3233	3233	FT
1614	3.3 MILES SE OF AGGREGATE PIT	ETLD	ACTIVE	UTM Z11 meters WGS84	4066275	595702	FT	115.9281	36.737378	3569		FT
1615	CANE SPRING	NS		NV ST PLN-NAD27			FT					FT
1616	DOD	AMS	ACTIVE	NV ST PLN-NAD27	772090	709862	FT	-115.950089011	36.869022275	3301		FT
1617	RWMS EAST 1000	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT

Data extracted September 2005 from the Bechtel Integrated Data Management System (BEIDMS)

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
1618	RWMS EAST 1500	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1619	RWMS EAST 0500	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1620	RWMS EAST GATE	ETLD	ACTIVE	UTM Z11 meters WGS84	4078991	593276	FT	115.95371	36.85223	3174		FT
1621	RWMS MSM-1 EAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1622	RWMS MSM-1 NORTH-NORTHEAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1623	RWMS MSM-1 NORTH-NORTHWEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1624	RWMS MSM-1 NORTHEAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1625	RWMS MSM-1 NORTHWEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1626	RWMS MSM-1 SOUTH-SOUTHEAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1627	RWMS MSM-1 SOUTH-SOUTHWEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1628	RWMS MSM-1 SOUTHEAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1629	RWMS MSM-1 SOUTHWEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1630	RWMS MSM-1 WEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1631	RWMS MSM-2 EAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1632	RWMS MSM-2 NORTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1633	RWMS MSM-2 NORTHEAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1634	RWMS MSM-2 NORTHWEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1635	RWMS MSM-2 SOUTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1636	RWMS MSM-2 SOUTHEAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1637	RWMS MSM-2 SOUTHWEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT

Data extracted September 2005 from the Bechtel Integrated Data Management System (BEIDMS)

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
1638	RWMS MSM-2 WEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1642	RWMS 5 NORTH	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1643	RWMS 6 NORTHWEST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1647	RWMS NORTH 1000	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1648	RWMS NORTH 1500	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1649	RWMS NORTH 0500	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1650	RWMS NORTHEAST CORNER	ETLD	ACTIVE	UTM Z11 meters WGS84	4079605	593461	FT	115.95156	36.85775	3205		FT
1651	RWMS NORTHWEST CORNER	ETLD	ACTIVE	UTM Z11 meters WGS84	4079459	592804	FT	115.95895	36.8565	3194		FT
1652	RWMS OFFICE	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1653	RWMS PIT 5	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1654	RWMS PIT 5 EAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1655	RWMS PIT 5 WEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1656	RWMS SEWAGE POND	SL		NV ST PLN-NAD27			FT					FT
1657	RWMS SOUTH 0500	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1658	RWMS SOUTH GATE	ETLD	ACTIVE	UTM Z11 meters WGS84	4079007	593214	FT	115.9544	36.852378	3174		FT
1659	RWMS SOUTHWEST CORNER	ETLD	ACTIVE	UTM Z11 meters WGS84	4078997	592805	FT	115.95899	36.85233	3168		FT
1660	RWMS TP BUILDING N	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1661	RWMS TP BUILDING S	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1662	RWMS TRU BUILDING NORTH	AMS	INACTIVE	NV ST PLN-NAD27			FT	-115.953925	36.852708 333	3210		FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
1663	RWMS TRU BUILDING SOUTH	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1664	RWMS TRU PAD NORTH	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1665	RWMS TRU PAD NORTHEAST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1666	RWMS TRU PAD NORTHWEST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1667	RWMS TRU PAD SOUTH	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1668	RWMS TRU PAD SOUTHEAST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1669	RWMS TRU PAD SOUTHWEST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1670	RWMS WEST 1000	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1671	RWMS WEST 1500	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1672	RWMS WEST 0500	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
1673	UE-5C WATER WELL RESERVOIR	OR		NV ST PLN-NAD27			FT					FT
1674	WEF EAST	ETLD	ACTIVE	UTM Z11 meters WGS84	4078853	593439	FT	115.9519	36.85097	3195		FT
1675	WEF NORTH	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1676	WEF SOUTH	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1677	WEF WEST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
1678	WATER WELL 5B RESERVOIR	OR		NV ST PLN-NAD27			FT					FT
13592	BOUNDARY STATION 360	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
13593	GATE 200	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13594	RWMS 1 OFFICE	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13595	RWMS 2 SOUTHEAST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
13596	RWMS 3 EAST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13597	RWMS 4 NORTHEAST	AMS	INACTIVE	NV ST PLN-NAD27	767998	709401	FT	-115.951772069	36.857737634	3303		FT
13598	RWMS 5 NORTHWEST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13599	RWMS 6 NORTH	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13600	RWMS 7 WEST	AMS	INACTIVE	NV ST PLN-NAD27			FT	-115.958611667	36.855195	3347		FT
13601	RWMS 8 SOUTHWEST	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13602	RWMS 9 SOUTH	AMS	INACTIVE	NV ST PLN-NAD27			FT	-115.57355	36.511383	3259		FT
13603	RWMS MSM-1 NORTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
13604	RWMS PIT 3	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13605	RWMS PIT 3 NORTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
13606	RWMS PIT 3 SOUTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
13607	RWMS PIT 4	AMS	INACTIVE	NV ST PLN-NAD27			FT					FT
13608	RWMS PIT 4 EAST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
13609	RWMS PIT 4 NORTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
13610	RWMS PIT 4 SOUTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
13611	RWMS PIT 4 WEST	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
151729	WEF NORTHEAST	AMS	INACTIVE	NV ST PLN-NAD27			FT	-115.951561667	36.852063333	3240		FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
151730	WEF SOUTHWEST	AMS	INACTIVE	NV ST PLN-NAD27			FT	-115.953196667	36.850948333	3229		FT
151957	UE5PW-1 MET TOWER	MET	ACTIVE	NV ST PLN-NAD27	766070	709999	FT	-115.949770278	36.852488609	970.7		METERS
151958	L1 MET TOWER	MET	ACTIVE	NV ST PLN-NAD27	765836	706083	FT	-115.963160213	36.851925752	972.9		METERS
152081	UE5PW-2 PPT	PPT	ACTIVE	NV ST PLN-NAD27	770396	709894	FT	-115.950018178	36.864372917		989.6	METERS
152225	WEIGHING LYSIMETER SOUTH	PPT	ACTIVE	NV ST PLN-NAD27	765964	705930	FT	-115.96367991	36.852280418		970	METERS
152226	WEIGHING LYSIMETER NORTH	PPT	ACTIVE	NV ST PLN-NAD27	765964	705930	FT	-115.96367991	36.852280418		970	METERS
152321	WELL 5B	AMS	INACTIVE					-115.582067	36.48065	3200		FT
152322	RWMS GCD TRAILER	AMS	INACTIVE									
152323	RWMS BLDG 5-6 ROOM 4	AMS	INACTIVE	NV ST PLN-NAD27			FT					
153047	P03U-3	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767911	709286	FT	-115.952160075	36.85755991			FT
153048	P03U-4	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767967	709258	FT	-115.952254348	36.857714299			FT
153049	P03U-5	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767938	709258	FT	-115.952255089	36.857634645			FT
153050	P03U-6	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767910	709258	FT	-115.952255805	36.857557738			FT
153051	P03U-7	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767966	709230	FT	-115.952350077	36.857712127			FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
153052	P03U-8	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767938	709230	FT	-115.952350793	36.85763522			FT
153054	P03U-10	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767855	709287	FT	-115.95215809	36.857406075			FT
153055	P03U-11	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767827	709287	FT	-115.952158806	36.857329168			FT
153056	P03U-12	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767882	709258	FT	-115.952256521	36.857480831			FT
153058	P03U-14	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767826	709258	FT	-115.952257953	36.857327016			FT
153059	P03U-15	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767910	709230	FT	-115.952351509	36.857558312			FT
153060	P03U-16	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767882	709230	FT	-115.952352225	36.857481405			FT
153062	P03U-18	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767826	709230	FT	-115.952353657	36.857327591			FT
153063	P03U-19	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767798	709287	FT	-115.952159547	36.857249514			FT
153064	P03U-20	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767798	709259	FT	-115.952255251	36.857250089			FT
153065	P03U-21	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767798	709230	FT	-115.952354373	36.857250684			FT
153068	P03U-24	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767770	709230	FT	-115.952355089	36.857173777			FT
153069	P03U-50	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
153072	P03U-3A	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767752.93	709336.22	FT	-115.951992467	36.857124711		3210.01	FT
153073	P03U-4A	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767605.09	709340.22	FT	-115.951982577	36.856718559		3205.86	FT
153074	P01U-1	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767168.107680876	708549.072733045	FT	-115.95469783	36.855534515		3195.24	FT
153075	P01U-2	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767158.371194891	708568.991253666	FT	-115.954629998	36.855507364		3195.26	FT
153076	P01U-3	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767100.214406686	708538.148533198	FT	-115.954736898	36.855348256		3193.79	FT
153077	P01U-4	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767034.218055542	708446.075903406	FT	-115.955053274	36.855168867		3195.07	FT
153078	P01U-5	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767035.197790819	708509.277968377	FT	-115.954837231	36.855170266		3193.52	FT
153080	P02U-1	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767245.72083031	708232.387693849	FT	-115.955778258	36.855754164		3198.58	FT
153082	P02U-3	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767202.798208333	708281.501005355	FT	-115.955611485	36.855635266		3196.9	FT
153083	P02U-4	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767045.026332834	708160.521978159	FT	-115.956028995	36.855204386		3195.18	FT
153084	P02U-5	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767022.463530358	708219.415739088	FT	-115.955828275	36.855141211		3194.8	FT
153085	P02U-6	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766815.070262009	708079.149390356	FT	-115.956312965	36.854574429		3192.42	FT
153088	P04U-1	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767696.33957121	707681.631267991	FT	-115.957649268	36.857003103		3198.47	FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
153089	P04U-2	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767694.588580887	707730.131482791	FT	-115.95748354	36.856997306		3198.15	FT
153090	P04U-3	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767693.593682384	707794.973091737	FT	-115.957261937	36.856993252		3198.18	FT
153091	P04U-4	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767556.451119449	707694.121870923	FT	-115.957610126	36.856618619		3196.79	FT
153092	P04U-5	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767555.979697105	707734.994051431	FT	-115.957470438	36.856616491		3196.73	FT
153093	P04U-6	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767553.756798275	707794.918041607	FT	-115.957265676	36.856609165		3197.17	FT
153094	P04U-7	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767424.290569793	707688.802493216	FT	-115.957631661	36.856255723		3195.21	FT
153096	P04U-9	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767425.54953431	707786.378484254	FT	-115.95729812	36.856257194		3194.91	FT
153097	P04U-10	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767298.877204496	707706.103354855	FT	-115.957575711	36.855910899		3193.34	FT
153099	P04U-12	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
153100	P04U-13	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767191.786081036	707679.684190884	FT	-115.957668728	36.855617292		3192.29	FT
153101	P04U-14	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767193.586587954	707737.717035451	FT	-115.95747033	36.855621055		3191.84	FT
153102	P04U-15	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767187.208622183	707800.3508747	FT	-115.957256415	36.855602261		3192.12	FT
153104	P04U-17	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767052.261082182	707727.311909032	FT	-115.957509481	36.85523309		3190.26	FT

Data extracted September 2005 from the Bechtel Integrated Data Management System (BEIDMS)

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
153105	P04U-18	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767051.821721218	707800.852192705	FT	-115.957258139	36.855230385		3192.33	FT
153106	P04U-19	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766889.518073576	707702.234736437	FT	-115.957599323	36.854786596		3188.35	FT
153107	P04U-20	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766888.972818574	707745.293565689	FT	-115.957452167	36.854784222		3188.71	FT
153108	P04U-21	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766890.513801928	707794.306564241	FT	-115.957284607	36.854787456		3188.64	FT
153109	P04U-22	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766748.026627134	707701.154752472	FT	-115.957606605	36.854397986		3186.84	FT
153110	P04U-23	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766747.382063871	707744.315666184	FT	-115.957459103	36.854395336		3186.9	FT
153111	P04U-24	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766746.522433184	707792.678315807	FT	-115.957293828	36.85439199		3186.88	FT
153112	P05U-1	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767691.711280677	707500.86668158	FT	-115.958267236	36.85699407		3198.5	FT
153113	P05U-2	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767690.090406763	707535.916651519	FT	-115.958147477	36.856988904		3198.09	FT
153114	P05U-3	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767687.075594501	707570.414564094	FT	-115.95802964	36.856979922		3197.51	FT
153115	P05U-4	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767568.454157872	707488.609124099	FT	-115.958312257	36.85665577		3197.52	FT
153117	P05U-6	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767565.966114048	707568.083208468	FT	-115.958040681	36.856647319		3197.41	FT
153118	NN-1 NORTH	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	768274.83	706467.05	FT	-115.961786094	36.858616697		3204.88	FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
153119	NE-1 EAST	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767229.06	709430.37	FT	-115.95168407	36.855683873		3196.62	FT
153120	NS-1 SOUTH	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	765790.28	708094.05	FT	-115.956288091	36.851759346		3171.16	FT
153122	P06U-1	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
153124	P06U-3	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
153125	P06U-4	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
153067	P03U-23	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767770	709259	FT	-115.952255967	36.857173182			FT
159201	CANE SPRING #1	BIO		NV ST PLN-NAD27			FT					FT
159202	CAMBRIC DITCH/0.0 MI FROM PUMP	BIO		NV ST PLN-NAD27			FT					FT
159241	CAMBRIC DITCH/0.3 MI FROM PUMP	BIO		NV ST PLN-NAD27			FT					FT
159242	CAMBRIC DITCH/0.7 MI FROM PUMP	BIO		NV ST PLN-NAD27			FT					FT
159243	CAMBRIC DITCH/1.0 MI FROM PUMP	BIO		NV ST PLN-NAD27			FT					FT
159741	CANE SPRING #2	BIO		NV ST PLN-NAD27			FT					FT
159742	CANE SPRING #3	BIO		NV ST PLN-NAD27			FT					FT
160021	CAMBRIC DITCH/10 M FROM PUMP	DITCH		NV ST PLN-NAD27			FT					FT
160022	CAMBRIC DITCH/200 M FROM PUMP	DITCH		NV ST PLN-NAD27			FT					FT
160023	CAMBRIC DITCH/500 M FROM PUMP	DITCH		NV ST PLN-NAD27			FT					FT
160024	CAMBRIC DITCH/OUTFLOW TO PLAYA	DITCH		NV ST PLN-NAD27			FT					FT
160441	CAMBRIC DITCH/0.1 MI FROM PUMP	BIO		NV ST PLN-NAD27			FT					FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
897469	BLDG 5-07 WOMENS RESTROOM	POT WTR END PT										
895644	ER-5-3	BH EM	ACTIVE	NV ST PLN-NAD27	773578	713137	FT	-115.938849	36.873045	3334	3334	FT
895645	ER-5-3 #2	BH EM	ACTIVE	NV ST PLN-NAD27	773586	713037	FT	-115.939191	36.873069	3334	3334	FT
727526	WATER WELL 5B-AMS	AMS					FT					FT
727528	WEF NORTH-ETLD	ETLD	ACTIVE	UTM Z11 meters WGS84	4078922	593411	FT	115.95221	36.8516	3158		FT
727529	WEF SOUTH-ETLD	ETLD	ACTIVE	UTM Z11 meters WGS84	4078828	593382	FT	115.95254	36.85075	3157		FT
728704	P03U-22	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767770	709228	FT	- 115.952361 925	36.857173 818			FT
749827	AREA 5 NORTH PER DELETE LATER	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
749828	NE-1 EAST DELETE LATER	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
749829	NW-1 WEST DELETE LATER	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
749830	NS-1 SOUTH DELETE LATER	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
830285	BUILDING 5-6 ROOM 4	AMS					FT					FT
830286	GCD TRAILER	AMS					FT					FT
830292	PIT 6	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
830294	TRENCH 8 SOUTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
830296	WEF COMPOUND FENCE SOUTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
870408	BUILDING 5-7	POT WTR END PT		NV ST PLN-NAD27			FT					FT
878767	90 DAY STORAGE AREA	90 DAY PAD										
153046	P03U-2	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767938	709286	FT	- 115.952159 385	36.857634 07			FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
153053	P03U-9	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767883	709286	FT	-115.952160792	36.857483003			FT
153061	P03U-17	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767854	709230	FT	-115.952352941	36.857404498			FT
153071	P03U-2A	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767845.41	709359.79	FT	-115.951909539	36.85737824		3213.01	FT
153079	P01U-6	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767034.008598411	708539.661343166	FT	-115.954733414	36.855166379		3193.79	FT
153087	P02U-8	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766785.103000653	708139.340387388	FT	-115.956108002	36.85449089		3191.77	FT
153095	P04U-8	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767425.101944558	707730.46259429	FT	-115.957489249	36.856257103		3194.94	FT
153103	P04U-16	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767049.664901581	707694.389298308	FT	-115.957622074	36.85522663		3190.3	FT
153123	P06U-2	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27			FT					FT
153066	P03U-22 DELETE LATER	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767770	709228	FT	-115.952361925	36.857173818			FT
891445	NEUTRON CALIBRATION DATA	BH										
153121	NW-1 WEST	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766695.75	706971.11	FT	-115.960103125	36.854269238		3177.67	FT
830293	PIT 7	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
830291	BLDG 5-31	ETLD	ACTIVE	UTM Z11 meters WGS84	4078981	593438	FT	115.9519	36.852124	3174		FT
10876	UE-5J	BH EXPL	ACTIVE	NV ST PLN-NAD27	775001	684500	FT	-116.03672	36.877513	3578	3578	FT
10880	U-5LS	BH EMP	ACTIVE	NV ST PLN-NAD27	772700	713499	FT	-115.937635	36.870626	3324	3324	FT

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
153116	P05U-5	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767566.523288953	707531.434148736	FT	-115.958165932	36.856649595		3197.6	FT
153086	P02U-7	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	766804.114301895	708104.564590544	FT	-115.956226377	36.854543818		3193.19	FT
153098	P04U-11	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767299.282727368	707738.793471482	FT	-115.957463968	36.855911348		3193.43	FT
153070	P03U-1A	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767906	709357.41	FT	-115.951916124	36.857544711		3212.58	FT
153081	P02U-2	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767216.108962373	708255.038398782	FT	-115.955701593	36.855672367		3197.62	FT
152082	UE5PW-3 PPT	PPT	ACTIVE	NV ST PLN-NAD27	771291	703460	FT	-115.971989373	36.866961624		1005	METERS
153045	P03U-1	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767966	709286	FT	-115.952158669	36.857710978			FT
153057	P03U-13	ACCESS TUBE	ACTIVE	NV ST PLN-NAD27	767854	709258	FT	-115.952257237	36.857403924			FT
727527	WATER WELL 5B-ETLD	ETLD	ACTIVE	UTM Z11 meters WGS84	4073315	591903	FT	115.9698	36.801211	3092		FT
830295	WEF COMPOUND FENCE NORTH	ETLD	INACTIVE	NV ST PLN-NAD27			FT					FT
902101	GCD05U-10A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902102	GCD05U-10B	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902103	GCD05U-20A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902105	GCD05U-30A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902106	GCD05U-30B	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
902107	GCD05U-40A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902108	GCD05U-40B	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902109	GCD05U-50A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902110	GCD05U-50B	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902111	GCD05U-65A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902112	GCD05U-65B	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902113	GCD05U-85A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902114	GCD05U-85B	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902116	GCD05U-119A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
902115	GCD05U-110A	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT
903964	RWMS LARREA #1	BIO		NV ST PLN-NAD27			FT					FT
903965	RWMS LARREA #2	BIO		NV ST PLN-NAD27			FT					FT
903966	RWMS LARREA #3	BIO		NV ST PLN-NAD27			FT					FT
903967	RWMS LARREA #4	BIO		NV ST PLN-NAD27			FT					FT
903968	RWMS SALSOLA #1	BIO		NV ST PLN-NAD27			FT					FT
903969	RWMS SALSOLA #2	BIO		NV ST PLN-NAD27			FT					FT
903970	RWMS SALSOLA #3	BIO		NV ST PLN-NAD27			FT					FT
903971	RWMS SALSOLA #4	BIO		NV ST PLN-NAD27			FT					FT
903972	RWMS ANNUAL #1	BIO		NV ST PLN-NAD27			FT					FT
903973	RWMS ANNUAL #2	BIO		NV ST PLN-NAD27			FT					FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
903974	RWMS ANNUAL #3	BIO		NV ST PLN-NAD27			FT					FT
903985	RWMS ATRIPLEX #1	BIO		NV ST PLN-NAD27			FT					FT
903986	RWMS ATRIPLEX #2	BIO		NV ST PLN-NAD27			FT					FT
903987	RWMS ATRIPLEX #3	BIO		NV ST PLN-NAD27			FT					FT
904021	TRENCH 1	BIO		NV ST PLN-NAD27			FT					FT
904022	TRENCH 4	BIO		NV ST PLN-NAD27			FT					FT
904023	PIT 1	BIO		NV ST PLN-NAD27			FT					FT
904037	GCD PLANTS	BIO		NV ST PLN-NAD27			FT					FT
904038	CONTROL	BIO		NV ST PLN-NAD27			FT					FT
904039	PIT 3	BIO		NV ST PLN-NAD27			FT					FT
904040	TRENCH 6	BIO		NV ST PLN-NAD27			FT					FT
1709548	GCD05U-110B	SOIL GAS	ACTIVE	NV ST PLN-NAD27			FT					FT
2163341	ER-5-2	BH EM			732500	682600		-116.044163	36.760807			
2163342	ER-5-3 #3	BH EM			773586	713037		-115.939191	36.873069			
2163343	ER-5-4	BH EM			755810	705950		-115.963866	36.82439			
2163344	ER-5-4 #2	BH EM			755710	705950		-115.963869	36.824115			
2163458	WEF WEST ETLD	ETLD	ACTIVE	UTM Z11 meters WGS84	4078910	593310		115.95334	36.8515	3000		FT

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
2165072	TRU PAD-RCRA	DRUM-55GAL		NV ST PLN-NAD27			FT					FT
2165077	TRU PAD RCRA	DRUM		NV ST PLN-NAD27			FT					FT
2173067	MERC HWY 1MI N OF CANE SPRG RD	BIO			4080000	588400						METERS
2177766	AREA 5 FLUME	FLUME										
2177767	NORTH WEIGHING LYSIMETER	LYSIMETER										
2177768	SOUTH WEIGHING LYSIMETER	LYSIMETER										
2178488	PO5U-VZMF-1	VZM										
2178489	PO5U-VZMF-2	VZM										
2178487	PO5U-VZMC-1	VZM										
2178490	PO5U-VZMF-3	VZM										
2178491	PO5U-VZMF-4	VZM										
2178492	PO5U-VZMF-5	VZM										
2178493	PO5U-VZMF-6	VZM										
2178494	PO4U-VZMC-1	VZM										
2178495	PO3U-VZMC-1	VZM										
2178496	PO3U-VZMC-2	VZM										
2178497	PO3U-VZMF-1	VZM										
2178498	PO3U-VZMF-2	VZM										
2178499	PO3U-VZMF-3	VZM										
2181862	UE5PW-1 ETLD	ETLD	INACTIVE		765761	709890			36.851662			
2181863	SC RWMS ETLD	ETLD	INACTIVE		765990	708249			36.852304			
2181864	WC RWMS ETLD	ETLD	INACTIVE		766976	707400			36.85503			
2181865	UE5PW-3 ETLD	ETLD	INACTIVE		771202	703602			36.866714			
2181866	NE RWMS ETLD	ETLD	INACTIVE		767977	709399			36.857738			
2181867	LYSIMETER ETLD	ETLD	INACTIVE		765941	705903			36.852217			
2181869	S P01U ETLD	ETLD	INACTIVE	NV ST PLN-NAD27	766611	708436			36.854006	3202		FT
902104	GCD05U-20B	SOIL GAS	ACTIVE	NV ST PLN-NAD27	767417	708120	FT			3178		FT

Data extracted September 2005 from the Bechtel Integrated Data Management System (BEIDMS)

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
2183005	UE5PW-1 CALPIT VZM	VZM										
2183006	PIT 5 NORTH VZM STATION	VZM										
2183007	PIT 5 SOUTH VZM STATION	VZM										
2183008	PIT3N VZM STATION	VZM										
2183009	PIT3S VZM STATION	VZM										
2183010	PIT3F VZM STATION	VZM										
2189535	BOOSTER TANK	ABOVE TANK										
2190028	BLDG 5-32	POT WTR END PT	ACTIVE	NV ST PLN-NAD27			FT					FT
2196225	RWMS BLDG 5-18 SEPTIC SYSTEM	SSS										
2199116	SUGAR BUNKER NORTH	AMS	ACTIVE		763949	707789		-115.957382306	36.846704008	3156		FT
2198301	TRENCH 3	BIO		NV ST PLN-NAD27			FT					FT
2200120	RWMS EXPANSION NW	ETLD	ACTIVE	UTM Z11 meters WGS84	4080242	592744	FT	115.95953	36.86356	3235		FT
2200121	RWMS EXPANSION NE	ETLD	ACTIVE	UTM Z11 meters WGS84	4080243	593403	FT	115.95213	36.8635	3234		FT
2201897	HAZ WASTE ACCUM AREA	DRUM										
2229815	C-1 SOUTH TANK	DW TANK										
10873	U-5I CABLE HOLE #2	BH CABLE	PLUGGED	NV ST PLN-NAD27	774854	709462	FT	-115.95138	36.876626	3408	3408	FT
10904	U-5 GCDT #1 DISPOSAL FACILITY	BH DISPOSAL	ACTIVE	NV ST PLN-NAD27	770001	710000	FT	-115.949666	36.863285	3242	3242	FT
2181870	N P01U ETLD	ETLD	INACTIVE	NVST PLN-NAD27/WGS84	767210	708624			36.855648	3190		FT
2181871	W P02U ETLD	ETLD	INACTIVE	NV ST PLN-NAD27	767030	708030			36.855165	3189		FT
2181868	W P03U ETLD	ETLD	INACTIVE	NV ST PLN-NAD27	767921	708090			36.857611	3190		FT
2251981	CLASSIFIED AREA	BIO		NV ST PLN-NAD27			FT					FT
2251982	PIT 2	BIO		NV ST PLN-NAD27			FT					FT
2262383	C-1 WELL HEAD	DW TANK										

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
2265021	BUILDING 5-19	POT WTR END PT		NV ST PLN-NAD27			FT					FT
2268851	FRENCHMAN LAKE	ETLD	ACTIVE	UTM Z11 meters WGS84	4072971	595499		115.92954	36.79775	3080		FT
2278453	JP-8	SSS										
2627375	AREA 5 RWMS	ETLD	INACTIVE									
2798983	MERCURY HIGHWAY	BIO										
2807741	P01U RADON	SOIL GAS										
2807742	CLASSIFIED WASTE AREA	SOIL GAS										
2807743	GCD RADON	SOIL GAS										
2807744	GCDT RADON	SOIL GAS	ACTIVE	NV ST PLN-NAD27	770001	710000	FT	-115.949666	36.863285	3242	3242	FT
2807745	LYSIMETER RADON	SOIL GAS	INACTIVE		765941	705903			36.85221783			
2807746	P02U RADON	SOIL GAS										
2807747	UE5PW-3 RADON	SOIL GAS	INACTIVE		771202	703602			36.86671437			
2807748	UE5PW-1 RADON	SOIL GAS	INACTIVE		765761	709890			36.85166269			
2807749	PIT 6 RADON	SOIL GAS	INACTIVE	NV ST PLN-NAD27			FT					FT
2807750	TRENCH 1 RADON	SOIL GAS		NV ST PLN-NAD27			FT					FT
2829721	CANE SPRING - BIOTA	BIO		NV ST PLN-NAD27			FT					FT
2845955	5B WELL HOUSE	WL POT	ACTIVE				FT					
2845956	5B WATER LINE	WL POT	ACTIVE				FT					
2858802	PIT 3 SUMP	DRUM										
2859421	CAU-140 SOIL DRUM 1	DRUM-55GAL										
2859422	CAU-140 SOIL DRUM 2	DRUM-55GAL										
2859423	CAU-140 SOIL DRUM 3	DRUM-55GAL										
2859424	CAU-140 SOIL DRUM 4	DRUM-55GAL										
2859425	CAU-140 SOIL DRUM 5	DRUM-55GAL										
2859426	CAU-140 SOIL DRUM 6	DRUM-55GAL										
2859427	CAU-140 SOIL DRUM 7	DRUM-55GAL										

AREA 5 MONITORING LOCATIONS

STATION	STATION ID	TYPE	STATUS	GRID_PLANE	NORTHING	EASTING	UNITS	LONGITUDE	LATITUDE	GROUND ELEVATION	REFERENCE ELEVATION	UNITS
2859428	CAU-140 SOIL DRUM 8	DRUM-55GAL										
2859429	CAU-140 SOIL DRUM 9	DRUM-55GAL										
2859430	CAU-140 SOIL DRUM 10	DRUM-55GAL										
2859431	CAU-140 SOIL DRUM 11	DRUM-55GAL										
2859432	CAU-140 SOIL DRUM 12	DRUM-55GAL										
2859433	CAU-140 SOIL DRUM 13	DRUM-55GAL										
2859434	CAU-140 SOIL DRUM 14	DRUM-55GAL										
2859435	CAU-140 SOIL DRUM 15	DRUM-55GAL										
2865621	BLDG 5-32 DRUM	DRUM	ACTIVE	NV ST PLN-NAD27								
2866202	RWMS 5 ANIMAL	BIO										
2866204	RWMS 5 PLANT	BIO-VEG										
2866863	MERCURY HWY/5-01 ROAD	BIO										
2875988	MERCURY HWY/CANE SPRGS INT.	AMS										
2875989	28-03 AND CANE SPRNGS INT.	AMS										

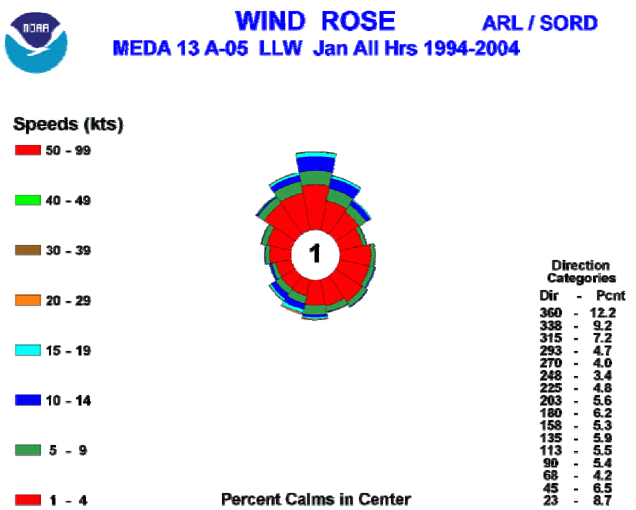
APPENDIX D

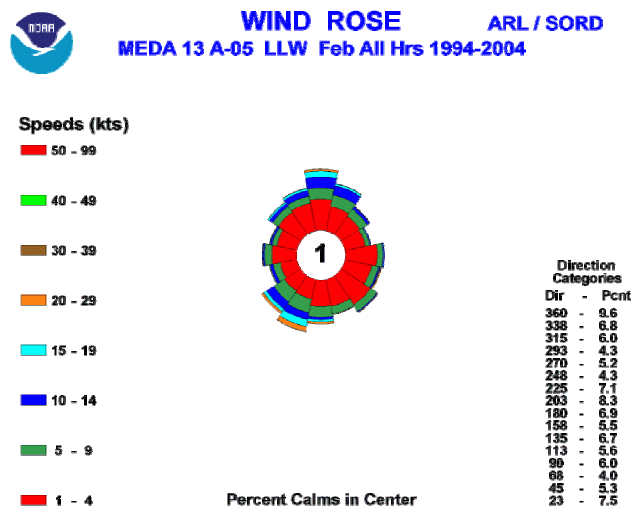
AREA 5 RWMS WIND DATA

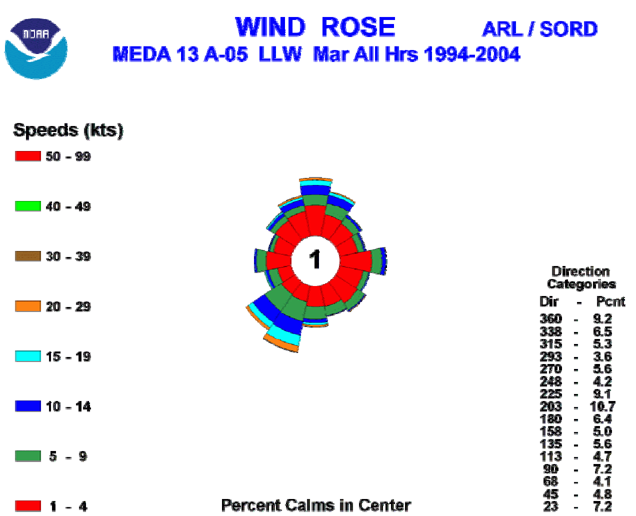
AREA 5 RWMS WIND DATA

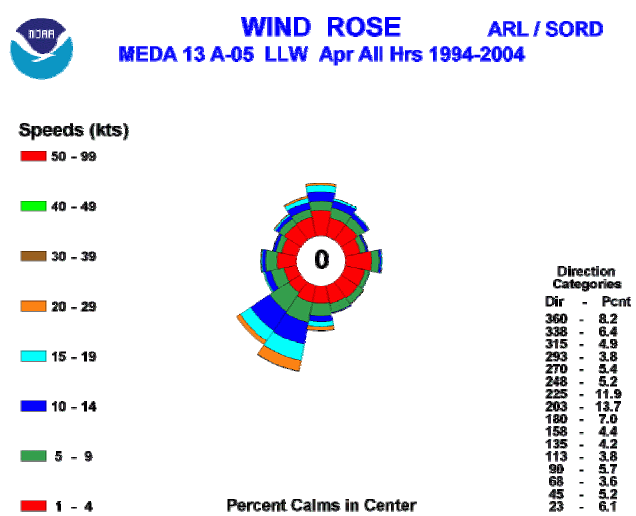
The following wind rose diagrams summarize hourly wind speed and direction data on a monthly basis for the 1994 through 2004 period of record at the Area 5 RWMS Meteorology Station. Velocity groups are represented by color. 1 knot = 0.514 meters per second = 1.151 miles per hour. Sixteen wind source directions are represented by the petals, where North 360 degrees is the top petal, and East 90 degrees the right-most petal. Percent frequency is represented by the length of the petals.

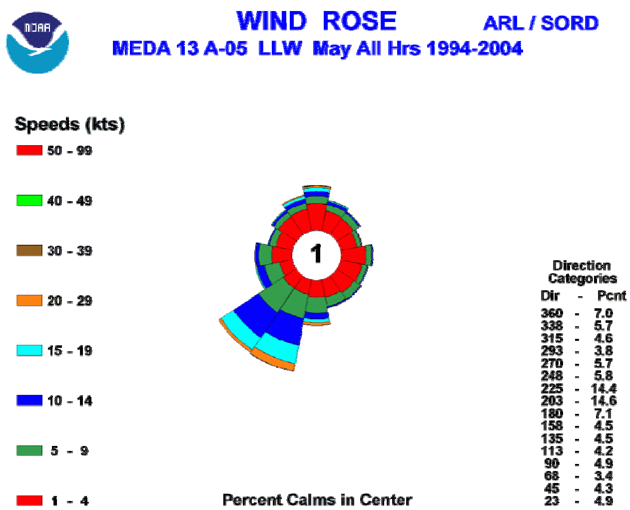
The wind roses are from the Air Resources Laboratory, Special Operations and Research Division. Further Nevada Test Site wind information is available from the DOE web site: http://www.sord.nv.doe.gov/products/climate/wind-roses/MEDA.

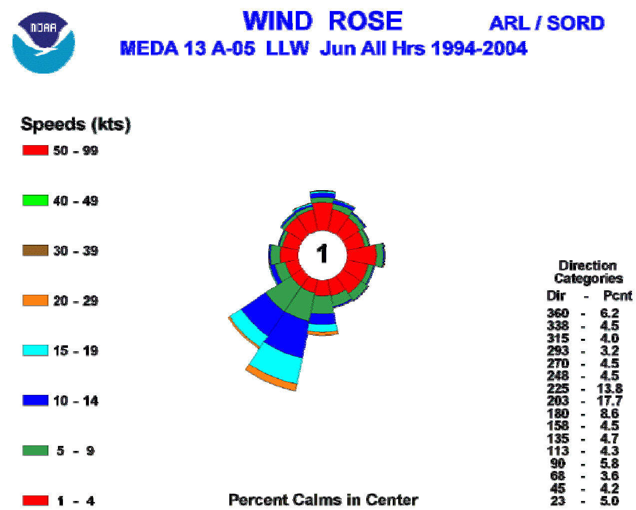


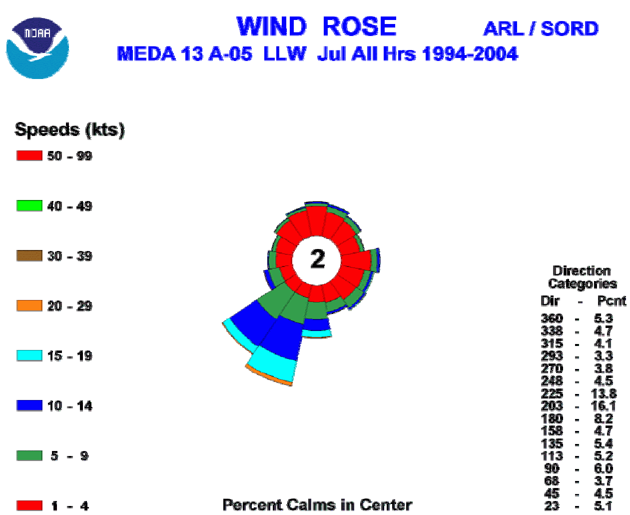


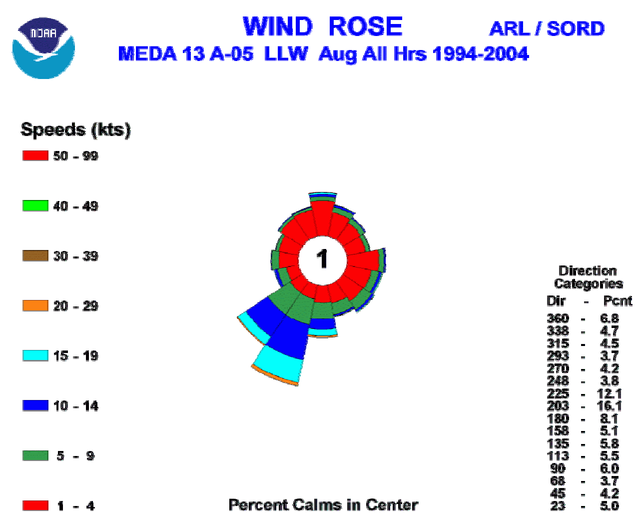


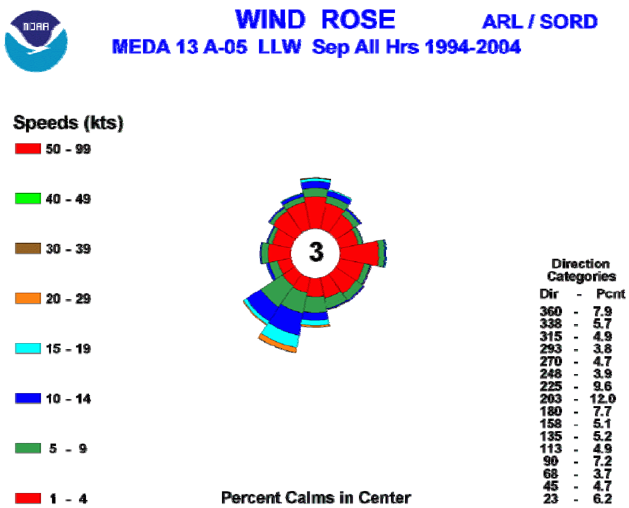


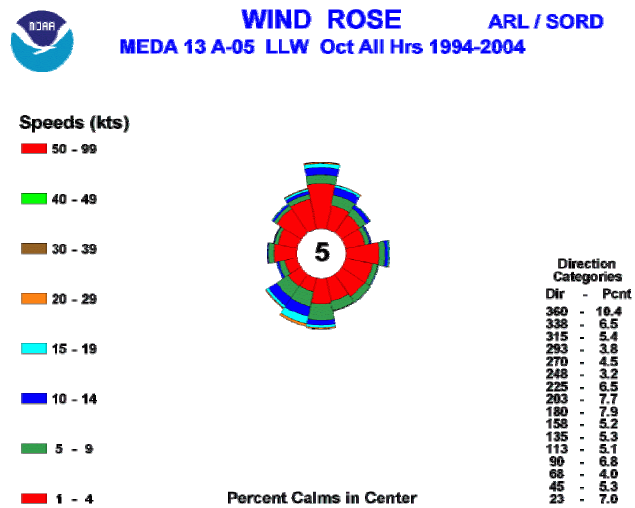

WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW May All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
1
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 7.0
338 - 5.7
315 - 4.6
293 - 3.8
270 - 5.7
248 - 5.8
225 - 14.4
203 - 14.6
180 - 7.1
158 - 4.5
135 - 4.5
113 - 4.2
90 - 4.9
68 - 3.4
45 - 4.3
23 - 4.9

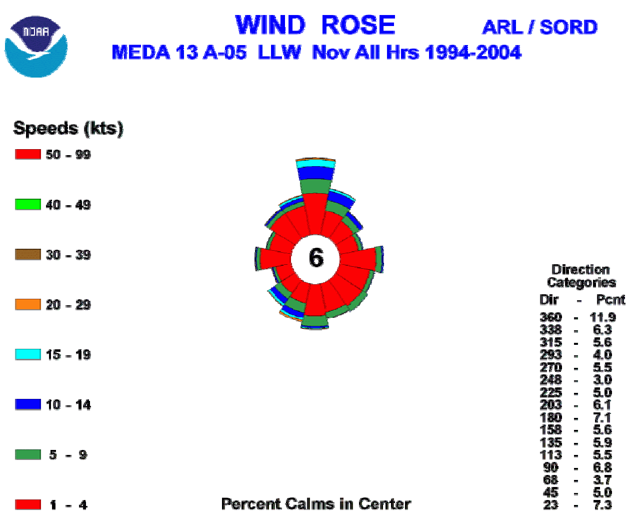

WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW Jun All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
1
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 6.2
338 - 4.5
315 - 4.0
293 - 3.2
270 - 4.5
248 - 4.5
225 - 13.8
203 - 17.7
180 - 8.6
158 - 4.5
135 - 4.7
113 - 4.3
90 - 5.8
68 - 3.6
45 - 4.2
23 - 5.0

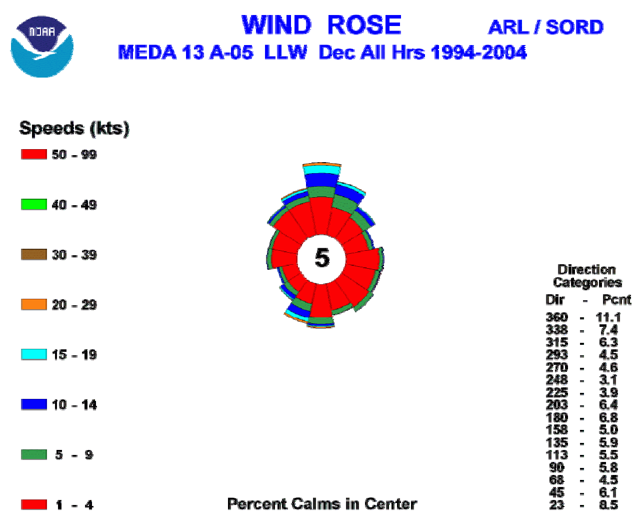

WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW Jul All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
2
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 5.3
338 - 4.7
315 - 4.1
293 - 3.3
270 - 3.8
248 - 4.5
225 - 13.8
203 - 16.1
180 - 8.2
158 - 4.7
135 - 5.4
113 - 5.2
90 - 6.0
68 - 3.7
45 - 4.5
23 - 5.1


WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW Aug All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
1
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 6.8
338 - 4.7
315 - 4.5
293 - 3.7
270 - 4.2
248 - 3.8
225 - 12.1
203 - 16.1
180 - 8.1
158 - 5.1
135 - 5.8
113 - 5.5
90 - 6.0
68 - 3.7
45 - 4.2
23 - 5.0


WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW Sep All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
3
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 7.9
338 - 5.7
315 - 4.9
293 - 3.8
270 - 4.7
248 - 3.9
225 - 9.6
203 - 12.0
180 - 7.7
158 - 5.1
135 - 5.2
113 - 4.9
90 - 7.2
68 - 3.7
45 - 4.7
23 - 6.2


WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW Oct All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
5
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 10.4
338 - 6.5
315 - 5.4
293 - 3.8
270 - 4.5
248 - 3.2
225 - 6.5
203 - 7.7
180 - 7.9
158 - 5.2
135 - 5.3
113 - 5.1
90 - 6.8
68 - 4.0
45 - 5.3
23 - 7.0


WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW Nov All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
6
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 11.9
338 - 6.3
315 - 5.6
293 - 4.0
270 - 5.5
248 - 3.0
225 - 5.0
203 - 6.1
180 - 7.1
158 - 5.6
135 - 5.9
113 - 5.5
90 - 6.8
68 - 3.7
45 - 5.0
23 - 7.3


WIND ROSE
ARL / SORD
MEDA 13 A-05 LLW Dec All Hrs 1994-2004
Speeds (kts)
50 - 99
40 - 49
30 - 39
20 - 29
15 - 19
10 - 14
5 - 9
1 - 4
5
Percent Calms in Center
Direction Categories
Dir - Pcnt
360 - 11.1
338 - 7.4
315 - 6.3
293 - 4.5
270 - 4.6
248 - 3.1
225 - 3.9
203 - 6.4
180 - 6.8
158 - 5.0
135 - 5.9
113 - 5.5
90 - 5.8
68 - 4.5
45 - 6.1
23 - 8.5

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APPENDIX E

BOREHOLE DATA AND WELL DETAILS

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SCIENCE TRENCH BOREHOLE ST-1 COMPLETION DIAGRAM

Source: Reynolds Electrical & Engineering Co. Inc, 1993. *Hydrogeologic Data for the Science Trench Boreholes at the Area 5 RWMS, Nevada Test Site*

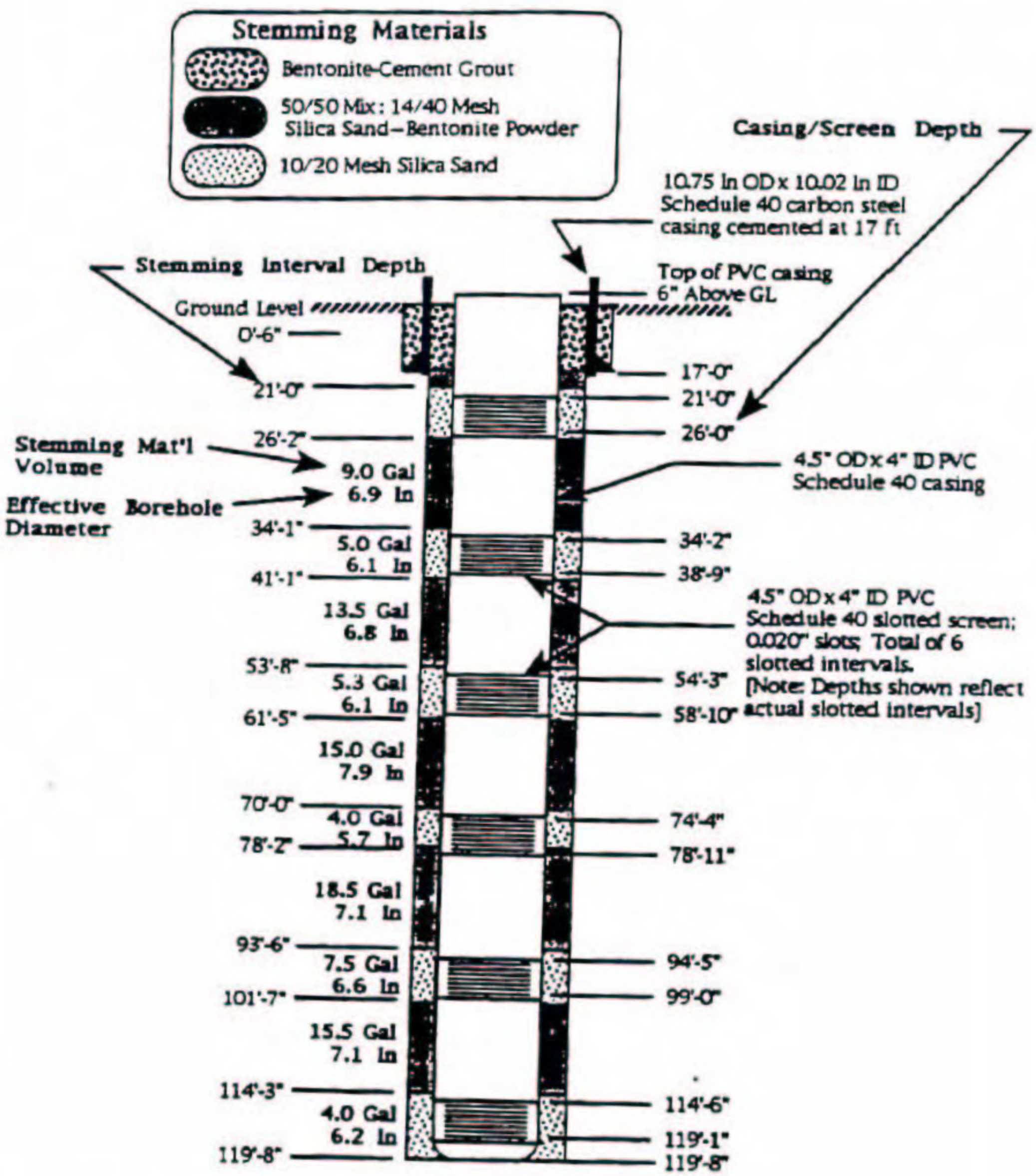


Figure I.1. Completion details for boreholes ST-1.

SCIENCE TRENCH BOREHOLE ST-2A COMPLETION DIAGRAM

Source: Reynolds Electrical & Engineering Co. Inc, 1993. *Hydrogeologic Data for the Science Trench Boreholes at the Area 5 RWMS, Nevada Test Site*

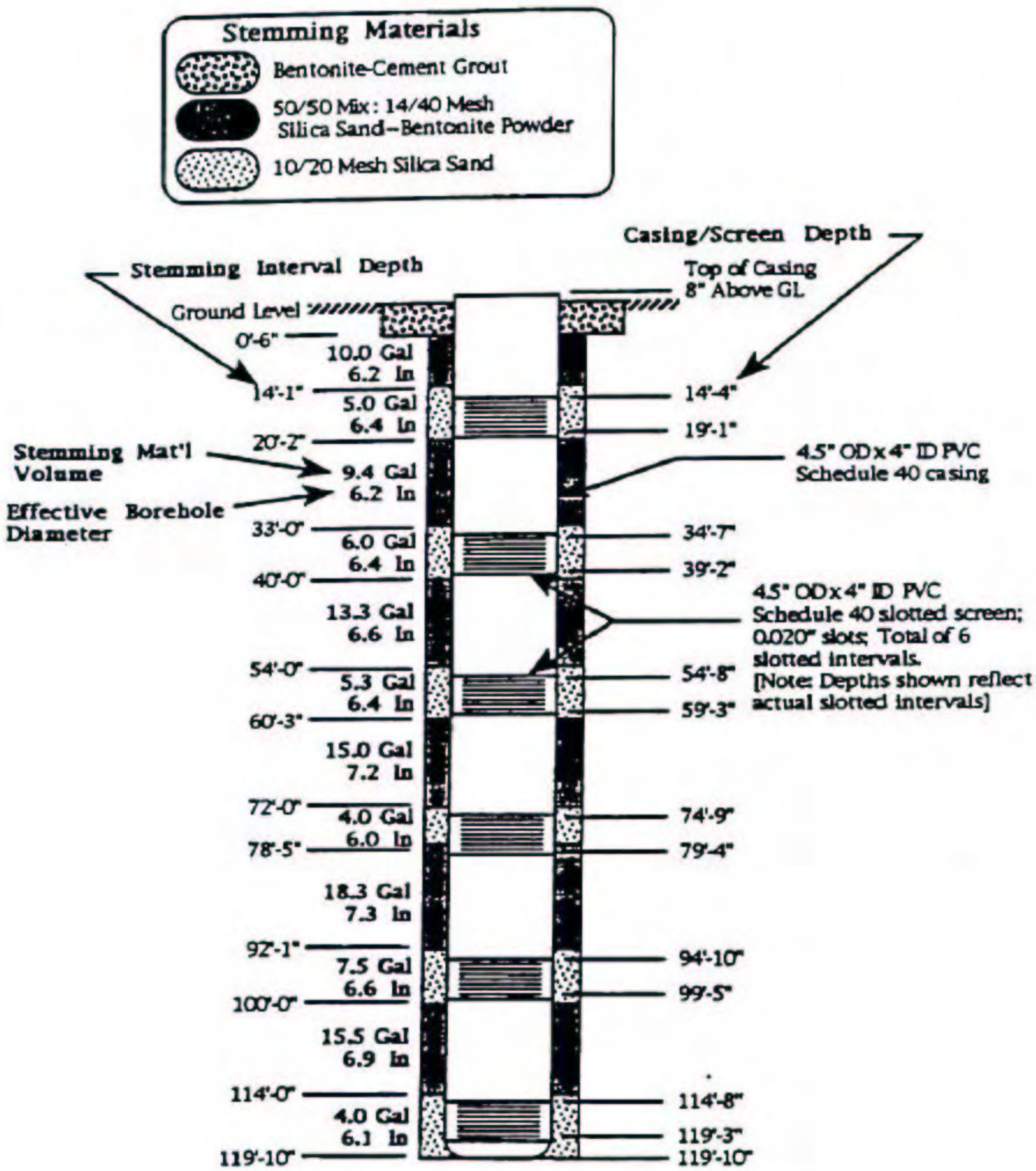


Figure I.2. Completion details for boreholes ST-2A.

SCIENCE TRENCH BOREHOLE ST-4A COMPLETION DIAGRAM

Source: Reynolds Electrical & Engineering Co. Inc, 1993. *Hydrogeologic Data for the Science Trench Boreholes at the Area 5 RWMS, Nevada Test Site*

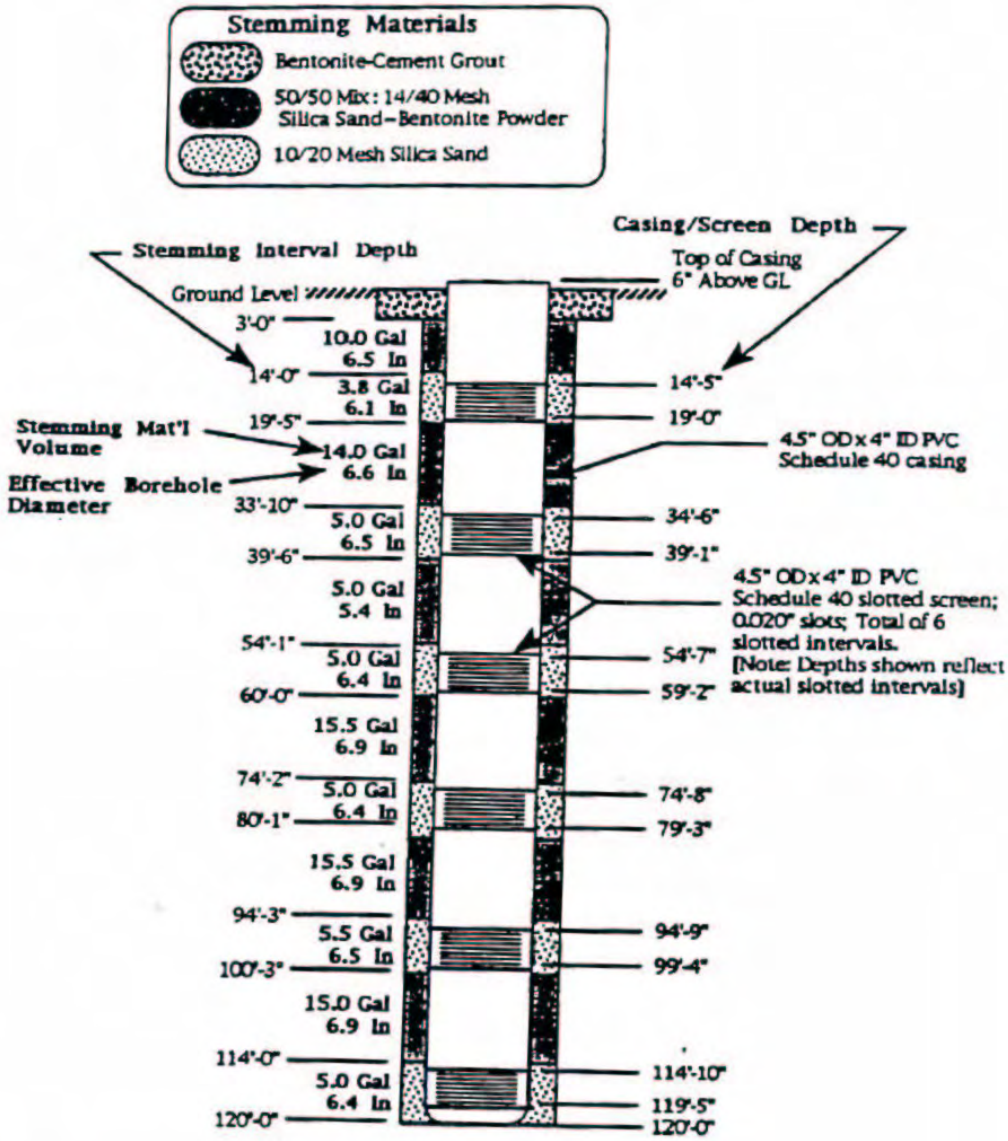


Figure I.3. Completion details for boreholes ST-4A.

SCIENCE TRENCH BOREHOLE ST-6A COMPLETION DIAGRAM

Source: Reynolds Electrical & Engineering Co. Inc, 1993. *Hydrogeologic Data for the Science Trench Boreholes at the Area 5 RWMS, Nevada Test Site*

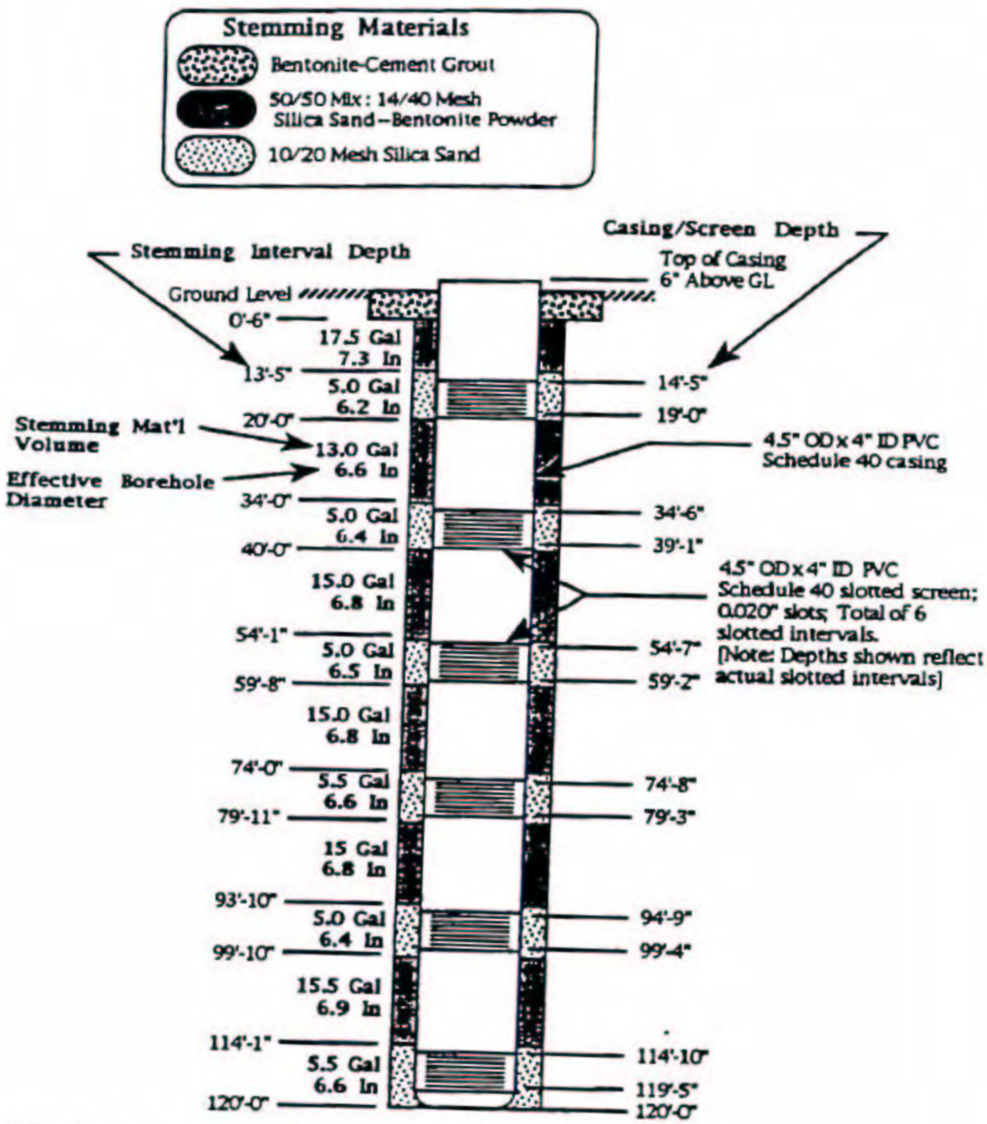
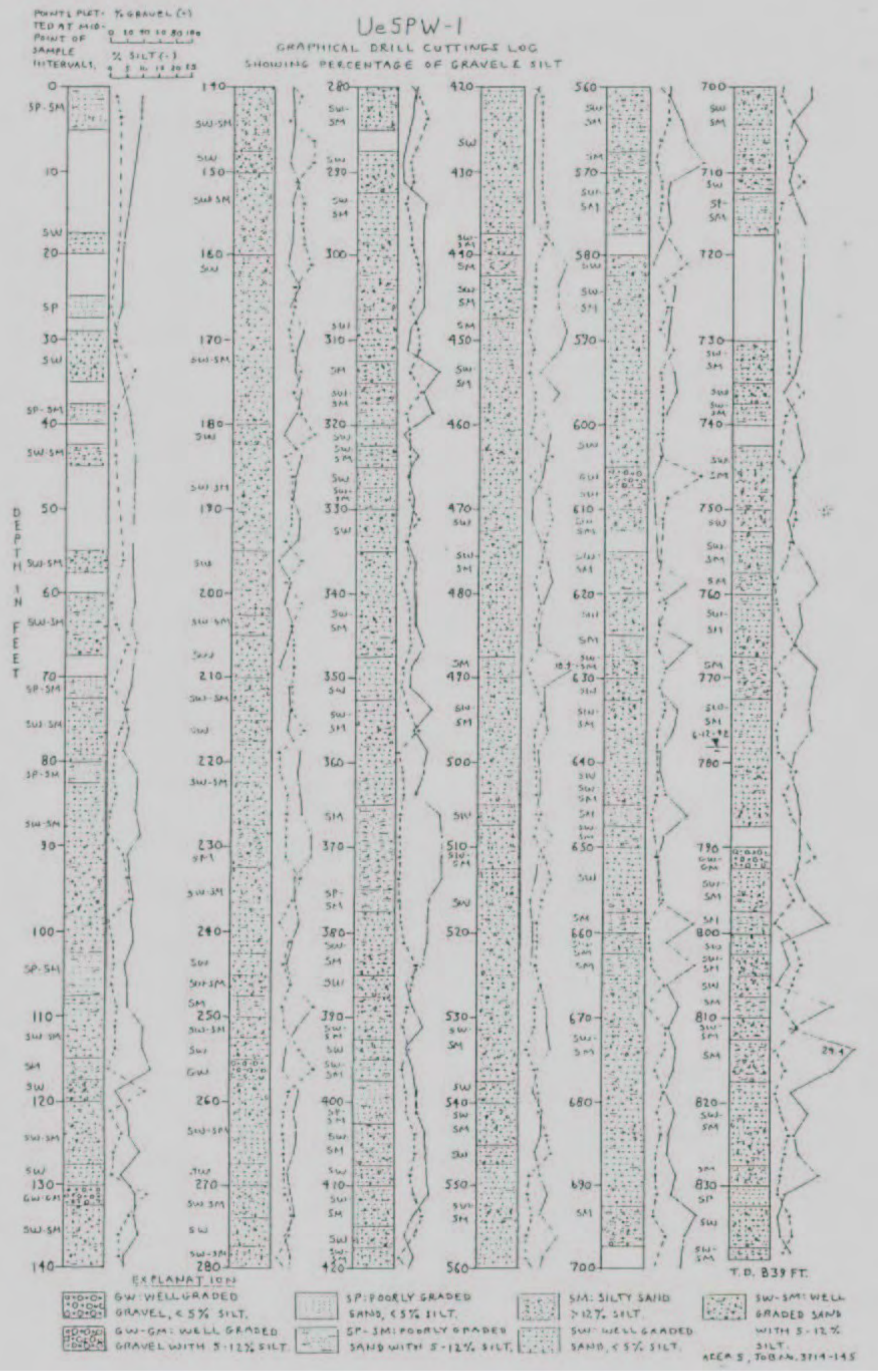


Figure I.4. Completion details for boreholes ST-6A.

UE5PW-1 BORING LOG

Source: REECo, February 1994. *Site Characterization and Monitoring data from Area 5 Pilot Wells, NTS, Nye County, Nevada*. DOE/NV/11432—74.

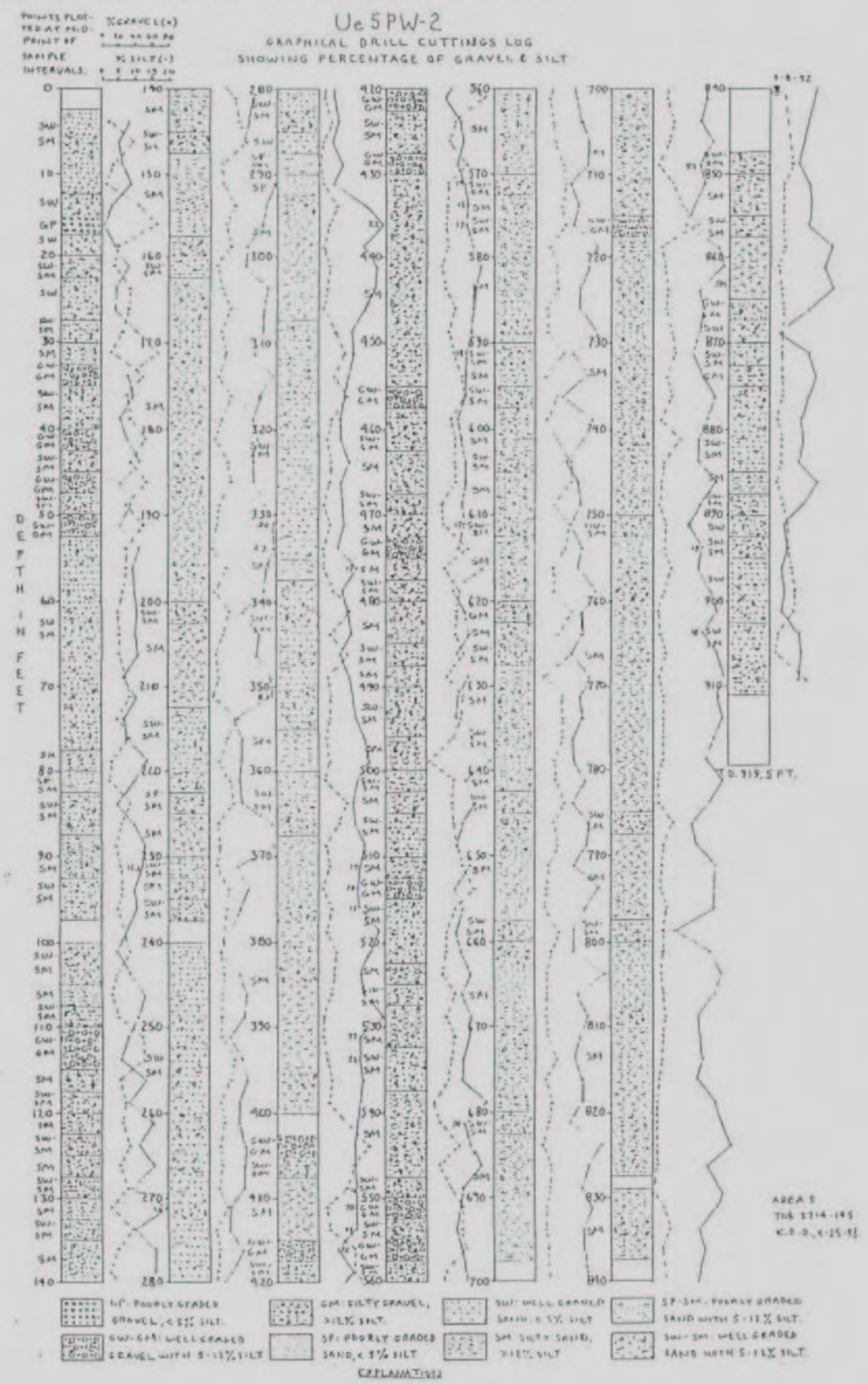
Appendix E.1.1 Profile of USCS Textural Classes



UE5PW-2 BORING LOG

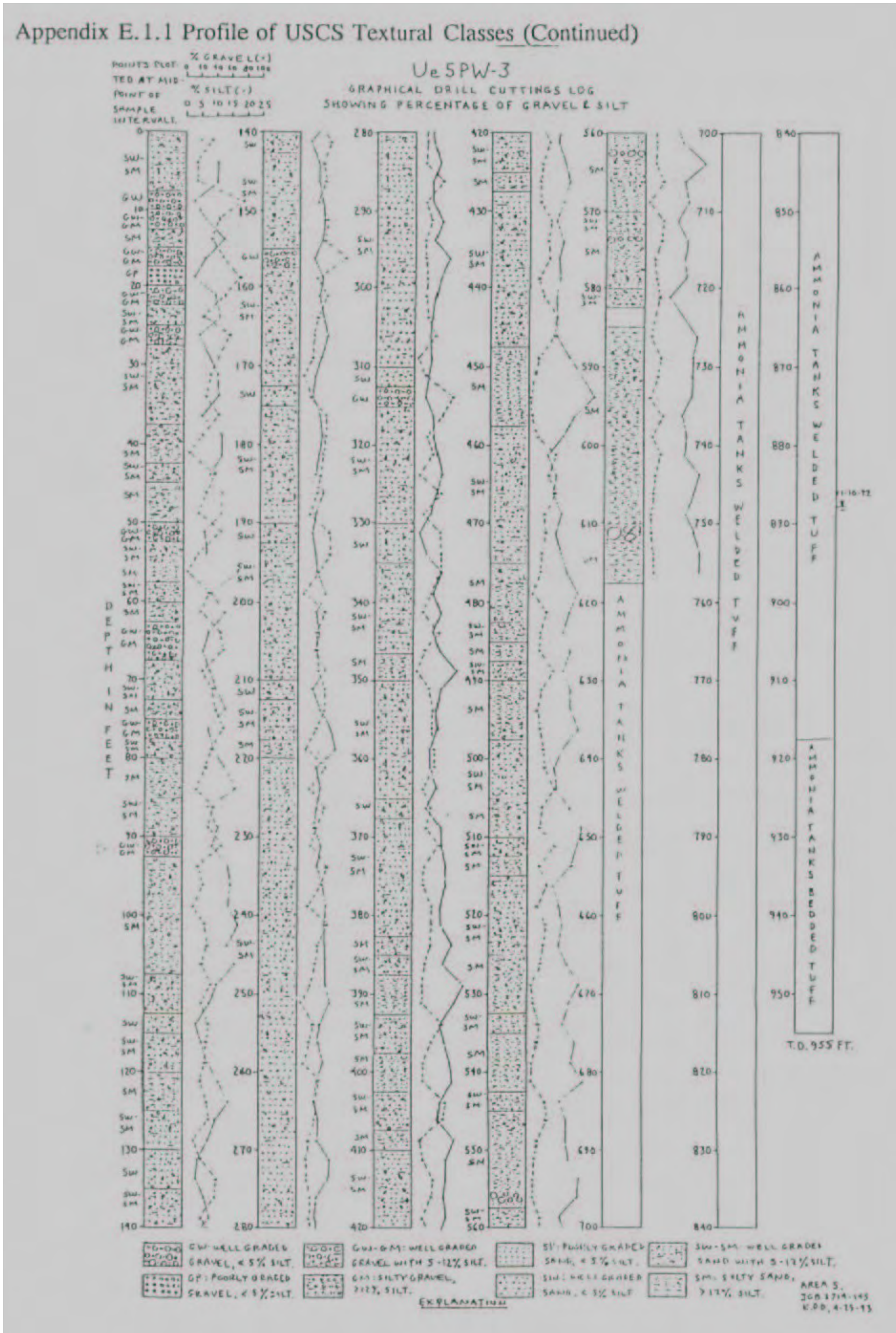
Source: REECo, February 1994. *Site Characterization and Monitoring data from Area 5 Pilot Wells, NTS, Nye County, Nevada*. DOE/NV/11432—74.

Appendix E.1.1 Profile of USCS Textural Classes (Continued)



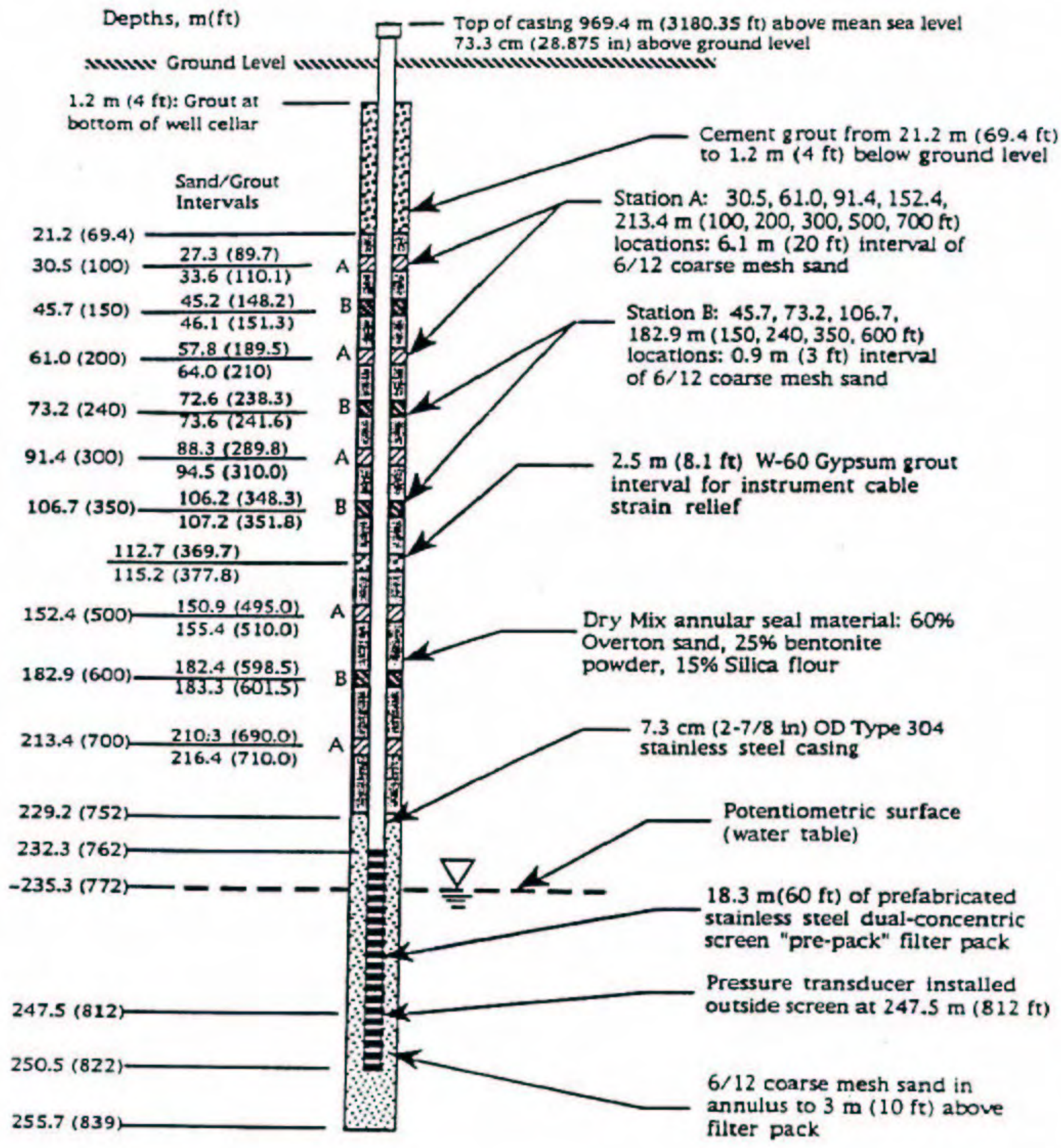
UE5PW-3 BORING LOG

Source: REECo, February 1994. *Site Characterization and Monitoring data from Area 5 Pilot Wells, NTS, Nye County, Nevada*. DOE/NV/11432-74



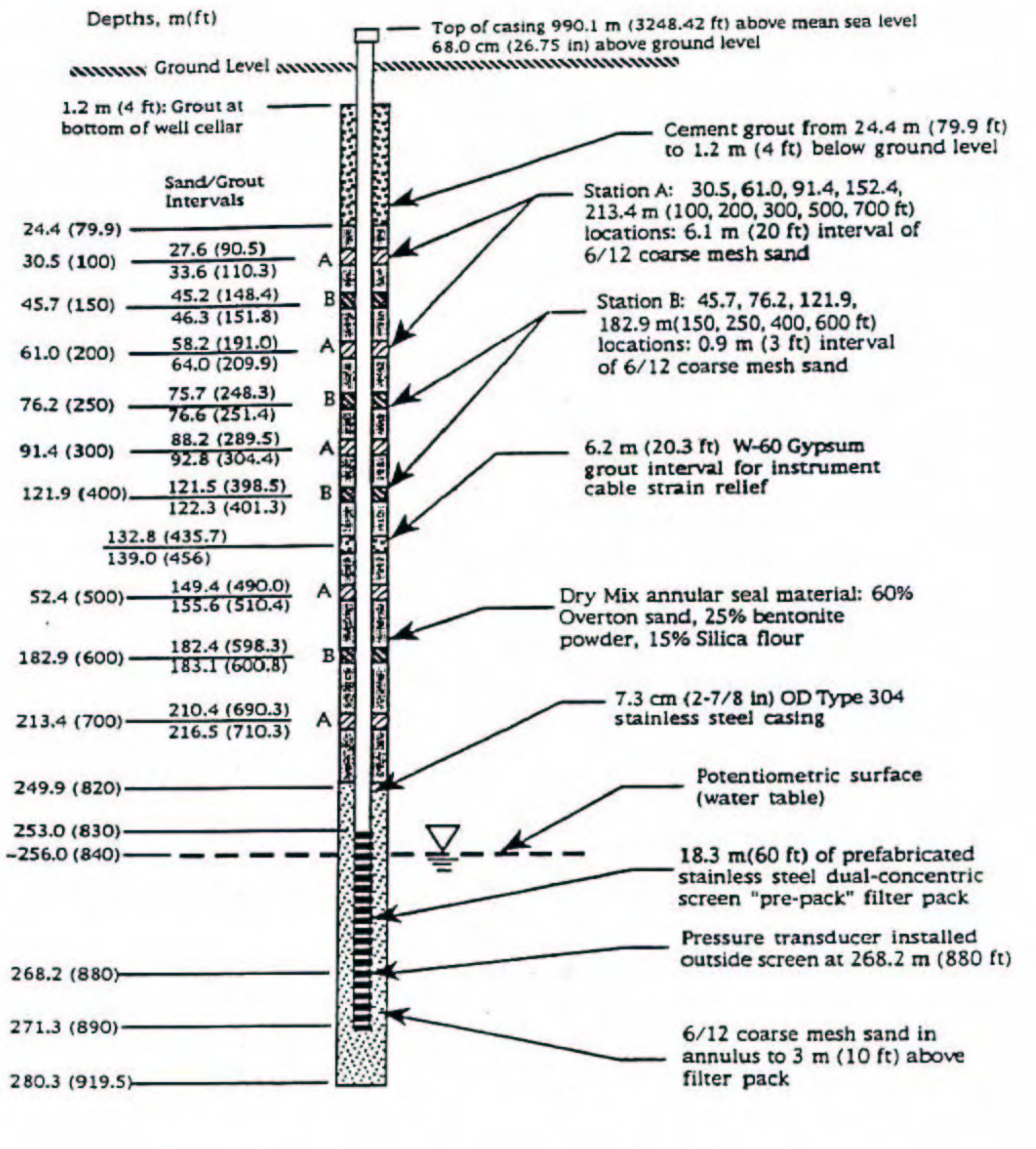
UE5PW-1 WELL COMPLETION DIAGRAM

Source: REECo, February 1994. *Site Characterization and Monitoring data from Area 5 Pilot Wells, NTS, Nye County, Nevada*. DOE/NV/11432—74.



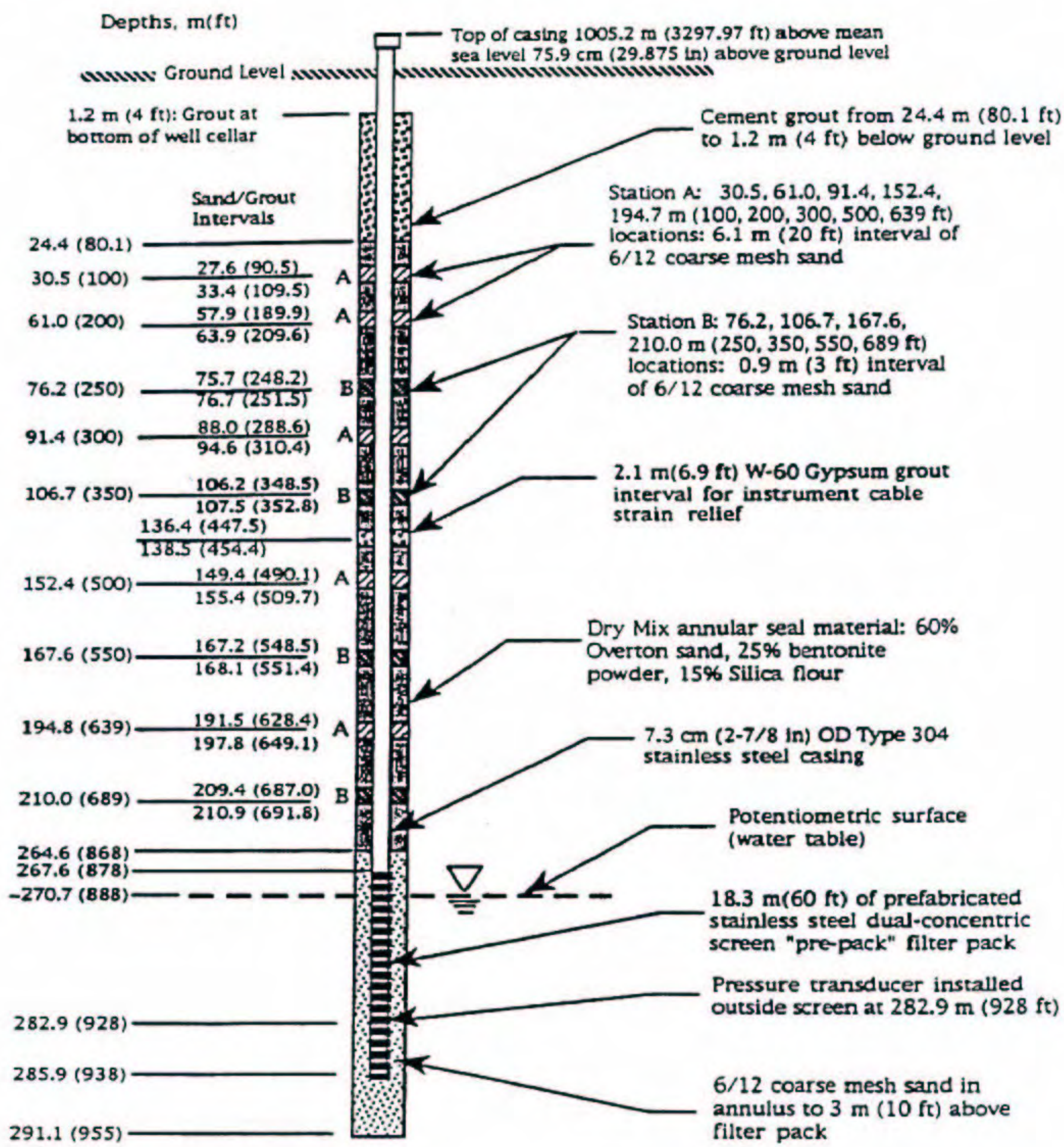
UE5PW-2 WELL COMPLETION DIAGRAM

Source: REECo, February 1994. *Site Characterization and Monitoring data from Area 5 Pilot Wells, NTS, Nye County, Nevada*. DOE/NV/11432—74.



UE5PW-3 WELL COMPLETION DIAGRAM

Source: REECo, February 1994. *Site Characterization and Monitoring data from Area 5 Pilot Wells, NTS, Nye County, Nevada*. DOE/NV/11432—74.



APPENDIX F

GROUNDWATER QUALITY DATA SUMMARY

MARCH 1993 THROUGH OCTOBER 2004 GROUNDWATER MONITORING

Well	Parameter	Total Number of Samples Analyzed	Number of Detections of Parameter	Units	Investigation Level	Minimum	Maximum	Mean of Detected Values Above MDL	Standard Deviation	Coefficient of Variance %	Latest Published (10/19/2004 Sample)
UE5PW-1											
	pH	29	29	unitless	<7.6 or >9.2	7.91	8.63	8.35	0.14	2	8.30
	Specific Conductance	29	29	mmhos/cm	0.440	0.320	0.401	0.376	0.014	4	0.372
	Total Organic Carbon[a]	27	7	mg/l	1	0.2	0.64	0.44	0.16	37	0.58
	Total Organic Halides[a]	29	3[b]	ug/l	50	12	20	17.3	4.6	27	<5.2
	Tritium	21	1	pCi/l	2000	<20	33.96 [c]	33.96	0	0	<20
	Ca	16	16	mg/l		12.5	15.5	14.04	0.9	6	13.1
	Fe	24	20	mg/l		0.008	0.059	0.021	0.012	58	<0.028
	Mg	16	16	mg/l		4.5	6	5.1625	0.37	7	5.2
	Mn	23	9	mg/l		0.0002	0.0066	0.0016	0.002	127	<0.0003
	K	16	16	mg/l		5.21	6.96	6.37	0.46	7	6
	Si	14	14	mg/l		24.3	32	27.95	1.76	6	28
	Na	24	24	mg/l		48	63.5	56.25	3.74	7	56.2
	SO_4	21	21	mg/l		32	37.3	35.02	1.52	4	37.3
	HCO_3	19	19	mg/l		117	157.5	129.45	10.6	8	138
	Cl	22	22	mg/l		8.4	12.3	9.88	0.75	8	10.1
	F	19	19	mg/l		0.95	5.7	1.35	1.06	78	1
UE5PW-2											
	pH	28	28	unitless	<7.6 or >9.2	7.99	8.81	8.33	0.20	2	8.32
	Specific Conductance	28	28	mmhos/cm	0.440	0.325	0.411	0.359	0.015	4	0.352
	Total Organic Carbon[a]	28	5	mg/l	1	0.39	0.90	0.61	0.19	32	0.90
	Total Organic Halides[a]	27	4	ug/l	50	3.7	23	11.6	8.8	77	<5.2
	Tritium	22	1	pCi/l	2000	32.2 [d]	32.2 [d]	32.2	0	0	<20
	Ca	16	16	mg/l		14.8	17.55	16.1	0.79	5	15.7
	Fe	23	16	mg/l		0.012	0.33	0.0869	0.0931	107	<0.028
	Mg	16	16	mg/l		5.68	7.1	6.52	0.036	6	6.7
	Mn	22	7	mg/l		0.0002	0.11	0.0211	0.0409	194	<0.0003
	K	16	16	mg/l		3.83	6.2	5.25	0.51	10	5.1
	Si	14	14	mg/l		23.8	29.45	27.43	1.47	5	27.9
	Na	23	23	mg/l		44.35	55	48.55	3.18	7	48.6
	SO_4	22	22	mg/l		26.4	31	28.55	1.02	4	29.6
	HCO_3	20	20	mg/l		110	150	127.83	9.79	8	139
	Cl	21	21	mg/l		7.4	9.9	8.65	0.61	7	8.9
	F	19	19	mg/l		0.81	1.3	0.98	0.14	14	0.9

Well	Parameter	Total Number of Samples Analyzed	Number of Detections of Parameter	Units	Investigation Level	Minimum	Maximum	Mean of Detected Values Above MDL	Standard Deviation	Coefficient of Variance %	Latest Published (10/19/2004 Sample)
UE5PW-3											
	pH	30	30	unitless	<7.6 or >9.2	8.13	8.87	8.35	0.20	2	8.24
	Specific Conductance	30	30	mmhos/cm	0.440	0.338	0.384	0.367	0.011	3	0.365
	Total Organic Carbon[a]	27	8	mg/l	1	0.22	1.7	0.65	0.46	71	0.83
	Total Organic Halides[a]	27	2 [b]	ug/l	50	9	20	14.5	7.8	54	<5.2
	Tritium	22	0	pCi/l	2000	<20	<20	NA	NA	NA	<20
	Ca	16	16	mg/l		15	17.1	16	0.55	3	15.6
	Fe	24	15	mg/l		0.0088	0.0453	0.02111	0.0116	55	<0.028
	Mg	16	16	mg/l		5.7	6.4	5.9	0.18	3	5.9
	Mn	23	8	mg/l		0.0002	0.0009	0.00045	0.0003	73	<0.0003
	K	16	16	mg/l		2.4	4.8	4.1	0.58	14	4
	Si	14	14	mg/l		26.4	31	27.65	1.12	4	27.3
	Na	24	24	mg/l		47.6	58.5	53.12	3.2	6	52.3
	SO_4	22	22	mg/l		29	33	31.42	1.09	3	32
	HCO_3	20	20	mg/l		115	138.5	126.16	6.68	5	136
	Cl	22	22	mg/l		7.6	11.8	9.12	0.87	10	9.4
	F	19	18	mg/l		0.78	1.26	0.95	0.12	13	0.8

Notes: Based on historic data presented in Nevada Test Site 2004 Data Report: Groundwater Monitoring Program Area 5 Radioactive Waste Management Site (Bechtel Nevada, February 2005).

a Excluding sample results later deemed false positives through retesting.

b Duplicates of these samples had TOX concentrations less than the method detection limit.

c Only sample result above the 20pCi/l method detection level for the entire period of record.

d Standard analysis performed, not enriched. Only sample for period of record above 20 pCi/l method detection level.

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